DOCUMENT RESUME

ED 470 077 IR 021 515

AUTHOR Dabbagh, Nada

TITLE Authoring Tools and Learning Systems: A Historical Perspective.

PUB DATE 2001-11-00

NOTE 11p.; In: Annual Proceedings of Selected Research and Development [and] Practice Papers Presented at the National Convention of the Association for Educational Communications and Technology (24th, Atlanta, GA, November 8-12, 2001). Volumes 1-2; see IR 021 504.

PUB TYPE Reports - Evaluative (142) -- Speeches/Meeting Papers (150)

EDRS PRICE EDRS Price MF01/PC01 Plus Postage.

DESCRIPTORS *Authoring Aids (Programming); Comparative Analysis; *Computer Uses in Education; *Courseware; *Educational Technology; Instructional Design; Instructional Materials; Internet; Learner Controlled Instruction; Material Development; World Wide Web

ABSTRACT

Authoring tools have evolved over the last decade based on technological and pedagogical innovations, from authoring bounded, program-controlled learning systems such as Computer-Based Instruction (CBI) to authoring unbounded, learner-centered environments such as Web-Based Instruction (WBI). This paper discusses the current state of authoring tools and their pedagogical effect on the development of learning systems. It provides a taxonomy of authoring tools and their underlying paradigms and a detailed table that compares and contrasts pedagogical attributes of CBI and WBI. The paper also discusses tow innovative approaches on how future authoring tools can preserve the level of usability and the instructional methods that instructional designers have become familiar with while allowing more powerful and flexible learning systems to be built. (Contains 36 references.) (Author/AEF)

Authoring Tools and Learning Systems: A Historical Perspective

By: Nada Dabbagh

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Nada Dabbagh
George Mason University

Abstract

Authoring tools have evolved over the last decade based on technological and pedagogical innovations, from authoring bounded, program-controlled learning systems such as Computer-Based Instruction (CBI) to authoring unbounded, learner-centered environments such as Web-Based Instruction (WBI). This paper discusses the current and future state of authoring tools and their pedagogical effect on the development of learning systems. It provides a taxonomy of authoring tools and their underlying paradigms; a detailed table that compares and contrasts pedagogical attributes of CBI and WBI; and it discusses two innovative approaches on how future authoring tools can preserve the level of usability and the instructional methods that instructional designers have become familiar with while allowing more powerful and flexible learning systems to be built.

What are authoring tools?

Authoring tools are software tools that enable instructional designers, educators, teachers and learners to design interactive multimedia and hypermedia learning environments without the knowledge of programming languages. "The premise behind authoring tools is the absence of a programmer or the ability of designers with little or no programming experience to develop and design instructional applications" (Hedberg & Harper, 1998). For example, multimedia authoring tools facilitate the development of Computer-Based Instruction (CBI) by masking the programming layer, and Web-based authoring tools facilitate the development of Web-Based Instruction (WBI) by masking the HTML scripting layer (Craney, 1996). In essence authoring tools are an accelerated application or simplified form of programming by virtue of their inclusion of pre-programmed elements for the development of interactive multimedia and the deployment of a point and click user interface to activate these elements. Authoring tools however accomplish their tasks using a certain methodology or paradigm that requires a type of heuristic or algorithmic thinking similar to that of programming languages (Siglar, 1999). Some of these paradigms include the scripting metaphor, the card-scripting metaphor, iconic/flow control, hypermedia linkage, the frame metaphor, the cast-score metaphor, the hierarchical object metaphor, and tagging (Kozel, 1997; Siglar, 1999). Table 1 provides a brief explanation of these heuristic paradigms and examples of authoring tools that utilize these paradigms.

