Web-Based Learning Environments: Current Pedagogical and Technological State

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Abstract

The Web is a firmly established, though virtual, reality. Educators, well aware of the potential of the technology, have adopted it for creating new Web-based learning environments. This article presents a study of the characteristics of Web sites as teaching and learning environments. The major questions addressed in this study were:

1. *What characterizes educational Web sites at the content, teaching, learning, and communication levels?*
2. *How do key teaching and learning issues appearing on educational Web sites relate to educators' expectations from the new technology?*
3. *What can a consideration of the current state of affairs teach us about further development and implementation of educational Web sites?*

To answer these questions we developed a classification scheme (the Taxonomy of WBLE); implemented it for the study of 436 educational Web sites focusing on mathematics, science, and technology learning; and elaborated on practical implications of the study's results. The overall picture we have unveiled may sound disappointing, and it can be summarized as "one step ahead for the technology, two steps back for the pedagogy." But a thoughtful discussion of the results suggests directions for the research and development of novel Web-based educational models. Results indicate that many educational Web sites are still predominantly text-based and do not yet exhibit evidence of current pedagogical approaches (e.g., use of inquiry-based activities, application of constructivist learning principles, and use of alternative evaluation methods). Suggestions for future WBLE development are provided. (Keywords: distance learning, Web site classification and evaluation, Web-based learning environments.)

The World Wide Web is currently a firmly established, though virtual, reality. A few years after its impressive breakthrough, from limited professional circles to everyone's working and social life, the Web constitutes an additional space in which people can communicate, work, trade, or spend leisure time. And increasingly, too, it is a place to learn (Berenfeld, 1996; Khan, 1997). This article presents a study of the characteristics of Web sites as teaching and learning environments.

Educators (teachers, developers, researchers, students), well aware of the potential of Web technology, have adopted it for creating new learning environments, thus yielding a huge repertoire of educational Web sites. The rationale behind this creative endeavor is the expectation that unique features of the technology (e.g., powerful information manipulation tools and communication means) will substantially contribute to the teaching and learning processes. Let us briefly review some salient technological features, relevant to educational processes.

The first and obvious key feature of the Web is the support for sophisticated *manipulation of information*. Information manipulation functions (e.g., generating, transmitting, storing, processing, and retrieving information) are at the heart of educational transactions. The possibilities of contributing to or of gaining access to online libraries, databases, journals, museums, and other public information repositories on the Internet may therefore qualitatively affect education.

The Web serves increasingly as a *communication facilitator*. Computer-mediated communication (CMC) is a powerful interaction medium (e.g., e-mail, group conferencing, and Internet Relay Chat), that enables students to communicate with peers, teachers, and experts and conduct collaborative work (Berge & Collins, 1995; Harasim, Hiltz, Teles, & Turoff, 1995).

The Web is also increasingly becoming a *creation environment*. Many user-friendly tools for the creation of Web-deliverable materials are currently available. These tools may support students' creativity and initiative, allowing them to generate and publish their own educational Web sites without mediators and with minimal technical assistance.

Finally, the Web also serves as an *instructional delivery medium*. Numerous Web sites provide digital educational activities and network-based courses for all grade levels in a large number of subjects (Hackbarth, 1997; Khan, 1997). The conception of the Web as a learning environment is instantiated in varied forms, from online versions of traditional CAI to innovative individual and group virtual-learning modes, such as the Virtual High School (http://vhs.concord.org) and the World Lecture Hall (www.utexas.edu/world/lecture).

Within the global network, already many Web-based learning environments (WBLEs) have been developed. These WBLEs reflect educators' attempts to wrap together knowledge in specific content areas and the above-mentioned technological features, in pursuit of learning goals. WBLEs differ from each other in many aspects, including the following:

- the identities of their originators (e.g., teachers, students, development centers, research centers)
- their goals
- their target populations
- the developers' pedagogical conceptions and beliefs, which are either explicitly stated or implicitly embedded in the site's design
- the configuration of technological features (e.g., communication tools and information resources)

An obvious outcome of this state of affairs is the high variability and the uneven educational value and quality that characterizes the growing aggregate of educational sites.

Given the continuous increase in quantity, the diversification in quality, and the high level of expectations in the educational community regarding the educational potential of the Web, we have reached a stage at which a mapping of the WBLE landscape is required. Regarding this need, the major questions addressed in this study were:

- What characterizes educational Web sites at the content, teaching, learning and communication levels? (detailed mapping of relevant features)
- What are the key teaching and learning issues appearing on educational Web sites in correspondence with the educators' expectations? (overall analysis and evaluation of trends and solutions)
- What can a consideration of the current state of affairs teach us about further development and implementation of educational Web sites? (practical implications and conclusions)

To answer these questions we developed a classification scheme, the Taxonomy of WBLE (Nachmias, Mioduser, Oren, & Lahav, 1999); implemented it for the study of 436 educational Web sites focusing on mathematics, science, and technology learning; and elaborated on the practical implications of the study's results. In the following sections, we briefly describe our classification scheme, present the study and its findings, and discuss these results and suggest directions for the further development of WBLE.

