Hypermedia Applications in Web-based Teaching and Learning Environments: The Role of Databases as Intermediaries

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Abstract

There are numerous benefits associated with integrating hypermedia applications into teaching and learning environments. However, simply adding a hypertextual component does not ensure increased success in teaching or learning. Various issues can transform hypermedia into a constraint rather than an enabler of learning. For instance, problems occur when users are new to either hypermedia environments or the topic of study in which the hypermedia is integrated. We argue that a web-based database can act as an intermediary in the integration of hypermedia applications into learning environments. In this paper, we describe the reasons for using a web-based database as well as stages of implementation. We conclude with two examples of projects that utilize databases in hypermedia learning environments as well as methods for the development of database-driven hypermedia environments.

INTRODUCTION

With the recent increase in the use of hypermedia applications for teaching and learning (Grabowski & Small, 1997), it is important to consider both the beneficial and constraining factors associated with the relatively new educational tool. Research has provided evidence that the structure and navigational freedom associated with hypertext environments can positively impact the learning process in a number of ways (Ayersman, 1996; Dillon & Gabbard, 1998; Hartshorne, 2005; Hede, 2002; Jonassen, 1996; Landow, 1992). First, they provide non-linear access to information, allowing students more freedom in the learning process (Nielsen, 1995; Reed & Oughton, 1997). Second, they allow students to access information in depth (Collier, 1987). This affords complex representations of basic concepts and comprehensive illustrations of more abstract concepts. A third benefit of hypermedia applications is that they address many of the attributes that foster meaningful learning (Jonassen, 2000). They are engaging to the learner (Jonassen, 1989), allowing for active learner participation (Landow, 1992), involve complex, contextual situations (Jonassen, 1989), and promote reflection (Hede, 2002).

Unfortunately, hypermedia technologies are not necessarily beneficial for all learning scenarios. Certain issues, such as learner ability, learner type, and level of learner activity, all impact the effectiveness of hypermedia learning systems. Dillon and Gabbard (1998) state that, while hypermedia "can offer techniques that can help the less able student perform better" (p. 345), lower ability learners typically have more difficulty effectively utilizing hypermedia. Jonassen and Wang (1993) found that field independent learners "are better hypermedia processors, especially as the form of the hypermedia

becomes more inferential and less overtly structured" (p. 7). Lee and Lehman (1993) suggest that the level of activity the learner engages in affects the learner's achievement in the hypermedia environment. Reed and Oughton (1997) found that more experienced hypermedia users take more nonlinear, and fewer linear steps through the hypermedia environment, thus increasing the effectiveness of the hypermedia application as a learning tool. They also suggest that the structure and freedom associated with hypermedia environments, while providing some benefits, can also be constraining to some learners (Reed and Oughton, 1997).

Other limitations involve navigational and experiential issues (Gardarin & Yoon, 1995). Problems with goal attainment, spatial disorientation, and knowledge acquisition are common among users unfamiliar with hypermedia environments and limited experience with the content being addressed. Due to inexperienced users having to perform multiple tasks such as information storage, restructuring, transfer, and evaluation, they often overlook important information, are overwhelmed by the learning environment, and feel cognitively overloaded (Astleitner & Leutner, 1995). Hence, when the environment or content is too new, hypermedia structures can initially be too advanced for many learners. Beaufils (2000) states that students would benefit from some sort of pre-structuring activity in advance of using the hypermedia.

DATABASES AS INTERMEDIARIES

Hypermedia technologies can be extremely powerful tools for teaching and learning provided one is strategic in implementation and use. In other words, in order to reap the benefits, the constraints associated with hypermedia must be addressed. A number of problems associated with the design of hypermedia systems can be addressed using database systems. Database systems can be defined as a series of programs in which various forms of information can be stored, organized, and retrieved, and often include database programs as well as other programs, such as presentation software (i.e. webpages). These systems can be used to address complexity issues related to navigation, flexibility, and organization of information, by reducing the sense of being overwhelmed. Database structures can also help low ability learners and those not experienced with hypermedia applications or the specific content area, as well as other issues presented by hypermedia structures (Jonassen, 2000).

