

Application of Bloom's Cognitive Domain Taxonomy to Database Design

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Abstract

Database System Design is a required course in nearly all undergraduate Computer Science and Information Systems curricula. We reflect upon a critical re-examination of our teaching of such a course in Database Design, invoking the tiers of learning espoused by Bloom, and propose some recommendations in light of desired levels of thinking skills and the availability of recently developed software applications, which, when properly invoked, engage our students in a broad range of learning activities, from the base level of knowledge attainment, to the transforming of students into dual roles as teachers of database topics, enabling them to reach the highest levels of learning.

Keywords: Database design, Bloom's taxonomy, learner involvement, authoring tools, AVI movies, crossword puzzles

1. INTRODUCTION

Database System Design is a required course in nearly all undergraduate Computer Science and Information Systems curricula. The topical content of such a course is relatively stable across different colleges and universities, and generally tries to achieve a balance between database theory (covering topics such as relationship characterization, data modeling (Entity-Relationship, Semantic Object), functional and multivalued dependencies, higher order normalization, concurrency control, etc.) and database application design (the study of a particular Database Management System (such as Microsoft Access 2000, Oracle 8, etc.)).

Pedagogical strategies for teaching a course in Database Systems Design traditionally follow a similar modality to that of other technical courses in a Computer Science or Information Systems curriculum. A significant amount of technical knowledge must be delivered to the student learners, and this often results in the Instructor for such a course becoming the 'sage on the stage,' while the students oft become passive listeners. An increased emphasis on student-centered learning objectives would warrant that the instructor spend more time becoming a 'guide on the side,' and hence involve students more actively in the learning and discovery process.

We shall describe some strategies we have implemented and planned in our teaching of Database System Design, invoking the range of thinking skills specified by Bloom's Taxonomy (Bloom, 1956), where we seek to address all levels of critical thinking by more

actively involving students in the learning process, and to reach the highest levels of learning by encouraging and requiring students to become partners and participants in the teaching process, thereby enabling peer-to-peer learning as well as collaborative efforts of students.

2. TYPICAL CONTENTS OF AN UNDERGRADUATE DATABASE DESIGN COURSE

An understanding of issues in Database Design has been a key component of the various curricula recommendations issued by ACM and other professional organizations. For instance, the 1991 Report of the ACM/IEEE-CS Joint Curriculum Task Force (ACM, 1991) defines "*Database and Information Retrieval*" as one of the nine subject areas comprising the discipline of Computer Science. The IS'97 - Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems recommendations (ACM, 1997), jointly developed by ACM, AIS and AITP, specify the course "IS'97.8 - Physical Design and Implementation with DBMS," as a required course for all Information Systems students, and requiring the highest level of competency.

The goals of the course IS'97.8 - Physical Design and Implementation with DBMS, are stated as follows (ACM, 1997):

"This course covers information systems design and implementation within a database management system environment. Students will demonstrate their

mastery of the design process acquired in earlier courses by designing and constructing a physical system using database software to implement the logical design.”

More recently, the Year 2001 Model Curricula for Computing (CC-2001), created by a Joint IEEE Computer Society/ACM Task Force to update the 1991 curricula recommendations of the group, released the Strawman_Report (<http://www.computer.org/education/cc2001/report/index.html>) in March, 2000, detailing the preliminary recommendations of this group. Information Management (IM) is identified as one of the thirteen ‘knowledge areas’ for Computing Curricula 2001.

