WEB-SITE STORY: DESCRIPTIVE AND PROSPECTIVE ANALYSIS OF WEB-BASED LEARNING ENVIRONMENTS

Rafi Nachmias

Tel-Aviv University, School of Education

Tel-Aviv, 69978, Israel

e-mail: nachmias@post.tau.ac.il

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RUNNING HEAD: DESCRIPTIVE AND PROSPECTIVE ANALYSIS OF WBLE

ABSTRACT

Web-based learning environments (WBLE), have emerged as the result of educators' attempts, in the pursuit of learning goals, to wrap together contents, pedagogy, and technological features of the Internet. This article provides an interim summary of a research project aiming to characterize and understand the role of WBLE in education. The article provides (a) a brief description of the project, which included the development of frameworks and tools for characterization, classification and analysis of educational websites, six different empirical studies of more than 1000 educational websites, and four prospective analyses of emerging trends in WBLE; (b) reflections on the methodologies used; (c) selected results and conclusions from the empirical studies which can be summarized as "one step ahead for the technology, two steps back for the pedagogy", and (d) a prospective analysis of trends in terms of their focus on macro, meso and micro level educational issues.

INTRODUCTION

Less than a decade since the inception of the WWW, the Internet has become a prominent space for people to communicate, work, trade or spend leisure time. And increasingly, too, it is a place for learning (Berenfeld, 1996; Khan, 1997; Bonk & Dennen, 2001; Mioduser & Nachmias, 2001). Aware of the potential of the Internet for education, a growing number of educational agents (e.g., universities, schools, community centers, museums, special interest groups, organizations), have entered the community of producers and users of web-based learning materials. web-based learning environments (WBLE), are the result of educators' attempts, in the pursuit of learning goals, to wrap together contents, pedagogy, and technological features of the Internet.

Among the 400 millions users of the Internet (estimate for the end of 2001), many are learners and students. Among the millions of web pages created in the last decade, many have educational purposes. As the educational portion of the web has grown, a variety of models gradually evolved. Many educational websites were designed to serve primarily as information containers. Others are focused on the delivery of instructional materials, creating novel and varied learning configurations (e.g., distributed teamwork, hybrid face to face/distance-learning modes, interactive distance learning). Under the common category of e-learning diverse solutions are grouped, such as on-line courses, virtual schools, and virtual campuses. Other models of using the web in education emphasize school-wide implementation aspects and the facilitation of communication between learners, schools, teachers, etc. A detailed description of a variety of models, along with examples and actual links to illustrative websites is provided elsewhere (e.g., Mioduser & Nachmias, 2001).

This paper presents an interim summary and critical analysis of the rapid and multifaceted development of web-based educational materials, relying on research work being carried out for the last four years in the Knowledge Technology Laboratory (http://muse.tau.ac.il/ktl) of Tel-Aviv University's School of Education.[1] Since 1997 our research group has been dealing with the classification and study of the characteristics of web educational environments, primarily (but not solely) for math and science education. These studies included: (a) the development of classification frameworks and tools for analyzing WBLE (e.g., Nachmias, Mioduser, Oren, & Lahav, 1999; Oren, Nachmias, Mioduser & Lahav 2000; Nachmias & Tuvi, 2001); (b) the analysis of the current state of affairs of WBLE in various subject areas (e.g., Mioduser, Nachmias, Oren, & Lahav, 2000; Gvili, 2000; Tuvi & Nachmias, 2001; Stock, 2001); and (c) the analysis of evolving trends in WBLES design and implementation (e.g., Mioduser, Nachmias, Oren, & Lahav, 1999; Tuvi & Nachmias, in press). After more than four years of research, we feel that time has come for a preliminary recapitulation. In consequence, the following sections of this article present a critical reflection on methodological aspects of the study of WBLE, a summary of the results of our studies, and a depiction of prospective lines of development of WBLE in education as identified in our studies. Our expectation is that this descriptive and prospective analysis will contribute to the dialogue and discussion between researchers, developers and users fostering an improved use of the web in education.

THE SCOPE OF THE WBLE STUDIES

First phase: Rationale and development of instruments

Initially, the project focused on the development the basic framework for characterization, classification and analysis of educational websites. In this phase, a taxonomy of WBLE characteristics and properties was developed. The basic taxonomy consisted of more than one hundred variables in four main dimensions: basic descriptive information (e.g., site ID, updating, population); pedagogical and educational

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[1] *Members of the team are (in alphabetical order): Orly Lahav, David Mioduser, Rafi Nachmias, Avigail Oren, and Inbal Tuvi, as well as the following graduate students: Vered Allisian, Itzak Gvili , Tamar Filip and Edna Stock.*

considerations (e.g., instructional model, interaction, cognitive processes); knowledge attributes (e.g., representational structure, navigation tools); and communication features (e.g., types of telelearning, communication means). For a detailed presentation of the taxonomy's rationale, background and description, refer to Nachmias, Mioduser, Oren & Lahav (1999).

In later stages, this taxonomy was revised according to specific needs. The revisions made were of two kinds: either expansion of the original framework to include additional aspects or to cover new subject areas (e.g., chemistry, history), or transformation of the original framework to deal with novel pedagogical configurations (e.g., virtual educational museums).

