Web Technologies for Multi-Intelligent Online Learning

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Introduction

Coupled with a theoretical foundation in cognition and learning, and an educational methodology based on cognitive constructivism (Chen, 2000) and the Theory of Multiple Intelligences (Gardner, 1983/1993), the research in Multi-Intelligent Online Learning builds on a technology foundation from adaptive hypermedia and online learning technology. The shaded rectangles on the right side of Figure 1 depict the technology foundation and the underlying schemata of the research. This paper provides a review of relevant literature and prior work in the field of online learning. Along with adaptive hypermedia technology, the area of online learning within Computer Science provides the technological foundation for the research in *Applying Multi-Intelligent Adaptive Hypermedia to Online Learning* (Dara-Abrams, 2002b).

This paper discusses Web-based online learning technology. To understand the research undertaken in Multi-Intelligent Online Learning, the reader is referred to a companion paper entitled *Overview of Research Study in Multi-Intelligent Online Learning* (Dara-Abrams, 2002h). The methodology of the research study is described in the companion paper entitled *Methodology of Research Study in Multi-Intelligent Online Learning* (Dara-Abrams, 2002g).

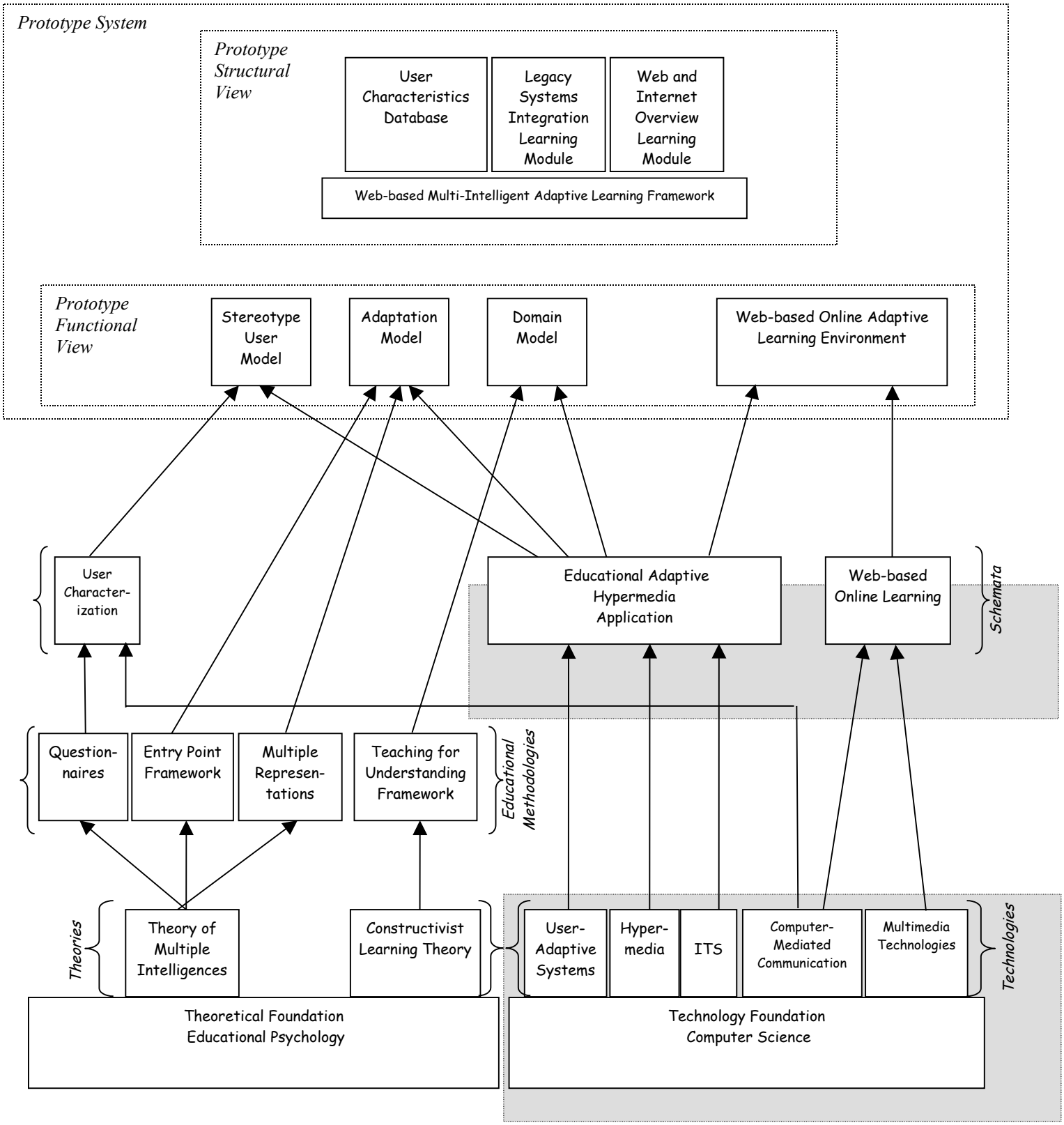
For information on the theoretical underpinnings of the study, the reader should consult the companion paper entitled *Theoretical Foundation in Educational Psychology for Multi-Intelligent Online Learning* (Dara-Abrams, 2002i). The educational methodologies that are employed in the Multi-Intelligent Online Learning prototype are described in the paper entitled *Educational Methodologies for Multi-Intelligent Online Learning* (Dara-Abrams, 2002e).