There are three primary ways in which database structures can act as intermediaries to hypermedia environments. First, database applications allow instructors to sort information. As a result, the instructor can create an environment where the user has less control over the environment and thus experiences less cognitive overload. More experienced and proficient users can be provided more control in the environment to enhance the learning experience. Having experienced database structures in the hypertextual learning environment, the user is better prepared for information presented via other hypermedia applications (Reed & Oughton, 1997). Second, databases are effective as pre-structuring tools (Brush, 2001). Database applications can be structured to involve similar tasks as hypermedia (information storage, restructuring, transfer, and evaluation), but in a manner that is less overwhelming to the learner. Third, Jonassen (2000) argues that the "greatest problem related to using hypermedia to facilitate learning is how learners will integrate the information they acquire in the hypertext into their own

knowledge structures" (p. 210). Database applications address this issue by helping students make their own content relationships (Jonassen, 2000), and then relate those relationships to their knowledge structures.

A generic example of this idea is illustrated when "surfing" the Internet. Imagine searching the World Wide Web without the aid of search engines. Jonassen (2000) refers to the Web as a "giant, distributed hypermedia knowledge base" (p. 177) and "a vast database of information that is unfortunately lacking in structure and organization" (p. 180). In order to effectively access, organize, and manipulate the vast amounts of information available on the World Wide Web, search engines are used. Search engines are database structures integrated into the hypermedia environment and allow the user to determine the value of information presented throughout the "search" process. The more experience users have with search engines, the more successful they are in accessing specific information via the World Wide Web. In sum, using web-based database structures in hypermedia applications assists in the process of "searching" the World Wide Web. In doing so, they act as intermediaries between the learner and the hypermedia environment. New enhancements in database design for web searching have tremendous potential but are as of yet unstudied.

To further explore this concept, we present two examples of hypermedia environments with databases embedded in their structure. The two examples are *Reading Classroom Explorer (*http://www.eliteracy.org/rce) and *Elementary Level Lessons in Physical Science* (http://ferdig.coe.ufl.edu/pt3physics)[1]. Both of these tools are used in various courses at the University of Florida in a preservice teacher education program and *Elementary Level Lessons in Physical Science* (ELLIPS) has been used for inservice professional development in Duval County Florida Schools. One focuses on exemplary literacy instruction (*Reading Classroom Explorer*), and the other is an online collection of elementary physical science lesson plans based on state standards (*Elementary Level Lessons in Physical Science*).

Reading Classroom Explorer

Reading Classroom Explorer (RCE) is an example of a hypermedia environment for preservice teachers studying literacy instruction. RCE was developed by a group of researchers at Michigan State University as a tool to allow preserve teachers to "engage preservice teachers as actively as possible in classrooms in which they can see teachers exercising their craft with a wide array of culturally and intellectually diverse student" (Ferdig, Hughes, & Pearson, 1998, p. 2). It is difficult to ensure that teacher candidates will be placed in a classroom where their mentor teacher will demonstrate exemplary literacy instruction. Even if their lead teacher demonstrates strategies that reflect the reform-oriented practice that the teacher candidates learn about in their studies, there is no guarantee that the classroom will represent the diversity that students will undoubtedly face in their teaching position. RCE is a hypermedia environment that was created to address these issues.

The RCE environment contains movies, transcripts, questions, reading resources and an interactive notebook. Movies and transcripts of exemplary practices are organized by themes, keywords, schools, cases, or by free-form text (Ferdig, Roehler, & Pearson,

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[1] Readers who are interested in exploring either tool may log-in with 'demo' and 'demo' as username and password in either system. For future use with students, please contact the authors.

2001, ¶ 3). In this example, the hypermedia environment uses a database structure to allow users to access and organize various media sources in an effort to observe specific examples of literacy instruction. Without the use of the database structure, users may feel overwhelmed by the amount of information presented, and the effectiveness of RCE would be significantly diminished.

