# Learning and Practicing SQL Online: Comparison of Different Methods for Teaching Basic Computer Science

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## ABSTRACT

UPDATED—July 14, 2020. With the emergence of pandemic, there is a sudden shift to online learning. This online learning motivates one to experiment with remote teaching and learning both for students as well as for professors over the world. Both the traditional and online learning approaches have their similarities and differences. The traditional approach demands the use of labor force for evaluation of results, whereas the online approach remains labor-free. Additionally, the re-usability of learning resources stored online aids individuals' to revisit concepts infinite number of times. Acknowledging the presence of pre-existing online learning platforms like YouTube, and Coursera, we try to understand the key question on how beneficial such virtual learning would be, through this paper. Thus, we investigate the influence of coding challenges and quizzes on the ability of students to learn basic programming concepts efficiently.

## Author Keywords

Learning; Online; MOOCs; Quizzes; Coding; Interactive Tutorials

## CCS Concepts

•**Human-centered computing** → **Human computer interaction (HCI);**

## INTRODUCTION

In current times online learning is emerging as MOOCs, YouTube and other online learning technologies are becoming a major part of every curriculum [3, 6, 1]. MOOCs often use intermediate quizzes in between the video lectures. These should help the learners to practice the contents interactively and thus to internalize them. Most of the time, however, these interactive exercises have to be specially programmed and created by the content creators with a greater effort compared to conventional methods such as exercise sheets, which are often given to students at the university. Conventional exercise sheets can be reused each semester, but the solutions still have to be corrected manually by the organizers of a module at the university. Thus, the number of students who can take part in a lecture is limited by the work capacity of the correctors.

MOOCs and their interactive quizzes and challenges have the advantage that they can be evaluated on-the-fly without manual correction by a human. Once a challenge has been implemented by some content creator it can potentially be used for a very large number of students. This is a clear advantage over conventional methods, but little is known if interactive quizzes or challenges actually help the user to better understand and remember the content [2, 4, 5]. This paper presents the results of a study that investigated the influence of intermediate coding challenges and quizzes on the ability of users to learn basic programming concepts more efficiently. The results should help to better understand the effect of intermediate tasks in online learning.

SQL, short for Structured Query Language, is widely used for the communication with databases and is the standard language for relational database management systems. This paper focuses on how different learning reinforcement methods affect the efficiency of learning simple concepts of SQL.

## RELATED WORK

Online learning plays an enormous role in today's world. In the literature various aspects of how online learning can be offered are discussed. [3, 6, 1] describe how online learning can be designed using MOOCs and interactive exercises. [2, 4] also examine how different methods are evaluated in everyday academic life.

## USER STUDY

The goal of this study was to find out how different learning reinforcement methods affect the efficiency of learning simple concepts of computer science. More specifically, we investigated how the different interaction methods we present in the following affect how well basic concepts of SQL can be learned.

### Apparatus

We used 3 different arrangements to evaluate different learning reinforcement methods. For the first arrangement we made a custom user interface which had videos provided by Khan Academy to learn basics of SQL. This arrangement consisted of 5 videos. All videos were short and no longer than 4 minutes. For the second arrangement we made another custom user interface which had the same 5 videos and interactive quizzes between each videos. Participants were alerted to incorrect answers in the quiz and the participants could not move on to the next video until they had the correct answer submitted in the formular on the website. The third arrangement used
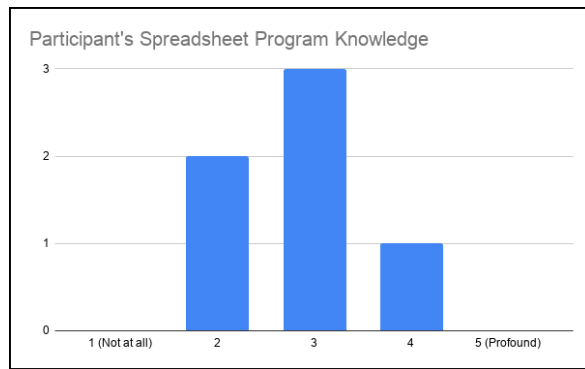
**Figure 1. Participant's Spreadsheet Program Knowledge**



**Figure 2. Learning system showing quizzes between the video lectures.** https://cthci-56e8f.web.app/interactive/1/1



**Figure 3. Demographic data on the participants of the study**

online learning system provided by Khan Academy for learning SQL, which consisted of same 5 videos and interactive coding challenges between them.