A TAXONOMY OF WBLE

For this study, we developed a practical tool for describing the complexity of the educational kaleidoscope that has been generated by the Web. Our taxonomy continues a research focus of the systematic analyses and evaluation of technology-based learning materials extending from the early years of computer-based instruction (cf., Blease, 1986; Shuell & Shueckler, 1989) to more recent work on Web-based instruction (cf., Berenfeld, 1996; December, 1998; Khan, 1998). It also addresses the accumulated experience and knowledge of the field of instructional design (cf., Dick, 1996; Gagné, Briggs, & Wagner, 1992). The taxonomy is a classification scheme reflecting the developers' educational philosophies by revealing how different functionalities are configured, knowledge is structured and represented, and communication features are implemented. (For a more detailed description of related work and the background for the development of the taxonomy see Nachmias et al., 1999.) Our taxonomy characterizes an educational Web site by approximately 100 variables in four main dimensions: basic descriptive information, pedagogical and educational considerations, knowledge attributes, and communication features.

The Descriptive Dimension

This dimension includes basic information regarding the location, creators, target population and relevant technical data of a site. The information is organized into six categories:

1. *site identification* (e.g., name, URL, authors, affiliation—academic institution, public organization, government authority, private company, school—and status as teacher or student)
2. *site evolution* (e.g., creation date, last updating, and sections under development)
3. *language* or languages used in the site
4. *target population*

5. *size*, indicated by the number of HTML pages
6. *subject matter*

The Pedagogical Dimension

The variables in this dimension unveil the developers' stance regarding the type of instruction elicited by their site (e.g., target learning processes, instructional configuration and means, collaborative work, feedback, and assessment). The variables in this dimension are organized in to the following 10 categories:

- *instructional configuration*, (e.g., Web-only resources or links to additional external resources)
- *instructional model* (e.g., directed and hierarchically organized, inquiry oriented, and open-ended)
- *instructional means* (e.g., hypermedia databases, virtual 3-D environments, online student modeling, and adaptive mechanisms)
- *interaction type* (e.g., browsing, answering questions, performing simple or complex activities, using online tools, and interacting with experts or peers)
- *cognitive process* elicited (e.g., plain information retrieval, complex processing of varied types of information, problem solving, and creative activity or invention)
- *locus of control* over the learning process
- *feedback* (e.g., automatic evaluation answers; and human expert's response, either synchronic or asynchronous)
- *help functions* offered in the site
- *learning resources* either embedded in the site's design or external physical and human resources
- *evaluation* (e.g., from standardized tests to alternative evaluation)

The Knowledge Dimension

This dimension relates to qualitative and structural issues concerning the site's knowledge and support for knowledge navigation. This dimension comprises the following four categories of variables:

- *representational structure*, aiming to identify the organizational template underlying the knowledge stratum (e.g., linear, branching, or Web structure)
- *representational means* (e.g., text, still image, dynamic image, interactive image, and sound; the frequencies of their respective uses in a site)
- *type of knowledge* (e.g., declarative, procedural, dynamic/systemic models of phenomena or systems, and continuously updated)
- *navigation tools* (e.g., thematic indexes, image maps, time lines, iconic directional pointers, search facilities, and location maps)

The Communication Dimension

Networking, by definition, implies communication—people's interaction with knowledge, other people, or both. The fourth dimension of the taxonomy relates to communication features in the following four categories:

- *types of telelearning*, focusing on the different shapes of distance learning using technology may take (e.g., tele-information handling, teleinteraction, telemanipulation, and telecreation)
- *types of communication* (e.g., synchronous and asynchronous)
- *link structure* of the site (e.g., hypertext links within the site and links to other sites, to other sites' databases, to non-Web tools and activities, to virtual reality environments, or to humans)
- *communication means* (e.g., e-mail, discussion group with or without moderators, chat facilities, videoconference capabilities, and MOO/MUD features).

METHOD

Sample

Because the defining properties of educational Web sites—their educational aims and features, structural attributes or boundaries and size—are still loosely defined and open to many interpretations, a random sample of Web sites was selected. Five evaluators were chosen as research assistants for this project. All five were students in the graduate communication and computers in education program at Tel-Aviv University's School of Education. All five students had a scientific background: one held a degree in physics, two in computer science, one in biology, and one in mathematics. All were science educators at the time, and all had taken graduate courses on educational use of computers and communication systems.

Each of the evaluators was assigned to find 100 educational Web sites. They were instructed to select Web sites that met the following criteria: (1) the site was deliberately developed for educational purposes, and (2) the site was clearly focused and identifiable as a specific instructional unit (e.g., by its focus on a specific topic or on a specific learning task). The first criterion means that although any site in the Web can be used as a resource for learning, only the sites explicitly defined by their developers as pursuing educational goals were selected. The second criterion was defined to avoid the selection of megasites—that is, Web sites that are in fact umbrella sites or general access sites to conglomerates of educational projects or Web pages. In addition, the content area for the selection of the sites for the present study was circumscribed to mathematics, science, and technology education. Neither the language of the Web site nor the age level of the target population were criteria for selection.

