Chapter 1

INTRODUCTION TO WEB-BASED EDUCATION

Informally, *Web-based education* (*WBE*) encompasses all aspects and processes of education that use World Wide Web as a communication medium and supporting technology. There are many other terms for WBE; some of them are *online education*, *virtual education*, *Internet-based education*, and *education via computer-mediated communication* (Paulsen, 2003).

Adapting from (Keegan, 1995) and (Paulsen, 2003), it can be said that WBE is characterized by:

- the separation of teachers and learners (which distinguishes it from face-to-face education);
- the influence of an educational organization (which distinguishes it from self-study and private tutoring);
- the use of Web technologies to present and/or distribute some educational content;
- the provision of two-way communication via the Internet, so that students may benefit from communication with each other, teachers, and staff.

Since 1990s, Web-based education has become a very important branch of educational technology. For learners, it provides access to information and knowledge sources that are practically unlimited, enabling a number of opportunities for personalized learning, tele-learning, distance-learning, and collaboration, with clear advantages of classroom independence and platform independence (Brusilovsky, 1999). On the other hand, teachers and authors of educational material can use numerous possibilities for Web-based course offering and teleteaching, availability of authoring tools for developing Web-based courseware, and cheap and efficient storage and distribution of course materials, hyperlinks to suggested readings, digital libraries, and other sources of references relevant for the course (Devedžić, 2003a, 2003b).

There is a number of important concepts related to Web-based education, such as e-Learning, distance education, and adaptive learning. The objective of this chapter is to introduce such concepts and the related technologies.

1. E-LEARNING

Electronic learning or *E-Learning* is interactive learning in which the learning content is available online and provides automatic feedback to the student's learning activities (Paulsen, 2003). In fact, it is much like *computer-based training* (*CBT*) and *computer-aided instruction* (*CAI*), but the point is that it requires Internet for access to learning material and for monitoring the student's activities. E-Learners usually can communicate with their tutors through the Internet. However, the focus is not on that communication; organization of and access to the learning content are more central to e-Learning.

Note the difference between WBE and e-Learning: learning is just one element of education, so WBE covers a much broader range of services than e-Learning. More precisely, e-Learning companies and other providers of e-Learning material usually focus on learning content, while different educational institutions interested in organizing WBE provide the whole range of educational services and support. Unfortunately, the terms e-Learning and WBE are often used as synonyms, which generates some confusion.

1.1 Alternative definitions

In this book, we adopt the aforementioned Paulsen's interpretation of the term e-Learning. Yet, for the sake of completeness it should be noted that there are definitions of e-Learning that include not only Internet as technological support for learning, but other media and resources as well. As an illustration, consider the definition that Eva Kaplan-Leiserson has included in her online e-learning glossary (2000):

> "E-learning covers a wide set of applications and processes, such as Web-based learning, computer-based learning, virtual classrooms, and digital collaboration. It includes the delivery of content via Internet, intranet/extranet (LAN/WAN), audio and videotape, satellite broadcast, interactive TV, and CD-ROM." (Kaplan-Leiserson, 2000)

The Web is full of definitions of e-Learning that provide even broader interpretation than Kaplan-Leiserson's. For example:

> "[E-Learning:] Broad definition of the field of using technology to deliver learning and training programs. Typically used to describe media such as CD-ROM, Internet, Intranet, wireless and mobile learning. Some include knowledge management as a form of e-Learning." (e-Learning Guru, 2005)

Explaining the possible inclusion of knowledge management as a form of e-Learning is beyond the scope of this book. *Mobile learning* (often abbreviated to *m-learning*) is a subform of e-Learning that can take place anytime, anywhere with the help of a mobile computer device. The role of that device is two-fold:

- to present the learning content;
- to provide wireless two-way communication between teacher(s) and learner(s).

1.2 Objectives, perspectives, tools, and learning modes

The convergence of the Internet and learning in e-Learning qualifies e-Learning as Internet-enabled learning, in terms of using Internet technologies to create, foster, deliver, and facilitate learning, anytime and anywhere (Obringer, 2005). One of the objectives of e-Learning is the delivery of *individualized*, comprehensive, dynamic learning content in real time - people and organizations need to keep up with the rapid changes and advancements of knowledge related to different disciplines, as well as to keep ahead of the rapidly changing global economy. Another objective is to facilitate the development of *learning communities* - communities of knowledge, linking learners and practitioners with teachers and experts.

There are two major perspectives of e-Learning - technological and pedagogical. Many interpretations focus on the technology (i.e., on the "e"). Others take technology only as a means of content delivery, emphasizing the need for learner-centered approach; to them, e-Learning in its essence is learning. The pedagogical perspective is interested primarily in explaining how people learn, how do they acquire skills and information, how their skills develop through learning over time, what are their preferred learning styles, and so on - and, only then, how the electronic delivery can be adapted to the learner.

E-Learning usually comes through an interaction between a learner and a simulated electronic environment pertaining to the domain of interest to the learner. In the context of WBE, the environment is Internet-based; in other variants, it can be Intranet-based, as well as CD-ROM-based. In all cases, it brings up a rich learning experience through interactive use of text, images, audio, video, animations, and simulations. It can also include entire virtual environments. It can be practiced individually, or in the classroom. It is self-paced hands-on learning.

E-learning environments can offer a number of learning tools, in a wide range of interactivity and sophistication. At the lower end of the scale are *indexed explanations and guidance* for learner's questions. The learner typically types in a keyword or phrase (or selects a keyword from a list) to search an underlying database for explanation. The environment replies with an explanation, or perhaps with step-by-step instructions for performing specific tasks. These can be further augmented through additional forms of online support like links to reference materials, forums, chat rooms, discussion groups, online bulletin boards, e-mail, or live instant-messaging support. The tools like chat rooms, discussion groups, online bulletin boards, and e-mail support access to instructors, but they all essentially pertain to *asynchronous mode* of learning. The most sophisticated and the most interactive environments provide tools for *synchronous mode* of training and learning, with instructor(s) organizing and guiding learning/training sessions in real time. With such environments, the learners log in and can communicate directly with the instructor and with each other through the Internet. In addition to Internet Web sites, supporting tools include audio- and/or video-conferencing, Internet telephony, or even two-way live broadcasts to students in a classroom (Obringer, 2005). The sessions can be scheduled at regular times for weeks or even months, enabling the learners to walk through the entire course. Within a single session, there is a range for possible collaboration between the learners - from purely individual learning and minimum cooperation with the other learners, to tight collaboration through shared electronic whiteboards and different communication tools. The instructor can monitor the learners' progress in a variety of ways, both disruptive and interactive.

1.3 Pros and cons

Before moving on to further discuss e-Learning in more details, it is necessary to answer a simple question: Why should we care about e-Learning? In other words, what are the advantages of e-Learning over traditional, classroom-based, face-to-face learning?