We used final project, which was offered by online learning system of Khan Academy for the evaluation of learning of all 3 arrangements.

### Task and procedure

We asked participants in the study to watch videos on SQL provided by Khan Academy. We divided the participants into three groups. The first group watched only the videos using the first arrangement and then participated in an online exercise/final project provided by Khan Academy (see figure 4). To solve the online exercises, the participants had to apply the knowledge they had learned from the videos. At all times we allowed participants to return to the videos in case they could not remember a particular concept of SQL or the correct syntax and they were encouraged to take breaks between watching different videos. Another group of two participants were assigned second arrangement and they were shown a quiz between the videos that they had to solve before they could move on to the next video lesson on SQL. Participants were alerted to incorrect answers in the quiz. In fact, the participants could not move on to the next video until they had the correct answer submitted in the formular on the website. Figure 2 shows an example of the quiz shown to the user after the first video lesson on SQL. In this figure you can see that the participant has already submitted a wrong answer in the first attempt and this answer is now greyed out. The participant has now the possibility to enter a new solution and can only continue when he has chosen the correct solution. The third group used the third arrangement and had to work on an interactive coding challenge between the videos instead of a quiz, for which exactly the concepts from the previous video were needed. The correctness of the entered solution was checked on-the-fly in the online system of Khan Academy and participants could only start with the next pair of video and code challenge once they had solved the previous code challenge correctly.

In addition to this quantitative experiment, we asked all participants, regardless of the exact learning method, to complete a quali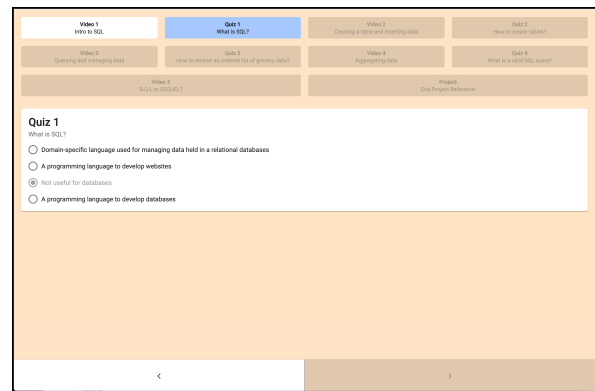tative survey that included multiple choice questions and some free text questions. The survey before and after the experiment differed only in that the survey before the quantitative experiment contained some demographic questions for the participants. We use the surveys to better understand whether the participants really feel they have learned something and how they judge how well the learning method they used contributed to the learning success. Some simpler knowledge questions about databases in general were also surveyed.
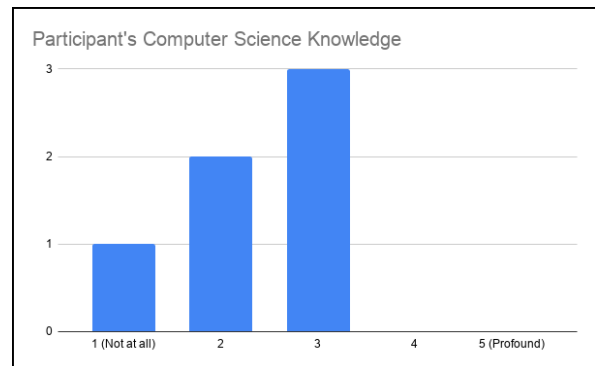
### Participants

6 participants volunteered in this study: 3 male and 3 female, between 20-25.

The participants had little or no experience with SQL databases or other computer science concepts as can be seen in figure **??**. They, however, had some basic experience with programming languages and, according to the survey before the experiment, were already well versed in traditional spreadsheet programs such as Microsoft Excel.