Table 1 – Authoring Paradigms

Authoring Paradigm	Explanation of paradigm	Examples of Authoring Tools
Scripting metaphor	Resembles a programming language in that it involves specifying all media elements by filename and interactions by coding	TenCORE Language Authoring System
Card/scripting metaphor	Uses an index-card structure or a book metaphor to link elements	Hypercard, Supercard, HyperStudio, TenCore, Toolbook II
Iconic/flow control	Uses icons to represent interactions and links them sequentially in a flow line that depicts the actual result	CourseBuilder, Authorware, IconAuthor, Authorware Attain
Frame metaphor	Uses icons to specify interactions and links them conceptually providing a structural flow	StorySpace, Digital Chisel, Astound, Quest, Multimedia Fusion
Hierarchical object metaphor	Uses an object metaphor like Object Oriented Programming which is visually represented by embedded objects and iconic properties	Dazzler Deluxe, Docent, Metropolis, MediaSweets, Toolbook II Instructor, Quest Net +, Oracle's Media Objects
Hypermedia linkage	Uses a hypermedia navigation metaphor to link elements	FrontPage, Dreamweaver, Homesite, Claris HomePage
Tagging	Uses tags in text files to link pages, provide interactivity and integrate multimedia elements	SGML, HTML, VRML, 3DML
Cast-score metaphor	Uses horizontal tracks and vertical columns to synchronize media events in a time-based fashion	Director, Flash, Javascript, Java

Authoring paradigms can be thought of as organizational structures that facilitate the design of instructional materials and learning activities. Depending on the paradigm used by a specific authoring tool, the design approach, development time, instructional capabilities, and learning curve (ease of use), could vary widely from one authoring tool to the next. Hedberg and Harper (1998) emphasize this point by stating that: "The organizing metaphor of the authoring system has become critical to the effective design of the final learning environment" (p. 1). Kasowitz (1998) however insists that the value of an authoring tool is measured by how well it can support a particular designer's task regardless of its strength or approach. In order to understand how authoring tools impact a designer's task, it is important to look at the evolution of authoring tools from a technological and pedagogical perspective.

Evolution of Authoring Tools

Authoring tools have evolved over the last decade based on technological and pedagogical innovations from authoring bounded, program-controlled learning systems such as Computer-Based Instruction (CBI), to authoring unbounded, learner-centered environments such as Web-Based Instruction (WBI). From a technological perspective, the Internet has revolutionized teacher-to-learner and learner-to-learner communication by making these interactions time and place independent through the use of email, discussion boards, and other Internet-based technologies that facilitate asynchronous learning and information delivery. Web-based course management tools now include such features and components under an integrated structure. The World Wide Web (WWW) has also dramatically altered the concept of hypermedia, which is a crucial attribute of an authoring tool's interface. Hypermedia has evolved from a predetermined finite internal linking structure contained within the boundaries of a learning system to an infinite external linking structure that knows no boundaries. The WWW has also changed the nature of instructional content and resources from a well-defined and stable knowledge base to an unfiltered and dynamic information base. CDROM-based authoring tools for example have commonly relied on stable content to organize and structure instruction, which is why the resulting learning system is bounded and program-centered. Alternatively, Web-based course management tools now include features and components that allow instructors and learners to modify content and contribute resources resulting in flexible and active information structures.

From a pedagogical perspective, this means more flexibility in the design of WBI. Depending on how the tools' features are used in a course by the instructor and the learners, the "pedagogical philosophy" underlying the teaching and learning process can range from a strict instructivist approach to a radical constructivist approach (Reeves & Reeves, 1997). A strict instructivist approach typically results in a Web-based course that has a tutorial structure in which the content is organized by the instructor and *delivered* or imparted to the students; and a radical constructivist approach typically results in a more learner-centered pedagogy where students use Web features as tools to construct their own knowledge representations by restructuring content and creating and contributing their own resources to the course structure (Bannan & Milheim, 1997; Reeves & Reeves, 1997). It is more likely therefore that courses initially designed for traditional learning environments and later transformed to a Web-based format using a Web-based course management tool will undergo a *pedagogical reengineering* that is more constructivist in nature (Dabbagh & Schmitt, 1998). The presence of Internet-based communication tools, collaborative tools, and Web publishing tools in Web-based course management authoring systems make such pedagogical implications possible.