Self-paced character of e-Learning is just one of the answers. Another one is that the costs of e-Learning are usually lower, once the course is put up - no physical resource allocation (location, time, and equipment). True, in synchronous learning additional costs are associated with the instructor managing the class, but altogether the costs should still be lower than in traditional courses. There is also some evidence that e-Learning progresses faster than traditional learning; this can be attributed to the fact that in e-Learning students can go much faster through the material they may be already familiar with. Furthermore, the material they consume is consistent - no slight differences caused by different instructors teaching the same material. Learning anytime and anywhere is attractive to people who have never been able to work it into their schedules prior to the development of e-learning. Another attractive feature is that online learning material can be kept up-to-date more easily than traditional one - the updated version is simply uploaded on a server and the students get access to improved material immediately. The material can make use of many didactic elements and tools, such as audio, video, related links, simulations, and so on, which can lead to increased retention and a stronger grasp on the subject. E-Learning is much easier to adapt to groups of students of different sizes and to corporate learning situations than traditional learning.

There is always some resistance to e-Learning by more traditionally oriented instructors and learners alike. Some instructors complain that organizing learning material for e-Learning requires much more work than in traditional settings, as well as that electronic communication with students is more time-consuming and less effective than face-to-face communication. Possibilities for "creative divergence" from the lecture topic and explanation of details and examples made up on the spot are still more numerous in traditional classrooms. Charisma of good teachers is lost in e-Learning, and so is socializing with peer learners.

A good alternative to "pure" e-Learning is *blended learning*, which is a combination of traditional classroom-based learning and e-Learning. In practice, it is worth considering an option of using blended learning to assure for initial acceptance of e-Learning. Moreover, and contrary to the loss of charismatic face-to-face teaching, in some cases experts who have problems articulating their knowledge and experience in the classroom provide excellent e-Learning courses.

1.4 Organizing e-Learning material

Back to learning content again, it is crucial to the success of e-Learning that instructors organize the learning material in a way suitable for interactive electronic delivery. The worst thing to do here is to copy traditionally written learning materials and simply paste them in the course for learners to display them on their screens. Contrary to that naïve practice, putting up an e-Learning course is a long process that requires maximum effort from the instructor and the support team. There are many hurdles along the way in that process, hence educational institutions offering online courses (e.g., universities) may have entire departments for helping instructors organize their e-Learning material. It is no wonder that even experienced instructors often need such a help - they may be teachers in domains like humanities and medicine, that focus on things other than computer-based delivery of knowledge.

There are a few simple rules to follow in organizing e-Learning material. All of them can be seen as learner-centered instances of more general rules of good pedagogy and human-computer interaction (HCI). First of all, it is important to clearly define the target audience (the learners and their skill levels) and the learning objectives (i.e., what the learners should be able to do once they go through the course). If the course delivery medium is the Web, organizing the learning material on the server side is only one part of the problem - it is also necessary to bear in mind the client's hardware and bandwidth to ensure for real time delivery. Next, it is a must to break the material into manageable modules (chunks) such as chapters and lessons, enabling the learners to grasp the overall structure of the material and map it to the course objectives, as well as to follow details in chapters and lessons more easily. There are authoring tools that support instructors in preparing their material that way. For example, Figure 1-1 shows how the instructors create chapters and lessons for an e-Learning course in the domain of radio communications and coding systems (Šimić and Devedžić, 2003), (Šimić et al., 2005). Each module should typically take a learner about 15-30 minutes to cover. Also, online learning material must be as easy as possible to navigate. Difficult navigation frustrates the learners and causes them to leave, which in the case of WBE is a matter of a mouse click. Indexing topics and terms across the course and interconnecting them with hyperlinks is usually the key to effective navigation. Last but not the least, animation and multimedia contents should add value and improve learning efficiency, recall, and retention, but not drive the learner away from the main objective(s). Overdone animation and multimedia can produce as much frustration as poor and clumsy navigation. Authoring tools normally support easy incorporation of animation and multimedia in e-Learning material by providing a set of easy-to-use controls.

Studies have shown that for e-Learning systems and applications to be effective, the presentation of information on the screen is important. The way the information organized on the screen, as well as different interactivity options (such as quizzes, hints, and multimedia to enhance all that) should clearly reflect frequently used structures and metaphors in the domain of interest. For example, Figure 1-2 shows a screenshot from Code Tutor, the actual system for learning radio communications and coding systems that uses the learning material mentioned in the context of Figure 1-1. In this case, the text and graphics presented on the screen (related to the domain concept "FSK transmission") can be augmented by a suitable audio clip and a spectral analysis diagram. They are the usual means of illustrating concepts in the domain of radio communication and coding. Still, it is left to the learner to activate them or to decide to go along without them.

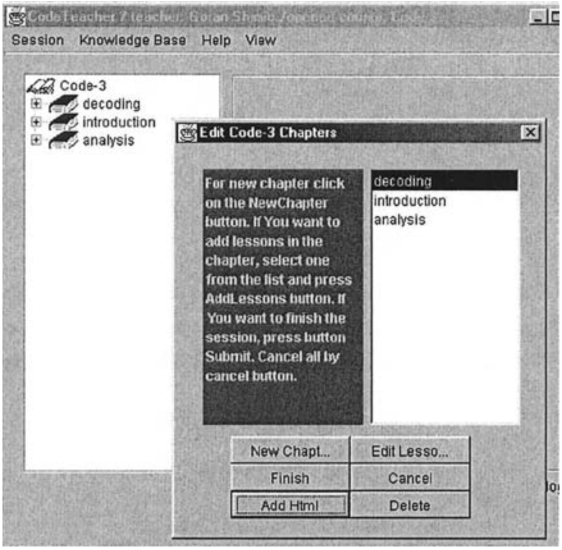
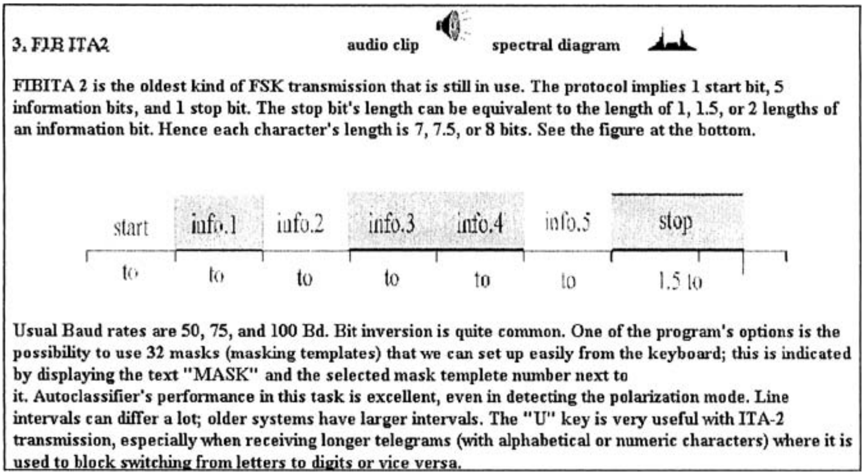


Figure 1-1. An example of creating material for an e-Learning course


3. FIB ITA2 audio clip spectral diagram

FIBITA 2 is the oldest kind of FSK transmission that is still in use. The protocol implies 1 start bit, 5 information bits, and 1 stop bit. The stop bit's length can be equivalent to the length of 1, 1.5, or 2 lengths of an information bit. Hence each character's length is 7, 7.5, or 8 bits. See the figure at the bottom.

