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SQL Question-Led Learning Application

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Abstract: SQL is the most widely used programming language for retrieving and organising data from relational databases. However, students have trouble writing SQL statements. This paper proposes a question-led learning approach to write SQL statements for students taking the Database course through a desktop learning application developed based on the ADDIE model using Visual Studio 2019 and Visual Basic .NET language. Results of testing and user feedback was generally positive with some suggestions of improvement in terms of user interface, question, and audio.

Keywords: e-learning, question-led learning, SQL

1. Introduction

Structured Query Language (SQL) is a standard computer language that is used for managing and performing various operations on the relational database management system (RDBMS) [1] that supports SQL commands [2] to create database and table structure [2], establish relational models with data, and retrieve necessary facts from the database [3]. One of the common subjects for computer science or information technology university students is Database and one of the topics is SQL [4]. Many students found it hard to understand and write SQL statements [5]. We did a pre-test on 30 Diploma Information Technology (DAT) students in Universiti Tun Hussein Onn Malaysia (UTHM), 17 females and 13 males, age 20, to evaluate their understanding on SQL. Only seven students pass the pre-test with higher than 60% marks.

Thus, this paper proposed a question-led learning of SQL through a standalone learning application to help Database students improve their understanding about SQL. Question-led approach uses questions to lead students through the process of solving problems [6]. Use of questions in learning process proven better than conventional teaching [7] as it motivates thinking and learning [8], enhance focus and enable reflection of learning processes [9], support problem-solving [10], effective in knowledge integration [11] and increase self-regulated learning competence [12]. The application

covers Data Definition Language (DDL) and Data Manipulation Language (DML). We built a desktop application because most students have a personal computer, and it will not require an internet connection. Our application runs on the Windows operating system as it is the most popular. The application will be significance to students. Understanding SQL will help them get a better grade for the Database course, better GPA for that semester, and better CGPA at the end of study, which will increase graduate employability, chances of entering a good company, and a good income.

Table 1: Comparison between existing SQL learning applications with proposed application

Application Name	SQL Code Play	SQL Practice Pro	Learn SQL and Database Management	SQL Question-Led Learning
Query input	/	/	x	/
Query Output	/	/	x	/
Visibility of system status	x	x	/	/
Match between system and the real world	/	/	/	/
User control and freedom	x	x	x	/
Error prevention	/	/	/	/
Recognition rather than recall	/	/	/	/
Help and documentation	x	/	x	/
Aesthetic and minimalist design	/	/	/	/

Table 1 compares some existing SQL learning applications based on 10 usability heuristic for user interface by Nielsen Norman Group [13] in terms of platform, query input, query output, visibility of system status, match between system and the real world, user control and freedom, error prevention, recognition rather than recall, help and documentation, aesthetic, and minimalist design.

First usability heuristic is query Input. For application SQL Code Play and SQL Practice Pro, both applications have a query input for user key in their answer in the answer field. But for Learn SQL and database management applications, this app does not have an answer field for users to key in their answer. Next, query output. Or application SQL Code Play, SQL Practice Pro, Learn SQL, and database management, all this application have a query output that display the output at the end of the session to tell the user whether the answer they have filled in is the correct answer or the incorrect answer. Follow up with the correct answer at the output if the user enters an incorrect answer. Then, visibility of system status. For application SQL Code Play, SQL Practice Pro, Learn SQL, and database management.

The design of these three applications is to keep users informed about what is going on, through appropriate feedback within a reasonable amount of time. Match between system and the real world, for application SQL Code Play, SQL Practice Pro, Learn SQL, and database management. The design of these applications is to use the users' language such as use words, phrases, and concepts familiar to

the user, rather than internal jargon. Follow real-world conventions, making information appear in a natural and logical order.

Next, user control and freedom. For application SQL Code Play, SQL Practice Pro, Learn SQL, and database management. Users often perform actions by mistake. The developer has created one or more clearly marked "emergency exits'' for users to exit the unwanted actions without having to go through a long process. Furthermore, error prevention. For application SQL Code Play, SQL Practice Pro, Learn SQL, and database management. All these applications have good error messages and have been provided to the system, the best designs carefully prevent problems from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

Then, recognition rather than recall. For application SQL Code Play, SQL Practice Pro, Learn SQL, and database management. Instead of offering consumers a long tutorial to memorize, System Offer assists in context. Its purpose is to reduce the amount of data stored in the user's memory by making components, actions, and alternatives visible. The user should not have to recall data from one part of the interface to the next. When needed, information essential to use the design (e.g., field labels or menu items) should be displayed or easily accessible.