Each of the five evaluators was instructed to look for approximately 100 Web sites either by browsing or using search engines. All evaluators' sets were integrated into a common list that was screened for duplicates and approved by the senior research team. Of the 524 sites initially selected, 436 were included in the final sample (www.tau.ac.il/~ktltau/wbl/wbl_data.html). Sample selection took place in March 1998.

Characterization of the Selected Web Sites

Each of the five evaluators was assigned approximately 90 randomly selected Web sites to be characterized according to the WBLE Taxonomy previously described (Nachmias et al., 1999). To maximize the common framework of analysis, all researchers attended several meetings during which the taxonomy was discussed and experimentally applied to some Web sites. The evaluation process was carried out during April and May 1998. By June 1998, the database of 436 Web sites was completed.

Database Validation

To assess the validity of the database, a sample of approximately 25% of the Web sites was analyzed once again by a different evaluator. As a result, five variables (out of the 110 variables of the taxonomy) were excluded from subsequent data analysis. All other variables met the criterion of at least 90% match between evaluators and were therefore regarded as valid. This stage was completed by the end of June 1998.

RESULTS

The Descriptive Dimension

Table 1 presents basic descriptive information about the Web sites in our study. Academic institutions and museums are the main contributors of educational Web sites in our sample (approximately one-third of the sites each). Public organizations, private companies, and varied educational agents are among the generators of the remaining third. It should be noted that these figures do not necessarily represent the actual distribution of educational sites by their originators but the biased distribution resulting from our sampling procedure.

Table 1. Basic Description of Web Sites (*N* = 436)

		n	Percent
Site creators	Academic institution	152	34.8
	Public organization	40	9.2
	Private company	73	16.7
	Museum	145	33.3
	Education factors	26	6.0
Language	English	388	89.0
	Hebrew	53	12.2
	Arabic	2	0.5
Target population	Kindergarten	4	0.9
	Elementary school	92	21.1
	High school	270	61.9
	College or university	61	14.0
	Further education	9	2.1
Site size (HTML pages)	1–3	135	31.0
	4–10	66	15.1
	11–30	91	20.9
	31–70	64	14.7
	more than 70	80	18.3

Approximately 90% of the sites in our sample were in English, the dominant language of the Web, with approximately 12% in Hebrew and some in Arabic, representing Israel's languages.

Sixty-two percent of the sites were aimed at the upper elementary level, 22% at the elementary level, and the remaining 16% at higher education.

Data about the number of HTML pages per site showed that approximately one-third of the Web sites were small (1–3 pages), one-third were medium size (4–30 pages), and the remaining were large (more than 30 pages). Given that one of the selection criteria was the site's topical focus, the size of the Web site might be an indicator of the extensiveness and complexity of the specific topic.

The evolution of the Web sites is described in Table 2. The date of creation was available for approximately 60% of the sites. A clear trend can be observed in pace of growth from 1993 to date. From year to year the number of sites increased by a factor of 2–3. Thus, most sites in our sample were created within the last two years. Data about the last update showed that approximately half of the Web sites were updated by their authors within six months preceding the review, and approximately 42% had not been updated for more than a year. Only a few sites (8.5%) were still under development.

Table 2. Sites' Evolution in Terms of Creation, Update, and Completion Time

		n	Percent
Year of Creation	1993	3	0.7
	1994	11	2.5
	1995	22	5.1
	1996	62	14.2
	1997	151	34.6
	1998	8	1.8
	Not available	179	41.1
Last Update	More than a year ago	183	42.0
	8 months	27	6.2
	6 months	39	8.9
	4 months	82	18.8
	2 months	105	24.1
Completion	Completed	399	91.5
	Under construction	37	8.5

Table 3 shows the distribution of sites by subject matter issues. Given that our sample refers only to mathematics, science, and technology sites, the table shows that all major science disciplines are represented, and that most Web sites deal with biology, physics, or mathematics topics. Three-quarters of the sites deal with one subject area only; approximately one-quarter of the sites was multidisciplinary.

The Pedagogical Dimension

Table 4 focuses on the pedagogical features of the Web sites. More than 93% of the sites support individual work. Less than 3% support online collaborative

Table 3. Distribution of Web Sites by Subject Matter

		n	Percent
Discipline	Biology	110	25.2
	Physics	146	33.5
	Mathematics	98	24.6
	Chemistry	28	6.4
	Technology	54	12.4
	Earth science	40	9.2
	Computer science	10	2.3
	Astronomy	30	6.9
	Other	66	15.1
Multidisciplinary	One discipline	331	75.9
	Two disciplines	63	14.4
	Three disciplines	19	4.4
	More than three	15	3.5

* *Percentages add up to more than 100% because some sites dealt with more than one discipline.*

work, and 12% include learning activities that suggest classroom collaborative work as supplements to the online work.

Analysis of the instructional models embedded in the sites shows that a traditional, hierarchical, highly structured, and directed instruction mode still prevails. Only 28% of the sites support inquiry-based learning.

Web technology offers a wide range of possibilities regarding instructional means. Data show that the most frequent means implemented are informational (65%) and structured activities (48%). Open-ended activities, tools, and virtual environments are included in approximately 7%–13% of the sites. Very few sites include online adaptive mechanisms.