Usual Baud rates are 50, 75, and 100 Bd. Bit inversion is quite common. One of the program's options is the possibility to use 32 masks (masking templates) that we can set up easily from the keyboard; this is indicated by displaying the text "MASK" and the selected mask templete number next to it. Autoclassifier's performance in this task is excellent, even in detecting the polarization mode. Line intervals can differ a lot; older systems have larger intervals. The "U" key is very useful with ITA-2 transmission, especially when receiving longer telegrams (with alphabetical or numeric characters) where it is used to block switching from letters to digits or vice versa.

Figure 1-2. An illustration of how multimedia should be used discretely and at the learner's will

Using video in e-Learning applications can put the subject into its context of use, encourage active participation from trainees, and build on existing knowledge. Video clips can be followed by some questions (Obringer, 2005). Further augmentation includes combining portions of video clips with question answering in order to explore different scenarios. For example, a portion of a video can "formulate a problem" for a learner to work on, and can be ended with a couple of related questions. Based on the learner's answers, another video clip will be shown next, along with some explanations. Each further video clip corresponds to a different scenario, thus the learner can understand the consequences of making his/her choices when answering the set of questions put after the first clip was shown.

The same line of reasoning can be followed when deciding to incorporate animation and simulation in the material. A typical example is capturing a series of mouse moves and keystrokes to select a menu item or perform a certain action that an application enables, and using the capture as an animated example of interacting with the application. Likewise, the so-called *rollover* enables changing an image on the screen when the student moves the mouse over it (or over a "hot spot"), thus bringing his/her attention to another graphics of interest. Rollovers can be also effective when used to bring up a question to answer, or to open another line of exploring the material.

Finally, some further tips from HCI apply to e-Learning as well. For example, colors and fonts should be used with care. Contrast must be ensured between background and font colors, and complex coloring such as gradients may interfere with the system performance over the Internet. Of course, sacrificing quality and aesthetics is never a preferred option, so whenever possible good-quality graphics and multimedia are worth keeping (provided, of course, that they are used to reinforce learning, not just for the sake of using it). Too much text on the screen should be avoided, and feedback should be given to the student after each quiz he/she takes.

2. DISTANCE EDUCATION

Nowadays, *distance education* and WBE are often used as synonyms. However, distance education is a more general concept of the two, and is certainly broader than and entails the concept of e-Learning. The term distance education is also often used interchangeably with *distance learning*; strictly speaking, distance learning is only one aspect and the desired outcome of distance education.

Distance education uses a wide spectrum of technologies to reach learners at a distance, not only the Web - written correspondence, text, graphics, audio- and videotape, CD-ROM, audio- and videoconferencing, interactive TV, and fax. Distance education or training courses can be delivered to remote locations in both synchronous and asynchronous mode, and do not exclude classroom-based learning and blended mode.

Distance education has long history. In the past, it was conducted mainly through written correspondence. Then from the Early XX century radio broadcast program was used in distance education extensively, and was gradually replaced by TV from 1950s onwards. Then came PC computers, the Internet, and other modern technologies.

This book adopts the following definition of distance education:

> "Distance education is planned learning that normally occurs in a different place from teaching and as a result requires special techniques of course design, special instructional techniques, special methods of communication by electronic and other technology, as well as special organizational and administrative arrangements." (Moore and Kearsley, 1996)

2.1 Features

The most important features of distance education include:

- separation of teachers and learners (as in WBE) in time, location, or both;
- mediated information and instruction;
- organizational and planning activities (as in both e-Learning and WBE);
- the use of pedagogy and instructional design;
- the use of technology (e.g., telecommunications facilities) when live instruction should be conveyed at a distance in real time;
- a range of educational services (such as learning, communication, and assessment);
- different services to account for the administration of learners, teachers, and courses;
- delivery away from an academic institution, in an alternate location such as at work, at home or a learning or community center, yet in the form of a structured learning experience.

Distance education is a planned teaching/learning experience designed to encourage learner interaction and certification of learning. It may be accomplished on a point-to-point basis or on a point-to-multipoint basis. The forms of distance education include individual participation, teleseminars, teleconferences, Web conferences, electronic classrooms, and so on.

2.2 Pros and cons

Bonk and King (1998) list a number of advantages of distance education over traditional classroom-based education:

- students can do their work and "attend" class at their convenience;
- learning anytime and anywhere, which is specially convenient for adults with professional and social commitments;
- extensive curricula, often with international span;
- shy students sometimes open up;
- student disruptions and dominance are minimal;
- students can generate a huge amount of useful information through their postings; these can be used to enforce reflection and creative comments, hence teachers can support using the postings to extend interaction among students while driving them to focus on the content, as well as to initiate metacognitive activities and comments while pulling out interesting questions, themes, or questions for discussion;
- numerous opportunities for online advice and mentoring by experts, practitioners, and other professionals in the field;
- discussion can extend across the semester and create opportunities to share perspectives beyond a particular course or module.

Despite these obvious advantages of distance learning, there are also problems that have to be resolved (Valentine, 2005):

- the quality of distance instruction may be lower than that of face-to-face instruction - it is effective teachers who teach students, not the technology used;
- cost effectiveness of distance education is not always as high as promised - there are many elements in the cost of distance education that are often underestimated (e.g., the cost of converting the teaching material, the cost of extra equipment needed, and the like) and that, when taken into account more realistically, can make the cost of distance education quite comparable to that of classroom-based education;
- the technology may be expensive, and there is a possibility of not utilizing all of its potential (due to, e.g., the lack of training, the instructor's attitudes about using the technology, and hardware problems like malfunction of equipment (it can ruin the delivery and the entire course!));
- instructors' concerns must be taken into account (not all instructors' attitudes towards using technology are positive, and many instructors complain that distance education incurs much more work than face-to-face lecturing due to the fact that Internet-based communication may take considerably more time than live communication in class);

- students' concerns must be taken into account (for a variety of reasons, not all students are positive about distance education; for example, they may prefer live instruction and teachers using visual clues, or more intensive collaboration than that enabled by current technology, or they may show less tolerance for ambiguity, and so on).