### Design

As learning is involved in evaluation of this study and we always present the same set of learning material, we chose a between-group design for this study. That means each participant did only one of the three presented learning methods: NOTHING, QUIZZES and CODECHALLENGE. The study lasted around 45 minutes for each participant.
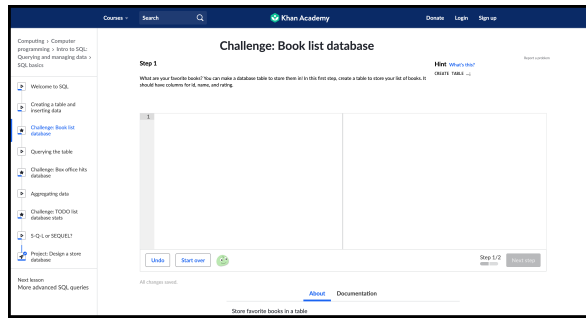
**Figure 4.** Final project that for all participants. Provided on Khan Academy: `https://www.khanacademy.org/computing/computer-programming/sql/sql-basics/pp/project-design-a-store-database`
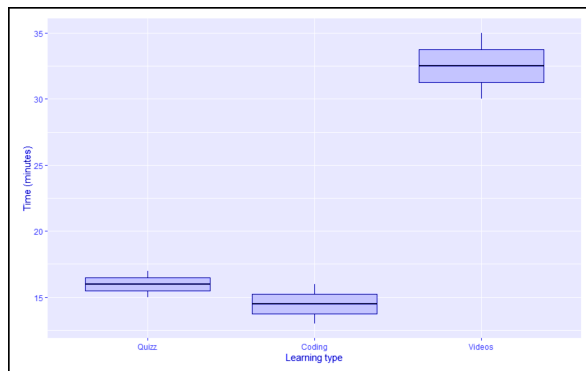


**Figure 5. Boxplot showing differences of time taken to complete final task by differnt groups**



**Figure 6. Average number of SQL commands (after the study)**
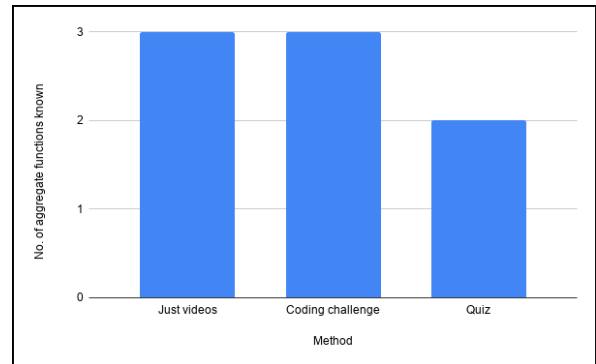


**Figure 7. Number of known Aggregate functions (After the study)**

The independent variables were the three different arrangements using different learning reinforcement methods and the dependent variables were time taken to finish the final project.

## RESULTS

During the study, we recorded the time taken by user to complete the final task and the average time taken by participants varied considerably. Average time for participants using the first arrangement to solve the final task was 33 minutes, whereas for participants using arrangement 2 and 3 was 16 minutes and 15 minutes respectively (see figure 5). One-way ANOVA test proved that there were statistically significant differences between the means of different learning reinforcement methods ($F_{(2,3)}$= 31.5, $p<0.05$). Post-hoc Tukey HSD was used to further see the difference between the 3 methods and it was found that there wasn't much difference between learning with intermediate coding challenges and intermediate quizzes. However, learning with intermediate coding challenges or quizzes had differences when compared to learning with just videos.

The survey data also shows that participants learned the content best with the interactive coding. Participants before the experiment had no prior knowledge of SQL commands. However, after the experiment, participants learning with intermediate coding challenges could remember more SQL commands than in the two other learning methods presented in this study,
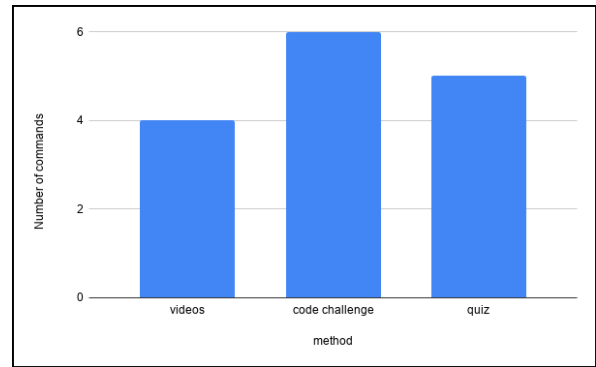
where participants learning using interactive coding challenges remembered on average 6 SQL commands (see figure 6).

## DISCUSSION

Interestingly, participants who only watched the video remembered aggregation functions a little better compared to participants who did the quizzes (see figure 7). This is probably due to the number of participants and could be a mistake in the data. A further study with more participants would have to be conducted to confirm this hypothesis. From this study, it is quite clear that solving intermediate quizzes or intermediate coding challenges helped the participants to learn simple concepts of SQL efficiently and actually help the user to better understand and remember the content. Regardless of the exact method of learning, the data shows that students felt they had learned something about SQL and are now able to implement a simple database for a very simple project.

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