Information Management consists of the following components:

- *IM1: Database Systems (history, database components, functions, architecture, independence, etc.)*
- *IM2: Data Modeling and the Relational Model (E-R modeling, object modeling, relational model, referential integrity, relational algebra, etc.)*
- *IM3: Database Query Languages (SQL, QBE, etc.)*
- *IM4: Relational Database Design (functional dependencies, normalization, etc.)*
- *IM5: Transaction Processing (failure and recovery, concurrency control, etc.)*
- *IM6: Distributed Databases (distributed data storage, query processing, concurrency control, etc.)*
- *IM7: Advanced Relational Database Design (multivalued dependencies and higher order normal forms, etc.)*
- *IM8: Physical Database Design: (B-trees, indexed files, etc.)*

A closer examination reveals that the Year 2001 Model Curricula for Computing maintains a stricter focus on database theory and design issues, while IS’97 embeds database design issues within the overall framework of design strategies for information systems in organizations. Note that the Year 2001 Model Curricula for Computing provides no mention of any specific topical focus devoted to commercially available database management system software, though, in practice, most universities use such tools as a balanced component within a Database Design course. On the other hand, while IS’97 mentions “designing and constructing a physical system using database software,” the topical content of IS’97 also pays no specific focus to commercially available database management software.

In numerous universities, a single course in Database Design must serve the needs of both Computer Science majors and Information Systems majors (and possibly other segments of interested students). In such

a case, if we consider the intersection of content of the CS-oriented Year 2001 Model Curricula for Computing, and the IS-oriented IS’97, it appears that the following contents of the Year 2001 Model Curricula for Computing undeniably reside in the intersection of these two models:

- *IM2(Data Modeling and Relational Model),*
- *IM3(Database Query Languages),*
- *IM4(Relational Database Design)*
- *IM7(multivalued dependencies and higher order normal forms),*

while IM5(Transaction Processing), IM6(Distributed Databases) and IM8(Physical Database Design) (and probably even IM1(Database Systems)) do not reside in the intersection. Such a course common to both CS and IS majors will typically include some significant discussion and utilization of a commercially available database software system, with relevant assignments and projects using the database software. We note also that there are issues of depth vs. breadth, and that certain topics might receive more detailed treatment depending upon the intended audience.

The authors are associated with a technological university, where a single introductory course in Database Design serves the needs of both Computer Science and Information Systems undergraduates, and follows material in the intersection of the two curricula paradigms heretofore mentioned, augmented by two commercially available database software packages, one typical of a relational database management system (Microsoft Access 2000), the other emphasizing a semantic object modeling application development system (Wall Data’s DBAPP Developer 2.5). The textbook used is (Kroenke, 2000).

In this paper, we reflect upon a critical re-examination of our teaching of such a course in Database Design, and propose some recommendations in light of desired levels of thinking skills and the availability of recently developed software applications, which, when properly invoked, engage our students in a broad range of learning activities, from the base level of knowledge attainment, to the highest levels of learning by transforming students into a dual role as teachers of database topics.

3. CONSTRUCTIVISM AND WEB LEARNING

It is clear to all that the Internet and related Information Technology are transforming the structure and fabric of society, in ways exceeding that of the Industrial Revolution. Higher education, perhaps more conservative and resistant to change in the past than one might have expected, is seeking to capitalize on this trend by creating opportunities for enhanced delivery of course content. Web-based education, and web-based learning environments, are becoming the essential fabric

of many universities, either in 'stand-alone' (Distance Learning mode) or as an adjunct to traditional face-to-face classes. (Aggarwal, 2000)

As universities expand into web-based learning environments, they are creating new opportunities in both traditional face to face learning environments as well as the newer web-based classrooms. A pure linear transfer of in-class lectures and pedagogical practices to the Internet 'bandwagon,' while concurrently ignoring the strengths of the new technologies, does not do justice to the potentialities of enriched media in the learning process. The trends which are occurring in higher education permeate both these modalities, and are characterized by (Aggarwal and Bento, 2000) as consisting of:

- *transitions from non-active classroom lectures to hands-on, student centered, interactive learning environments*
- *the perception of the student as a 'customer' with enhanced levels of control over the pedagogical process*
- *a learning marketplace where traditional providers of higher education (universities) face increased competition from for-profit enterprises seeking to carve a niche as content providers.*

