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ANIMATED DATABASE COURSEWARE: USING ANIMATIONS TO EXTEND CONCEPTUAL UNDERSTANDING OF DATABASE CONCEPTS[*]

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ABSTRACT

Teaching abstract concepts can be best supported with supplemental instructional materials such as software animations. Visualization and animations have been shown to increase student motivation and help students develop deeper understandings. Through an NSF funded CCLI grant, a set of animations to support the teaching of database concepts is being developed and made freely available. Current modules available cover areas such as database design, interactive SQL, stored procedures and triggers, transactions and database security. In this paper, we provide an overview of the Animated Database Courseware (ADbC) as well as provide examples of how this software might be utilized in the classroom.

INTRODUCTION AND OVERVIEW OF THE ANIMATED DATABASE COURSEWARE

Teaching conceptual understanding is challenging. For many students, commonly used teaching methodologies such as lectures and textbooks are not sufficient to aid in the assimilation of abstract concepts. In many disciplines, including computer science, animations and visualizations have been touted as a means to provide additional instructional support to convey complex and dynamic topics. For instance, animations have been used in the teaching of algorithms, machine execution, networking and programming. Animations can also be applied to other areas of computing such as databases. In this paper, we present the work of a CCLI grant [# 0717707] funded by the National Science Foundation. The intent of this project, referred to as Animated Database Courseware (ADbC), is to develop a set of software animations that support the teaching of database concepts.

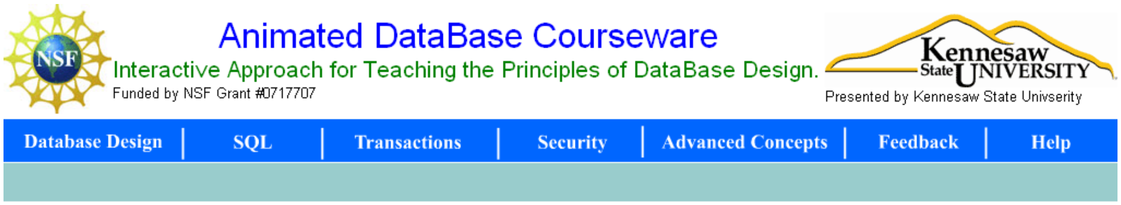
While the achievement of learning outcomes as a result of using animations has been mixed, there is evidence that animations do support the teaching and learning process. Animations have been found to increase student motivation and visualizations have been found to help students develop understanding of abstract concepts which are otherwise considered to be 'invisible.' [4] In their study of ways to introduce the idea of pervasive computing to students, [7] cites that using words and pictures helped students construct verbal and pictorial mental models as well as to build connections between them and increased their ability to understand the precepts of the topic under study. Further, [2] notes that the capacity of animations to portray information in a different way engages the use of an additional cognitive channel, thereby, reducing the learner's overall cognitive load. Whatever the case, providing multiple venues of learning support such as supplemental instructional materials does contribute to heightened levels of student learning.

A review of the literature revealed very few animations or visualized tutorials that support the teaching of database concepts. A majority of these programs focus specifically on some aspect of SQL or query execution. For instance, W3Schools [5] offers an interactive SQL tutorial and [1] provides a simulation system to enable students to visualize the steps required to execute a database query. The WINRDBI Educational Tool [6] developed at Arizona State University provides an interpreter that allows students to program in interactive SQL, relational algebra, domain calculus or tuple calculus. While these tools are useful, they tend to focus on only one specific aspect of database technologies. In contrast to these programs, the Animated Database Courseware project is targeted at a wider audience and aims to incorporate a broader array of topics. For instance, ADbC is focused at students pursuing majors in many different areas of computing including computer science, information systems and information technology. Consequently the courseware does not cover tuple or domain calculus, and animations related to relational algebra are provided as a bridge to understanding the basic principles of SQL.