3. VIRTUAL CLASSROOMS

The terms *virtual classroom* and *Web classroom* are often used in the context of contemporary distance education and WBE to denote any means of live or pre-programmed Internet broadcast of information and/or a Web-based environment meant to support teaching and learning. When learners and teachers "meet" in the virtual classroom, they actually simultaneously access a particular URL that is dispensing information.

Such a computer-accessible, online learning environment can fulfill many of the learning facilitation roles of a physical classroom in much the same way a blackboard does for a real classroom. In fact, virtual classrooms are often modeled after the metaphor of a physical classroom. The interface of the supporting software may present a desk for each student, a teacher's desk, cupboards of resources, presentation board (virtual blackboard), module/assignment notebook, tools for chats and written communication among the teacher and the class or among the peer learners, access to online resources and tests, and even classroom posters (Rodriguez, 2000).

Note a difference between classrooms with physically present learners and virtual classrooms with remote interaction. In the former, Web technologies and other electronic devices and tools support teaching, learning, and communication *in addition* to live interaction among the students and the teacher(s). Such classrooms are also often called Web classrooms, but are in fact technology-enriched typical teacher-moderated classroom situations with physical presence of both the students and the teachers. In the latter case, physically remote students and teachers use appropriate software environments and Web technologies as *the* means to interact, both synchronously and asynchronously.

3.1 Architecture and modes of interaction

Architecturally, a Web classroom is usually a client-server learning environment designed as in Figure 1-3. Students and teachers work in a real or in a virtual classroom; in both cases, students can learn either individually or collaboratively. The Web technology connects the teacher(s) on the server and the student(s) on the client side.

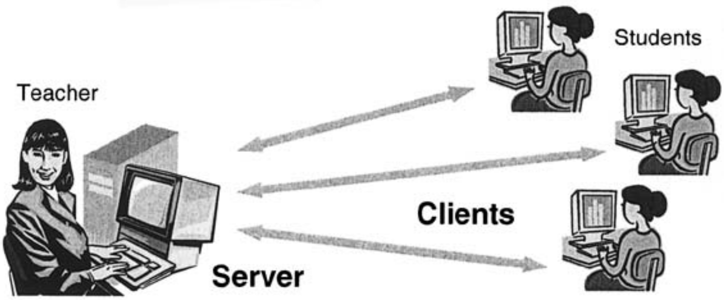


Figure 1-3. Client-server architecture of a virtual classroom

As a minimum, there are four modes of a student's interaction with a virtual classroom (Devedžić, 2005a):

- *authentication* - logging in for a new session;
- *learning* - selecting a material to learn from and browsing and reading the corresponding illustrated modules; in a typical case, some of the module pages are filled with text and graphics, and some of them also have supporting audio and video clips;
- *assessment* - answering questions the system asks after the learning of a module is completed;
- *validation* - the mode in which the system checks and updates the student model (see section 5 in this chapter for more details about student models) by estimating the student's knowledge about different topics from the material he/she was supposed to learn.

In addition to these four basic modes, virtual classrooms often support other means of interaction, such as referencing (e.g., browsing digital libraries from within the virtual classroom), collaboration (among peer learners, by using specific software tools integrated with the virtual classroom (see below)), and running simulations and online experiments.

The teacher(s) on the server side typically perform(s) the tasks such as authentication, starting the server, monitoring the students' sessions, editing and updating the learning material, and stopping the server, as well as complete class and course administration[1]. Of course, these tasks are rather diverse (system administration, authoring, teaching, and assessment), hence in practice they are done by several specialists. Some of the tasks are very different from those on the student side - for example, course administration, as well as editing and updating the learning and assessment material, which are allowed only to the teacher(s). A specific server-side module, also accessible only by the teacher, is used for monitoring the students' sessions.

[1] This may be done by using either an integrated or an external learning management system.

In some cases, the server can also arrange for personalization of the learning tasks it supports. In fact, from the learner's perspective the server supporting personalization appears as an intelligent tutor with both domain and pedagogical knowledge to conduct a learning session (again, see section 5 in this chapter for more details). It uses a presentation planner to select, prepare, and adapt the domain material to show to the student. It also gradually builds the student model during the session, in order to keep track of the student's actions and learning progress, detect and correct his/her errors and misconceptions, and possibly redirect the session accordingly.

3.2 Technology and software

There is a variety of Internet-enabled technologies that can be involved in virtual classrooms (Erickson and Siau, 2003), (Muehlenbrock and Hoppe, 2001), (Pinkwart, 2003):

- video conferencing;
- digital video (searching digital video libraries and live digital video transmission);
- Internet television (high definition TV transmission over the Internet);
- streaming media Web casts (playing multimedia contents as they are downloaded, without waiting for the entire download to complete);
- a range of different local student computers (desktop, notebooks, tablets, etc.), all locally networked and with access to the Internet;
- live board and other devices and accessories.

Likewise, depending on the domain and the pedagogical setting, different specific software components can be involved as well (Constantino-González et al., 2002), (Pinkwart, 2003):

- specific workspace tools for different domains, integrated with visual modeling languages and various construction kits (e.g., entity-relationship modeling elements for the domain of database design), to help the students learn more efficiently by solving problems in the domain of interest;
- different modeling and simulation tools, all with specific domain-related functionality and semantics; these can be defined externally, in the form of tool palettes (e.g., stochastic palette, system dynamics palette, Petri net palette,...) that encapsulate domain dependent semantics;
- general "discussion board";
- editing tool for taking and collecting individual notes;
- hooks to standard text processors, spreadsheet programs, and other frequently used applications;
- electronic worksheets that can be distributed and collected by the teacher;

- intelligent monitoring tools that can give both individual feedback and information for the teacher; the teacher can use such information to possibly enforce independent thinking and more active participation by some students;
- student tracking tools; for example, when a student finishes navigating a particular module, the system may record it so that the next time it will automatically bring the student to the next module or "learning space";
- collaborative learning support tools (such as shared and private workspace environments, tools for exchanging settings and data between learners and groups, chat rooms, and discussion forums);
- specific problem-creation tools for teachers to prepare initial problem descriptions for students to solve, using some corresponding visually orientated languages;
- specific help-creation tools for teachers to help the students when solving problems (by providing hints, using annotation elements and free hand input);
- electronic gradebook for teachers; students can also see their own grades and compare them to class averages;

More advanced and certainly technically more demanding virtual classrooms enable real-time, two-way, or multisite link between participating students using virtual reality software (Erickson and Siau, 2003), (Johnson et al., 2000). For example, in the approach called tele-immersion (Ott and Mayer-Patel, 2004), remote teachers and learners may appear to each other as virtual reality avatars (usually represented as cartoon-like figures) who can converse, demonstrate work in progress, lecture to a classroom, or even "get together" in a virtual laboratory to perform an online experiment. The technical, hardware, software, and telecommunications requirements here are extremely complex.

