Benefits of Cloud Services in Education: A Perspective of Database System Students

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Abstract

Currently, there is a growing trend in the use of cloud-based services to support education. The importance of these services is that they are publicly available, allowing students to access these distributed resources most transparently. In this work, a model of satisfactory learning measurement is proposed to analyze the benefits, from the students' perspective, of cloud services related to education. A case study performed in a Database Systems course is presented; in this, under-graduate students can remotely manage database systems using cloud services. The benefits of an online access scheme compared to those of traditional database access are measured in terms of usability and the principles of cognitive load theory.

2012 ACM Subject Classification Applied computing → Interactive learning environments

Keywords and phrases Cloud Computing, Satisfactory Learning, Database Systems

Digital Object Identifier 10.4230/OASIcs.ICPEC.2020.13

1 Introduction

The identified trends in the use of cloud computing in education are clear, ranging from the design of cloud-oriented learning environments for future information technology specialists to the training of information technology specialists to enable them to obtain competencies in the use of cloud technologies [9]. Cloud computing is a distributed computing paradigm, where, instead of acquiring information technology products, users access shared resources under various service models through a net-work, usually the Internet [5]. In universities, cloud computing technology, and the construction of learning management platforms improve the rate of resource utilization for teaching processes [6]. It is essential for an educational organization, with its budgetary constraints and sustainability challenges, to use the most appropriate cloud training for a teaching activity. In [1] there is a comparative analysis of how cloud computing technology can be used in e-Learning systems in favor of higher education. The results demonstrate that in addition to cost, there are technical benefits of using Cloud computing, such as, customer's preferred operating systems, stable virtu-al machines, fully redundant architecture, security firewalls, flexibility to meet new requirements, elasticity in new requirements and flexibility in design, among others.

In the case of traditional database system courses, it is essential to highlight that for the delivery of the course, a set of infrastructure software and tools a required, which often must be installed on servers in the institution or on the students' computers. Technically, the benefits of choosing cloud services, that can be accessed remotely, could be related to the reduction of management and maintenance responsibilities. In that sense, there are efforts like DBLearn [10], a Web-based adaptive e-learning system designed especially for database and SQL related courses. The DBLearn system provides several advantages over current systems, solving the major problem of teaching a database course to students of different learning styles and knowledge levels.

First International Computer Programming Education Conference (ICPEC 2020).
Editors: Ricardo Queirós, Filipe Portela, Mário Pinto, and Alberto Simões; Article No. 13; pp. 13:1–13:7
OpenAccess Series in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

Despite the efforts made in related research work, it is still unclear how cloud computing-based services can benefit to education, and, particularly to database systems students. To achieve this goal, we establish the following research question:

- Is there a significant benefit in terms of satisfactory learning of students who use cloud services for database systems compared to students who locally access soft-ware for the same purpose?

To evaluate these benefits, we focus on two types of indicators; on the one hand, those related to the usability of systems [8] and, on the other hand, the theory of cognitive load [12]. Regarding usability, it allows determining the extent to which users can fulfill a task in a satisfactory, effective, and efficient way, emphasizing the context in which they operate, and the specific tasks performed. For cognitive load theory (CLT), primary knowledge consists of generic cognitive skills and cannot be taught because they are acquired unconsciously.

The model proposed in this work is focused on measuring how satisfactory is a learning environment based on cloud services for database system students. Subsequently, a case study is presented, in which a group of university students is evaluated, which are divided into two groups: a control group and an experimental group. The control group will be asked to carry out a set of activities that involve the use of traditional tools for database system courses. The experimental group will be asked to perform the same set of activities but under an online environment using cloud services for database systems. Finally, the results and conclusions are presented and analyzed.

2 Benefits of a cloud-based solution

Cloud computing providers offer their services according to three fundamental mod-els: Infrastructure as a service (IaaS), platform as a service (PaaS), and Software as a service (SaaS) [6]. Every day there is a growing list of critical applications that are implemented and consumed through cloud services under the Software as a Service (SaaS) mechanisms. The following are some of the benefits of implementing a cloud-based solution [11]:

- The cloud model is efficient and profitable, where the user pays only for re-sources he consumes.
- There are no problems due to the maintenance and updating of the infrastructure and physical hardware.
- The cloud service provider offers autoscaling capabilities.
- Allows you to work from anywhere at any time and from any device
- Accelerates application development.