From a different perspective, the maturation of constructivist theories of learning, whose impact in the past has primarily been in the lower grades, is ripe for extended applications in higher education. Constructivists believe that the primary role of teaching is not to lecture, explain, or otherwise attempt to "transfer" knowledge, but to create situations for students that will foster their making the necessary mental constructions. Constructivism emphasizes active learners, the linking of new knowledge to prior knowledge, and the application of understanding to authentic situations. Constructivists view learning as a dynamic internal process, where learners actively "construct" knowledge by connecting new information to what they already know, rather than as a process characterized by passive reception of facts. The building of knowledge is, thus, not obtained through increased teacher lecturing. Rather, there is a decrease in the amount of teaching, and a corresponding increase in the depth of student projects. Based upon these constructivist notions, we have sought to devote a greater focus on the database projects we present to our students, to insure that scenarios are created which encourage students to achieve constructivist goals.

Papert (Papert, 1993) dichotomizes educators as either Schoolers or Yearners. Schoolers continue the pedagogical path that they were traditionally exposed to, while Yearners strive to change. The authors, as Yearners, have sought to innovate and depart from some of the traditional precepts of teaching courses such as Database Design, by creating, wherever possible,

enriched learning environments and database projects for our students, as per the constructivist doctrines. Often, this will take the form of database design projects where students are placed in instructor-generated scenarios (akin to 'case studies') where they need to construct a database application, given some fairly general problem specifics stated by the CEO of a hypothetical corporation.

4. REVIEW OF BLOOM'S TAXONOMY

Bloom's Taxonomy is a nomenclature of labels for describing those levels of intellectual activity which occur during the human behavioral change we know as learning. It is generally applied to the cognitive domain of learning, which comprises the development of intellectual abilities and problem-solving skills. This is in contrast to the affective domain (emphasizing feelings and emotions, and the development of interests, abilities, values and appreciation) and the psychomotor domain (which is concerned with motor skills).

The effort to develop a taxonomy of learning was initiated in 1948 by a group of educational psychologists, and culminated in the 1956 book by Benjamin Bloom (Bloom, 1956). The categories in the Cognitive Domain are as follows (with the topmost representing the highest level of critical thinking skills):

- VI. Evaluation (judging the value of material for a given purpose)*
- V. Synthesis (putting parts together, in alternative manners, to form a new whole)*
- IV. Analysis (decomposition of learned material into its component parts so that its structure may be better understood)*
- III. Application (making use of learned material in new or unfamiliar situations)*
- II. Comprehension (lowest level of understanding, one step beyond recall, the ability to grasp the meaning of material)*
- I. Knowledge (recall of previously learned material)*

Evaluation, Synthesis and Analysis are generally referred to as higher order thinking skills, while Application, Comprehension and Knowledge comprise the basic skills. It is generally viewed that a serial structure is in place, namely, one cannot effectively address higher order thinking skills unless and until the levels below them have been covered. The Bloom taxonomy has been widely applied to K-12 learning situations, and, to a lesser extent, university environments. Teacher preparation programs will often emphasize that Bloom's taxonomy be recognized in the creation of daily lesson plans, and sets of key words, model questions and verbs (such as John Maynard's work (Maynard) at the University of Texas, are available to enable educators to create examination questions and assignments which address each level of the Bloom Taxonomy.

Much of the focus of higher education, particularly the measurement instruments which students encounter (such as examination questions), by and large, are primarily measuring Knowledge, the lowest level of critical thinking. The expectations of a given academic program might sometimes provide a given ceiling to the expected level of thinking skills, but often an artificial ceiling is established by the inability of instructors to recognize or acknowledge the higher order thinking skills within Bloom's Taxonomy. A focus on Knowledge, Comprehension and Application is often sufficient for the training of a *technician*, and quite often will lead to satisfying entry level positions, but for the training of a *scientist*, particularly a Computer Science or Information Systems professional, delving into the higher categories of Analysis, Synthesis and Evaluation becomes an essential component of their preparation for professional careers.