Interactivity could be considered one of the major potential contributions of digital technology to instruction. The data show that the lowest level of interaction according to our scale, namely browsing, is also the most frequent (76%). In approximately one-third of the sites, question-and-answer tasks were included. Simple interactions, in which clicking or dragging objects on the screen activated a predetermined script, appeared in approximately 42% of the sites. More complex interactions (e.g., manipulation of a number of variables) or use of online tools were included in 3%–7% of the Web sites. Interaction with other people (e.g., expert or peers), mainly asynchronous, was found only in 13% of the Web sites. Feedback features (either automatic or human) are included in only a small number of the sites, with this being far below their presence in pre-Web digital learning materials (cf. Azevedo & Bernard, 1995; Cohen, 1985; Cyboran, 1995). Help features were found at three levels: technical help (e.g., installation of required fonts or plug-ins) were found in 21% of the sites, contextualized content help (e.g., glossary or translation) in 25%, and didactic help (e.g., explanations and examples) in 17%.

The most frequent cognitive processes elicited by the activities were information retrieval (52%) and memorizing (42%). Information analysis and

Table 4. Number of Sites That Include Instructional and Learning Variables

		n	Percent
Instructional configuration	Individualized instruction	407	93.3
	Classroom collaborative learning	54	12.4
	Web collaborative learning	12	2.8
Instructional model	Directed	330	75.7
	Inquiry based	123	28.2
Instructional means	Information base	283	64.9
	Tools	56	12.8
	Structured activity	21	48.4
	Open-ended activity	43	9.9
	Virtual environment	30	6.9
	Student modeling/adaptive mechanism	9	2.1
Interaction type	Browsing	333	76.4
	Multiple choice question	137	31.4
	Simple activity	185	42.4
	Complex activity	13	3.0
	Online tool	28	6.4
	Expert consultation	58	13.3
Cognitive process	Information retrieval	229	52.5
	Memorizing	183	42.0
	Information analysis and inferencing	142	32.6
	Problem solving and decision making	22	5.0
	Creation and invention	20	4.6
Locus of control	Student controlled	377	86.5
	Software environment controlled	77	17.7
	Mixed initiative	26	6.0
Feedback	Automatic	71	16.3
	Human asynchronous	17	3.9
	Human synchronous	7	1.6
Help functions	Technical help	91	20.9
	Contextualized content help	152	34.9
	Didactic help	73	16.7
Learning resources	Resources within the Web site	363	83.3
	Linked Web resources	135	31.0
	Additional external resources	93	21.3
	External resources only	4	0.9
	Real-time data collection	6	1.4
	Ask an expert	38	8.7
	Ask a peer	17	3.9
Evaluation	Standardized tests	29	6.7
	Alternative evaluation	7	1.6

inferencing were supported by activities in approximately one-third of the sites. Only a few sites support higher-level processes such as problem solving or creation and invention.

Students' control over their work is supported in 86% of the sites. However, this figure should be considered in relation to the finding that the most frequent interaction mode in the sites is browsing, meaning that student's locus of control consists primarily of navigating through the Web pages.

Educational Web sites can be considered as a bundle of varied representational and pedagogical resources. In this category of the taxonomy, we looked for the different types of resources in the sites, and whether these were constrained to Web resources or complemented classroom resources. We found that 83% of the sites rely on resources within the site, only 31% provide links to other Web resources, and 22% refer the learners to additional external resources— that is, those in which the Web site is only one component of the learning environment. Very few sites refer to experts and peers, either online or offline, as learning resources.

Evaluation means, either standardized or alternative, are rare in educational Web sites.

The Knowledge Dimension

Web sites are, above all, repositories of knowledge. In our analysis of the knowledge dimension of educational sites, we looked at features such as representational structure, representational means, or navigation tools. The representational structure of the knowledge in the Web sites can be of various types: isolated units (one-page sites, 23%), linear sequences of Web pages (16%), branching structure (31%), or network structure (30%). These figures show that in less than one-third of the sites, knowledge is represented in a network-like structure that is generally claimed to be the quintessential representational template of the Web.

The great majority of the sites presented declarative knowledge (92%). Procedural knowledge appeared in 20% of the sites, and qualitative knowledge in only 7%. Only a few sites (4%) offered support for the knowledge to be expanded by the learners.

Table 5 shows the frequency distribution of representational means in the Web sites. As could be expected, text is the dominant information conveyor in the Web. Visual means (e.g., images, photos, and illustrations) are less frequent, but were still included in approximately 60% of the Web sites at least once per page. Approximately 15% of the sites do not include any visual information. Interactive images, sound effects, and real-time data updating were rarely found (1%–4% of the sites). Animation, mainly adornments in the form of visual image loops, appeared at least once in almost 20% of the sites.

Frequency of appearance of navigation tools is presented in Table 6. The most frequent support means for navigation within a Web site is indexing (approximately 70% in the home page as links to other pages in the site, 20% as links within the page, and 30% as visual indexes or content bars), resembling the traditional orientation means of the print technology. Surprisingly, sophisticated navigation tools more suitable to the Web environment (e.g., image maps or search engines) appeared in only a relatively small number of sites.