Despite these benefits, research needs to be done on the impact that cloud architecture has on student learning. In this sense, in the next section we will present a satisfactory learning measurement model, understood satisfaction, as a measure that can provide information on the effectiveness of instructional design.

3 A satisfactory learning measurement model

The satisfactory learning measurement model is a proposal developed by Bradford [3], who detected a correlation coefficient between satisfaction and cognitive load separating academic performance. In this sense, the model focuses on the measurement of three indicators to reduce the cognitive load: awareness, challenge, and commitment.

To measure usability, we take an instrument developed by [4], called the system usability scale (SUS). SUS is a survey consisting of 10 questions that are measured on a simple 5-point Likert scale (ranging from 1-totally disagree 'to 5-totally agree), which offers a global view of subjective assessments of usability. Table 1 shows the questions that are part of the SUS survey.

Table 1 SUS questions.

Q1	I think I would like to use this system frequently.
Q2	I found the system unnecessarily complicated.
Q3	I think the system is easy to use.
Q4	I think I need the support of a technical person to use this system.
Q5	I found that the various functions in this system were well integrated.
Q6	I think there are too many inconsistencies in this system.
Q7	I imagine that most people would learn to use this system very quickly.
Q8	I found the system very complicated to use.
Q9	I felt very safe using the system.
Q10	I needed to learn many things before I could start using this system.

In the case of cognitive load, an instrument proposed by [7] is used. Regarding the awareness indicator, four questions are posed to examine whether the curriculum and assignment instructions were clear (questions 11-14). Regarding the challenge indicator, three questions were established to relate the degree of student satisfaction with the degree of challenge they face (questions 15-17). Regarding the commitment indicator, three questions were asked to relate the relevance of the different types of learning activities to the needs and objectives of the students (questions 18-20). Table 2 presents the ten questions used in the cognitive load - satisfaction questionnaire.

Table 2 Cognitive Load - Satisfaction questions.

Q11	I think the instructions and guidelines for experimenting were clear.
Q12	I think it was understood how the solution to the problem is found, the expected results, and the evaluation process.
Q13	I think the informative sessions and the material presented helped me solve the problem.
Q14	I think this activity will be useful for the development of fu ture projects with the tools presented.
Q15	I believe that the development of this activity challenges my abilities to solve these types of problems.
Q16	I think that solving the problem itself is a significant achievement.
Q17	I can solve this problem and others, more complicated, of the same type.
Q18	I think this experiment is relevant to the course and my curriculum.
Q19	I believe that communication, discussions, or debates with my classmates and the teacher are essential.
Q20	I think this type of activity encourages me to develop solutions for me.

4 Design of the experiment

The experiment was carried out with third-year university students (N = 80) of the Relational Databases course for the program of Technology Manager degree, which contains the classic content of an introductory database course for non-computer science students: entity-relationship model, relational model, design of relational databases, structured query language, transaction control, and concurrency and per-form backup and recovery. The students who participated in the experience were divided into two groups: an experimental group (N = 40) and a control group (N = 40). The same teacher instructed both groups of students.

The experimental procedure consist in twenty 60-minute sessions were conducted for over six months. The first five sessions were for installing a MySQL platform with a database manager. The control group had to install personal laptops with MySQL Workbench database manager [2]. The experimental group create a Google Cloud account (1-year free account with $300 to use) and create instances of Cloud SQL with the PhPMyAdmin database manager [11]. The rest of the fifteen sessions, both groups, manage databases, execute SQL queries and backup and restore databases. After the end of the experiment, all students answered the usability and cognitive load questionnaires.

5 Presentation and importance of the results

The results of the usability questionnaire, both for the control group and for the experimental group, are shown in Figure 1 with a density diagram. In the case of questions 2,4,6,8 that are expressed negatively, the adjustment has been made so that they can be visualized in the same way as those expressed positively. We can observe that, in all cases, the students of the experimental group had a better perception of the usability of the experiment under a cloud services scenario.