Instructional Products of Authoring Tools

The nature of instructional products has also evolved with advances in authoring tools. Interactivity as an instructional variable can no longer be "trivialized to simple menu selection, clickable objects, or linear sequencing" as is the case with most program-controlled CBI (Sims, 1995). Ambron & Hooper (1988) describe interactivity as "a state in which users are able to browse, annotate, link and elaborate within a rich non-linear database" (cited in Sims, 1995, p. 1). Web-based course management tools include note-taking tools, Web development tools, self-assessment tools, communication tools and collaborative tools for learners, encouraging a continuous dialogue between the user and the courseware such that the learner is productively and continuously active (Jonassen, 1988). This dialogical view of interactivity seems to align with a learning strategies perspective where learners are using technological tools as cognitive tools to generate their own learning (Sims, 1995). For example, with the inclusion of learner tools in authoring systems, learning environments are becoming increasingly student-centered. Learners can create and organize information in a meaningful way and take responsibility for their own learning.

Another variable that has greatly influenced instructional products developed with authoring tools is the ease with which collaborative activities can be facilitated with Internet-based technologies embedded in Web-based course management tools. The focus shifts from interaction with an instructional program to human interaction in the context of group activities. With user-specific tools, connectivity, and greater ease of use, opportunities for goal-oriented projects by teaming students to work on creating Web based projects can be truly maximized.

CBI and WBI: Instructional Attributes

In order to better understand the evolution of authoring tools from a pedagogical perspective it is important to compare the instructional attributes of Computer-Based Instruction (CBI) and Web-Based Instruction (WBI) since these are the two primary instructional or 'courseware' products generated through the use of authoring tools, with the understanding that CBI utilizes CDROM (or non-Web-based) technology to deliver its courseware, and WBI utilizes Internet (or Web-based) technologies. The type of delivery medium has played an important role in determining what instructional designs are possible. As Clark and Lyons (1999) state: "The lesson that we have learned over decades of technological evolution is that each new medium provides instructional capabilities that are unique. And each medium demands a new approach to exploit its capabilities for promoting

learning." Table 2 compares and contrasts pedagogical attributes of CBI and WBI on instructional approaches, content features, instructional activities, scope of interaction, feedback, and evaluation.

Table 2 – Instructional Attributes of CBI and WBI

CBI – Instructional attributes	WBI – Instructional attributes
Lends itself to a program-centered or instructivist approach due to the closed-system nature of the courseware, hence the need to predetermine the instructional content and instructional interventions (automated delivery)	Lends itself to a student-centered or constructivist approach due to the open-system nature of the courseware, hence the potential of dynamically altering the instructional content and instructional interventions
Content is fixed, has an inherent structure and remains generally stable no matter when it is accessed by a user	Content is dynamic, instructors and learners can contribute new knowledge and add new resources to the course content
Instructional sequence and learning contexts are externally driven by objectives and tasks	Instructional sequence and learning contexts can be internally driven by learners
Restricted to references and resources embedded in product (browsing is limited to the particular CDROM)	Links to a multitude of Web sites can be readily embedded (browsing is [un] limited to the WWW)
Focus is generally on creating sequential media such as print, audio and video	Focus is shifting from media delivery tools to communication tools
Instant feedback is available through programmed interactions but less potential for personal or meaningful feedback	Learner-to-learner and instructor-to-learner interaction options providing meaningful peer and instructor feedback
Limited interaction with other learners and instructor	Unlimited interaction with other learners and instructor
Instructional activities typicaly consist of drill and practice exercises, trial and error learning or simulations with accelerated rounds of skill practice	Instructional activities generally consist of browsing links, searching online databases, posting using threaded-discussions and email, Web publishing
Testing of learner outcomes generally involves pre-tests, posttests, and multiple-choice questions	Testing of learner outcomes generally involves assessing communication skills, Web-based projects, organization of information and synthesis of content
Lends itself to criterion-referenced assessment	Lends itself to authentic assessment (peer evaluations, multiple assessors, and multiple forms of assessment)