Adaptive hypermedia and Web-based online learning technologies are used to design and implement the prototype Multi-Intelligent Online Learning framework and modules. The adaptive hypermedia technology employed in the prototype is described in a companion paper entitled *Adaptive Hypermedia for Multi-Intelligent Online Learning* (Dara-Abrams, 2002a). The Web-based online learning technology described in this paper along with the adaptive hypermedia technology discussed in the companion paper (Dara-Abrams, 2002a) contribute to the development of the prototype, which is described in the paper entitled *Design and Implementation of a Multi-Intelligent Online Learning Prototype* (Dara-Abrams, 2002d). The

papers entitled *Formative Evaluation of a Multi-Intelligent Online Learning Prototype* (Dara-Abrams, 2002f) and *Conclusions of Research Study in Multi-Intelligent Online Learning* (Dara-Abrams, 2002c) discuss feedback from prototype users and interpret formative evaluation data, offering suggestions for improvement of the prototype and drawing conclusions from the research study.

In this paper, an overview of online learning systems is provided to assist the reader in developing an understanding of the capabilities of existing online learning systems. The reader can gain an appreciation of the weaknesses of generic tools used for online learning as well as technology facilities employed for online learning. With the field of online learning in a fairly embryonic state, using different terms to describe facilities, features, and systems, it helps for the reader to have an understanding of the categorization schemes currently used to describe online learning systems. Comparison charts provide brief descriptions of various types of online learning systems. Following a discussion of categorization schemes, one particular scheme is followed to provide an overview of extant Web-based software tools and environments for online learning. The paper concludes with a summary, integrating aspects of the theoretical foundation and the technology foundation for Multi-Intelligent Online Learning.

Figure 1 Technology Foundation of Multi-Intelligent Online Learning in Computer Science



Online Learning

Starting in the 1970s, early computer-mediated communication (CMC) technologies, such as email and computer conferencing, were employed to support efforts in online education. Although development was performed in a piecemeal fashion and early systems had definite shortcomings, online education offered important potential benefits (Harasim, 1999). Communication, interaction, and collaboration among students and faculty were encouraged and supported despite the limitations of systems built with early networking tools.

Starting in the early 1980s, efforts focused on developing asynchronous, place-independent approaches, providing text and multimedia content via many-to-many computer-mediated learning systems. This educational approach is sometimes referred to as network-mediated collaborative learning (Harasim, 1999). In collaborative learning environments, students actively construct knowledge through a highly interactive group process, a very different approach from the one-to-many transmission model of education via instructor-delivered lectures. Although technology advances in networking during the 1980s initially supported this new form of collaborative learning, users soon encountered the limitations of systems built with generic networking tools (Harasim, Hiltz, Teles, & Turoff, 1995).

Weaknesses of Generic Tools

Early online learning systems were built using generic networking tools, such as email, conferencing, and newsgroups. However, these tools were *applied to* online education rather than *designed for* online education (Harasim, 1999). Thus, instructors were forced to redesign their classroom lectures and activities to conform to online learning systems. In addition, models and tools were not available to support and shape the virtual learning environment, thereby increasing the administrative, organizational, and pedagogical tasks, difficulties, and costs to deliver education online (Harasim, 1999).

Analysis of shortcomings of these early online learning systems indicated that problems arose from the facilities lacking in these generic online learning environments. Such generic online learning environments were found to be limited in the following ways (Harasim, 1999):

- No standard organizational scheme for course material.

- Not tested or proven to be effective for instructional purposes.
- Lack tools and require significant development effort and technical support.
- Lack underlying models that support collaborative learning, knowledge building, and learning strategies with multiple representations of concepts and knowledge.

Technology Facilities for Online Learning

In order to address the shortcomings of online learning systems built with earlier generic tools, let us now consider technology facilities used to build current online learning systems (sometimes referred to as e-learning systems).

Multimedia Technologies.

There are a number of different media-based technologies that provide delivery services for e-learning solutions (Cisco, 2001). These technologies include:

- Broadcast Video - live, streaming video, audio and slides.
- Video on Demand - on demand pre-recorded video and/or audio with accompanying graphics that can be accessed by a learner.
- Virtual Classroom
    - Combination of a browser-based Web conferencing tool and audio conferencing.
    - Interactive graphics, slide shows, audio and video clips, and Web pages.

Interactive graphics and sophisticated audio and video capabilities increase the interest level in some online learning environments though some still rely on Microsoft PowerPoint (or similar presentation software) slides for presentation of content. Other systems combine PowerPoint slides with an audio or video lecture, simulating the delivery of a lecture-based in-person course. However, it is important to keep in mind that multimedia features should support learning objectives rather than detract from the presentation of Web-based learning content.

Computer-Mediated Communication (CMC) and Collaboration.

Computer-Mediated Communication (CMC) includes such facilities as email, computer conferencing, informational Web sites, network news, bulletin boards with asynchronous postings, synchronous discussion forums, and chatrooms. Saunders, Sigmon, and Bull define Internet collaboration tools as: “protocols, hardware, and software which allow individuals to

exchange information in real time, in particular, using audio, video, file transfer, chat (typing), application sharing (e.g. spreadsheets), and white boards (drawing)" (Saunders, Sigmon, & Bull, 1998). Rheingold (1993/2000), a pioneer in the development of virtual communities, builds online social networks for organizations using a variety of CMC and collaboration tools. These tools allow users to incorporate text, graphics, streaming media, and/or HTML into their message board posts through a Web browser interface. In addition, Rheingold suggests using group calendaring, threaded discussion forums and online chat facilities to facilitate collaboration and learning among virtual community members. Some collaboration software provides facilities to handle personal to-do lists, calendar functions, and photo albums in addition to the more typical facilities of file sharing, and threaded discussion groups (Collabrio, 2001).

Classroom Management and Assessment.