Figure 1 shows the title screen of the *Reading Classroom Explorer*. Included on the screen are links to statements regarding the background of RCE, how to gain access to RCE, reasons to use RCE, and other user information. These resources provide the user with introductory knowledge on the RCE system, in an effort to increase the user's comfort level. Also included on the title screen is the "log-in" section of RCE. After submitting a *username* and *password*, the hypermedia environment is customized, depending on the user-type. This is the beginning of the database environment. Customizing user-types allows the ability to control access to various functions of *Reading Classroom Explorer*. For example, the "Instructor" user-type is allowed access to an "Instructor" Discussion forum and the "RCE User" is allowed access to a "General" Discussion forum, in addition to the movie clips information.

Figure 1. *Reading Classroom Explorer title screen*
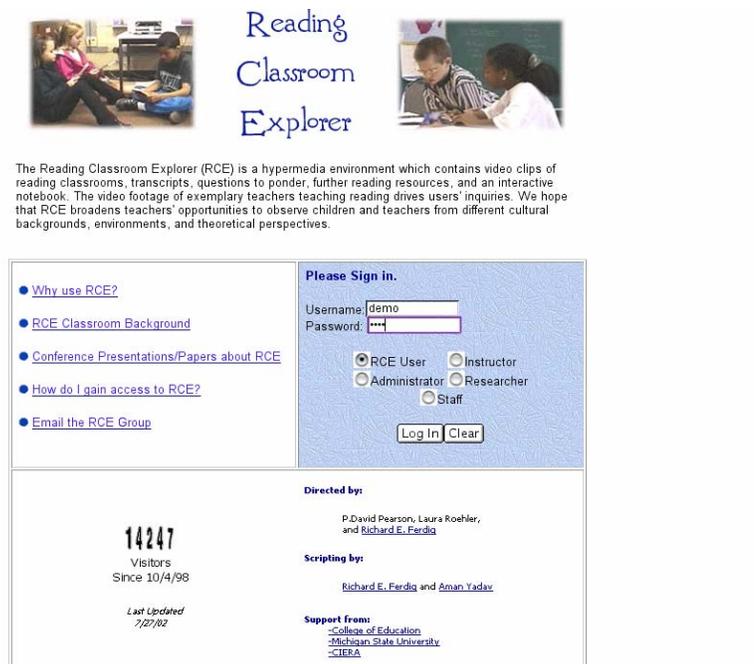
After the initial log-in is completed, the database-embedded hypermedia structure is continued on the initial search screen. Figure 2 shows the initial search screen for the "RCE User". While a database structure was used initially to customize RCE for various user-types, here a database structure was used to address issues of navigation, flexibility, organization of information, and complexity issues. As seen in Figure 2, movie clips are organized by school, theme, keyword, and transcripts. In an effort to increase the user's familiarity with the hypermedia environment, brief statements are given concerning each

of the search methods. Also, in the right-hand frame, brief directions are given on how to initiate a search.

Figure 2. *Reading Classroom Explorer initial search screen*
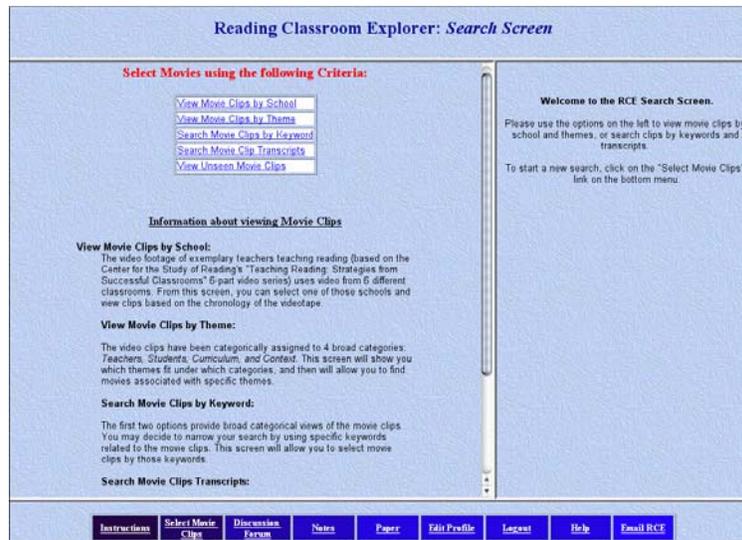