The development of the Animated Database Courseware is an ongoing project. Topics currently available include database design, interactive SQL, stored procedures and triggers, transactions and security. The tutorials and exercises developed emphasize and reinforce core concepts and skills. The ADbC currently consists of over 70 animations or tutorials categorized into four main modules further divided into sub-modules. Courseware prototypes for this work have been made freely available and may be found at http://adbc.kennesaw.edu.

Several updates have recently been made which include additional examples in several sub-modules including Converting Scenarios to E-R and Normalization. Additional sub-modules have also been added to the Security module. Finally a total re-structure of the navigational scheme and standardization of the user interface have been implemented as have assessment exercises for many of the sub-modules. These assessments allow student answers to be retained and stored and also provide an option for the student to submit their answers to faculty for review.

Figure 1 displays the navigational menu of the ADbC. The navigational scheme remains constant regardless of which module is chosen.



Animated DataBase Courseware

Interactive Approach for Teaching the Principles of DataBase Design.

Funded by NSF Grant #0717707

Presented by Kennesaw State Univserity

Figure 1 – Navigational Menu

METHODS FOR USING ADBC IN A CLASSROOM SETTING

The method in which instructional software is used is as much, if not more important, than the software itself. There are many ways that animation software may be incorporated into the classroom. Some of these methods include:

- Faculty use the courseware in class while explaining a new topic.
- Students use it for reinforcement of topics presented. For example, a student in an advanced database class or in a graduate course may use the animations to review concepts learned in the past.
- Students reference the courseware when they are doing homework and need assistance in finding solutions to homework exercise problems.
- Students are assigned an exercise using the software.
- Students employ the software in a stand-alone manner to learn new topics.

Currently, most sub-modules in the Animated Database Courseware can be easily employed in any of the ways discussed above. However, to make the animations more self-explanatory, additional explanations and hints are being incorporated to further facilitate the use of the animations as stand-alone teaching tools. Below we present examples of three different programs and how they might be used in a classroom setting. The first example demonstrates symbol systems used in the development of E-R diagrams and employs the use of the animations in the classroom as well as for student reinforcement. The second example, converting E-R diagrams to tables, focuses assigning the animations as student exercises and the third example focuses on student use of the animations as a source of reference to complete assigned exercise problems.

Database Design – E-R Diagram Notation Sets

Constructing models is an abstract activity and when constructing E-R diagrams this is complicated by the fact that no standard symbol set exists. This contributes to student confusion. The purpose of the sub-module, Database Design: E-R Diagrams, is to depict the different E-R diagram notations commonly in use. Students are provided with the opportunity to display different notation sets for different relationships as well as to display the various implementations side-by-side. Figure 2 depicts the E-R diagram notation animation displaying various notation sets for a 1-N binary identity. This animation can be easily shown in class to exemplify the different symbols used to construct E-R diagrams and can also be used as a reference for students when asked to interpret or create these diagrams.