Classroom management and assessment tools are typically found in Web-based learning environments such as Learning Management Systems (LMS), Course Management Systems (CMS), and Total e-Learning solutions. Beshears (1999) divides these types of tools into those that are intended for instructor use, those that support student work, and those that perform administrative functions.

The faculty tool set may include:

- Online grade book and grade reporting tool (i.e. to allow students to view grades)
- Quiz/Survey development tool
- Course Web site backup, download, upload facilities, Web-based file management
- Student account, student group, and grader account administration tools
- Student access tracking (how many articles posted/read, which pages accessed)
- Page access tracking (number who accessed a page and when) and page counters
- Course Web site glossary building tool
- Course Web site indexing, course announcements, calendar administration tool

The student tool set includes such facilities as the following:

- Student self-evaluations
- Student accounts and group work areas for Web page publishing

- Course content annotation facility and bookmarks
- Web-based email and discussion groups, real-time chat rooms and whiteboards
- Individual grade and progress status reports and grade distribution status report

The administrator tool set may include the following:

- Course Web site creation, duplication, and deletion and course Web site backups
- Course Web site downloading and uploading
- Course Web site statistics, including number of students in course, file space used, number of hits on site, first and last access date
- Course Web site student account administration – batch mode account and course roster management

Learning Objects.

Learning objects can be defined as "any entities, digital or non-digital, which can be used or referenced in technology-supported learning" (Innes, McGreal, & Roberts, 2000). Learning objects may be components, lessons, modules, courses, or programs. Learning objects can be described as: "adaptable, affordable, accessible, discoverable, durable, interchangeable, interoperable, manageable, reliable, and re-usable" (Innes, McGreal, & Roberts, 2000). According to Dan Daniel, the Chief Information Officer (CIO) for NYUonline, the term in its current usage has several meanings. A learning object should be limited to objects with the following characteristics:

- Instructional – acquiring a new skill or gaining proficiency in a new concept.
- Discrete and focused – smaller than a lesson, module, or course, teaching a focused concept through a fairly small unit of instruction.
- Self-sufficient – each object can stand on its own without relying on other content.
- Targeted - appropriate to learner's skill level, not too easy and not beyond skill level.
- Interactive - offering opportunities for the learner to interact with the material.
- Reusable – learning objects should be constructed so that they can be assembled into larger courses and mixed and matched in various ways to create new courses.
- Searchable – to be able to reuse a learning object, must be easy to identify and access. Objects can be stored in online searchable repositories or libraries.

- Valid – concepts presented should have practical, real-world application.
- Standards compliant – learning objects should run on standard Web platforms and require no special plug-ins or additional applications to run. Learning objects should adhere to applicable standards. (NYUonline, 2001).

Founded in 1994 as a National Science Foundation-funded project and initially hosted by Apple Computer, the Educational Object Economy (EOE) Foundation supports the development of online learning communities through the development and distribution of component-based tools (EOE, 2001). The EOE develops tools for sharing learning objects designed to support the formation of communities engaged in building shared knowledge bases of learning materials.

Categorization Schemes for Online Learning

Harasim, Hiltz, Teles, and Turoff (1995) describe seven models or learning approaches used for educational computer networks. The categorization into seven different learning approaches is depicted by Yuen and So (1999) as in Table 1.

Table 1 Online Learning Approaches

E-Lectures	Electronic Lectures, presenting instructional materials online.
Ask-an-expert	Interaction between an expert and a group of students in a question-and-answer communication model.
Mentorship	To facilitate Mentor-apprentice interaction online.
Tutor support	To implement face-to-face tutor-student interaction online.
Access to Network Resources	Making the information on the Internet and other electronic media available to students.
Informal Peer Interaction	To facilitate communication on the network in an informal manner.
Structured Group Activity	Curriculum-based group learning activities online.

The top four categories: e-lectures, ask-an-expert, mentorship, and tutor support are based on the use of instructors, mentors, and experts to serve as online resource personnel and provide support to students (Harasim et al., 1995). The lower three categories are student-centered, involving the student or learner in accessing relevant information, interacting with peers, and participating in structured group activities.

Yuen and So (1999) indicate that there is significant overlap among these learning approaches and propose categorizing the seven models in terms of their approaches to information as follows: Information Transmission, Information Discovery, and Information Construction. In their classification, Yuen and So (1999) view E-lectures as a form of Information Transmission and Access to Network Resources as a form of Information Discovery. However, Yuen and So (1999) do not distinguish among the other five approaches of Ask-an-expert, Mentorship, Tutor support, Informal Peer Interaction, and Structured Group Activity, choosing to group them all under the category of Information Construction. Yuen and So (1999) note that the amount of user control increases from Information Transmission, the first category, to Information Construction, the third category.

Khan (2000) lists various names used for e-learning activities: “Web-Based Instruction (WBI), Web-Based Training (WBT), Web-Based Learning (WBL), and Internet-Based Training (IBT)” (Khan, 2000). According to Smith, Murphy, and Teng (2001), a study conducted by the Distributed Centre (sic) for Learning Technologies at Mount Allison University for TeleEducation in New Brunswick, Canada categorizes online learning environments into three categories: self-paced, group-learning, or Learning Management Systems (Smith et al., 2001).

A survey conducted for Industry Canada by Gram, Mark, and McGreal (1998) classified new media development and delivery tools into the following categories. However, many of the tools have disappeared through market consolidation, while others have added new functionality.