Table 5. Distribution of Sites by Representational Means

	Not at all		Once in the Site		50% of Pages in the Site		One Per Page		More than One	
	n	Percent	*n*	Percent	*n*	Percent	*n*	Percent	*n*	Percent
Text	2	0.5	0	0	3	0.7	24	5.5	407	93.3
Image	63	14.5	64	14.7	55	12.6	117	26.8	137	31.4
Interactive image	419	96.1	10	2.3	1	0.2	1	0.2	5	1.2
Animation	357	81.9	35	8.0	18	4.1	18	4.1	8	1.9
Sound	426	97.7	6	1.4	1	0.2	2	0.5	1	0.2
Real-time updating	431	98.9	0	0	3	0.7	1	0.2	1	0.2

Table 6. Presence of Various Navigation Tools in the Web Sites

	n	Percent
Index in home page	307	70.4
Local page indexing	82	18.8
Content bar	131	30.0
Tool bar	9	2.1
Time line	5	1.1
Alphabetical bar	15	3.4
Image map	28	6.4
Permanent frame index	34	7.8
Internal search engine	38	8.7
Knowledge map	29	6.7

The Communication Dimension

Unique features of Web technology that may contribute the most to educational processes are those related to communication with distant knowledge and people (e.g., peers and experts). Table 7 shows the frequency of inclusion of varied communication means. By far the most frequent tool is e-mail (65% of the sites). Only some of the means supporting group interactions are included, and these are found in a few sites (e.g., discussion groups or chat—approximately 2%–4%), while others are not supported at all (e.g., MOO/MUD environments and videoconferencing). Distance work (e.g., teleoperation and telecreation) is supported in less than 2% of the sites.

Because of the popularity of chat environments and online multi-user games among school-age Web users, we expected to find a great deal of support for synchronic activities. However, only approximately 4% of the sites provided any kind of synchronous activities.

Table 7. Presence of Various Communication Means in the Web Sites

Communication Type	n	Percent
Synchronous activities	17	3.9
Communication means		
E-mail	283	64.9
Discussion group without mediator	15	3.4
Discussion group with mediator	10	2.3
Chat	8	1.8
MOO/MUD	0	0
Videoconference	0	0
Telemanipulation	1	0.2
Telecreation	7	1.6

Another defining feature of the Web is the network of links enabling the user to navigate both within the site as well as to other sites (Table 8). Approximately two-thirds of the sites included links among pages in at least half of the pages. Only approximately one-quarter of the Web sites included links to other Web sites in at least half of their pages, while 58% of the sites did not have any links to other Web sites.

Table 8. Configuration of Links in the Web Sites

	Not at all		Once in the Site		50% of Pages in the Site		One Per Page		More than One	
	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent
Within	116	26.6	32	7.3	20	4.6	50	11.5	218	50.0
External	253	58.0	68	15.6	37	8.5	32	7.3	46	10.6

External Link Statistics

Links to	n	Percent
External databases	74	17.0
External tools	12	2.8
External activities	42	9.6
Virtual reality devices	8	1.8
Human communication	25	5.7

An analysis of the kind of external resources toward which the users are directed shows that approximately 17% refer to external databases, approximately 10% to external activities pages, and a few more to various other resources (e.g., virtual reality environments and human resources).

We looked for the differential presence of selected properties (or variables) in sites aimed at different age levels and created by different developers. Table 9 shows the results of the cross-tabulation of selected variables by target population. The population levels considered were elementary (K–6; 96 sites in our data set); secondary, comprising junior high and high school (270 sites); and higher education (70 sites). This indicates that for the sampled sites, most development efforts in the K–12 range are directed toward the upper-elementary grade levels.

Table 9. Cross-Tabulation of Selected Variables by Target Population

	K–6 (n = 96)	High School (n = 270)	College or University (n = 70)	Mean (n = 436)	χ^2
Classroom collaborative learning	10.4%	15.9%	1.4%	12.4%	11.20 **
Web collaborative learning	0%	4.4%	0%	2.8%	7.58 *
Inquiry-based activity	20.8%	34.4%	14.3%	28.2%	14.46 **
Open-ended activity	6.25%	11.1%	10%	9.9%	1.88
Complex activity	2.0%	4.0%	0%	3.0%	3.53
Online tool	3.1%	6.2%	11.4%	6.4%	4.66
Expert consultation	8.3%	14.0%	17.1%	13.3%	3.08
Problem solving and decision making	1.0%	5.5%	8.5%	5.0%	5.17
Creation and invention	3.1%	4.4%	7.1%	4.6%	1.52
Automatic feedback	9.3%	16.6%	24.2%	16.3%	6.67 *
Human asynchronous feedback	0%	5.9%	1.43%	3.9%	7.99 *
Human synchronous feedback	0%	2.2%	1.43%	1.6%	2.23
Technical help	16.6%	20%	30%	20.9%	4.68
Contextualized content help	34.3%	35.5%	31.4%	34.9%	0.50
Didactic help	15.6%	18.5%	11.4%	16.7%	2.11
Evaluation: standardized tests	3.1%	6.3%	12.8%	6.7%	6.31 *
Evaluation: alternative evaluation	1%	1.8%	1.4%	1.6%	0.31
Index in home page	66.6%	69.2%	80%	70.4%	3.91
Content bar	30.2%	29.6%	31.4%	30%	0.09
Image map	5.2%	7.4%	4.3%	6.4%	1.20
Synchronous activities	2%	3.3%	8.6%	3.9%	5.15
E-mail	61.4%	65.5%	67.1%	64.9%	0.70
Discussion group without mediator	1%	5.2%	0%	3.4%	6.63 *
Discussion group with mediator	0%	3.7%	0%	2.3%	6.29 *
Links within the site	63.5%	65.2%	72.9%	66.1%	1.80
Links to external sites	25%	24.8%	34.3%	26.4%	2.68

*p < .05. **p < .01.