5. FACILITATING BLOOM'S LEVEL I AND II THROUGH CROSSWORD PUZZLE DESIGN

The teaching of an upper division course in Database Design provides a unique challenge to the instructor, in terms of achieving a proper balance between theory and practice. Initial chapters in Database Design texts, and introductory lectures, focus on defining the fundamental concepts in the database area, including the definition of terms such as database, relations, attributes, relationships, integrity, metadata, DBMS, indexes, redundancy, relational database, primary keys, etc. Our experience has demonstrated that beginning Database students are often lackadaisical, in terms of motivation, to grasp the precise meaning and definitions of key terms used in the Database field. The introductory chapter reading in Database texts is often 'dry' due to the needed emphasis on defining the key terms in the field. The further challenge for the Database Instructor is to enliven the chapter through some interesting exercise, which not only supports the Bloom Level I of factual knowledge recall, but goes beyond this into Level II by requiring some basic understanding of the Level I material.

Several researchers have proposed pedagogical strategies for achieving and measuring the Bloom Level I of factual knowledge. Most notable has been the work of (Daigle, 1998), who, in teaching the history of computing, initiated a 'College Bowl' activity in the classroom, where student teams contributed questions to a history of computing database, and then newly generated teams became participants in the pseudo 'College Bowl' competition. The collaboration and active learning aspects of the process enabled the instructors to cover more material in the given time frame, with enhanced student interest, and the attainment of team cooperation skills by individual students.

In our teaching of Database Design, we have (with a similar goal of Daigle) sought to create a meaningful, interesting and motivating pedagogical activity to support the attainment of Level I Database knowledge, so fundamental for comprehension of forthcoming database concepts beyond the introductory chapters. The vehicle we use is a classic one, the Crossword Puzzle.

Whereas traditional crossword puzzles have clues consisting of vocabulary words, places, people, titles, foreign language expressions, etc., what we have chosen to implement is to have each clue relate to some aspect of Database Knowledge (Bloom Level I) or Database Comprehension (Bloom Level II). Our crossword puzzle assignments are 'open book' in the sense that we encourage students to use the textbook and lecture notes resource in order to verify their responses to each of the clues.

The challenge to the crossword puzzle designer for Database Design is to not only create a comprehensive set of clues to cover the desired Bloom Level I and II outcomes, but also to design the crossword diagram, and ensure that the intersecting and interlocking squares provide correct words. Fortunately, this latter design activity is readily accomplished via the availability of crossword generator software, so the designer can focus his/her activity on the creation of the 'clues' to achieve the outcomes desired from the exercise.

While several crossword generators are available, we seek in the classroom setting to always identify the source of the software used in the creation of any material, since students will often pursue these to augment their personal software libraries. Since the numerous shareware versions have registration fees, and commercial versions are costly, our choice for a crossword puzzle generator was restricted to public domain software, and we have used Word Junction (Waldman & Heath, 1995). The public domain Word Junction is freely downloadable at: <http://www.pcmag.ziff.com/~pcmag/utills/wj.htm> . Word Junction requires that the designer provide the 'word-clue' file, which can be created using any available text editor (such as the Microsoft Windows accessory Notepad), and Word Junction will generate the complete crossword puzzle.

For Distance Learning classes teaching Database Design, it is desirable to have a Web-Based version of a crossword puzzle design (Word Junction will not generate html), and again, one that is in public domain. We have successfully used, and recommend, the JCROSS crossword generator within the Hot Potatoes 4.1 Suite, which is a suite of interactive educational programs, created in JavaScript and HTML at the University of Victoria Computer-Aided Language Learning Laboratory, and distributed by Half-Baked Software. The Hot Potatoes 4.1 suite is free to

individuals of non-profit organizations, such as educational institutions, and may be freely downloaded at: <http://web.uvic.ca/hrd/hotpot/>

6. FURTHER REFLECTIONS ON USING BLOOM'S TAXONOMY IN TEACHING DATABASE DESIGN

Our pedagogical objective is to recognize, implement and deploy tools and methodologies to move from one tier of the taxonomy to another higher tier. We study and design methods that assist students to acquire higher levels of learning in the spirit of Bloom's taxonomy.