A noticable shift from directed to open-ended hypermedia learning environments can be detected in the instructional attributes listed above. According to Hannafin, Hill & Land (1997), directed learning environments use "structured algorithmic approaches to convey a discrete identifiable body of knowledge" and "learning is externally driven via explicit activities and practice." Directed learning environments can also be described as bounded (well-defined), happening in real time, instructor (or program) controlled, and relying on stable information resources (Chambers, 1997). The instructional attributes for CBI listed above certainly fit these criteria. Open-ended learning environments (OELE) on the other hand emphasize generative learning, authentic contexts, and guided discovery approaches where learners take responsibility of learning and evaluate their own needs (Hannafin et al., 1997). Additionally, in OELEs metacognitive abilities take precedence over mastering content and asynchronous communication is paramount in supporting learning tasks. WBI however can still result in a directed approach if the inherent features of the Web are not effectively utilized by all participants in the learning environment. For example, it is possible to design a Web-based course that is self-contained and requiring minimal instructor intervention and interaction with other learners. Practice and feedback activities can be embedded in a Web-based course much like they would be in a CBI course and learners can proceed through linearly-sequenced tutorial-like content presentations at their own pace, resulting in a program-centered learning environment. Caution must be exercised to insure that WBI is not just CBI delivered over the Web.

Classes of Authoring Tools

Authoring tools can be grouped using several variables e.g. type of author/adopter (e.g. corporate developer versus teacher educator), type of delivery medium (e.g. CDROM versus Internet), type of operating system (Windows versus Macintosh), type of scripting metaphor, cost, ease of use, range of user base (e.g. learners, instructors, developers), level of technical support, type of interface, market share, media capabilities, instructional design capabilities, etc. In this paper, authoring tools are grouped by the type of delivery medium (CDROM versus Web-based), and the type of instruction produced relative to the specific features

of the delivery medium (CBI versus WBI). The reason for this grouping is based on two principles. First, that the effectiveness of an authoring tool can best be measured by examining the types of instructional and learning strategies it supports (Dabbagh, Bannan-Ritland, & Silc, 2001); and second, that to date, authoring tools have been primarily used to develop two types of instruction: Computer Based Instruction (CBI) and Web-Based Instruction (WBI).

Although most authoring tools designed to deliver instruction on a CDROM have Web delivery capabilities (Internet "play" capabilities through the use of plug-ins), those tools were not originally designed to take advantage of the inherent and unique features of the Web such as connectivity, asynchronous communication, global accessibility, and ubiquitous use. Based on this fundamental distinction we classify authoring tools into two main categories: CDROM-based and Web-based. Examples of CDROM-based authoring tools are Hypercard, Authorware, and Toolbook. Examples of Web-based authoring tools are Macromedia's Dreamweaver, Claris HomePage, and Microsoft's FrontPage. Figure 1 provides a visual of these two classes of authoring tools and some distinguishing characteristics of each.