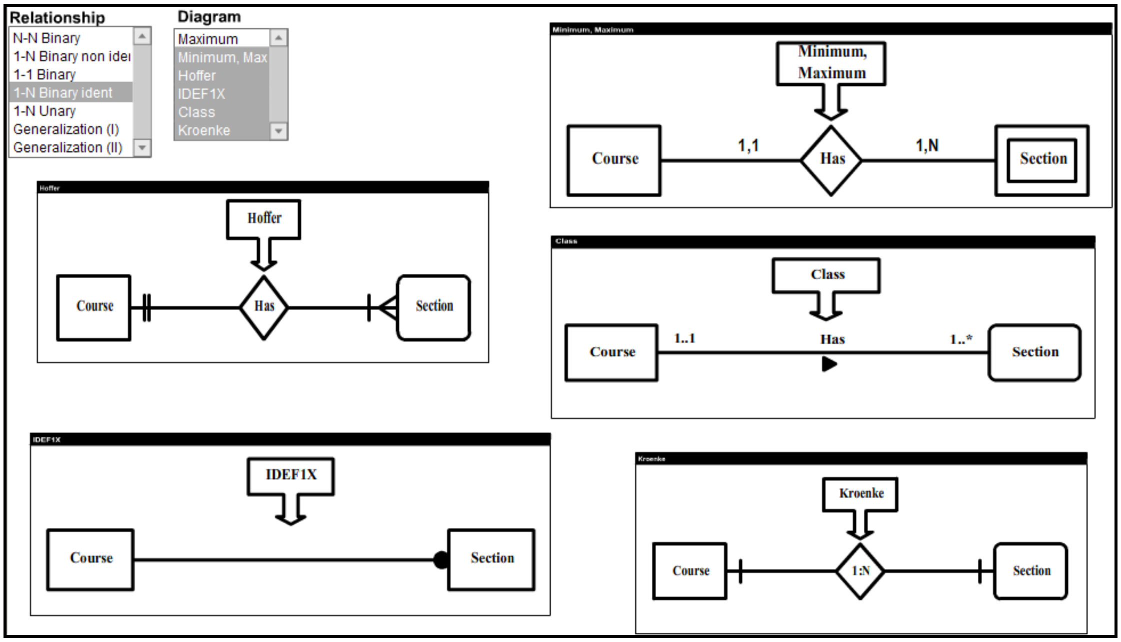
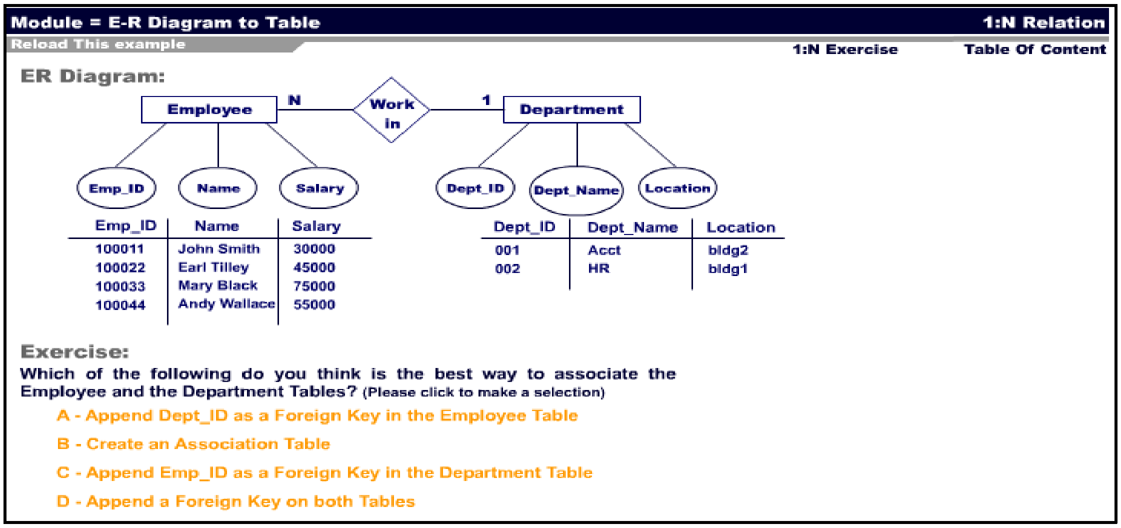


Figure 2. Comparing E-R Diagram Notation Sets

Converting E-R Diagrams to Tables

Another task students are often asked to complete is to map an E-R diagram to a database implementation. This is demonstrated in the sub-module Database Design: Converting E-R to Tables. One way to employ this animation is to use it to show an example in class. Figure 3 depicts the one-to-many binary mapping. The correct answer (option a) as well as the most frequently chosen wrong answer (option c) are discussed in class and then students are assigned the homework exercise of appropriately updating the database. Figure 4 shows the result of the selection of the correct answer as well as the necessary SQL commands to update the database. Figure 5 depicts what would happen if the worst possible option was chosen. Note that for the correct answer, students only have to construct a simple Insert, Update or Delete command. For the wrong answer, multiple complicated SQL commands would be required.