Of the small percentage of Web sites fostering any form of collaborative learning, most are targeted at the high school level–in fact, they were all targeted at this level. Similarly, the largest number of inquiry-focused sites targets the same age level. And the largest number of sites including evaluation means, mainly in the form of standardized tests, belonged to the higher education level. Conversely, a very low (or even null) level of collaborative work, discussion groups, or human-based feedback was found at this level of Web sites.

Of similar interest are the results related to variables for which no difference was found among sites aimed at different population groups. No difference was found regarding:

- most instructional modes (e.g., open-ended, problem-solving, and creation activities)
- instructional means (e.g., online tools, technical, contextualized or didactic help, and expert consultation)
- navigation aids (e.g., index, content bar, and image map)
- or configuration of the information (e.g., links within the site or to external resources).

These findings are particularly interesting considering our expectation that different needs and requirements at each age level would demand different instructional solutions.

Table 10 (pp. 69–70) shows the cross-tabulation of the same set of variables by Web site source or developers. The majority of sites in our sample were by academic institutions and museums. Different types of institutions act according to different goals and beliefs regarding their educational roles, and it could be expected that these differences would find their way into the design of the Web sites. The picture resulting from our data is not clearly consistent. In 11 out of 26 variables, significant differences among the developers were found. For 10 of these variables, the largest number of sites containing the given feature was generated by *academic institutions* (e.g., automatic feedback, contextual help, index-type navigation aid, and moderated discussion groups) and by *public organizations* (e.g., Web-based collaborative learning, open-ended activities, human asynchronous feedback, standardized tests, discussion-groups without moderator, and wide linkage to external sites).

The features mostly included in sites generated by *private companies* were different types of help (e.g., expert consultation and technical and contextual help), proven navigation aids (e.g., content page and content bar), and a fairly rich linkage structure. The features mostly included in *museum*-generated sites seem to be in line with the expected characteristics of educational activities in museum environments (e.g., collaborative, inquiry-based, and problem-solving activities; contextual help; and links within the site).

DISCUSSION

Web technology's transition from its early rudimentary stages to the current "everyone-can-do-it" stage, generated high expectations among educators. These expectations relate to the Web's potential effect on educational processes in three main domains by fostering

Table 10. Cross-Tabulation of Selected Variables by Site Developer

	Academic Organization (n = 152)	Public Organization (n = 40)	Private Company (n = 73)	Museum (n = 145)	Education/ Other (n = 26)	Mean (n = 436)	χ^2
Class collaborative learning	10.5%	10.2%	10%	17.2%	0%	12.4%	7.44
Web collaborative learning	5.2%	7.5%	1.38%	0%	0%	2.8%	12.30*
Inquiry-based activity	28.9%	25%	20.5%	33.8%	19.2%	28.2%	5.62
Open-ended activity	14.5%	27.5%	2.7%	4.8%	3.8%	9.9%	26.99**
Complex activity	2.6%	5%	5.5%	1.4%	3.8%	3.0%	3.55
Online tool	9.2%	10%	5.5%	2.7%	7.7%	6.4%	6.23
Expert consultation	17.1%	12.5%	21.9%	2.8%	26.9%	13.3%	24.78**
Problem solving and decision making	8.5%	7.5%	4.1%	13.8%	3.8%	5.0%	8.68
Creation and invention	3.9%	10%	8.2%	2%	3.8%	4.6%	7.15
Automatic feedback	30.2%	10%	12.3%	6.2%	11.5%	16.3%	35.01**
Human asynchronous feedback	6.5%	12.5%	0%	1.4%	0%	3.9%	17.28**
Human synchronous feedback	2.6%	5%	1.3%	0%	0%	1.6%	6.74
Technical help	23%	20%	23.2%	18.6%	1.5%	20.9%	1.62

Table 10, cont.