- Media Creation Tools – HTML, PDF, various text formats, and graphics tools
- Web Publishing tools – HTML editors, Macromedia Dreamweaver
- Conferencing tools – chat, Internet telephony, videoconferencing, collaboration tools
- Internet Enabled Authoring Systems
- Integrated Distributed Learning Environments

Jackson (2001) suggests categorizing online learning systems by format or function. Categorizing by format, Jackson lists the following types of online learning systems:

- Directed study (or Asynchronous "Self study")
- Instructor-led Events (or synchronous "live, real-time" learning)

- Small Group Collaboration

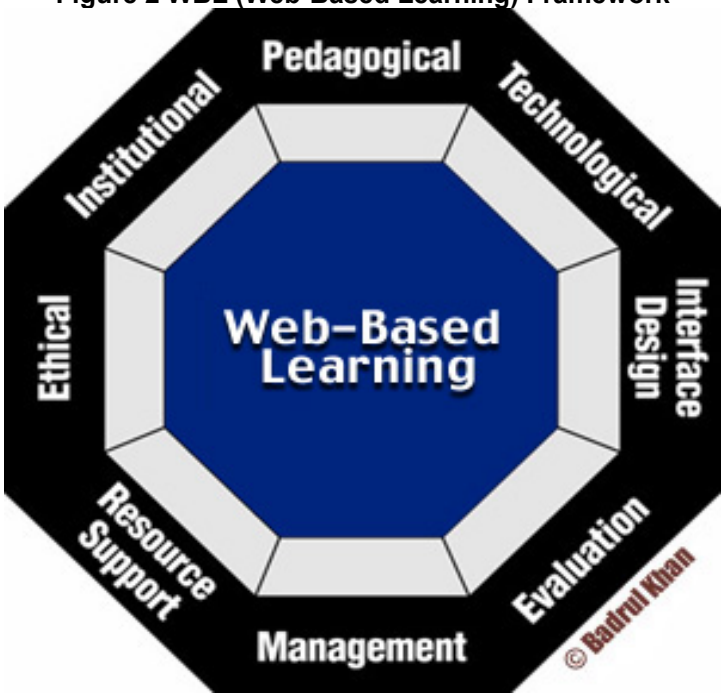
Categorizing by function, Jackson (2001) lists these types of online learning systems:

- Authoring tools – multimedia creation tools.
- Course Management Systems (CMS) – content delivery, assessment, administration.
- Educational Delivery Systems - real-time "virtual classrooms" or “collaboration tools."
- Learning Management Systems (LMS) – similar to course management systems with an integrated view of all active courses, with assessment and goals tracking facilities.
- Learning Content Management Systems (LCMS) - integrates standard Learning Management System features, authoring tools, and knowledge management tools.

In the Consortium for Information Technology in Education (CITE) study, Smith et al. (2001) organize online learning systems into synchronous environments, course management systems, learning management systems, total e-learning solutions, and related e-learning tools.

Figure 2 depicts the elements of an online learning experience.

Figure 2 WBL (Web-Based Learning) Framework



(Khan, 2000)

Existing Online Learning Systems

An article presented at the Sixth International Conference on User Modeling, entitled *Work in Progress: Learning Styles, Media Preferences, and Adaptive* Education (Danielson, 1997), refers to a plan to develop a sophisticated Web browser to support a Web-based instructional system. The new browser would capture and employ information about students' learning styles and media preferences (Danielson, 1997). Such information would be gathered through the browser and would allow the system to adapt multimedia materials to the preferences of each individual student. For their prototype, the research group developed a set of forms and CGI (Common Gateway Interface) scripts to adapt Web-based instructional materials according to students' learning styles and media preferences. However, the article ends with a note that the research group is too small to develop a prototype of the sophisticated type of browser that would automatically capture and make use of student preferences in delivering different multimedia presentations of instructional materials. Therefore, the Santa Clara University based research group was seeking a partner to undertake the development effort. The author also notes that reaching agreement on a standard taxonomy for learning styles would be another challenge in the accomplishment of the proposed approach (Danielson, 1997).

In addition, there are a number of educational hypermedia systems that have been developed in research settings that adapt to students based on their mastery of the content as they progress through the course (Calvi & De Bra, 1997). These systems use the adaptation methods and techniques described earlier in the companion paper entitled *Adaptive Hypermedia Technology for Multi-Intelligent Online Learning* (Dara-Abrams, 2002a). However, these systems are generally categorized as educational hypermedia applications (Brusilovsky, 1998) rather than as online learning systems and therefore information about them is not found in surveys of online learning systems (Harasim, 1999). Yet, such educational hypermedia systems offer access to instructional materials via a standard Web browser and are therefore a type of online learning system. The difficulty arises from the fact that online learning systems generally arise from the use of Internet and Web technology whereas educational adaptive hypermedia applications arise from the use of adaptive hypermedia.

The research in *Applying Multi-Intelligent Adaptive Hypermedia to Online Learning* (Dara-Abrams, 2002b) employs the same type of technology approach as educational adaptive hypermedia applications (De Bra, 1998). Thus, from the perspective of the application technology approach, the research in this dissertation is more closely related to that of educational hypermedia applications (Brusilovsky, 1998; Calvi & De Bra, 1997; Chen, Yang, & Zhang, 2000; De Bra, 1998, Eklund & Brusilovsky, 1998) than that of Internet-based online learning systems (Gram, Mark, & McGreal, 1998; Harasim, 1999; Harasim, Hiltz, Teles, & Turoff, 1995; Smith et al., 2001). In addition to educational hypermedia application technology, the Multi-Intelligent Online Learning prototype developed for the research study (Dara-Abrams, 2002d) uses an Internet/Web framework for content delivery. Therefore, for the sake of understanding the different technology development threads, it is useful to consider systems that have arisen from the development of Internet-based online learning systems.