3.3 Problems, challenges, and open issues

Teaching in a Web classroom is definitely not just posting notes and readings. Individual instructors participating as teachers in virtual classrooms must completely rethink and reorganize and prepare their courses to be delivered via virtual classrooms. This includes preparing slides, course notes, handouts, etc. especially for virtual classrooms, as well as designing new types of assignments for remote students participating in virtual classrooms. Moreover, they need to devise interesting activities such as debates and role plays or games, and put all of their material in digital form on the Web regularly during the course.

All such activities mean hard work. In other words, technology for virtual classrooms is there, but it does not reduce the workload for instructors; it just changes its nature to an extent. In spite of technological differences, the goals and objectives of teaching in virtual classrooms remain the same as in traditional classrooms - increasing the learning outcomes, accommodating differences among the students in terms of their learning styles, goals, and capabilities, giving individual attention to students in need, and so forth. To achieve all this, instructors often need to give more feedback to students outside the class, to increase the course development time, and to continuously improve the learning material they prepare. Also, all activities and assignments must be pre-planned and uploaded. As a result, the workload for teachers often increases beyond the expected level.

Furthermore, appropriate logistics must be organized to support Web classes; for example, new students should be able to put course material orders, arrange for downloading large and restricted multimedia files, and get their accounts to participate in class conferences. This creates the need for a distance student support office and computer system support team. Even simple technical problems can easily lock out the students if the solution is not found quickly and effectively.

Another important open issue of Web classrooms is that of realistic evaluation of the student's activities and the environment itself. It is a good idea to have the students fill in some questionnaires periodically, to get an insight into how their attitudes and attributes change over time. Still, it is not enough. The monitoring tools mentioned in the previous section complement direct communication and feedback, and can indicate problems in using and acceptance of the Web classroom. For example, such tools may help the teacher(s) track the amount and type of the students' activities, the hours they spent in the virtual classroom, the number of logons, and the number and proportion of individual student contributions to the class activities. All these parameters indirectly indicate the students' motivation and possible problems in using the software tools involved. On the long run, internal assessment of student performance through comparison of grades for the same exams and assignments (as in traditional classes) can indicate problems with the class, the software support, and the communication between the teachers and the learners.

Success of a Web classroom depends also on the students' sense of being a part of it, just as with real classrooms. The students should feel the virtual classroom is *the* place for them to go not only to participate to learning activities, but also to find the resources they need. The classroom should be their starting point ("portal") in looking for the necessary resources such as different documents, multimedia objects, links, and problem-solution examples to practice with. A virtual classroom should be designed after the metaphor of a real classroom full of resources. Furthermore, the design of virtual classrooms must support the students in developing a sense of "going to the classroom" from their own locations to present intermediate results of their longer term projects, unconstrained by contact time of limited duration that often occurs in traditional settings. So, virtual classrooms should be the platforms for display of student projects as well, not only the course material.

An interesting question that still requires a lot of efforts and elaboration in spite of some initial developments is related to the possibility of building software "shells" for creating configurable Web classrooms. An early idea of Rodriguez (2000) along this line suggests development of a domain- and class-independent general Web-based environment that can be instantiated into a virtual classroom by tailoring it according to the teachers', students' and educational institutions' preferences.

4. PREREQUISITES FOR ACCEPTANCE

End-users of WBE expect not only provision of effective, high-quality educational and training material, but also smooth integration of this material and training with advanced educational and technological frameworks and Web classrooms. They also want to integrate the material and educational services they get from WBE with their day-to-day operational environments and workflows within which they operate (e.g., industrial, government or academic settings). As a consequence, it is necessary to map the WBE technology to core educational workflows in order to achieve effective instruction through WBE.

That mapping is not easy; education workflows are often extremely complex, with many complicated dependencies. Most of educational workflows involve creation of, access to, teaching and/or manipulation of learning material and other resources, as well as interaction and communication between different categories of users of WBE systems (teachers, researchers, learners, advisors, and administrators).

On the other hand, learners (who are the most important end-users of WBE systems) demand high-quality WBE in terms of content, pedagogy, and technological framework.

4.1 Educational workflow issues

Education workflows provide the necessary abstractions that enable effective usage of computational resources, and development of robust, open problem-solving environments that marshal educational, computing and networking resources (Vouk et al., 1999).

WBE systems must support coexistence, interaction, and seamless integration of end-user's education workflows with his/her other workflows, such as legislative, scientific and business workflows. For example, many students from industry that work during the day may prefer to schedule their logs onto a WBE system at times that suite them, e.g., evenings or weekends. They cannot match their work-place processes with the traditional school, college or university teaching workflows. To account for problems like this one, WBE systems have to disaggregate the traditional synchronous teaching/learning cycle into a number of smaller, primarily asynchronous components with only minor synchronous interactions.

The complexity of educational workflows is the primary reason why many WBE systems remain in laboratories and never make their way to practical environments and use. Many unsuccessful systems suffer from inappropriate functionality and instruction models, poor evaluation of the system usability and users' interaction with it, and the lack of flexible, plug-in design for incorporating new functionalities easily to accommodate different learners' needs.

To better understand the workflows in educational processes and how WBE systems map to those workflows, it is necessary to clearly identify different (albeit non-exclusive) categories of people involved and their roles in the processes.

There are four major categories of users of WBE systems - students, instructors, authors, and system developers. In addition to them, other categories of users may be interested in WBE systems, such as parents of the students, employers of continuing and adult education students, educational administrators, and government officials.

System developers are responsible for development and maintenance of the WBE system framework. They must be knowledgeable in software and communications engineering, Web engineering, HCI and interface design, education, knowledge bases, and artificial intelligence. They develop authoring tools, Web-based platforms for end users, and system interfaces, and assist authors in courseware generation.

Authors are courseware developers. In most of cases, they are not computer and system experts, so the authoring tools and interfaces that system developers create for them must be easy-to-learn and easy-to-use; in other words, the authors should concentrate on the content development rather than struggle with the system intricacies (Vouk et al., 1999).

Instructors sample, select, customize, and combine learning materials, existing lessons, projects and courses, and develop new curricula, courses, and projects. They also deliver the course material and take care of teaching, assessment, grading, and reviewing student projects.

Students and *trainees* (i.e., *learners*) are the most important and most numerous users of WBE systems. The entire design of a WBE system and framework must be learner-centered, bearing in mind that they demand easy-to-use and intuitive interfaces, timely access to and updates of learning materials, reliable communications, teacher's support when needed, collaboration with peer learners in virtual classrooms, information about their grades and/or progress in the courses, and so on. Security issues are of prime concern to learners; it is mandatory for a successful WBE system to ensure for protecting the learners' work and projects from data losses and unauthorized access. Also, WBE systems must account for learners' diversity. This is especially true for the systems that target international adult learners interested in continuing education and lifelong learning. The learners' age differences and geographic distribution, different times they log on to "attend classes", their different profiles and backgrounds, as well as different cultures they come from and lifestyles they practice, make WBE system design, organization, and administration extremely complex. Instructors must support this diversity and simultaneously maintain high quality and integrity of the educational delivery.