	Academic Organization (n = 152)	Public Organization (n = 40)	Private Company (n = 73)	Museum (n = 145)	Education/ Other (n = 26)	Mean (n = 436)	χ^2
Context content help	42.8%	40%	35.6%	24.8%	34.6%	34.9%	11.09*
Didactic help	16.4%	12.5%	13.7%	20%	15.4%	16.7%	2.14
Evaluation: standardized tests	10.5%	12.5%	6.8%	6.9%	7.7%	6.7%	14.22**
Evaluation: alternative evaluation	1.3%	5%	2.7%	6.9%	0%	1.6%	4.78
Index in home page	79.6%	75%	72.6%	60%	61.5%	70.4%	15.26**
Content bar	30.2%	45%	28.7%	28.2%	19.2%	30%	5.97
Image map	7.9%	12.5%	4.1%	5.5%	0%	6.4%	5.63
Synchronous activities	7.2%	5%	1.4%	1.4%	3.8%	3.9%	8.35
E-mail	71%	70%	56%	60%	73%	64.9%	7.72
Discussion group without mediator	6.6%	7.5%	1.4%	0.7%	0%	3.4%	11.66*
Discussion group with mediator	5.3%	5%	0%	0%	0%	2.3%	13.01*
Links within the site	66.4%	67.5%	68.5%	65.5%	57.7%	66.1%	1.07
Links to external sites	27.6%	47.5%	19.2%	24.8%	15.4%	26.4%	13.05*

*$p < .05$. **$p < .01$.

- new pedagogical forms emerging out of unique features of the technology (a "Webagogy"?)
- improved information organization, representation, and handling capabilities
- enhanced communication processes among students and teachers and support for collaborative learning

Our aim in this study was to assess the extent to which educational Web sites—that is, sites deliberately developed for educational purposes—realize the potential and fulfill the expectations. Accordingly, in the following sections of the discussion we elaborate on the study results in these three domains.

Pedagogical Characteristics of WBLEs

Current pedagogical approaches support learning processes that require the students' active involvement in the construction of knowledge (Kafai & Resnick, 1996), their interaction with peers and experts (e.g., collaborative learning, distributed cognition [Perkins, 1993], and scaffolding [Vygotzky, 1978]), the adaptation of instruction to individual needs (Reuser, 1996), and new ways to assess students' knowledge and learning (Mioduser, Venezky, & Gong, 1998). Our expectation was that the development process of educational Web sites would be based on these approaches. Moreover, given the innovative character of the technology, it could be expected that it would give rise to new pedagogical forms and instructional strategies. Notwithstanding, the results indicate that this is not the case. Only 28.2% of the sites include inquiry-based activities, and more than three-quarters were highly structured, placing control over the learning process mainly with the computer. Most sites elicit cognitive processes such as information retrieval (52.5%) or rote learning (42%), fewer focus on analysis and inference processes (32.6%), and even fewer on problem solving and decision making (5%). Only a small number of sites include student modeling and adaptation mechanisms. Considering the fact that network technologies appear to be an ideal milieu for the implementation of collaborative work, it was highly disappointing to find that only 2.8% of the sites support any form of collaborative learning. These results conclusively show that the pedagogical approaches favored by educators and researchers for the development of valuable learning environments are still far from being implemented in most educational Web sites.

For the configuration of instructional modes and means offered by educational Web sites, once again expectations exceed the actual state of affairs. The gap is most evident if we consider the accomplishments reached within the field of digital technology in education in its previous form, namely nonnetworked instructional software. Regarding interaction types, we found that most sites include browsing (76.4%) or simple forms of interaction (42.4%), and few sites offer complex (3%) or even online (6.4%) activities. Few sites include any form of feedback, either automatic (16.3%) or human (5.5%). Most sites offer resources and means related to information handling (65%). Only a few offer the student online tools (12.8%) or resources external to the site itself such as links to other sites (31%) or experts (8.7%).

Pre-Web educational materials offer fascinating examples of the multiple ways by which educators succeeded in harnessing the new technologies to educational needs and goals (e.g., constructivist environments, intelligent tutoring systems, and sophisticated multimedia learning environments). Against this rich background, and looking at pedagogical qualities and resources, the vast majority of educational Web sites prove to be the unripe fruits of the promising but still immature Web technology.

Information Representation and Handling

Web technology is doubtlessly at its best concerning all functions related to the representation, organization and manipulation of information. The process initiated several decades ago with the massive eruption of radio, television, and cinema technologies is reaching impressive achievements with current digital imaging and integrated media technologies. In cultural terms, the visual world (e.g., still images, icons, video clips, animated graphics, and movies) in its linguistic status has reentered the scene, in stronger presence and meaning than in its pre-Gutenberg incarnation. High-level and sophisticated integrated media is perhaps one of the defining characteristics of Web sites today.

Our results show that regarding their information representation and handling qualities, educational Web sites lag behind state-of-the-art sites (it should be noted that we are not interested in educators' technical—and even pyrotechnical—use of imaging technology, but only in their use of visual languages). The vast majority of sites are still heavily based on text (93% of the sites include more than one text field in all their pages). Approximately 58% of the sites include at least one image per page; most sites do not include interactive images (96.1%), animated images (81.9%), or sound.

Regarding structure and organization of knowledge, the Web is the realization of a well-defined model: the hypertext (or hypermedia) model (Negroponte, 1995). Nonlinear structure, complex linkage within and between information units, and appropriate navigation and search tools are defining features of this model. Our results reveal only a shallow presence of these features in the evaluated Web sites. Only approximately half of the sites included within-the-site links to a reasonable extent (more than one link per page), and approximately 11% of the sites refer to other sites (external links) to a similar extent.