Most online learning systems, as we can see in the tables in the rest of this paper, use a standard Web browser to provide access to educational materials. Some systems employ a combination of telecommunications technologies, such as audio conference facilities through standard telephone lines along with information delivery via a standard Web browser. The remainder of this paper employs the categorization scheme developed for the CITE study (Smith et al., 2001) to discuss various Web-based software tools for online learning. Tables 2 through 9 provide a comparison of online learning environments using information from the CITE study as well as the researcher's experience in using demonstration and licensed versions of the software.

A major distinction among existing online learning systems is whether they offer synchronous capabilities or asynchronous facilities, or a combination thereof. Synchronous facilities provide a virtual classroom setting, employing technology to move the entire classroom onto the Internet, along with the whiteboard, interaction with the instructor, and support for lecture facilities. These systems focus on making the classroom environment distance-independent but not time-independent, offering "anywhere learning" but not "anytime, anywhere learning." The concept behind synchronous systems is the desire to support the interaction that occurs in a physical classroom in which a group of students meets at the same time with the instructor. In a

physical classroom, the instructor conveys the same information to the entire group of students at the same time, answering questions during the course of the lecture. Synchronous online learning systems attempt to mirror this interaction, using the Internet as the delivery vehicle to alleviate location-dependence. Systems offering synchronous facilities are described briefly in Table 2. Tables 3 through 9 offer brief descriptions of self-paced systems based on asynchronous delivery of instructional materials.

Table 2 provides brief descriptions of synchronous learning environments. Synchronous learning environments use audio or video conferencing (or a combination thereof) as their primary delivery modality. Synchronous learning environments may offer asynchronous facilities as well as student management and progress tracking features (Smith et al., 2001).

Table 2 Synchronous Learning Environments

Product/ Company/ URL	Learning Approach	Description	Comments
Centra Symposium 5.0 Centra www.centra.com	Synchronous, Instructor-led	Live, interactive virtual classroom with voice-over-IP audio conferencing and shared workspace environment for collaboration.	1st with voice-over-IP at dialup bandwidth. Software license or ASP services.
HorizonLive HorizonLive www.horizonlive.com	Synchronous, Instructor-led	Streaming live audio presentation accompanied by Web-content in PowerPoint style presentation.	Can demonstrate live software and use whiteboard.
LearnLinc Mentergy Inc. www.mentergy.com	Synchronous, Instructor-led	Live virtual classroom. Audio conferencing. Blended e-learning. Live & self-paced e-learning, authoring & design tools. Integration with LMS.	Mentergy formed from Allen Communication, LearnLinc, & JohnBryce Training.
ONE TOUCH Knowledge Systems e-Learning Solution ONE TOUCH Systems Inc. www.onetouch.com	Synchronous, Instructor-led	Integrated suite of hardware and software applications. Integrates full-motion video, duplex audio, and two-way data interaction. One-way video, two-way voice & data.	Interactive voice & data exchange. Record live PC e-learning sessions for on-demand, self-paced use.
Virtual Educator CINECOM Corp. www.cinecom.com	Synchronous, Instructor-led	Instructor-controlled distance learning. Video conferencing, multi-point video and audio, instructor-led Web discussions, shared whiteboard, help-desk.	CineCom® Internet Channel Server (CICS) controls content distribution to large audience through user login and authentication scheme.

Tables 3, 4, and 5 provide brief descriptions of systems that are considered to be Course Management Systems. Course Management Systems (CMS) focus on the development and delivery of self-directed or self-paced education, providing administrative support to track student enrollment and progress toward completing courses, along with assessment and grading facilities. With student management and tracking facilities as well as content-creation tools, CMS are generally lower-cost systems used by educational institutions (Smith et al., 2001).

Table 3 Course Management Systems (part 1)

Product/ Company/ URL	Learning Approach	Description	Comments
Anlon 4.0 (IntraKal) Anlon Systems www.anlon.com	Asynchronous, Self-directed	Course content organized as single page with links to course reading, Web pages, & other documents	IMS-compliant. Course homepage, roster, and content. Exams, surveys, & grade book
Education Information System (EIS) BKM Research & Development Inc. www.bkm.ca	Asynchronous, Self-directed. Synchronous – real-time chat, check for mentor online.	Component approach to development, delivery, student & content tracking. Lessons presented as interactive slides with brief text & audio component.	Good for self-directed, mastery learning, e.g. how to use a product. Content developed with Virtual Studio, delivered via Virtual Instructor.
Blackboard 5 Blackboard Inc. www.blackboard.com	Asynchronous, Self-directed	Strives to be an "end-to-end e-learning solution." Has evolved from CMS with content creation & delivery via simple templates to more scalable LMS with campus-wide features.	Collaborative development by Cornell University students & faculty. Active in IMS standards development Supports metadata standards.
COSE (Creation of Study Environments) Cambridge Software Publishing www.longman.net	Asynchronous, Self-directed	Structure for educators to combine traditional educational resources - lectures, audio-visual, notes, & seminars with interactive media - simulations, software tools, electronic resources, external Web sites & multimedia.	Cambridge Software Publishing independent business unit within Addison Wesley Longman multimedia publishing group. Supports IMS 0.6 draft content packaging & IMS 1.0 metadata specs.
CyberProf How-Why, LLC www.howhy.com	Asynchronous, Self-directed	Adds interactivity to course material, supports Perl and Java source code. FileBrowser authoring tool.	U of Illinois Center for Complex Systems Research, Physics Dept. 7/01 introduction
Internet Classroom Assistant Nicenet www.nicenet.org	Asynchronous, Self-Directed with Synchronous tools	Free Web-based learning environment for classrooms, distance learning programs and collaborative academic projects	Conferencing, personal messaging, document sharing, scheduling & link/resource sharing to a variety of learning environments.
IntraLearn IntraLearn Software www.intralearn.com	Asynchronous, Self-directed	Online learning platform built on Windows NT/2000 and SQL Server. Tools to create, deliver, manage, & measure Internet/Intranet- based interactive learning.	AICC Certified, SCORM, IMS/LRN2 compliant. Configurable e-learning applications for mid-size enterprises.