Figure 3 illustrates the next two steps in using RCE. After a 'Search Type' is selected, all items related appear in the left frame of the screen. In this example, the user chose to "Search Movie Clips by Theme", so all available themes appear in the left frame. After selecting a particular theme, all movie clips associated with the selected theme appear in the right frame. The user in the example above chose to search the "Creating a Literate Environment" theme. RCE then searched the relational database and provided links to all movies associated with the "Create a Literate Environment" theme.

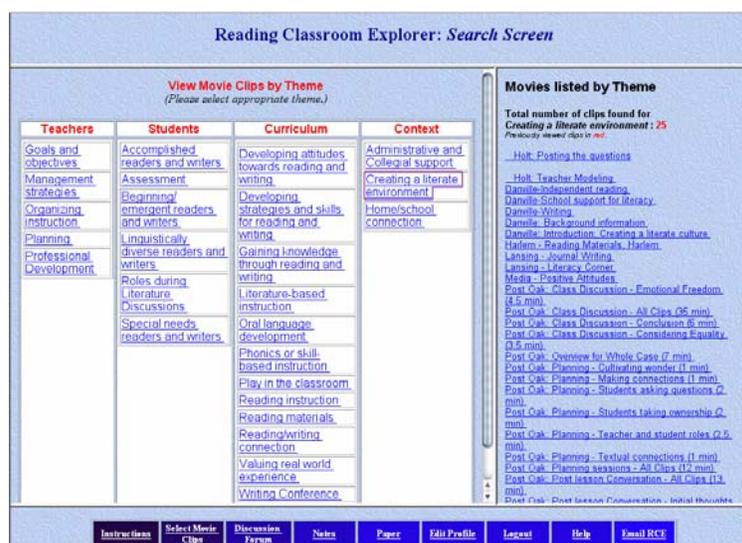*Figure 3*. *Reading Classroom Explorer initiated search screen*

Figure 4 illustrates the outcome of selecting a particular movie theme. The user is then given a number of options. These include viewing the movie clip itself (upper left hand corner), access to the movie transcript (upper right hand corner), a place to add notes (middle right hand section), previously asked questions (middle left hand section), and related information, themes, and keywords (bottom).

Figure 4. Reading Classroom Explorer movie clip selection
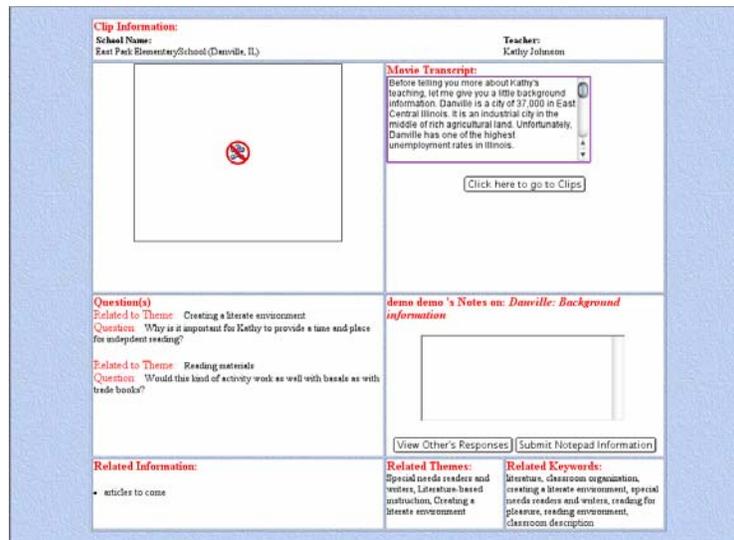
Accessing the complex amount of information presented in the *Reading Classroom Explorer* without the database structure could prove troublesome for many users, not only because of the sheer amount of data available, but also because users are new to *both* teaching *and* the technology. With RCE, the user is presented with a method of sorting the information provided without experiencing the cognitive overload that might otherwise occur. The database acts as a pre-structuring tool and also assists students in making their own content relationships and adding these to their own knowledge structures.