Emp_ID	Name	Salary
100011	John Smith	30000
100022	Earl Tilley	45000
100033	Mary Black	75000
100044	Andy Wallace	55000

Dept_ID	Dept_Name	Location
001	Acct	bldg2
002	HR	bldg1

Exercise:

Which of the following do you think is the best way to associate the Employee and the Department Tables? (Please click to make a selection)

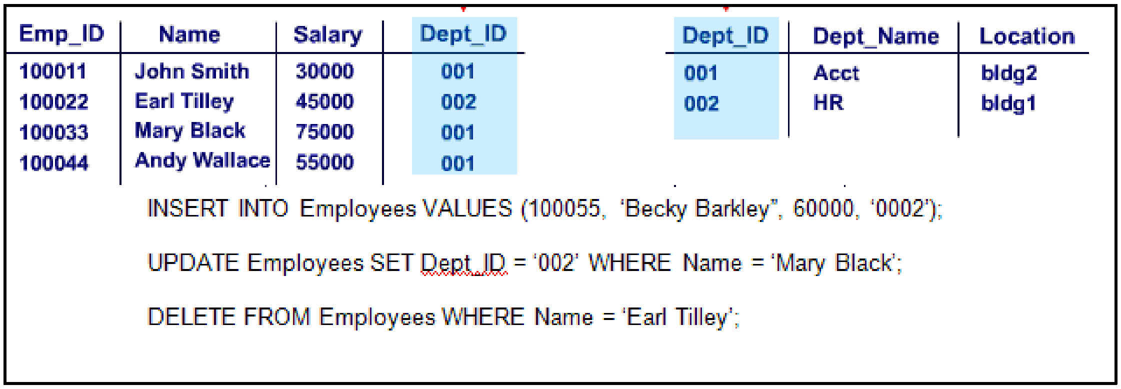
A - Append Dept_ID as a Foreign Key in the Employee Table

B - Create an Association Table

C - Append Emp_ID as a Foreign Key in the Department Table

D - Append a Foreign Key on both Tables

Figure 3. One to Many Mapping Example

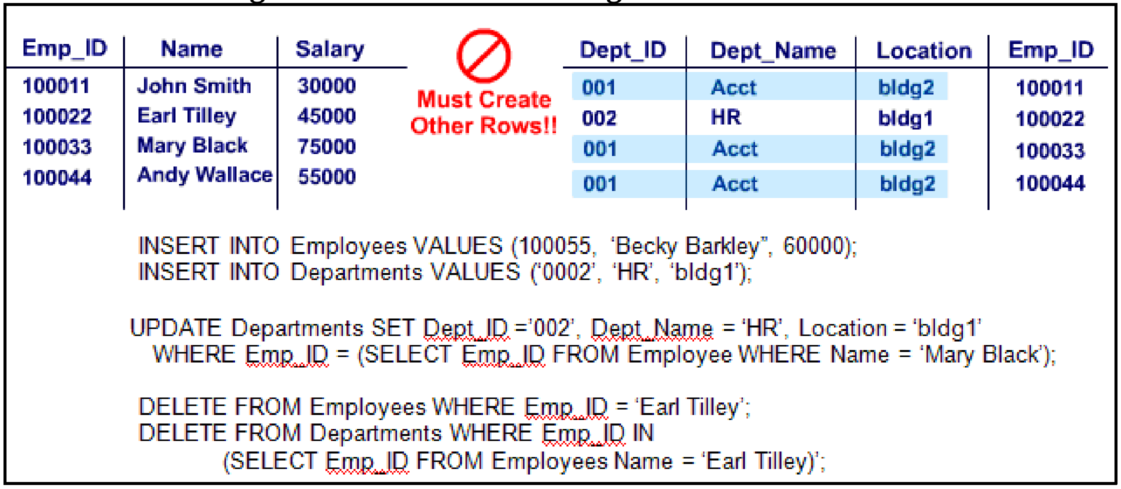


Emp_ID	Name	Salary	Dept_ID
100011	John Smith	30000	001
100022	Earl Tilley	45000	002
100033	Mary Black	75000	001
100044	Andy Wallace	55000	001