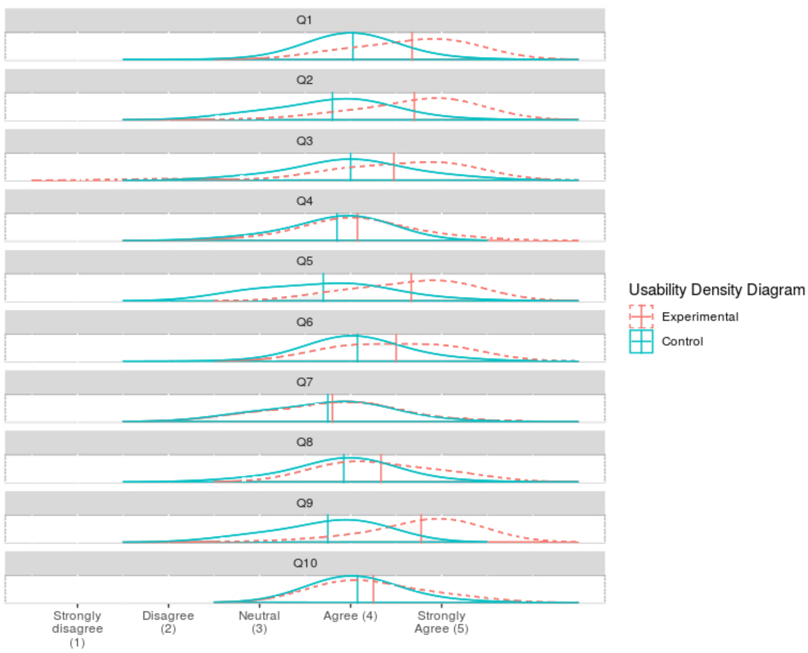

Figure 1 Diagram of the density of responses to the usability questionnaire for both groups.

In the case of the cognitive load questionnaire, in general, in each of the evaluation criteria, the results of the experimental group were closer to agreeing in comparison with the same results of the control group (Figure 2). In the case of the awareness indicator (questions 11–14), based on the responses of each of the groups, the experimental group showed better performance to find solutions and solve the experiment, compared to the control group. Regarding the indicator of commitment (questions 18–20), the experimental group showed a better perception of the relevance of the different types of learning activities concerning the needs and objectives of the students, which improves the cognitive load – satisfaction for these students.

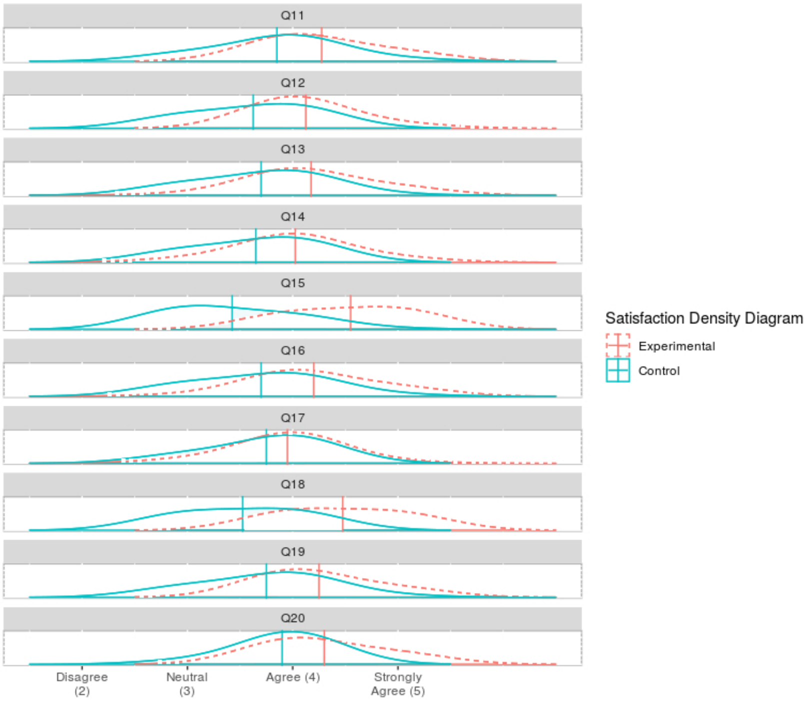

Figure 2 Diagram of the density of responses to the satisfaction questionnaire for both groups.

