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Development of Thinking Skills Through the Use of Database Software

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Abstract

The aim of the project described in this paper was to examine the effects of database software tool usage on students' ability to manipulate data, to define hypotheses and queries using Boolean operators and to draw conclusions in the context of the standard biology curricula. Special instructional materials were developed in order to enhance those skills.

Keywords

Cognitive skills, science education, database, information retrieval skills

1 INTRODUCTION

For the last five years an effort has been made to integrate computerized applications into various curricula. These include word processors, spreadsheets and databases. Using such computerized tools students can sort and retrieve textual, numeric and visual data and their higher level cognitive skills can be enhanced by formulating queries, analyzing data, drawing conclusions and discriminating between the wheat and the chaff.

Our concern in this work was the use of database software integrated into the biology curriculum. Database programs are computerized tools which enable data storage, organization and retrieval. The data is organized in forms each containing fields and values of various items. Items can be retrieved and using various search options like browsing, sorting and queries. While working with database software, students may develop high order cognitive skills such as inquiry skills and critical thinking (Hannah, 1987; Hunter, 1985; Perkins, 1985; Pon, 1984; Strickland and Hoffer, 1989; Waston, 1988; Waston & Strudler, 1988-1989). It has been well established that information retrieval skills are better developed within subject matter (Freeman & Tagg, 1985; Perkins & Salomon, 1989).

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The aim in this project was to evaluate the effects of using a biology database program, fully integrated into the curriculum, on the development of higher level thinking skills of ninth graders. In order to further develop those skills, a set of instructional materials was developed.

2 THE DEVELOPMENT OF COMPUTERIZED INSTRUCTIONAL MATERIALS

Throughout the planning and developing stages of the project, the following five major problems had to be overcome:

- What would an ideal biology topic be that can be taught via database software?
- How can we best take advantage of the computerized application in order to enhance higher level cognitive skills?
- How should we teach the basic functions of the software, without creating sensory overload as a result of the novelty of the subject matter combined with the complexity of the software?
- How can we overcome the issue of heterogeneous levels of students in regard to subject matter familiarity and knowledge of computers?
- How can students be motivated to use the new tool?

Human nutrition was the topic that was chosen. This topic is part of the standard curriculum and students are usually motivated to study this particular topic because of its obvious relevance to their everyday life. In order to master this subject, students must manipulate large amounts of data, synthesize this data, create tables and draw conclusions.

The instructional materials set included the following items:

- a data disk for the database software
- an activities booklet for the students
- a teacher's guide

There were two subject matter specific goals. The first was to enhance proper nutrition awareness. The second was to broaden knowledge of the basic food components.
There were three skill-specific aims. The first was to develop problem solving skills; the second was to develop higher thinking skills such as analysis, synthesis and application, and the third was to develop the ability to use a database in order to retrieve relevant data. The two affective domain-specific aims were 1) to develop student motivation towards the subject matter at hand and 2) to develop student motivation to work with computers in general and in particular to use database software.

For each of the two hundred kinds of food found in the data disk, information regarding its components was given for instance: carbohydrates, fats, proteins, minerals and vitamins. In addition the energy level of each food was provided as well.

Among the different student activities included in the student booklet:
- an introductory activity meant to guide their use of the database software
- a basic research project using the software
- complicated queries

The activities were sequenced according difficulty levels. Each of the activities offered suggestions for further inquiry. Troubleshooting procedures, basic help tips and a few additional activities were included in the teacher guide.

3 STUDENT ASSESSMENT

The following hypotheses were tested:
- Experimental group students gain better understanding of information retrieval processes such as query definition, sorting data, using Boolean operators (and, or, not) as part of query definition.
- Experimental group students define a research question better after the intervention.
- Experimental group students demonstrate better understanding in the above topics, in comparison to the control group students
- Experimental group students' positive attitudes towards both biology and computing skills improve as a consequence of the intervention.

3.1 Population

Two-hundred and forty-five (245) students from seven (7) ninth grade heterogeneous classes participated in the project. Three classes used database software during eight subsequent lessons to study human nutrition and the other four classes served as a control group. The control classes studied the identical topic using traditional methodologies based on the standard textbook. The classrooms' teachers were trained according to the model proposed by the authors (Friedler and Greensfeld, 1994).

3.2 Procedure

A pre/post test (pen and paper) design was used. A pretest was administered to assess skills such as arranging data in a table, sorting information according to various criteria, the ability to phrase a query using Boolean operators and the ability to draw conclusions. The same skills were assessed at the end of the intervention.

An additional test was administered to the experimental group in which the student's ability to conduct a computerized experiment using the database was evaluated. All tests were content-bound and referred to the relevant topics in the biology curriculum.