Added Value. RCE research has suggested a number of important benefits of this design. Pre-service teachers have demonstrated a deeper understanding of teaching and learning as well as enhanced use of intertextuality (Ferdig, Roehler & Pearson, 2001, 2002); pre-service candidates are more engaged in discussions and are more willing to participate in *uptake* (Ferdig & Roehler, 2003); and students show greater gains when it comes to their abilities with technology (Oliver et al, 2002). The current database searching structure is topic and keyword based; future studies will examine the benefits of finding new ways to access the database, i.e. using a *Google*-like searching tool, as well as comparative analyses of the number of choices to access necessary materials.

Elementary Level Lessons In Physical Science

Elementary Level Lessons in Physical Science (ELLIPS) was developed by a group of researchers at the University of Florida as part of a PT[3] grant to aid in the structuring and organization of science content for elementary teachers (Hartshorne,

2005). ELLIPS is a hypermedia environment for both preservice and inservice teachers designed to improve the effectiveness of elementary science instruction. Components of ELLIPS include a collection of various searchable elementary school level Physical Science activities organized according to topic, type of activity, grade level, amount of equipment needed, and the Sunshine State Standards (statewide academic standards for all K-12 Florida students), teacher science content resources organized by topics paralleling the subject areas in the lesson plan search, a teacher discussion forum, and the ability to compose and read reviews on individual elementary science lessons included in the tool.

As a tool for preservice teachers, ELLIPS is a component of the course, *Our Physical World: Physical Science for Elementary Teachers*, an introductory-level physical science content course focusing on concepts and skills that would be appropriate for elementary level students. As a tool for inservice teachers, ELLIPS was integrated into a 6-week elementary science professional development workshop series. While discussing basic physical science principles emphasizing everyday applications, events also emphasize the acquisition of pedagogical content knowledge for the elementary Physical Science teaching (Duggan-Haas, Enfield, & Ashman, 2000; Hartshorne, 2005). Due to the fact that preservice and inservice elementary teachers are often inexperienced with the content of a typical introductory Physical Science course, (Hurd, 1982) a hypermedia environment was designed to aid in the structuring and organization of the material. In this case, the hypermedia environment consists of a database structure that allows the user to organize the material more easily. As these courses developed, preservice and inservice teachers began adding various activities to the database, and, in the process, developing a greater awareness of the content relationships between various topics.

ELLIPS is a web-based tool that also allows teachers to access various Physical Science activities, based on certain criteria. The various search mechanisms allow the teachers to utilize, manipulate, and organize the data in a way that is more meaningful to their particular needs. Again, without the use of the database structure, users may not only feel overwhelmed by the amount of information presented, but also lack the opportunity to create relationships between various topics and the effectiveness of ELLIPS would be significantly diminished.

As with the *Reading Classroom Explorer*, an initial title screen provides various information about the tool. This includes (See Figure 5) the origin of the resource, instructions for use, various contact information, and more. Again, the database structure is initiated by the log-in process, in which different user-types are provided with access to different site functions.

After submitting a username and password, the ELLIPS user then advances to the hypermedia environment. On this screen, the user is prompted to choose from a number of options, including searching for lessons using varying criteria, reading and posting discussion topics, or searching for content resources by related to a specific topic. Figure 6 provides an example of the lesson plan search option, as well as the layout of the environment if the "Sunshine State Standards" search option was chosen. After selecting an initial search option, the user is prompted to select from various choices, each depending on the origin of the initial search criteria chosen.