Regarding the challenge indicator (questions 15-17), the experimental group showed a better relationship between the degree of student satisfaction and the level of challenge they face; In this case, satisfaction has been the main reward of the students, which facilitates the additional memory load required, thus relieving the cognitive load and increasing the overall well-being of the students.

Making a comparison of the scores obtained for both the usability scale and the cognitive load scale, a scatter diagram was shown in Figure 3. In this diagram, we can see that the control group obtained a mean score slightly higher than 70 points in the case of the usability scale, equivalent to a rating of "Acceptable / Good" and slightly less than 70 points in the case of cognitive load. For the control group, the average of values obtained on the SUS scale is around 85 points, with a rating of "Excellent" and an average of 80 points for the case of cognitive load.

Taking into account the above, we can conclude that the students of the experimental group that uses instances of cloud services had significant benefits in terms of indicators related to usability and cognitive load compared to the control group of students who used the local database installation.

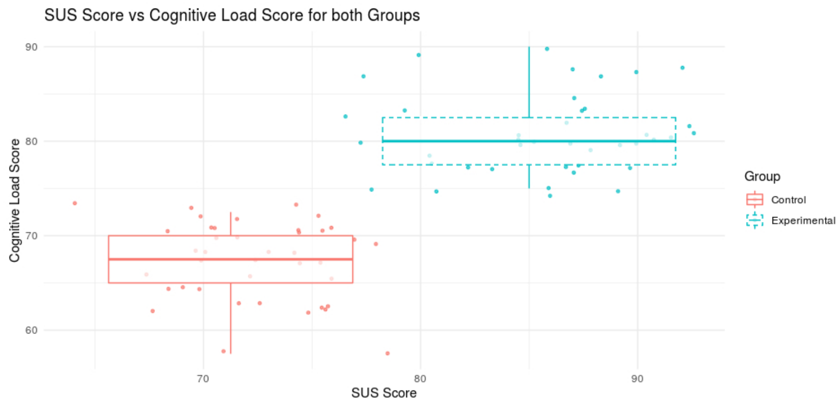

Figure 3 Comparison of scores for both groups.

Based on the above results, we can provide reliable answers to the research question established at the beginning of this document. For usability, both groups consider the development of the experiment as a pleasant experience, although the experimental group expresses greater satisfaction than the control group. In the case of the cognitive load, we can conclude that the experimental group has better results for the indicators of awareness, challenge, and commitment than the control group. For each of the questions related to these indicators, the control group students describe their experience as less satisfactory concerning the experimental group that used the cloud-based instance of the database. The satisfaction of the students in the experimental group has, in turn, a positive impact on the cognitive load and, subsequently, on their learning. Concerning the relationship of the cognitive load and usability scales, we see that the students of the experimental group have a better relationship between both scales than the control group, which shows that our model is adequate in determining that satisfactory learning is the result of a good relationship between usability and factors that tend to reduce cognitive load.

6 Conclusions and future work

In this work, we have shown the benefits that cloud services can present for students and education. A satisfactory learning model based on usability and cognitive load has been presented. It has been shown that cognitive load indicators have a positive impact on satisfactory learning in those students who use a cloud instance of data-base servers. On the other hand, we highlight how cloud services implementation for data-base servers shows better usability than one in which the servers are used locally. The main disadvantages that we find in a scheme based on cloud services are the dependence on a good internet connection and the need for a credit card to generate the free Google Cloud account. This is an ongoing work, which must be completed with another type of analysis, where the impact of the proposed model on academic performance is shown, as well as other factors that can benefit learning and complete its validation. Future work is aimed at demonstrating the validity of the model presented in more learning scenarios, with the final objective of providing a comparative study of all possible benefits, advantages, and limitations.

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