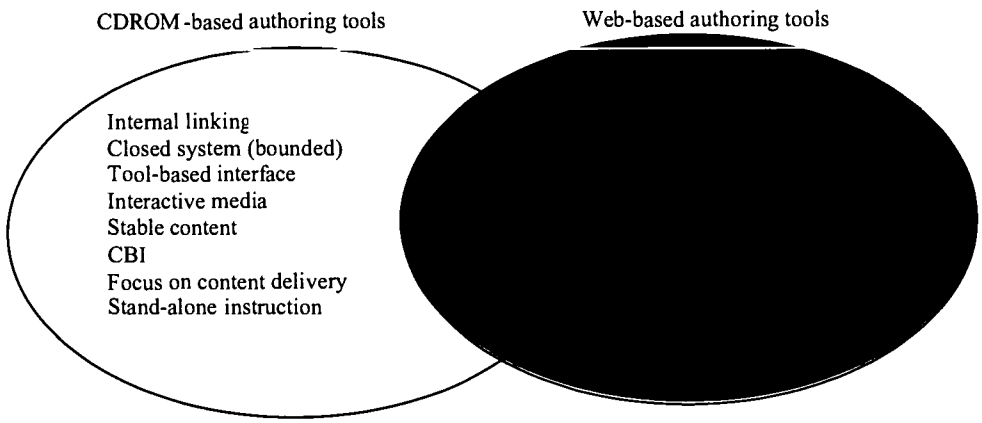

Figure 1 – Classes of Authoring Tools

Web-Based Course Management Tools

Another class of Web-based authoring tools known as Web-based course management tools emerged when Web-based authoring tools were being increasingly used to create Web-based courses for online learning. The need for a more integrative structure to manage the delivery of such courses and facilitate the migration from face-to-face classroom instruction to WBI, resulted in the development of "one stop one shop" applications such as WebCt and Blackboard. Unlike previous Web-based authoring tools, those tools include instructor tools, learner tools, and technical administration tools allowing for different types of users, and for multiple Internet-based activities embedded within the tool itself. Table 3 lists the three classes of authoring tools identified above and the general features of each.

Table 3 – Features of Authoring Tools

Category	General Features	Instructional Products
CDROM-based Authoring Tools Examples include: Hypercard, Authorware, Toolbook II, Director	• Tool-based interface • Utilized with CDROM and videodisc technologies • Closed system (does not allow user to go beyond the boundaries of what's there) • Content is generally stable • Most linking is internal, could have external links requiring firing up a browser • Can be Internet-enabled through "plug-ins" • Require installation therefore operating system dependent • Require a steep learning curve in order to take full advantage of their features • Used mostly by developers	• Computer-Based or Computer-Assisted Instruction (CBI/CAI) • Simulations • Games • Microworlds • Tutorials • Individualized instruction • Programmed Instruction • Self-contained interactive modules • Mastery learning • "Canned" or stand-alone instructional products • Standard testing programs (e.g. SAT) • Criterion-based testing

	and instructional designers to produce instructional software • Do not have specific instructor or learner tools (only developer tools)	
Web-based Authoring Tools Examples include: FrontPage, DreamWeaver, Claris Homepage, Homesite	• Browser interface • Utilized with Internet-Based technologies • Open system (allows user to go beyond the boundaries through external linking to the WWW) • Extensible • Dynamic content • Enables active/collaborative media • Require a steep learning curve in order to take full advantage of their features • Used by a variety of users to develop Web sites for multiple purposes • Do not have specific instructor or learner tools	• Single Web pages and integrated Web sites for the purposes of information presentation to support classroom instruction • Structured Web sites resulting in a variety of formats for WBI • Personal and institutional homepages • Web publishing • Organization of Web-based resources • Complex animations and interactions when used with high level scripting languages (Java, Javascript, C++) and other Web development tools
Web-based Course Management Tools Examples include: WebCt, Blackboard, TopClass, Virtual-U, LearningSpace	• Browser interface • Utilized with Internet-Based technologies • Open system • Easy to use • Dynamic content • Enables active/collaborative media • Have specific tools for instructors, learners and administrators • Embedded communication tools (email, discussion forums, group tools) • Used primarily to manage and deliver online learning in educational institutions and online training in corporate settings	• Distance education programs • Courseware (WBI) • Knowledge networks • Asynchronous & synchronous learning environments • Distributed learning environments

Scalability and Usability

It is evident from the table above that authoring tools have evolved on three fronts: networkability, level of use (user-base), and ease of use. CDROM-based authoring tools were primarily designed for software developers and became popular mechanisms for supporting the production of CBI where learners interact with an instructional program to gain mastery of a certain skill or knowledge (Kasowitz, 1998). The World Wide Web (WWW) shifted the focus of interactivity from interaction with an instructional program to interaction with other learners (global interaction) (Kearsley & Shneiderman, 1998), and from accessing materials on bounded delivery vehicles such as CDROMs to accessing unbounded and dynamic information through a network of global resources on the Web itself (Clark & Lyons, 1999; Hedberg, Brown, & Arrighi, 1997).