As students become familiar with basic concepts, they accumulate KNOWLEDGE (information). Through assignment of less complex homework, and the creation of simple presentation and teaching modules by students, the learner moves from the KNOWLEDGE tier to COMPREHENSION, and eventually, to the APPLICATION tier.

The individual pieces of information, as the learner achieves an understanding of their meaning, become knowledge building blocks. As students become familiar with the concepts (through deployment of the above tools), his/her understanding deepens (formation of the knowledge object building blocks). The students then become ready to apply building blocks to new situations that would require, as appropriate, the previously understood blocks, thereby reaching the Application tier.

One should therefore create situations for the learner to apply his/her knowledge, in order to develop a deeper understanding (Comprehension). Then, through practice (Application), one can integrate blocks of concepts into complete and sound systems (Analysis and Synthesis).

As the topics advance, the level of the complexity and the demands on the students increase. Eventually, students will be expected to put together individual building blocks, responding to instructor assigned database application projects. Out of these lifeless, scattered pieces of knowledge objects, a complete, working physical database application system will emerge. These knowledge object blocks will be put together in such a way that a sound and correct database system comes to life.

The process of moving from building individual blocks to the creation of an integrated working database application system using these blocks, corresponds to migrating from the Application tier to the Analysis tier (deciding what type of block(s) are needed, how to create them, how to use them, how to satisfy objectives, etc.) and from there to the Synthesis tier (how to group the blocks and how to establish efficient and effective communication among groups of knowledge objects).

Finally, if one establishes a policy whereby students anonymously evaluate each other's performance on projects, then students will have the opportunity to evaluate peer work in terms of completeness, correctness and efficiency.

Experience and time are the two most influential factors in the process of refinement and selection of pedagogical tools and processes. Following are some suggested tools and methods which may be applied, at various points in the process of teaching database design and development, in order to reach higher levels of learning (i.e., the upper tier of Bloom's taxonomy).

- *Learner involvement through teaching, by the student creation of multimedia teaching modules (AVI movies) and Powerpoint presentations*
- *DBMS Mapping (i.e., we use the practicality of the DBMS to concept-map and illustrate various database design issues from the conceptual and theoretical domain, such as referential integrity, joins, relationships, etc.)*
- *Home Mini-Tests (instructor assigned homework which enable students to gain a deeper understanding (Bloom Level II) of the knowledge gained in the classroom and textbooks).*
- *Database Projects (which require students to apply their knowledge and understanding to new and/or more complex situations)*
- *Evaluation (whether done by the instructor or student teams, this process can and should be a learning experience for the students.)*
- *Teamwork (through true collaboration, there is synergy in different aspects of learning).*

7. LEARNER INVOLVEMENT

Student involvement through student-generated multimedia teaching modules draws individual learners from a passive mode to an active mode. Students become an active part of both teaching and learning when we require them to accept the dual role of a conventional student as well as the instructor. Students are assigned to teams, and within each team, individuals take responsibility for the gathering, creation and presentation of new material, based on their current knowledge level and exploration of new concepts, and discovery of new approaches to presenting and teaching traditional topics.

The students are exposed to two modes of teaching:

Creation of AVI teaching movies

A topic is assigned to a group of students. They are to create a multimedia module using suggested software tool(s), to teach either already familiar

concepts, or to explore and teach new concepts. Students will gain experience in applying multimedia technology to communicate their message through audio and video applications.

‘Powerpoint’ presentations to the class

Students are responsible for selecting a topic, researching it, and presenting it in the classroom, under the assumption that their fellow students have nil knowledge of the subject matter. The ‘burden’ of teaching will fall on the presenter. Presentation topics are selected only after basic and crucial concepts have been identified, examined and ‘digested.’ These topics are often supplemental to the course curriculum. Students will be working in groups, and each group builds their presentation through teamwork.