A special test was developed to assess the students ability to build complex tables and to analyze the information presented in the tables. For example, the students were presented with a text in which detailed data about six planets was summarized. The students had to sort the variables which were presented and to build a comprehensive table out of the variables and their values.

The following table and its adjunct questions is an example of how the students' ability to phrase a query and to analyze data were assessed.

Bird's Name	*Order*	*Average Mass (Kg)*	*Number of Offspring*	*Chick*	*Location of Nest*
Goose	Anseriformes	3.000	8	precocial	ground
Quail	Galliformes	0.090	11	precocial	ground
Partridge	Galliformes	0.500	12	precocial	ground
Ostrich	Struthioniformes	150.000	15	precocial	ground
Sparrow	Passeriformes	0.025	6	altricial	trees, mountains, houses, holes
Starling	Passeriformes	0.085	6	altricial	trees, mountains, houses, holes
Goldfinch	Passeriformes	0.013	5	altricial	trees, bushes
Bulbul	Passeriformes	0.035	4	altricial	mountains, trees, houses
Falcon	Raptorial birds	0.180	5	altricial	mountains, trees, houses
Hawk	Raptorial birds	0.270	5	altricial	trees
Kite	Raptorial birds	0.800	3	altricial	mountains, trees, houses
Eagle	Raptorial birds	5.000	2	altricial	mountains, trees, caves
Vulture Egyptian	Raptorial birds	2.000	2	altricial	mountains, trees, caves
Vulture Griffon	Raptorial birds	7.300	1	altricial	mountains

Figure 1 Table of birds

Question 1
How many birds have an average of five offspring?
1. 5
2. 3
3. 2
4. 1

Question 2
How many options for different nest locations appear in the table?
1. 1
2. 4
3. 7
4. 8

Question 3
How many birds have an average of up to six offspring?
1. 2
2. 4
3. 11
4. 13

Question 4
Phrase a question which will refer to the information which appears in the table in the columns of "Number of Offspring" and "Chick". The answer to this question is all of the following four birds: goose, quail, partridge and ostrich.

Question 5
Phrase a question which will refer to the information which appears in the table in the "Order" and "Average Mass (Kg)" columns and to which the answer is all of the following five birds: sparrow, starling, goldfinch, bulbul and falcon.

Question 6
Phrase a question which will refer to the information which appears in the table in the "Order", "Number of Offspring" and "Chick" columns and to which the answer is all of the following three birds: sparrow, starling and goldfinch.

A different group of questions referred to sorting and query skills and the ability to understand the use of Boolean operation. For example; Is the group of vegetables which includes at least 100 mg calcium bigger or smaller than the group of vegetables of 100 mg calcium and 5 mg iron?

4 RESULTS

Following are some of the preliminary results:
Most of the students are able to master the basic technique of the database program after six hours. The database program is suitable for use in an heterogeneous class in which the ability of the students is very varied. Learning with the database program

enhances the ability of the students to use Boolean operators (x=67.5 % in the experimental group; x=58.2 % in the control group).

The ability to phrase a question referring to the relevant criteria is better in the experimental group (x=69.8%) in comparison to the control group (x=60.3%). The use of the database program has not improved the ability of the experimental group to build a table (x=84.6% in the experimental group; x=85.6% in the control group). The understanding of the subject matter (e.g. human nutrition) has improved following the use of the database program (x=55.6% in the experimental group; x=45.9 in the control group).

While learning with the database program the students have improved their attitudes toward the tool. Most of the experimental group students mentioned in the interviews that using the software has enhanced their attitudes towards the use of computers in school and towords biology. Moreover, they all mentioned that the use of the software has helped them to acquire tools of thinking which will be available to them in various areas in the future.

The average grade of the experimental group in the computerized test, using the database software was 82.3. All students expressed satisfaction regarding the test and referred to the test as an intellectual challenge.

5 DISCUSSION

Learning with the use of the database program is becoming widespread in schools. In this project we have looked at the contribution of software to the ability to solve problems in biology. Data retrieval and analysis is an important skill which integrates completely with the notion of enquiry learning in the sciences in general and in teaching and learning biology in particular. Using the database software the students process information, make profound conclusions and find new relationships among various data items.

The ability to ask research questions is one of the major abilities in science teaching. It is common to say that the proper defining of the question is half way to reaching the solution. The use of database software improves the ability to ask and phrase questions and to use Boolean operators. These findings make software a valuable tool in the improvement of thinking skills, which in itself is a major requirement for an independent learner.

Further research should be done in order to look at proper ways to integrate database software in different school areas, as well as looking at teacher training issues which are involved in the integration of such tools into the curriculum.

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7 BIOGRAPHY

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