A great deal of theoretical and empirical work has been done regarding curricular issues within the context of the print technology (e.g., West, Farmer, & Wolff, 1991). Do these curricular models fit the features, possibilities and constraints of the new technology? For example, should curricular principles related to scope and sequence of content and activities developed for linear technology be adapted to the hyperlinked nature of Web technology? The intuitive answer is that curricular theory should be revised and perhaps expanded in light of these new features. Perhaps a convincing illustration can be found in the results regarding navigation tools in the evaluated Web sites. Most sites include indexes (70%), several more contain content bars (30%), and only a few contain more sophisticated tools such as image maps, knowledge maps, or internal search engines. Both structure and orientation aids in most sites are reminiscent of curricular solutions that were devised for the previous (print) technology.

Communication

The Internet is more than an information environment. Perhaps its foremost function is to serve as a multifaceted environment for communication (Mitchell, 1995). A considerable number of communication modes and tools are offered to the users (e.g., e-mail, data transfer, discussion groups, and synchronous video and audio support for collaborative work). This technological infrastructure has great potential for the development of unique learning transactions and modes (e.g., collaborative learning among students in distant locations and implementation of the apprenticeship model by involving students and experts in network-supported group work).

The results of this study show that most Web sites used only limited communication resources. The most (and almost sole) present resource in the sites is e-mail (approximately 65% of the sites). Other tools such as discussion groups, chat, or any form of distant work (e.g., telemanipulation and telecreation) were found only in a few sites. Moreover, features aimed at supporting working groups or learning communities were not found in any of the evaluated sites. The gap between expectations and actual implementation is even more evident in the communication domain than in the domains previously discussed: the technological resources exist, and they are being successfully implemented in other areas of people's life (e.g., work, professional training, banking, and shopping). In addition, human transactions and transactions between humans and information resources are quintessential to education, and it is not hard to conceive endless forms of support that communication technology could offer for these processes. Today, this support is not yet a function in most educational Web sites.

CONCLUSIONS

One step ahead for the technology, two steps back for the pedagogy. This statement seems to depict the pattern affecting educators' assimilation of new technologies for the past few decades. This phenomenon is not unique to education. The effects of the interplay between technological innovations and humans has been a topic of study both at the individual (e.g., cognitive processes and attitudes) and the social (e.g., cultural transformations) levels (cf. Ihde,1990; McLuhan, 1964; Negroponte, 1995; Olson, 1976; Salomon, Perkins, & Globerson, 1991). In the early 1920s, Ogburn (1964) coined the term *cultural lag* to refer to the differential reaction of distinct groups or parts of a culture to innovations and changes. Facing the advent of a technological innovation, different populations react at different paces and adopt different attitudes. The assimilation process of the innovation then proceeds through various transition stages. Successful assimilation will depend on the individual's increase of awareness to the relevance of the essential features of the new technology to his or her life (e.g., work, learning, and leisure time) as well as on the development of appropriate social constructs (e.g., at the economical or cultural levels). History-of-technology textbooks frequently quote the examples of the first cars conceived as carriages-without-horses or the first movies as filmed theater plays. Practitioners had to go through a complex maturation process until new languages and unique qualities were developed in manufacturing cars or film making.

As experienced educators we hold substantial models regarding the varied facets of our practice (e.g., how to build a lesson plan, assess a learner's performance or behavior, and develop a learning unit). These models are usually tied to the (technological) resources at hand, and they affect each other mutually. It seems reasonable to assume that when facing the assimilation of a new technology we use these models as input to the process. The result is usually a transition period during which the known models are replicated by means of the new technology. When first assimilating computer technology, developers replicated the programmed instruction paradigm (Garner, 1966) by means of the new technology, initially in the form of electronic worksheets and booklets, which evolved in time into sophisticated drill-and-practice and structured-tutoring software (Venezky & Osin, 1991). Our claim is that this study reveals a similar transitional phenomenon regarding the vast majority of educational Web sites. Most sites' main component is the information base built on the hypermedia CD-ROM model (even links to external sites are currently included in many hybrid CD-ROM/Web products). As for interactivity features based on the implementation of new technological resources (e.g., forms, Java applets, and Shockwave), most online activities resemble the automatic-feedback (behaviorist-like) transactions of classic CAI (e.g., multiple choice, select the correct part, and assemble the correct configuration).

In light of these results, one can adopt the skeptics' perspective and argue that Web technology has little to offer education. But, adopting a more thoughtful perspective, one may alternatively reflect on the character of this transitional stage and generate new possible models and trends based on substantial educational needs.

We are members of the community of educators who deal with the problems involved in the assimilation of Web technology to education (Mioduser, & Oren, 1998; Nachmias, Mioduser, & Shemla, 2000). Although in this study we have referred to the educational Web sites population in quantitative terms, we are aware that a number of fascinating sites of high pedagogical quality exist on the Web. But our main purpose in this study, rather than to focus on the exceptions, was to map and learn the current trends of available resources for educators and learners. Based on these findings, the next steps should focus on the research and development of novel Web-based educational models (Windschite, 1998) and on the implementation of a revised configuration of the technology-assimilation evolutionary loop: two steps ahead for the pedagogy/technology, one step back for reflection and mindful planning of subsequent steps. ■

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