The WWW also created the need for tools to develop Web pages which began with simple text editors to create HTML files and evolved to Web-based authoring tools which continued to grow in functionality integrating more user features and Internet-based technologies leading to the development of Web-based course management tools. The learning curve dropped sharply with Web-based course management tools as the interface became more template-controlled ("choose-it-and-we'll-do-it-for-you") and the functions more context sensitive, extending the user-base to multiple user profiles. With little or no prior experience in authoring, instructors, learners, university administrators, and corporate developers are all able to easily explore the potential of these integrated tools to create, engage-in, manage, and deliver online learning.

Current Authoring Tools

Authoring tools can be traced back to the 1960s when "computer-assisted instruction was viewed as an economically viable way to distribute teaching expertise" (Huntley & Alessi, 1987, p. 259). In 1997, Kozel documented about 50 commercial multimedia authoring tools not counting highly specialized niche tools. Most of the market's share was spread among the most popular tools: Aimtech's IconAuthor, Allegiant's Supercard, Allen Communication's Quest, Asymetrix Toolbook II line (Asymetrix is now Click2Learn), Macromedia's Director and Authorware, and mFactory's newer object-oriented metropolis. Currently, Macromedia claims to own 80% of the authoring market between their two tools, with Director possibly dominating this market share. Other tools with a loyal following include: Claris' Hypercard, Oracle's Media Objects, Apple's MediaTool, and Discovery Systems CourseBuilder.

In a survey on the usage of Web authoring tools on the Web conducted by Security Space in July of 2000, the following WYSIWIG (What You See Is What You Get) tools were listed in descending order of percentage use: Microsoft's FrontPage, Netscape's Composer, Adobe Page Mill, NetObjects Fusion, HotMetal Pro, IBM HomePage Builder, NetObjects Authoring, Macromedia's Dreamweaver, Allaire's Home Site, and IBM NetObjects TopPage However when taking the mind-set of a professional Web developer responsible for a medium-sized company's Web efforts, Oliver Rist of InternetWeek (1998) selected three WYSIWIG Web authoring tools that are powerful enough to develop cutting-edge pages, yet visual enough to do so quickly and easily. The three tools were Microsoft's FrontPage, Adobe's Page Mill, and Macromedia's Dreamweaver, with FrontPage coming out on top in terms of an "all-in-one professional-level design and management tool", and Page Mill and Dreamweaver following closely behind. In a more recent roundup of Web-based authoring tools, PC magazine in its May 4th, 2000 issue gave Dreamweaver first place for advanced site design with an average user rating of 9/10, and FrontPage first place for basic site design with an average user rating of 7/10. Allaire's Home Site received an honorable mention in the same issue and was highly recommended for developers who prefer complete control over their HTML code due to its thorough code-editing capabilities.

Web-based course management tools (WBCMT) represent yet another share of the market which clearly lies in the education sector since the main purpose of these tools is to facilitate the management and delivery of online courses to support e-Learning and distance education programs. In a recent survey by the U.S. Department of Education's National Center for Educational Statistics (NCES), it was reported that the number of distance education programs increased by 72 percent from 1994-95 to 1997-98 and that an additional 20 percent of the institutions surveyed plan to establish distance education programs within the next three years (The Institute for Higher Education Policy, 2000). It was also reported that 1.6 million students were enrolled in distance education courses in 1997-98. It is not surprising therefore that institutions and faculty members are increasingly feeling pressure to offer Web-based courses to meet economic and student demands and the recent proliferation of WBCMT seems to be in answer to this demand. Examples of WBCMTs include WebCt, Blackboard, Convene, Embanet, Real Education, eCollege.com, Symposium, TopClass, WebMentor, E-Web, Web Course In A Box, Internet Classroom Assistant, Lotus Learning Space, Softarc's FirstClass, Serf, Virtual-U, and Eduprise to mention a few.