Presentation topics should be assigned based upon the student’s technical background. Those who have industrial experience can be asked to bring their related work experience into the classroom. Through such presentations, students will become motivated by learning how the course material relates to pragmatic situations, and thus perhaps benefit them in obtaining a job. Also, they will obtain exposure to standard industry practices and the latest technology, and establish possible connections and understanding of potential employers.

We strongly believe that the ultimate level of learning is reached through teaching. Therefore, regardless of the position of a student in Bloom’s tier, s/he can reach the highest levels of critical thinking through teaching, provided that the student has attained the prior levels of learning through various tools we have described (home-mini-tests, projects, instructor-provided lectures, and other related resources).

It is highly recommended that individuals (instructors and students) who are implementing/practicing these ideas and methodologies, develop a clear understanding of Bloom’s taxonomy of critical thinking levels, such that the practitioner acquires a brain map of the mechanics of the process. This way, students can be inspired to prepare teaching modules which results in them acquiring a higher level of learning skills.

DBMS Mapping

The DBMS (Database Management System) is used as the vehicle to concept map database design and development concepts from theory to practice. Database development packages are used to carry students from the Knowledge /Comprehension tier to higher tiers of Bloom’s taxonomy, by mapping DBMS concepts. DBMS packages are initially used to concept map simpler ideas (creating knowledge objects building blocks). Gradually, through more complex tasks, students are asked to create a complete database system using previously designed building blocks. Through the proper design of homework and projects, the learner is

given the opportunity to accumulate knowledge, deepen understanding of the units of information, and to apply the concept to solve new and simple problems. Later, through analysis, the learner is able to attack more involved tasks. Eventually, through more complex design assignments and projects, all the parts have to be integrated into a working system.

As the application of the theory through DBMS packages becomes more involved and covers a wider range of concepts, the learning curve becomes steeper and deeper. When at the time of materialization of a complete physical database system, the student has entered the Synthesis learning tier.

Home Mini-Tests and Database Projects

Throughout the semester, homework and database projects are assigned to meet particular needs of students, with the objective of progressively carry them from the current level of learning to the next higher level. At the beginning of semester, the emphasis is on accumulation of knowledge and deepening the understanding of the concepts. At this stage, the homework is of a simpler and of more repetitive/recall nature, such as through the use of our Crossword Puzzles. By reviewing basic and crucial concepts, we believe that a strong foundation for more complex concepts will be established (Comprehension). Throughout the semester, there is a delicate balance between incorporation of new knowledge and the deepening and integration of existing knowledge.

As students apply their knowledge and gain insight, through the application of the acquired knowledge to simple problems, they acquire Application level learning skills. Then, through Analysis, they can build and choose proper building blocks. The integration of these blocks into groups of working components, and subsequently into a complete and sound system, is accomplished in the Synthesis tier.

Evaluation

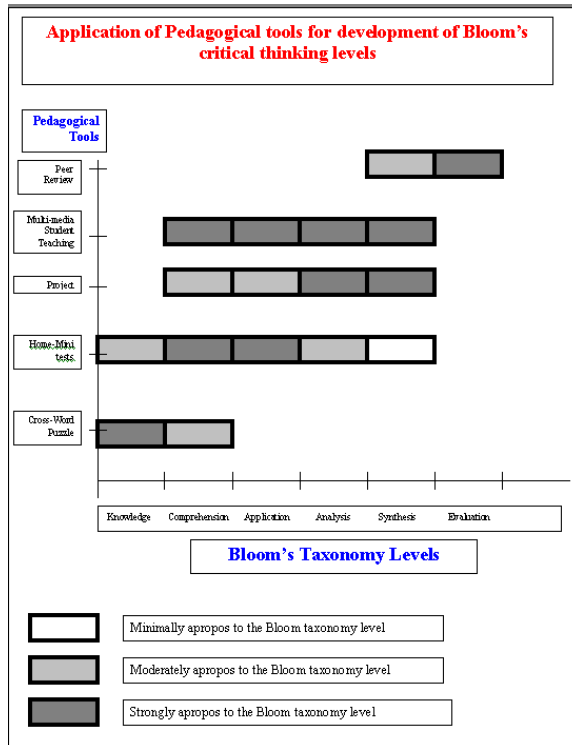
Evaluation is the assessment of completeness, correctness and efficiency of the product, one level beyond the synthesis level. Students should be given the opportunity to judge. Through evaluation of their peer’s work, student’s gain exposure to new ways of thinking (and expand their knowledgebase). As a student studies their peer’s work, each unknowingly will be comparing his/her own work to the work under study, and develop new insights and alternative approaches of how things could have been done. Evaluation is the highest level of learning.