Dept_ID	Dept_Name	Location
001	Acct	bldg2
002	HR	bldg1

```
INSERT INTO Employees VALUES (100055, 'Becky Barkley", 60000, '0002');

UPDATE Employees SET Dept_ID = '002' WHERE Name = 'Mary Black';

DELETE FROM Employees WHERE Name = 'Earl Tilley';
```

Figure 4. Results of Choosing the Correct Answer



Emp_ID	Name	Salary
100011	John Smith	30000
100022	Earl Tilley	45000
100033	Mary Black	75000
100044	Andy Wallace	55000

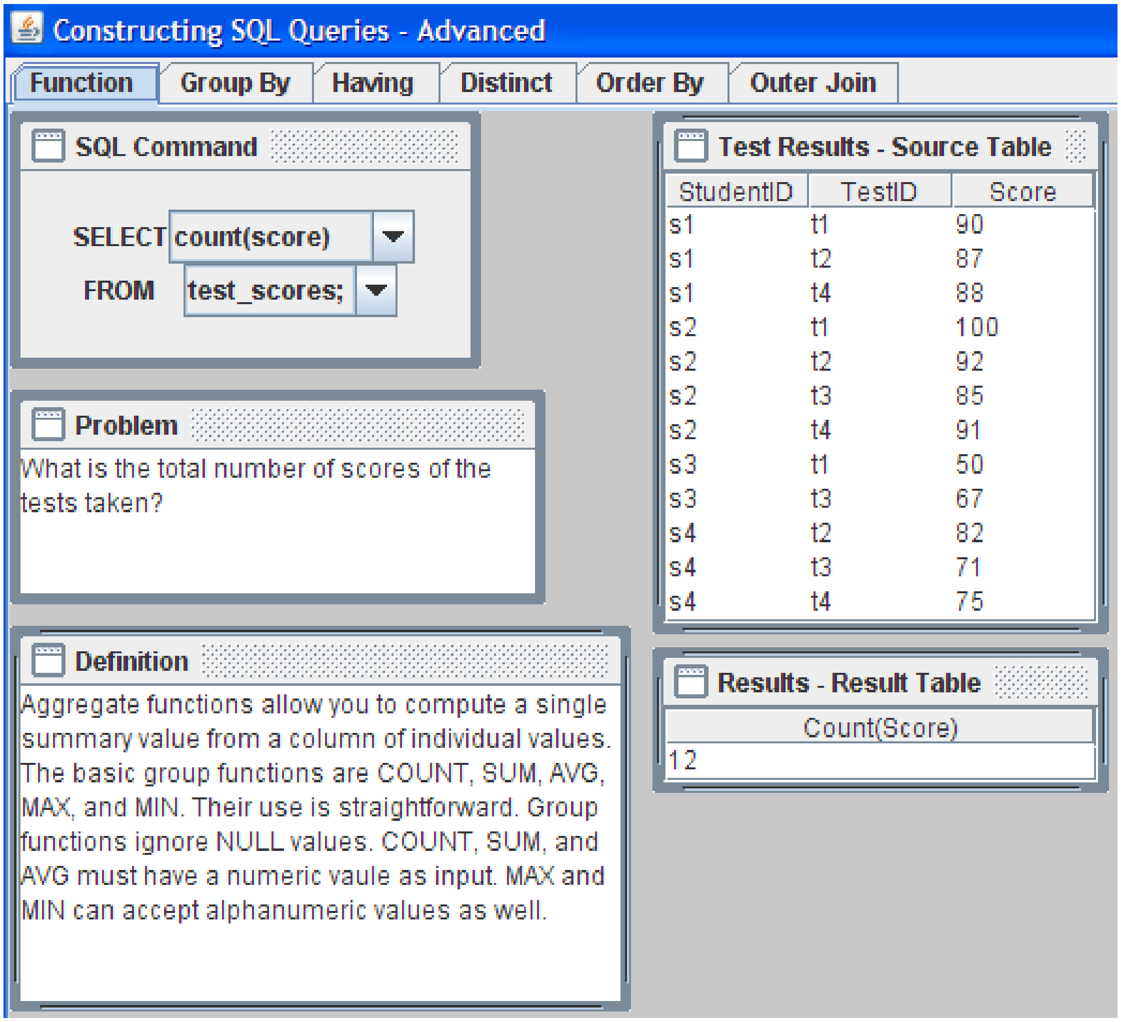
Dept_ID	Dept_Name	Location	Emp_ID
001	Acct	bldg2	100011
002	HR	bldg1	100022
001	Acct	bldg2	100033
001	Acct	bldg2	100044

```
INSERT INTO Employees VALUES (100055, 'Becky Barkley", 60000);
INSERT INTO Departments VALUES ('0002', 'HR', 'bldg1');

UPDATE Departments SET Dept_ID ='002', Dept_Name = 'HR', Location = 'bldg1'
   WHERE Emp_ID = (SELECT Emp_ID FROM Employee WHERE Name = 'Mary Black');

DELETE FROM Employees WHERE Emp_ID = 'Earl Tilley';
DELETE FROM Departments WHERE Emp_ID IN
         (SELECT Emp_ID FROM Employees Name = 'Earl Tilley)';
```