These applications have been providing documentation to help users understand how to complete their tasks. Finally, aesthetic, and minimalist design. For application SQL Code Play, SQL Practice Pro, Learn SQL, and database management. The system maintains the text and visual design focused on the most important elements. Information that is irrelevant or is used seldom should not be included in user interfaces. Every additional unit of data in an interface competes with the relevant units of data, lowering their relative visibility.

2. Materials and Methods

The project is created based on the ADDIE model which includes Analysis, Design, Development, Implementation, and Evaluation phase [14].

2.1 Analysis

Our SQL pre-test on 30 DAT students found that only seven gets higher than 60% of marks. This proves that many students have trouble understanding how to write SQL statements.

2.2 Design

Learn screen is divided into three columns (**Figure 1**). Learn screen displays menu on the left and score on the right. The centre of screen will have the diagram, final code, current code and learn section. All sections except Menu changes according to selected subtopic.
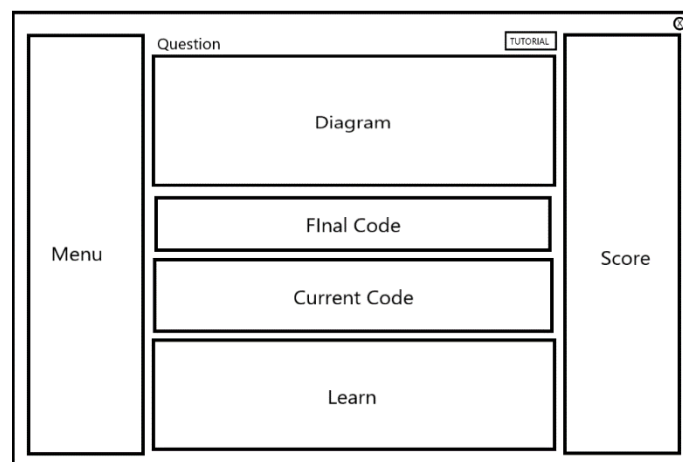
Figure 1: Design of Learn screen

2.3 Develop

Visual Studio 2019 selected as the Integrated Development Environment with Visual Basic .NET as the programming language. The display of the output table is created using Canva. Tutorial message box displayed after the user runs the application and if the user clicks the Tutorial button at the top of Learn screen (**Figure 2**).
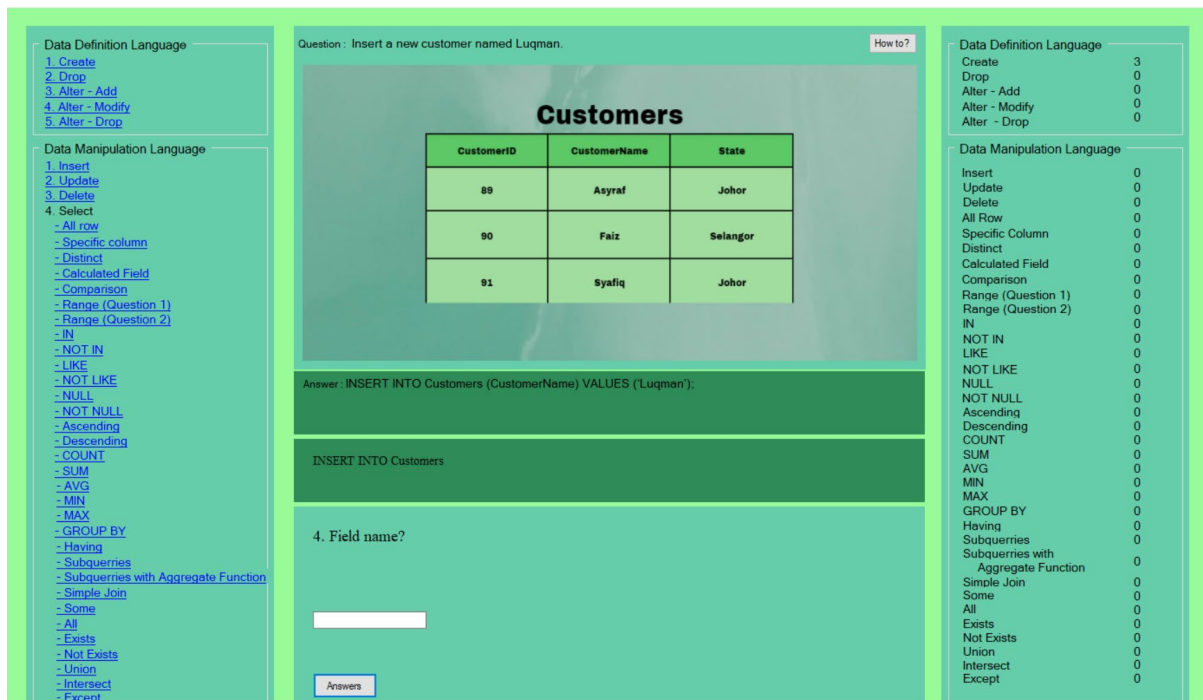
Figure 2: Learn screen