Eduventures.com (a leading e-Learning independent industry analyst firm), in an October 2000 industry research report established that Blackboard had the strongest market position at the time the report was published. The same report also stated that WebCt had also reached a sizable share of the market and that with its partnership with Thompson Learning it is in an excellent position to match or even surpass Blackboard in the coming months. The report mentions Campus Pipeline and Jenzabar as other WBCMT category leaders in e-Learning (Stokes, Evans, & Gallagher, 2000). Eduventures.com also predicts that the higher education e-Learning business will eventually be dominated by two or three large players, or maybe even one "killer" player. Other popular Web-based course management systems include Learning Space, Virtual-U, and TopClass (Mann, 1999). For a more comprehensive list of authoring tools and a comparative analysis of their features, visit Bruce Landon's Website at: http://www.ctt.bc.ca/landonline/index.html.

Future Implications of Authoring Tools

As discussed at the beginning of this paper, the aim of authoring tools is to automate entirely or partially the courseware construction process by supporting tasks such as the ability to create screens, screen objects such as menus and buttons, link content to other content, and sequence material (Bell, 1998). The lack of specific design principles however often restricts the kinds of instructional designs these tools support leading in many instances to the creation of simple drill and practice programs or uninteresting tutorials. "The result is a tool that supports a broad range of possible instructional applications, some of which may be good, and some of which are likely to be poorly executed, but none of which will have been created with much guidance from the tool itself" (Bell, 1998, p. 76). Murray (1998) further emphasizes this shortcoming of authoring tools when he states that "commercial authoring systems excel in giving the instructional designer tools to produce visually appealing and interactive screens, but behind the presentation screens is a shallow representation of content and pedagogy" (p. 6). So how do we preserve the level of usability and the instructional methods that instructional designers have become familiar with, and add additional tools, features, and authoring paradigms that will allow more powerful and flexible learning systems to be built?

There are two approaches that attempt to answer this question both based in an information technology perspective. The first proposes that Intelligent Tutoring Systems (ITS) need to be embodied by authoring tools to allow additional levels of abstraction, modularity, and visualization in order to achieve more powerful and flexible authoring paradigms (Bell, 1998; Murray, 1998). The second proposes that new metaphors for authoring tools need to be developed to match current theory (Hedberg & Harper, 1998), and that "of all the metaphors likely to survive, *objects* stand the greatest chance because they reflect an evolutionary improvement in the software engineering world" (Kozel, 1997, p. 42).

A New Authoring Paradigm

The object model represents an inevitable evolution in application development since interactive multimedia is both created in and delivered as software making it easier to author complex programs by thinking of interactive elements as objects. The organizing metaphor of the authoring system has become critical to the effective design of the final learning environment (Hedberg & Harper, 1998). This calls for a new authoring paradigm allowing users to spend more time designing at the conceptual and pedagogical level instead of focusing on the features of the tools to produce more engaging instructional designs (Robson, 2000). Currently for example, authoring tools for the construction of Web documents offer a page metaphor with hypertext as the dominant link structure allowing more of a "top-down" design process than the screen metaphor of more traditional low level multimedia authoring tools such as HyperStudio (Hedberg, Brown, & Arrighi, 1997). All to say that the paradigm or metaphor of an authoring tool can guide or restrict the types of instructional designs possible.

Object Oriented Designs

Both the ITS approach and the dominance of a 'true' object metaphor have one objective in common: introducing a pedagogical layer to an authoring tool in order to enable the design of more intelligent and flexible learning environments. According to Murray (1998) this is primarily achieved by representing instructional strategy and instructional content separately and by modularizing the instructional content for multiple use and reuse. This principle allows for embedding the pedagogy in the tutor for the proponents of the ITS approach, and in the properties of objects for the proponents of the object-oriented model. Such tools (in which strategy and content are separated) can facilitate the design of instructional actions by modifying the behavior of an intelligent tutor (in the ITS case), or specifying the relationship between objects (in the object model) based on the specific needs of the learner or the pedagogical characteristics of the content being taught.