Table 4 Course Management Systems (part 2)

Product/ Company/ URL	Learning Approach	Description	Comments
The Learning Manager (TLM) CBTS Pty Limited www.cbts.com.au	Asynchronous, Self-directed	Web-based integrated system for development, delivery, management & assessment of learning in conventional classrooms or distributed learning environments.	IMS-compliant. Course map, glossary, chat, handouts, assignments, announcements, email, course outline, testing, gradebook, threaded discussion.
LearningSpace Lotus Development www.lotus.com	Three modes – Self-directed, Asynchronous, Synchronous.	Distance learning platform integrating live (virtual classroom), asynchronous & self-paced content delivery.	AICC & IMS compliant. Can deliver AICC-compatible off-the-shelf courseware. Create, plan, & deliver courses.
Mallard University of Illinois www.cen.uiuc.edu	Asynchronous, Self-directed	Asynchronous instructional environment in use at educational institutions. Secure environment.	Test students via interactive quizzes & automated intelligent grading.
Manhattan Virtual Classroom Open Source Development Network manhattan.Sourceforge.net	Asynchronous, Self-directed	Open source environment with many standard tools for delivering learning content on the Internet.	Designed for Linux. Completely free. Available under GNU public license.
Enterprise Education Server Mentorware Inc. www.mentorware.com	Asynchronous, Self-directed	Integrated Java components. Collaborative content development, content management, & delivery. Learning Objects.	Training sessions or just-in-time Mentoring through metadata search. Customized Learning Paths.
Knowledge Centre Meridian www.meridianksi.com	Asynchronous, Self-directed. Synchronous when chat rooms used.	Courseware delivery & management, integration with existing courseware, course & student management, curriculum development, interface to database applications.	Coffee Shop (where bulletin board system, newsletter, peer net are found), library, career center, notepad, glossary, and online help system.
mGen Enterprise mGen Enterprise www.mgen.com	Asynchronous, Self-directed	Delivers asynchronous training materials, streaming video content, student information.	Multimedia authoring tool included. Template-driven, rich media questions.

Table 5 Course Management Systems (part 3)

Product/ Company/ URL	Learning Approach	Description	Comments
Multi-media Integreator Applied Courseware Technology (ACT) www.integreator.com	Asynchronous, Self-directed	Built on Integreator Pro. Offers guided approach to designing CBT, multimedia, & stand-up training.	Task-based user interface guides user through creating effective multimedia-based & other training.
Prometheus Intuitive Networks www.prometheus.com	Asynchronous, Self-directed	Community-based open architecture software platform.	IMS-compliant. Form-driven. Faculty create courses using self-guiding workflow and "Q&A."
eSocrates Learning Community Server eSocrates www.esocrates.com	Asynchronous	Course syllabus, assignments, learning resources, schedule, bulletin board, class email, grade tracking, links to learning resources.	Software & Web-hosting service that allows instructors to create & launch own courses.
Theorix e-com inc. www.e-com.net	Asynchronous, Synchronous	Virtual classrooms. Menu-driven interface to email, bulletin board, chat. Non-linear course-building template library.	IEEE, IMS, AICC, & SCORM standards compliance.
TopClass WBT (Web-based Training) Systems www.wbtsystems.com	Asynchronous, Self-directed. Some synchronous features.	WBT's e-learning product line. Integrated Centra collaboration & video conferencing for live interactive discussions.	Runs on Oracle database. AICC, IMS, LRN, SML standards compliance.
Virtual-U Virtual Learning Environments (VLEI) www.vlei.com	Asynchronous, Self-directed. Real-time chat only synchronous tool.	Icons represent various areas of navigation. Asynchronous and synchronous facilities support courses - email, bulletin board, chat, whiteboard, application sharing, gradebook.	Conceptualized by Harasim & Calvert, Virtual-U Research Project at Simon Fraser University, Canada. IMS-compliant.
WebCT WebCT www.webct.com	Asynchronous, Self-directed	Interface that allows for design of content & layout, tools to facilitate learning, administrative tools for tracking learning process.	Can be integrated with IMS-compliant campus systems. Self-assessment, progress-tracking, search tools.

Table 6 provides information on Learning Management Systems (LMS), which focus on the management of the learning process and are designed for large-scale corporate enterprise customers. With support for third party courseware, LMS generally do not include content development tools. Content is usually stored separately in an enterprise-class SQL database, increasing scalability but also increasing the cost of such solutions (Smith et al., 2001).