Incorporating different education workflows in a WBE system for such a diverse user population requires careful elaboration of many possible scenarios that frequently occur in practice, and designing the system to support such scenarios. For example, consider the course delivery workflow. To support it, the system first needs information about the course syllabus, schedule, and learner profiles. Based on an analysis of the learners' backgrounds, qualifications, and preferred learning styles, the system can produce a suitable mapping between the learners' profiles and course topics. This mapping can be used as the basis for deciding about the teaching approaches and strategies to apply when teaching specific topics. The mapping should clearly indicate feedback points and an estimate of the process feedback rates, as well as requirements and points for assessment and material reinforcement information. In the end, all this information should be represented in terms of the system functionalities, taking into account available resources, teacher's and author's preferences, and so on. This final representation may include teaching alternatives to increase the system's adaptivity.

Education workflow information can be appropriately combined with the system's options for collaborative activities. Typical collaboration options include:

- collaboration among the learners - groupware that facilitates sharing of results, explanations, discussion among remote learners, etc.);
- collaboration among the authors - this often comes in the form of joint courseware development (each author contributes to the part of the course related to his/her domain of expertise); the authoring tools and the educational institution's access to repositories of learning material may reduce effort through reuse of existing material in new courseware, provided that consistent formats are enforced throughout the institution's courseware;

- collaboration among educational institutions through *virtual laboratories* - access to and sharing of special, expensive state-of-the-art facilities (e.g., remote electron-microscope labs and similar applications), online experiments, and simulations developed by different educational institutions and made accessible to other institutions or remote groups of learners.

4.2 Quality-of-service in WBE

In learner-centered WBE systems, quality-of-service (QoS) can be measured in terms of quality of the educational content, quality of the system's pedagogy, and quality of the technological framework (including educational paradigm support and networks) (Vouk et al., 1999).

Quality of educational content. Intuitively, learners will more frequently want to access good-quality educational material than poor one, and will have better understanding of the topics covered by high-quality material. In order to assure wide acceptance of educational material by different students, it is necessary to constantly evaluate the material and to insist on instructors' and authors' responsibility to constantly update the material according to the evaluation results.

Typical measures of quality of educational content in learner-oriented workflows include quality of lessons, appropriateness of the teaching/learning paradigm, quality of user-system interactions, semantic interoperability, and so on.

High-quality WBE systems also support rapid integration of new developments and research results in the fields they cover into their curricula. To achieve that, the instructors must keep up-to-date with the latest advances in rapidly changing fields and collaborate intensively with authors and system developers, so that they can update the courseware in a timely way. Research in rapidly changing domains (such as genetics and computing) is very intense, hence courseware updates must be frequent in spite of geographical, institutional, and other dispersion of researchers, all categories of WBE users, and educational institutions. The key to achieving such a high level of QoS is intensive network-based collaboration between researchers and the WBE instructors, authors, and students.

Quality of pedagogy. Good pedagogy of learner-centered teaching means adaptation to the learners' individual and group needs, learning goals, and preferred learning styles, in order to increase learning efficiency. To this end, a WBE system must have some means of measuring learning and providing adaptive feedback to the learner in terms of the pace and depth of the presented material. The adaptive feedback should result from the learner's observed interaction with the system and from the system's estimate of the knowledge transfer rate specific to the particular learner. The system typically observes the learner's interaction during tests, problem solving, question/answer sessions, and explanation requests/generation.

In addition, learner-centered WBE systems must support using different benchmarks and measurements for evaluation of teaching and learning effectiveness, as well as evaluation of educational paradigms, with respect to knowledge transfer, retention rates, assessment statistics, graduation rates, and other related metrics.

Quality of technological framework. True, content and pedagogy may be thought of as central to the learning efficiency, but the quality of the technology involved *does* matter. Attractive technology may be a driving force in the initial acceptance of a WBE system, and vice versa - poor technology and low performance of the system may frustrate the learners and drive them away.

Much of the metrics used to qualify the QoS of the technological framework applied in a WBE system are related to the network. Traditionally, they include the network bandwidth the system requires to operate at a certain level of performance, keystroke delays, end-to-end response delay, probability of loss of data, jitter, and throughput. These are objective measures. Other metrics involve subjective factors, e.g., the system's availability, reliability performance, scalability, and effectiveness, as perceived by the learners.

One of the frequently used approaches to adaptation of a WBE system to different network access conditions at learners' sites is to provide different representations of the same content and let the learners configure the system's presentation facilities to match their situation. The representations to consider range from simple text-based ones that sacrifice much of the richer HCI capabilities for the sake of quicker response times, to bandwith-greedy representations like rich animations and video.

It is crucial to the system's success to maintain direct communication lines for learners' feedback and error reporting, as well as to provide rapid and timely response to their feedback. Another important QoS issue here is centralized maintenance and system-wide synchronization of content and software. Master storage and version history of educational content should be a must.

Finally, there are a number of issues related to security and privacy. To name but a few, note that administration of remote assessment, electronic cheating and copying of homework and assignments, and letting only the right student know his/her grades without revealing that information to the others, must be considered in WBE with extreme care.

5. INTELLIGENCE AND ADAPTIVITY

Two effective ways of improving QoS of a WBE system are to introduce intelligence in the system and to make it adaptive to individual learner's needs and interactions. Introducing intelligence in WBE comes in the form of synergy between WBE and the more traditional field of intelligent tutoring systems. Achieving WBE system's adaptivity leads to an intersection of WBE with the field of adaptive hypermedia systems, and the result is called adaptive educational hypermedia systems.

5.1 Intelligent tutoring systems

Intelligent tutoring systems (*ITSs*), or *intelligent educational systems* (*IESs*), use methods and techniques of *artificial intelligence* (*AI*) to improve the processes of computer-based teaching and learning.

5.1.1 Architecture

Figure 1-4 shows traditional organization of an ITS, discussed extensively in (Wenger, 1987). *Domain* or *instructional content* of an ITS (specifying what to teach) is referred to as *Expert Module*, whereas different *teaching strategies* (specifying how to teach) from the *Pedagogical Module* drive the teaching/learning sessions. The purpose of the *Student Model* (or *Learner Model*) is modeling the student's mastery of the topics being taught, in order to dynamically adapt the process of instruction to the student. ITSs can support *individual learning*, where one human student learns from the artificial *tutor* (the three modules just mentioned) and all the communication goes through the *Interface Module*. Others support *collaborative learning*, by enabling multiple students to learn from the system as a group, interacting both with the system and among themselves. There can also be one or more *learning companions* in the system. These are artificial co-learners, programs that learn from the tutor (using machine learning techniques and simulated knowledge acquisition) the same topics as the student does, providing competition, assistance, and further motivation to the student. All ITSs use various *knowledge representation* and *reasoning* techniques from AI. *ITS shells* and *authoring tools* are integrated software environments that support development of the actual systems (Devedžić, 2003a; 2003b).