Figure 5. *Elementary Level Lessons In Physical Science (ELLIPS) title screen*


Figure 6. *ELLIPS: Sunshine State Standards search option screen*
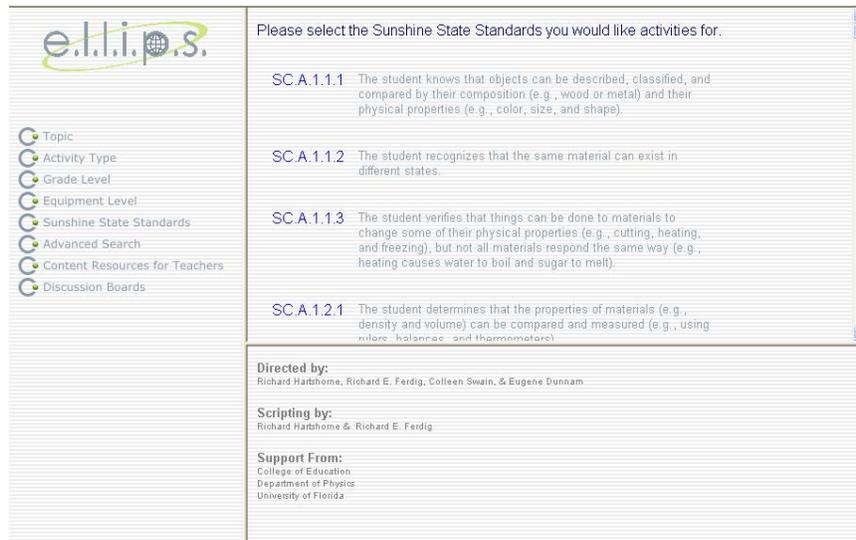
In the example above, the user has opted to search for activities related to the Sunshine State Standard "SC.A.1.2.4: The student knows that different materials are made by physically combining substances and that different objects can be made by combining different materials" (Brogan, 1995), as seen in Figure 7. This search returned ten activities associated with the particular search option selected. In Figure 7, the user is also given information related to the 'Activity Type' and 'Equipment Level' for each activity returned, as well as a brief description of the lesson. The user can also read reviews or comments that other teachers have made about a particular lesson, or compose their own review or comment related to the lesson. The first lesson listed, *Chem4Kids*, is

a computer-based tutorial on matter. From this point, the user can select any activity returned, and the activity will be presented in a new browser window.

Figure 7. *Sunshine State Standard activities returned screen*
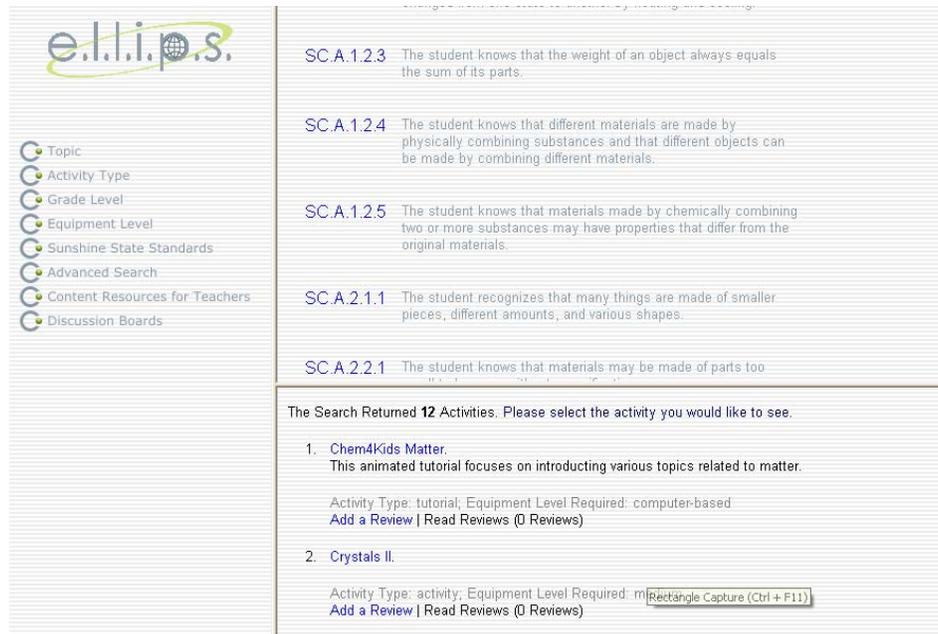
Similar to RCE, information that is both complex and often new to the learner is being presented using ELLIPS. Accessing this information without the database structure embedded in the hypermedia environment would be much less effective than using the embedded database. Due to the environment and content being new to the learners, many of the constraints of hypermedia would have been evident without the integration of the database application with the hypermedia environment. Another important note is that the strengths of each medium, databases and hypermedia, were a major focus during the development of ELLIPS. The database structure was used for the storage, organization, and retrieval of information while the hypermedia structure was used to address navigation, structure, and presentation of the information. All of these factors contributed to a more effective learning environment.