Table 6 Learning Management Systems (LMS)

Product/ Company/ URL	Learning Approach	Description	Comments
EMSuniverse Certify Online www.certifyonline. com	Asynchronous, Self-paced	Database-driven solution that enables learning objects to be used for multiple courses. Delivers third-party content.	IMS MetaData standards for learning objects. Content developed with other tools.
Docent Enterprise Docent Inc. www.docent.com	Synchronous or Asynchronous	Web-based knowledge-exchange software platform. Integration of LMS and Content Delivery Server.	Content provider can decide whether to set up Learning Server as asynchronous or synchronous.
FlexTraining Learning Management Software Online Development www.flextraining.com	Asynchronous	Lets educator build & deliver Web-based training. email, online notebook, course content, automated course evaluations.	AICC-compliant. Compatible with content creation tools, MS FrontPage, Office, Macromedia Flash.
SmartForce Global LMS icGlobal www.icglobal.com	Asynchronous. Synchronous if client wants WebEx or Centra.	Enables organizations to develop, track, manage e-learning events & instructor-led training. Object-based.	Acquisition by SmartForce 4/9/01. icCampus LMS renamed SmartForce Global LMS.
Ingenium Click2learn.com Inc. home.click2learn.com	Synchronous or Asynchronous	Ingenium Workstation, Web Connect, Messenger Express, Report Browser, Data Update & Import Tool.	AICC-compliant. Formerly Asymetrix. Scalable solution using Oracle or MS SQL databases.
ILMS (Integrated Learning Management System) ISOPIA Inc. www.isopia.com	Asynchronous or Synchronous	Designed for complete management of training business, supporting classroom, CBT (CD-ROM based), & Web-based training media.	ISOPIA recently acquired by Sun Microsystems.
Saba Learning Enterprise Saba Software Inc. www.saba.com	Asynchronous, Self-directed	Human capital development Automates steps in learning lifecycle for learners and providers.	Level 1 AICC certified, ADL, IMS, IEEE. Instructor-led, online & self-paced learning.
THINQ Training Server LMS THINQ learning.thinq.com	Synchronous or Asynchronous	Content management, performance management, workflow capabilities. Integrated access to content.	AICC-compliant. Allows third party solutions for testing & assessment, virtual classrooms, & authoring tools.

Table 7 describes online learning systems that are considered to be Total e-Learning Solutions. Total e-Learning Solutions are complete online learning packages, including learning environments hosted by vendors. With content included or developed in conjunction with subject matter experts from customer organizations, these packages are customized as needed for individual organizations (Smith et al., 2001).

Table 7 Total e-Learning Solutions

Product/ Company/ URL	Learning Approach	Description	Comments
eCollege Distance Solution eCollege.com www.ecollege.com	Asynchronous, Self-directed	eLearning software & services provider. Enterprise-wide eLearning offering. Partners with educational institutions to build & support eLearning communities.	Founded as Real Education Inc. Content from textbook and new media publishers. Built first online campus in 1996.
Jones e-education Jones e-education Inc JonesKnowledge.com www.jonesknowledge.com	Asynchronous, Self-directed	Interactive course environment with threaded discussion, real-time chat. Collaborative student workspace, document sharing, control, & tracking	Comprehensive turnkey solution for educational institutions. Proprietary educational content loaded into course management software.
Embanet Embanet Corp. www.ebanet.com	Asynchronous	Outsourcing services for organization's e-learning infrastructure needs. Converts, develops, delivers courses.	Customized surveys. Offers Blackboard, FirstClass, IntraLearn, Prometheus, WebCT.
LiveTraining LiveTech Solutions www.livetechsolutions.com	Asynchronous, Self-directed	Infrastructure enables users to deliver, assess, manage, & administer training materials online. Course assessments & tracking.	LiveTutor – integrated online course delivery program, course material delivered frame-by-frame.
My SmartForce Hosted e-Learning SmartForce www.smartforce.com	Asynchronous, Self-directed	Content created around e-learning objects in Instruction, Collaboration, Practice, and Assessment.	AICC, LRN, SCORM compliant. SmartForce LMS tracks learning object activity.
eSocrates Web Learning Environment eSocrates www.esocrates.com	Asynchronous	Collaborative pedagogy via online learning community development. Course syllabus, assignments, resources, schedule, registration, email, conent.	Learning Community Server (Course Management System). Web Learning Environment (Total e-Learning Solution).
Vlearn System Knowledge Window www.aboutkw.com	Asynchronous	Internet enabled corporate training courseware. Component-based tool used by KnowledgeWindow to customize solutions.	Formerly STG International & VLearn International. VLearn's content creation used by company's services.

Tables 8 and 9 provide brief descriptions of tools that are used to support online learning systems. Related e-Learning Tools do not constitute entire online learning environments but can be used to develop content or support learning activities (Smith et al., 2001).

Table 8 Related e-Learning Tools (part 1)

Product/ Company/ URL	Learning Approach	Description	Comments
ClassNet Iowa State University classnet.cc.iastate.edu	Self-directed	Free service hosted by Iowa State University on secure servers. Software for managing Internet-based instructional activities. Designed for educators who have developed and posted content elsewhere.	Classnet does not create or host content. Online tests and assignments, automatic grading, student management, portfolios
FirstClass Collaborative Classroom Gold Centrinity Inc. www.centrinity.com	Asynchronous, Self-directed with the Synchronous chat tool	Communication, collaborative learning and scheduling software. email, discussion forums, chat, calendars, pager support, Web publishing.	Centrinity result of SoftArc acquisition by MC^2 Learning Systems
FirstClass Intranet Server Gold Centrinity Inc. www.centrinity.com www.softarc.com	Asynchronous	Dragging-and-dropping graphic files & attachable audio & video files in documents, scheduling. Publishing on intra/Internet without need to know HTML	Server notification of messages and calendar events through pager.
Flax De Montfort University, UK www.cms.dmu.ac.uk/coursebook/flax	Asynchronous, Self-directed	Java application that creates interactive Web-based Coursebooks (tutorials). Outputs HMTL pages & Java applets.	Reviewed in 2001 CITE study, but research project not available on the university Web site as of 7/5/01.
IMSeries Learning Technology Systems www.imseries.com	Asynchronous	Integrated instructional design & administrative system. Lesson-planning, customized Web interfaces, database implementation.	Built-in Web server allows user access to functions and data via standard Web browser.
NetSynergy Mentergy Inc. www.mentergy.com	Asynchronous, Self-directed	Plug-in for developer product, Designer's Edge. Creates CBT & stand-up training. Point, click, drag, & drop to create HTML pages. Pre-built templates.	Formerly Allen Communication, acquired by Gilat Communications, marketed by Mentergy
PlaceWare PlaceWare www.placeware.com	Synchronous & Asynchronous	Web conferencing system allows users to schedule & hold videoconferences on Internet, create presentations.	Started as Xerox PARC LambdaMoo multi-user game environment. IMS-compliant. Synchronous & asynchronous features.