Team-Work

After the learner has assumed a more active role, the dynamics of learning are accelerated through teamwork. Students are encouraged (or required) to work as a group, for preparation and completion of

teaching material. The nature of the assignment enforces group communication and collaboration. Students discuss and transfer what they have learned, their ideas and objectives (teaching). In addition, in order to complete their work, students on a team will seek to gain and maintain one another's consensus on the level and depth of content, presentation style and other related issues.

Our recommendations for tool deployment are summarized as follows:



8. STUDENT-GENERATED HYPERCAM & CAMTASIA MOVIES AS A FORM OF LEARNING

If teaching is truly the highest form of learning, and if teaching encourages students to utilize their higher order thinking skills, including synthesis, analysis, and evaluation, then in the constructivist sense we should seek opportunities for our students to engage in some form of teaching. In an advanced 'Special Topics' (asynchronous) Distance Learning section dealing with database management systems, we decided to experiment with projects in which students played the role of teachers, requiring students to teach topics such as the exploration of the graphical user interface in DBAPP Developer 2.5 for creating semantic object data models, and advanced issues in Microsoft Access 2000, including switchboards, macro design and applications, action queries, subreport and subform design, etc.

In a face-to-face synchronous class, students (or student-teams) could present their teaching in the 'sage-on-the-stage' mode, but this was not possible in the asynchronous distance learning mode (using WebBoard), in which the course was taught. The Distance Learning class was divided into e-teams (electronic teams), where each e-team consisted of two 'e-buddies.' The student-generated teaching projects would be accomplished using application programs which completely captured the student's interactions with the database design software, while concurrently recording the student's voice as he/she presented the knowledge, guided the comprehension, motivated, applied the database design concepts to new situations, analyzed, and synthesized - in short, the student teaching followed the identical pedagogical 'Bloomian' goals which an experienced instructor would seek to accomplish.

There are several multimedia software products available which allow the user to capture all screen interactions as well as to record voice. These include:

- *Microsoft Camcorder*
- *Lotus ScreenCam*
- *Hypercam (from Hyperionics, Inc., <http://www.hyperionics.com>)*
- *Camtasia (from TechSmith Corporation, <http://www.techsmith.com>)*

Of these four products, only Hypercam and Camtasia enjoy cross-platform support in the various versions of Microsoft Windows, and produce their output in industry-standard AVI (Audio-Video Interleaved) format. Thus, Hypercam and Camtasia were chosen for the course, and students were required to have these programs. The author provided students with a step-by-step overview of the basics of using these products to create the AVI teaching modules, and students after mastering the basics were able to explore the complete functionality of these products for creating their own AVI's. The selected products are shareware with specific time-limited evaluation periods, and the combined evaluation periods of the two products enabled students to have several months of free usage, and many students were sufficiently impressed with the capabilities of these products that they ultimately paid the registration fees to acquire them.

In addition to recording the audio and video, limited AVI editing is also available with these products. With Camtasia, there are actually two distinct components: Camtasia Recorder (to record the audio and video) and Camtasia Producer (which includes audio-video editing capabilities). Hypercam relies on a companion product to perform the audio-video editing.

Based upon our preliminary experience, we offer the following guidelines and recommendations for instructors who wish to utilize student-generated AVI

movie projects in order to strive for the elusive higher-order thinking activities in our students.