The left column shows two topics of SQL in Database which is Data Definition Language (DDL) and Data Manipulation Language (DML). For the DDL, there are three keywords. That is Add, Delete and Alter which consist of five subtopics. For the DML, there are four keywords. That is Insert, Update, Delete and Select which consist of 35 subtopics. The right column shows the current score after user answers each question. Score increased and decreased by one point for every correct and wrong answer. There will be a sound effect that acts as the indicator for the correct and wrong answer. Each section in the center column changes according to subtopic selected. Total questions for each subtopic are different. The diagram section displays the table for the output for every subtopic. The final code section displays the final code to each subtopic. Current code section will change according to answer input by the user. Learn section will display the question for every subtopic. There are two types of question which is multiple choice answer using a radio button and the subjective question using the textbox. The question will change when the button Answer is click.

2.4 Implementation

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The source code of the project then will be built on the Visual Studio. Then, the execution file will be upload to the Google Drive and the link for the application was given to 30 (13 males and 17 females) DAT students at UTHM via WhatsApp. Testers need to download four files and launch the sql.exe file.

2.5 Evaluation

Users answered a pre-test before using the application and a post-test after to see whether there is a change in performance or not. Both tests have the same 19 questions. After using the application, users also need to fill in a questionnaire modified from [15] divided into three parts. Part A is regarding demographics of the respondents. Part B is made up of 35 five-point Likert scale questionnaire ranging from strongly disagree to strongly agree, organised into 15 sections. Part C offers two open-ended questions about the positive aspects about the application and suggestions for an improvement. Tests and questionnaire developed using Google Forms. Link to tests and survey given via WhatsApp.

3. Results and Discussion

Table 2: Comparison between pre-test and post-test

Question	Correct		Change
	Pre	Post	
1. Create	4	9	+
2. Drop	18	21	+
3. Alter – Modify	2	4	+
4. Insert	16	19	+
5. Update	13	16	+
6. Delete	17	22	+
7. Distinct	12	14	+
8. Between	15	20	+
9. IN	11	16	+
10. NULL	21	25	+
11. DESC	24	26	+
12. MAX	26	20	-
13. Group By	19	21	+
14. Having	8	12	+
15. Subqueries	4	6	+
16. Subqueries with Aggregate Function	15	15	=
17. Simple Join	13	20	+
18. Some	15	20	+
19. All	16	17	+

Table 2 compares result of pre and post tests. 17 questions have a positive change (number of correct answer increase after using the application), one question have a negative change (number of correct answer decrease after using the application), and one question remains unchanged (number of correct answers is the same before and after using the application). It shows that our application help students understand SQL.

Table 3: Summarization of survey responses

Question	1	2	3	4	5
Visibility of system status					
1.My answer is correct or wrong.	00.00	00.00	10.00	33.33	63.33
Match between the system and the real world					

Question	1	2	3	4	5
2. Terms and phrases are like that in Database course	00.00	00.00	00.00	36.7	63.3
3. Arranged in a logical order.	00.00	00.00	3.3	43	53
Learner control and freedom					
4.Easy to navigate	00.00	00.00	3.33	50.00	46.67
5.I can exit the application at any time.	00.00	00.00	00.00	40.00	60.00
Consistency and adherence to standards					
6. The same concepts, words, symbols, situations, or actions refer to the same thing.	00.00	00.00	6.67	30.00	63.33