Table 9 Related e-Learning Tools (part 2)

Product/ Company/ URL	Learning Approach	Description	Comments
Teamscape Teamscape Corp. www.teamscape.com	Synchronous or Asynchronous	Training management - curriculum & resource planning, student enrollment, competency management, student transcripts, reporting.	AICC, IMS-compliant. Connects to learning content from third-party providers, custom content, conferencing.
Trainersoft.com Trainersoft www.micromedium.com	Asynchronous	Course creation software with multimedia, image transitions, email, chat groups, testing features.	Distribution Wizard distributes courses as HTML or as executable.
Tutornet Tutornet.com Group www.tutornet.com	Synchronous, Student-led	Real-time interactive tutoring service. Live teachers in virtual classrooms help students	Live tutoring for elementary to college-age students, various subjects.
WebBoard O'Reilly www.webboard.oreilly.com	Asynchronous/ Synchronous	Web forums and chat software. Web-based tool. Communication solutions for a wide range of communities.	One of the earliest vehicles for threaded discussions on the Internet.
WebMaker De Montfort Univ, UK westworld.dmu.ac.uk	Asynchronous	Knowledge Structuring tools. HTML preparation & production – resource linker & HTML generator.Concept map converted to HTML.	Addresses need for structuring entire courseware project prior to development.
WebTeach University of New South Wales www.pdc.unsw.edu.au	Asynchronous	Facilitates discussions through classroom teaching strategies within virtual classroom.	CGI script supports Notice Board, Seminar Room, & Coffee Shop virtual locations.

Summary

The research described in the dissertation entitled *Applying Multi-Intelligent Adaptive Hypermedia to Online Learning* (Dara-Abrams, 2002b) is a new approach to online learning. This approach uses the Theory of Multiple Intelligences (Gardner, 1983/1993) and the learner's most developed intelligences as the basis of a stereotype user model (Kobsa, 1993; Rich, 1979, 1989). The online learning system may be considered to be a type of course management system, focusing on the development and delivery of asynchronous training (Smith et al., 2001). However, the only tracking of learner progress is done through the Course Tracker, which is not currently linked to any assessment or grading facilities as educational institution-based course management systems usually are.

The prototype Multi-Intelligent Online Learning system designed for the research study is a prototype online learning system, delivering content via Web-based online learning technology. However, the prototype system differs from the online learning systems presented in Tables 2 through 9 in this paper, which focus on content delivery rather than on content adaptation to meet the needs of specific learners. An integration of the Theory of Multiple of Intelligences (Gardner, 1983/1993) with stereotype user modeling (Kobsa, 1993), and the Entry Point Framework (Davis, 1996, Gardner, 1999a) and multiple representations (Gardner, 1999a) with adaptive hypermedia technology (Brusilovsky, 1998; De Bra, 1998) and Web-based online learning technology (Harasim, 1999) has not been prototyped or formatively evaluated in online learning systems prior to the research study in *Applying Multi-Intelligent Adaptive Hypermedia to Online Learning* (Dara-Abrams, 2002b).

Recognizing the need to adapt instructional materials to individual students, the proposal for an instructional system using a more sophisticated Web browser to identify and adapt instructional materials based on students' learning styles and media preferences (Danielson, 1997) points in a similar direction to Multi-Intelligent Online Learning. However, both the technology approach of Danielson's initial prototype that employs forms and CGI scripts and his proposed approach of a new Web browser differ from the adaptive hypermedia technology and use of a standard Web browser in the technology approach of Multi-Intelligent Online Learning. In

addition, Danielson's study uses learning styles and media preferences as the basis for adaptation rather than basing the adaptation and user model on the Theory of Multiple Intelligences (Gardner, 1983/1993).

Other educational hypermedia applications present content based on a user model and offer adaptive hypermedia technology similar to that used in the dissertation prototype system (Brusilovsky, 1998; Calvi & De Bra, 1997; De Bra, 1998; Eklund & Brusilovsky, 1998). However, these educational hypermedia applications do not base their adaptation on the Theory of Multiple Intelligences (Gardner, 1983/1993) and do not approach the task of adapting content based on the characterization of the user in terms of his/her three most developed intelligences. Rather, content is adapted based on the level of understanding of the learner. Therefore, Multi-Intelligent Online Learning offers a novel approach to online learning through the adaptive presentation of content, employing a user model based on the Theory of Multiple Intelligences (Gardner, 1983/1993), an adaptation model based on multiple representations (Gardner, 1999a) and the Entry Point Framework (Gardner, 1999a), and a domain model employing the Teaching for Understanding Framework (Perkins, 1998). With a foundation in cognition and learning theory (Dara-Abrams, 2002i) and adaptive hypermedia (Dara-Abrams, 2002a) and online learning technologies (this paper), Multi-Intelligent Online Learning interweaves the theoretical and technological foundations, which are instantiated in the development of a Multi-Intelligent Online Learning prototype (Dara-Abrams, 2002d).

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