Currently most authoring tools limit the designer to the pre-programmed modules of the tool and to the underlying assumptions of highly structured instructional design models (Hedberg & Harper, 1998). Furthermore, the typical ID process makes it difficult for instructors to communicate their content requiring instructional designers to see a lot of content in order to understand what the instructor wants (Robson, 2000). An object oriented approach would resolve this problem since it would be easier for instructors to translate their content into learning resources (e.g. I use lectures, assessment items, resources, etc.) and instructional designers can then create a prototypical environment matching the instructor's expectations without seeing any content at all (Robson, 2000).

Learners as Producers of Hypermedia Learning Systems

Another critical factor that could impact the pedagogical use of authoring tools is whether the learner is perceived as the *user* or *producer* of hypermedia learning environments. Hedberg et al. (1997) argue that if the activities of the learner are regarded as the central focus in an educational context then learners should be thought of as software (courseware) producers rather than software users in the development of educational software for both bounded CD-ROM titles and unbounded Web-based resources. They propose the integration of learner tools that allow users for example to organize information in a meaningful way by positioning elements on the screen, creating new links, and generating multimedia objects. Such cognitive tools could include a notebook to copy, edit and format text; a visual graphics tool to create marker buttons that point to multimedia elements such as video, audio, or pictures and enable the learner to manipulate those elements; and a cognitive mapping tool (concept mapping tool) allowing flexible information representation. The *learners as producers* concept supports a generative approach to learning, which aligns with a constructivist epistemology.

Learning Objects Systems Architecture

Learning objects systems architecture is also paving the way to support the generative use of authoring tools (Bannan-Ritland, Dabbagh, & Murphy, 2000). A learning objects system adopts an object-oriented approach for storing and metatagging instructional content and instructional strategies. Uneditable media objects called 'primedia' can be stored in a database and accessed for multiple uses in multiple contexts. Primedia can range from low to high granularity depending on their relative size as a learning resource, with highly granular resources increasing the efficiency of online instructional support systems due to their greater potential for reusability (Quinn, 2000; Wiley et al., 1999). With database-driven websites becoming increasingly popular it is certain that the future of hypermedia learning environments will be powered by such technologies instead of the static, 'hard-coded' HTML documents. Authoring systems will be designed for the creation of generically encoded reusable information allowing the design process to proceed by specifying learning resources, creating links among the resources and authoring content independently of format (Davidson, 1993; Robson, 2000). The idea is to define learning objects or resources such that each learning resource has specific instructional properties enabling its pedagogic integration with other resources. Depending on who creates, assembles and links these objects, the pedagogical philosophy of the hypermedia learning environment can vary from an instructivist to a constructivist approach resulting in a directed or open-ended learning environment as discussed earlier in this paper when comparing and contrasting CBI and WBI.

Currently Web-based authoring tools and Web-based course management tools do not facilitate the construction of learning objects however they do support some reusability of content due to the inherent archival nature of the Web as a delivery medium. They also support cognitive tools that enable users to engage in reflective and collaborative practices. In an evaluation of Web-based course authoring tools conducted by Dabbagh, Bannan-Ritland, and Silc (2001), it was revealed that the intersection between pedagogical considerations and the attributes of Web-based authoring tools yields the most educational impact. It was suggested that a comprehensive advisement mechanism included within Web-based authoring tools, and providing guidance in

the areas of pedagogical approach, instructional strategy, and on-line support and resources will facilitate more effective and engaging instructional designs. Perhaps such a pedagogical advisement layer can be embodied by authoring tools using an ITS approach or a learning objects systems architecture approach in the future in order to enable the design of more intelligent and flexible learning systems.

Conclusion

This paper discussed the heuristic paradigms and organizing metaphors underlying authoring tools and their impact on the design of hypermedia learning systems. In addition, the evolution of authoring tools from a technological and pedagogical perspective was discussed by comparing and contrasting the instructional attributes of the two primary courseware products developed using authoring tools: CBI and WBI. Three classes of authoring tools were also identified and the features and associated instructional products of each class were provided. Finally, an overview of current authoring tools, their market share, perceived shortcomings, and new authoring paradigms and their implications on the design of intelligent and flexible learning systems was discussed.

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