- i. *For enrollment in such a class, students should have their own personal computers with sound card and speakers, a microphone, and either a CD-Writer or ZIP drive.*
- ii. *Divide the class into e-teams consisting of two e-buddies (i.e., members of a particular e-team). E-teams will be responsible for managing the teaching of the DBMS products, will provide a single submission where they must fully document the management of the project (i.e., who did what.)*
- iii. *E-teams must be encouraged to do proper planning for their ultimate movies, with extensive rehearsals, and prepared scripts.*
- iv. *Provide the e-teams with Bloom's Taxonomy Of Learning Activities, and encourage the e-teams to not only seek to teach the fundamental knowledge (Bloom Level I), but also to provide the examples, insights and commentaries which reach into the higher order learning activities.*
- v. *Teaching can be done in small modules, which allows for easier audio-video editing, and the smaller modules can easily be combined into larger modules, or embedded within Microsoft Powerpoint slides.*
- vi. *Some e-teams may prefer to have one e-buddy do the keyboard and mouse interactions with the DBMS software, while the other e-buddy does the audio-recording, but most e-teams will probably prefer that one e-buddy do both (though they will alternate). This is a matter of individual team preference, but in both cases, e-buddies should carefully critique the work each e-buddy completed, and not be afraid of editing or even discarding a module which fails to accomplish the intended goals.*
- vii. *E-teams should be allowed to view the completed movie projects of other e-teams, in order to benefit from the group effort. In this sense, we are creating a collaborative learning environment. When carefully controlled, one e-team may be allowed to share in the evaluation of the work of another e-team, using the taxonomy levels of learning from Bloom as a measurement instrument to award a grade.*
- viii. *The AVI files generated by these applications will become large, with some projects exceeding 200 megabytes. Submissions must be on CD's or ZIP disks. For sharing projects in the collaborative learning environment, students should*

convert their AVIs to a streaming format (such as Microsoft's ASF) and stream to a server using a codec optimized for screen capture (Camtasia Producer excels in this area).

- ix. *Compared to the grading of traditional projects, the instructor is forewarned that grading an AVI movie requires viewing the entire movie, with no shortcuts. It is a time-demanding process. We are reminded of Papert's remarks (Papert, 1993) on Mathematics (the art of learning), and that giving yourself time is the first principle in the art of learning.*

When properly implemented, student-generated teaching via AVI movies presents a marvelous opportunity for Database instructors to become Yearners and Constructivists, and cultivate the complete range of thinking skills of our students.

9. AUTHORWARE QUIZLETS AND THE POTENTIAL FOR DATA MINING

We believe that on-line quizzes (which need not be a component of the course grade for a student) can be an effective tool to provide necessary feedback to the student on the level of their acquired knowledge of database concepts, their comprehension of these topics, and their ability to apply the comprehension to new situations. Attaining these lower levels of Bloom's critical thinking skills are crucial if the student is to proceed into the desired higher Bloom levels. One activity we are experimenting with is to have the students prepare the questions and solutions for the bi-weekly on-line quizzes (quizlets).

To assess the effectiveness, and particularly the extent of the usefulness of the introduced components, on-line quiz performance data may be collected and analyzed. Macromedia Authorware provides the capability to record student performance throughout their usage of the system. It therefore creates the opportunity for researchers to mine and analyze the data at appropriate time intervals. Through the study of data, not only one can draw conclusions concerning the effectiveness of the system in general, but also the interdependencies of different topics.

10. CONCLUSIONS

We have described herein some initiatives we have undertaken in our teaching of the traditional Database Design course, and provided the cognitive and philosophical basis for our endeavors. We encourage others who teach database design (and comparable courses) to be 'Yearners' and make the commitment to experiment with the road 'less traveled by' (Frost, 1969):

I shall be telling this with a sigh
Somewhere ages and ages hence
Two roads diverged in a wood, and I
I took the one less traveled by
And that has made all the difference.

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