Question	1	2	3	4	5
Error prevention					
7. The application is designed such that I cannot easily make serious errors.	00.00	00.00	10.00	50.00	40.00
Recognition rather than recall					
8. Objects to be manipulated, options for selection, and actions to be taken are visible.	00.00	00.00	3.33	26.7	70.00
9. I do not need to recall information from one question to another.	00.00	00.00	20.00	33.3	43.3
10. Instructions on how to use the system are visible or easily retrievable whenever appropriate.	00.00	00.00	20.00	13.33	66.67
11. Displays are simple.	00.00	00.00	20.00	26.7	53.3
Aesthetics and minimalism in design					
12. Application do not contain information which could distract me as I perform tasks	00.00	00.00	23.3	23.3	53.3
Recognition, diagnosis, and recovery from errors					
13. Error messages are expressed in plain language.	00.00	00.00	16.7	30.00	53.3
14. Error messages define problems precisely and give specific instructions for recovery	00.00	00.00	16.7	30.00	53.33
Simplicity of navigation, organisation, and structure					
15. Simple navigational structure	00.00	00.00	26.67	20.00	53.33
16. The navigational options are limited	00.00	00.00	23.33	30.00	46.67
17. Related information is placed together.	00.00	00.00	16.67	20.00	63.33
18.Information is organised hierarchically	00.00	00.00	16.7	26.7	56.7
19. The form has all the required hyperlinks (links).	00.00	00.00	13.3	20.00	66.7
Relevance of application content to the learner and the learning process					
20.Content is relevant, appropriate, and clear to me.	00.00	00.00	16.7	36.7	46.7
Clarity of goals, objective, and outcomes					
21. There are clear objectives and outcomes for learning encounters	00.00	00.00	16.67	23.33	60.00
22. The reason for inclusion of each subtopic is clear.	00.00	00.00	13	33	53
Level of learner control					
23.Have some freedom to direct my learning, and to have a sense of ownership of my learning.	00.00	00.00	16.67	33.33	50.00
24. I was given some control of the content I learn, and the sequence of units	00.00	00.00	13.3	33.3	53.3
25. I can take the initiative regarding the time, place, content, and sequence of learning	00.00	00.00	13.33	36.67	50.00
Feedback, guidance, and assessment					
26. I receive prompt and frequent feedback about my answer and the knowledge being constructed.	00.00	00.00	16.67	26.67	56.67
27. I was guided as I perform tasks	00.00	00.00	16.7	26.7	56.7
28.Quantitative feedback e.g., score is given so that I was aware of my level of performance.	00.00	00.00	13.33	36.67	50.00
Context meaningful to domain and learner					
29. Knowledge is presented within a meaningful and authentic context that supports effective learning.	00.00	00.00	13.33	23.33	63.33
30. Authentic, contextualised tasks are undertaken rather than abstract instruction	00.00	00.00	23.33	30.00	46.67
31.The application enables context- and content-dependent knowledge construction.	00.00	00.00	20.00	26.7	50.00
32.Learning occurs in a context of use so that knowledge and skills learned will be transferable to similar contexts.	00.00	00.00	10.00	43.33	46.67

	1	2	3	4	5
33. The representations are understandable and meaningful	00.00	00.00	10.00	30.00	60.00
Learner motivation and active learning					
34. The application has content that motivate and retain learners	00.00	00.00	10.00	23.3	66.7
35. To promote active learning and critical thinking, questions require learners to compare, analyse and classify information	00.00	00.00	10.00	23.33	66.67

1 - Strongly Disagree (%)

2 – Disagree (%)

3 – Neutral (%)

4 – Agree (%)

5 – Strongly Agree (%)

Table 3 summarizes survey responses. Testers reviewed the user interface as "simple" and "user-friendly", thus "easy to use", and the "position of the place to answer the quiz is so interesting". It has high accessibility as they "can use it anytime". However, testers suggested to improve the user interface by including "some picture to make it more interesting" (although diagrams are already used for all questions), "change the colour to make it interesting" and "pleasing to the eye" by using "matching colour background" and "add a bright colour palette as contrast", inclusion of animation, "change the font size", as it is "too small", and "organise the subtopic with scroll down function".

The application "add to my knowledge of database", "helps me improve my skill on how to use SQL syntax and I learned a lot" as it is "compact with information about SQL". The questions and "the purpose of the questions" are "easy to understand", thus "helps user to understand more". It also "test my mind". But some testers felt "hard for me to understand the question", hence "sometimes I don't know the answer". These contradict with some proposing making it more challenging by "adding more questions for me to improve my knowledge" and "set a timer to answer the quiz".

They also proposed to "add background music" to make it more "cheerful" and "enjoyable", as the audio used are only for right and wrong answer. Overall, some users "really enjoy" the application as it "give me more experience" and a "good app", while some asked to "make it more enjoyable". Some like the whole of application.

4. Conclusion

This paper proposed an alternative way to help write SQL statements through sequential questions. Comparison between pre and post-tests as well as survey feedback are generally positive. However, user interface improvements needed in terms of by graphic, colour, font, and navigation. Question design could be better by increasing clarity and challenge. Background audio can be added to enhance user experience.

Acknowledgement

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