Figure 5. Results of Choosing the Incorrect Answer

Interactive SQL

The SQL module includes an interactive SQL tutorial to help students learn to use basic and advanced SQL commands. Areas covered include table manipulation and query building and execution. In addition, there are separate sub-modules that explore implementing SQL commands through procedural code and developing an understanding of the relational algebra constructs that form the basis of the SQL language. Figure 6 depicts an animation that demonstrates the construction of a SQL query.



SQL Command

SELECT count(score)
FROM test_scores;

Problem

What is the total number of scores of the tests taken?

Definition

Aggregate functions allow you to compute a single summary value from a column of individual values. The basic group functions are COUNT, SUM, AVG, MAX, and MIN. Their use is straightforward. Group functions ignore NULL values. COUNT, SUM, and AVG must have a numeric vaule as input. MAX and MIN can accept alphanumeric values as well.

Test Results - Source Table

StudentID	TestID	Score
s1	t1	90
s1	t2	87
s1	t4	88
s2	t1	100
s2	t2	92
s2	t3	85
s2	t4	91
s3	t1	50
s3	t3	67
s4	t2	82
s4	t3	71
s4	t4	75

Results - Result Table

Count(Score)
12

Figure 6. Example Interactive SQL Animation

Not only can the interactive SQL sub-modules be used in class to demonstrate the execution of SQL commands, they provide an effective resource for students as they complete assignments requiring them to generate SQL code. To aid the novice student, we have developed a set of assignments in which students are directed to specific animations for reference. For example, students are asked to create SQL code that results in the return of the price of the most expensive product contained within a products table. Students are directed to the Interactive SQL -> Constructing SQL Queries - Advance -> Functions sub-module for help in completing this task. Additional example exercises may be found online at http://adbc.kennesaw.edu. Referenced sub-modules are included within parentheses directly after the specific task. During a lab session, students not previously exposed to SQL were observed using the SQL modules to efficiently find solutions to assigned problems.

CONCLUSION

The amount of content and concepts students are expected to assimilate during their academic pursuits continues to expand. Much of this content is abstract and requires students to develop a high level of conceptual understanding. The challenge as faculty is to provide means through which students are able to build these understandings. Often this requires providing students with multiple avenues through which to learn the material. Software animations have proven to be one way to supplement the teaching methods of computer science concepts including concepts related to database technologies. The Animated Database Courseware project provides a set of software animations to facilitate student learning and also provides an opportunity to include more depth and breadth to the concepts covered in a database course. Preliminary evaluations of the software have been positive. In surveys, students and faculty positively rate the value of the software. In a pilot control group evaluation, students taught using the software outperformed those who did not. Interactive supplemental instructional materials help students find pathways through which they are able to achieve greater understandings and higher levels of learning.

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