The Student Model is typically an *overlay model*, which means a vector of numerical values each one denoting the level of mastery of a single topic or concept from the domain model. Numerical values correspond to a certain scale, the highest value on the scale representing the expert level (complete mastery). The values get constantly updated as the student continues to learn from the system, to reflect the changes in his/her knowledge and learning. Alternatively, the Student Model can be organized as a set of *stereotypes*, each one defined as a fixed vector of numerical values. The system then categorizes each student into one from the predefined finite set of stereotypes (e.g., novice, advanced, expert, and so on).

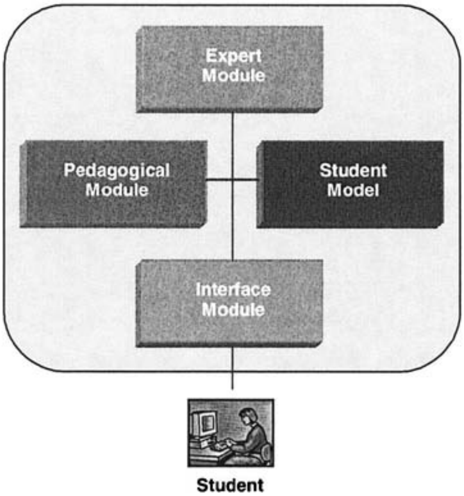


Figure 1-4. Traditional ITS architecture

From the perspective of learner-centered design and increased learning efficiency as an ultimate goal of ITSs, it is important to stress tight relation between the Student Model component and the personalization of the learning process. The Student Model stores all the necessary parameters about the specific student, such as his/her learning goals, learning history, learning style and other preferences, current level of topic/course mastery, and the like. It enables personalization of learning-material presentation and adaptive, learner-centered individualization of the learning process.

5.1.2 Instructional design

An important component of ITS engineering is *instructional design*. Instructional design comprises applying a set of principles to achieve effective, efficient, and relevant instruction. It usually includes five phases: analysis, design, development, implementation, and evaluation. In the context of ITSs, instructional design encompasses the theory and practice of design, development, utilization, management and evaluation of processes and resources for learning, as well as building them into intelligent learning environments (Devedžić, 2003a; 2003b). Instructional design issues affect the design of all four major components of an ITS shown in Figure 1-4.

The ultimate goal of instructional design in ITSs is to achieve a desired level of the learner's performance. The performance should be measurable.

For a good starting point in looking for comprehensive theoretical sources of instructional design, see (Ryder, 2005). A good glossary of instructional design can be found at (ID Glossary, 2005).

5.1.3 Web-based ITSs

One of the recent trends in the field of ITSs is development of *Web-based ITSs*. Other trends include simulation-based learning, dialogue modeling for instruction, multimedia support for teaching and learning, open learning environments, and support for life-long learning. There is also a growing attention on educational technology and standardization issues, software engineering of educational applications, pedagogical agents, and virtual reality environments for education. All of these trends clearly overlap with more general WBE approaches and methodology.

Development of Web-based ITSs has started in Mid-1990s. First-wave Web-based ITS like ELM-ART (Brusilovsky et al., 1996) and PAT Online (Ritter, 1997), to name but a few, were followed by a number of other learning environments that used Web technology as means of delivering instruction. More recent Web-based ITSs address other important issues, such as integration with standalone, external, domain-service Web systems (Melis et al., 2001), using standards and practices from international standardization bodies in designing Web-based learning environments (Retalis and Avgeriou, 2002), and architectural design of systems for Web-based teaching and learning (Alpert et al., 1999), (Mitrović and Hausler, 2000). Rebai and de la Passardiere try to capture educational metadata for Web-based learning environments (Rebai and de la Passardiere, 2002).

5.2 Adaptive learning

It is not feasible in conventional WBE to create static learning material that can be read in any arbitrary sequence, because of many interdependences and prerequisite relationships between the course pages (De Bra, 2002). However, *adaptive hypermedia* (*AH*) methods and techniques make it possible to inform learners that certain links lead to material they are not ready for, to suggest visiting pages the learner should consult, or automatically provide additional explanations at the pages the learner visits, in order to scaffold his/her progress. *Adaptive educational* *hypermedia systems* (*AEHSs*) apply different forms of learner models to adapt the content and the links of hypermedia course pages to the learner (Brusilovsky, 1999), (Henze and Nejdl, 2003).

AEHSs support *adaptive learning*, using technology to constantly measure the learner's knowledge and progress in order to adapt learning content delivery, presentation, feedback, assessment, or environment to the learner's needs, pace, preferences, and goals. Such systems make predictions of what the learner needs to attain his/her goals, respond to such needs, allocate resources, implement change, and thus improve personalization of the learning process. The system can be designed to use predictive strategies prior to instruction delivery and learning sessions, during the instruction (based on the learner's interaction), or both.

5.2.1 Adaptive hypermedia

AH systems merge hypermedia with user modeling technology and can be applied in a variety of application areas; however, one dominating area is education (De Bra, 2002).

AH enables overcoming the problem of presenting the same content to different users in the same way, regardless of their different interests, needs, and backgrounds. The AH approach is to maintain a user model for each specific user and to adapt its interaction with the user in different ways according to that model.

AH provides two general categories of adaptation:

- *content adaptation* (Wu et al., 1998), or *adaptive presentation* (Brusilovsky, 1999) - presenting the content in different ways, according to the domain model (concepts, their relationships, prerequisite information, etc.) *and* information from the user model;
- *link adaptation* (Wu et al., 1998), or *adaptive navigation* (Brusilovsky, 1998) - the system modifies the availability and/or appearance of every link that appears on a Web page, in order to show the user whether the link leads to interesting new information, to new information the user is not ready for, or to a page that provides no new knowledge (De Bra, 2002).

There are several techniques for content adaptation. The system may provide explanations using *conditional text* - different segments of text-based explanations are turned on and off and presented to the user as needed, based on whether his/her user model meets some condition(s) or not. Some systems use a variant of conditional text called *stretchtext* - allowing the user access to the portions of explanation estimated to be either beyond his current comprehension or irrelevant/unimportant. The same idea can be applied not only in explanation generation, but also in ordinary presentation of material - the system simply maintains *different versions of pages* it presents to the users (or just *different versions of information fragments* within the pages), and selects the version to show according to the user model. A simple variant can be hiding advanced content from a novice user, or showing suitable additional content to more advanced users. A more sophisticated variant of different fragment presentation includes deciding also on the order of presenting them.