Added Value. Preliminary studies implementing ELLIPS indicate an increase in preservice and inservice teachers' science content knowledge as well as increased positive attitudes toward elementary science (Hartshorne, 2005). Other benefits included more individualized instruction, increased access to teacher resources and professional development opportunities, more comprehensive development of mental schemas, and more collaborative learning environments (Hartshorne, 2005). Future studies related to the database mechanism will investigate the influences of change in teacher content knowledge and attitudes toward science on student achievement, the sustained effects of the database-driven hypermedia environment over time, the effectiveness of database-driven hypermedia systems in less-structured professional development opportunities, comparative analyses studies related to accessing necessary information, and

examinations of specific aspects of hypermedia that result in more significant changes in teachers content knowledge and attitudes toward science (Hartshorne, 2005).

IMPLICATIONS

The use of hypermedia in the learning environment presents a number of possibilities. It allows for more complex learning environments, deeper learning to occur, and more learner control in the learning process. Being thrust into this new learning environment, however, can often overwhelm the learner. Database structures are familiar to many learners and, being used as an intermediary, can dampen the effect of the learner being overwhelmed by a novel tool and ultimately improve the effectiveness of hypermedia applications for many different learner types, especially the 'new learner'.

With the implementation of various technology-based initiatives and mandates (NCATE, 1997; No Child Left Behind, 2001), there has been an increase in focus on integrating technology into K-12 learning environments. With the increase of technology integration into the learning environment, hypermedia applications are becoming much more prevalent in the classroom. Therefore, it is important to use hypermedia in an appropriate and effective manner. As mentioned previously, database applications can help create more appropriate and effective hypermedia applications. In doing this, two major questions must be addressed: 1) What are some important considerations in developing and designing a database-driven hypermedia environment? and 2) How are database-driven hypermedia environments created? What follows is a discussion of each of these important questions.

What are some important considerations in developing and designing of a Database Driven Hypermedia Environment?

Related to the design and development of hypermedia tools, issue such as There learning objectives, the audience, and visualization must be addressed in order to appropriately deal with both the need and method of implementing a database as an intermediary in the learning environment. First, when deciding whether or not to create a hypermedia environment to address certain needs in the learning environment, it is crucial to assess whether a database-driven hypermedia environment is appropriate for the learning tasks. While other issues must be considered, sometimes the learning goals parallel the strengths of hypermedia and are contradictory to the strengths of databases. In learning situations where this is the case, it is appropriate to implement hypermedia as a stand alone tool. Secondly, and related to the previous issue, the audience is extremely important to consider when creating database-driven hypermedia environments. Issues such as the experience of the user with hypermedia, experience of the user with the content, learner type (field-dependent or field-independent), learner ability, and the level of user activity must all be taken into account when integrating database applications with hypermedia. The user's level of experience, with both hypermedia and the content will result in different types of use. More experienced users tend to take more non-linear steps while navigating through the environment, while inexperienced users tend to follow more linear steps.