Two most popular forms of adaptive navigation support are link annotation and link hiding. *Link annotation* refers to providing additional information about the page the link leads to, in the form of suitable visual clues such as color, additional text, additional symbol (e.g., bullet or icon), different shape of accompanying symbol (e.g., different bullet style), and blinking, all reflecting current information from the user model. For example, blue-colored links may be used to denote pages for novices, and red-colored ones may lead to pages for advanced users. *Link hiding* makes some links inaccessible or invisible to the user if the system estimates from the user model that such links take him/her to irrelevant information. In addition, an AH system may use *direct guidance* to make the user go exactly to the page the system deems the right one for the next step, or some *global guidance* such as showing the user a list of links for further steps sorted according to some criteria related to the information from the user model. In a more sophisticated variant called *map adaptation* (Wu et al., 1998), the hierarchical structure of links leading to different information is presented to the user in a form more suitable for navigation, such as a table, a tree, or a graphical map.

5.2.2 Adaptive educational hypermedia systems

AEHSs apply AH techniques to WBE systems. The users are now learners, and the adaptation comes at three levels (DeBra et al., 2004):

- *connectivity* - parts of the learning content are interlinked in a number of ways, allowing the learners to navigate it in numerous ways; the AEHS presents different links with different visual indicators of suitability and relevance for the learner, according to his/her learner model;
- *content* - the system shows additional information to the student to compensate for his/her lack of sufficient knowledge (as indicated in the student model), or it hides unnecessary information from the student if it concludes from the student model that the student already knows it and would not benefit from seeing it again;
- *culture* - AEHSs take into account different backgrounds, motivation, preferences, and styles of different learners and adapt the educational tasks to them according to differences in such information.

Adapting from (Brusilovsky, 1999), (De Bra, 2002), (De Bra et al., 2004a; 2004b), and (Wu et al., 1998), one can identify four major components of AEHSs, Figure 1-5[2]. *Domain Model* defines domain concepts and structure and roughly corresponds to the *Expert Module* in the traditional ITS architecture, Figure 1-4. *Student Model* represents the student's characteristics, most importantly his/her levels of knowledge of domain concepts. As with traditional ITS, the Student Model is typically an overlay model or a stereotype model. *Pedagogical Model* defines rules of access to parts of the Domain Model, according to the information from the Student Model. Many pedagogical rules follow directly from the structure of the domain, but many also come from the system's instructional design.

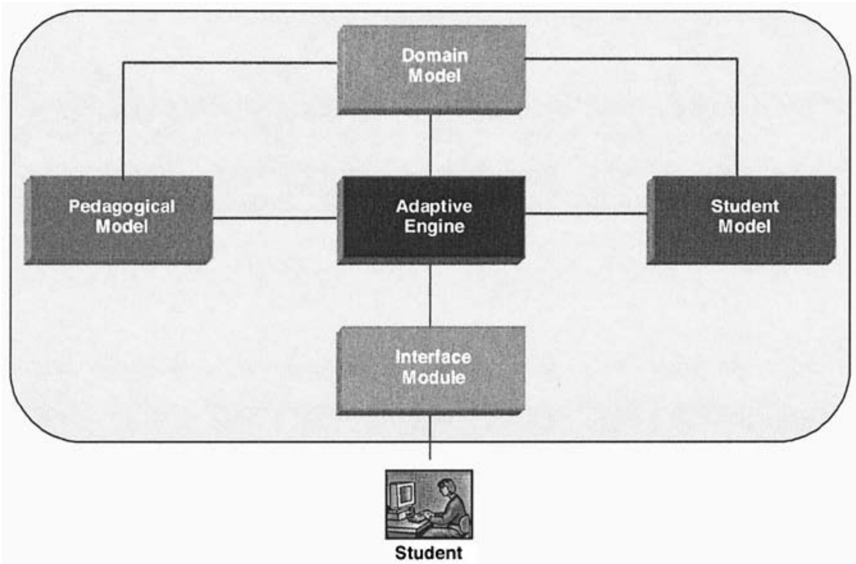


Figure 1-5. Simplified generic architecture of AEHSs

The distinctive feature of each AEHS is its *Adaptive Engine*. In reality, it is usually not just an engine, but an entire software environment for creating and adapting domain concepts and links. During the system operation, the adaptation mechanism itself uses information from the other modules to select, annotate, and present content to the user adaptively.

Obviously, AEHSs rely heavily on student modeling. Research and development of student models is one of the most important topics in adaptive WBE.

[2] The figure is shown in a simplified form for the sake of functional clarity; in reality, additional components exist to reflect the distributed nature of AEHSs.

6. SUMMARY

WBE is an important and fast growing segment of educational technology. It largely overlaps with the field of e-Learning, but it must be noted that learning represents only one aspect of education. WBE covers many other educational services, such as teaching, authoring, assessment, collaboration, and so on. Nowadays, most of distance education is implemented as WBE and use of virtual classrooms.

There is a lot of technological issues involved there, but it must be never forgotten that the ultimate goal of WBE is increasing the learning opportunities and efficiency, not the technology itself. In learner-centered design of WBE, educational workflows determine desired functionalities of WBE systems and quality of service provided to the learners is crucial to success or failure of any such a system.

Two important ways of increasing the quality of service of WBE systems and thus the likelihood of their success are to make them intelligent and adaptive. Intelligent tutoring systems already have a long tradition and recently often make a synergy with WBE. Adaptive educational hypermedia systems use many different techniques to adapt content delivery to individual learners according to their learning characteristics, preferences, styles, and goals.

However, there are several problems with WBE that both teachers and learners face (Devedžić, 2003a). Educational material on the Web is still highly unstructured, heterogeneous, and distributed as everything else on the Web, and current learning and authoring tools offer limited support for accessing and processing such material. The main burden of organizing and linking the learning contents on the Web, as well as extracting and interpreting them, is on the human user.

Next-generation WBE applications should exhibit more theory- and content-oriented intelligence and adaptivity, pay more attention to interoperability, reusability, and knowledge sharing issues, and look more closely to general trends in Web development. New fields of research and development, such as Semantic Web and Web intelligence, provide means for representing, organizing, and interconnecting knowledge of human educators in a machine-understandable and machine-processable form, as well as for creating intelligent Web-based services for teachers and learners. The following chapters discuss extensively how to use the results and technology of these other fields to make WBE more effective and more appealing to learners, teachers, and authors alike. Specifically, the chapters that follow introduce Semantic Web technologies and explain common prerequisites for creating *intelligent* WBE systems and applications. They also describe the kinds of intelligent WBE services that such systems should support and how to ensure for such support. They attempt to answer many practical questions of both engineering and instructional importance. For example, how can a search engine from the sea of educational Web pages select automatically those of most value to the authors, teachers, and learners in pursuing their educational goals?

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