The third issue relates to the structure of the database-driven hypermedia environment is the visualization of information. Visualization has many issues related to it, including the information hierarchy, how the information will be divided and displayed, how users will navigate the environment and access information, and the presentation of the information (Mukkerjea, 1999). All of these issues need to be very clear to the user. Confusion in the process of accessing, navigating, or analyzing presented information will diminish the effectiveness of the tool. However, information in which the process of accessing and navigating is clear, along with a well-structured presentation of information, will greatly enhance the integrated database-hypermedia environment.

How Are Database-Driven Hypermedia Environments Created?

There have been a number of methods of integrating database and hypermedia present in the research. In order to effectively integrate the two, it is essential to focus on the technical benefits of each. The strengths of databases lie in the storage, organization, and retrieval of information; while the strengths of hypermedia lie in the structuring and navigation of information, as well as the ability to track various user actions and address access issues (Bhaumik, Dixit, Glanares, Krishna, Tzagarakis, Vaitis, et al., 2001).

Relational Database Management Systems. Utilizing the first method, it is important to understand the manner in which database applications can work. In this method, the storage, retrieval, and analysis of data are controlled by a *Relational Database Management System (RDBMS)* through a series of computational statements, usually through some *Structured Query Language (SQL).* Various applications are sent from the database to the Relational Database Management System. Embedded in these database structures are methods of creating their own user interface through the Structured Query Language. Data can be queried, organized, and results viewed, all within the database structure (Hara & Botafogo, 1994). Methods of structuring and navigating throughout the data are addressed within the hypermedia environment.

Development Tools. Another approach, such as that implemented in the development of *Reading Classroom Explorer* and *Elementary Level Lessons in Physical Science* involves embedding database queries within hypertext-markup language (HTML). To do this, a tool that works between SQL and HTML must be used. One such tool is Microsoft's *Visual Studio©*, which includes *Visual Interdev©* and *FrontPage©*, as well as mySQL which includes PHP: Hypertext Preprocessor (PHP). These tools allow for the construction of database applications accessible via the World Wide Web. These database applications can then be embedded in the hypermedia environment (Bhaumik et al, 2001).

Reverse Engineering. One of the major problems with the two methods presented is that they involve the ability of programming in SQL or some other database application language, as well as an extensive knowledge of relational database structures. Another approach, presented by Popadopoulos, Vaitis, and Christodoulakis in 1996 (as cited in Bhaumik et al., 2001), uses a reverse engineering methodology in order to somewhat automatically produce the database environment. Queries are addressed based on the manner in which the data and relational structures are created in the reverse engineering

process. Their method provides a semi-automated method of integrating database structures into hypermedia environments.

While each of these three methods offers alternative approaches to the development of database-driven hypermedia environments, all require varying levels of skill and knowledge of database, hypermedia, and/or hypertext systems.

CONCLUSIONS

With the increased availability and improved usability of hypermedia authoring systems, the integration of hypermedia applications into the teaching and learning environment is likely to continue. While this rise in the integration of hypermedia into the learning environment presents a number of potential benefits, such as allowing for more complex learning environments, promoting deeper understanding, and allowing more learner control in the learning process, being thrust into this new learning environment can often overwhelm the learner. One method of diminishing this sense of being overwhelmed is to use database systems as intermediaries to hypermedia-based learning environments. The integration of database systems into hypermedia-based learning environments is useful in addressing many issues, such as navigation, information organization, and other complexity issues related to the hypermedia-based learning environments. Integrating database systems as intermediaries to hypermedia applications also provides support for inexperienced and low ability learners. Because database structures are familiar to many learners, using them as intermediaries can dampen the effect of the learner being overwhelmed by a novel tool, and ultimately improve the effectiveness of hypermedia applications for many different learner types, thus improving the teaching and learning environment.

Contributors

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