An expansion of the original framework is for instance the development of an additional dimension to the taxonomy to assess scientifically oriented educational websites. This dimension is focused on specific aspects such as the use of experiments and models, the inclusion of mathematical descriptions of natural phenomena, or the incorporation of materials based on an interaction of science, technology and society (Nachmias & Tuvi, 2001).

One example of a transformation of the original framework is the Learnet model -a framework for analyzing virtual learning communities. A Learnet is considered as the integration of three components: a virtual community (social dimension), hosted by an appropriate virtual environment (technological dimension), and embodying advanced pedagogical ideas (educational dimension). In the social dimension attributes such as sense of belonging, extent of presence, and status are considered. In the technological dimension the focus is on variables such as immersivity, multi-user options, or the variety of communication means offered. In the pedagogical dimension aspects such as learning configurations, opportunities for peer evaluation or for collaborative work are considered. For a detailed description of the Learnet framework see Oren, Nachmias, Mioduser, & Lahav (2000).

Second phase: WBLE studies

The second phase in the research project focused on the study of the websites as teaching and learning environments, using the instruments previously developed. The major questions addressed in this phase of the study were:

1. What characterizes educational web sites at the content, teaching, learning and communication levels?

2. How do key teaching and learning issues of educational websites relate to educators’ expectations from the new technology?

3. What can a consideration of the current state of affairs teach us about the further development and implementation of educational websites?

To start answering these questions we first applied the earlier developed taxonomy for studying 436 randomly selected educational websites in the subjects of mathematics, science and technology (Mioduser, Nachmias, Oren, & Lahav, 2000). Subsequently, we conducted several additional studies to assess websites on specific domains: chemistry (Tuvi & Nachmias, 2001), geometry (Stock, 2001) and physics (Gvili, 2000). In addition, we conducted a case study on academic virtual learning communities (Oren, Nachmias, Mioduser, & Lahav, 2000), and a study of virtual informal learning environments (e.g., educational museums) on the web (Filip, 2001).

Third phase: Prospective analysis

Whilst the previous phase aimed to map the current state of WBLE, in the third phase an attempt was made to identify promising trends in the educational implementation of the web technology (Mioduser, Nachmias, Oren, & Lahav, 1999). The prospective analysis was done by abstracting and formalizing innovative ideas, didactic solutions and models identified in the surveyed websites (e.g., Tuvi & Nachmias, in press, for sites on chemistry education). The result of this phase was a survey of the key issues on which researchers, developers and practitioners invest their creative efforts, shaping the WBLE R&D agenda.

Table 1 presents the overall WBLE project's research plan, including a list of the tools which were developed, the different studies conducted, as well the prospective analyses performed.

Table1: The WBLE research projects' scope and sequence

Classification tools		
Nachmias et al. (1999)	General Taxonomy of WBLE	
Nachmias & Tuvi (2001)	Classification scheme of the science education aspects	
Oren et al. (2000)	Classification scheme of Virtual Learning Environments	
Empirical Studies	***Domain***	***N of sites***
Mioduser, et al. (2000)	Math, Science & Technology	436
Tuvi & Nachmias (2001)	Structure of the Atom	95
Gvili (2000)	Physics	327
Stock (2001)	Geometry	90
Oren, et. al. (2000)	Virtual learning communities	4 (case studies)
Filip (2001)	Informal learning environments	50
		Total: 1004 Sites
Prospective Analysis		
Mioduser, et al. (1999)	Math, Science & Technology	
Tuvi & Nachmias (in press)	Chemistry	
Oren, et. al. (2000)	Virtual Learning communities	
Filip (2001)	Informal learning environments (e.g., museums)	

REFLECTIONS ON METHODOLOGICAL ISSUES

At the methodological level, the unique properties of the WBLE project presented interesting challenges and dilemmas. Issues such as the very nature of the population of the studies (i.e., websites), the definition of sampling and selection processes (i.e., what is the size and typology of the WBLE population out there on the web?), or the definition of relevant variables for data collection - all these demanded profound elaboration and mindful decision making by the research team. In this section an abridged account of the methodological side of the project is presented and a reflection on some of its shortcomings.

Description of the Methodology

In general terms, the development process of the methodological components of the project comprised the following six stages:

<u>Stage 1: Formulation of the research goals and objectives</u>

The motivation for conducting each study in the project came from two sources. The first was the aspiration, common to all studies, to understand the educational role of the Internet. The second was the particular wish to shed light on a specific educational area (e.g. chemistry education, mathematics education). As a result, two sets of goals were formulated, namely, general (shared) and per-study goals. The latter adjusted to the particulars of the web-entity under scrutiny, e.g., websites in a specific discipline (e.g., physics), or built upon a specific didactic model (e.g., collaborative inquiry).

<u>Stage 2: Development of classification framework and tools</u>

In this stage an analysis and classification scheme was developed according to the requirements and constraints of the general and specific goals, and the web-entity under examination. As described in the scope of the study, first the basic skeleton of a taxonomy was developed comprising variables related to the content, pedagogical, and communication aspects of the websites. This basic instrument evolved, as it was expanded and even transformed to respond to the needs of the different studies.

Stage 3: websites sampling

In all studies, random samples of websites were selected. For a site to be selected it had to respond to two main criteria: (a) the site was deliberately developed for educational purposes; and (b) it could be clearly identified as a focused instructional unit (e.g., by centering on a specific topic, or presenting a specific learning task), and (c) its contents fitted the requirements of the specific study (e.g., Euclidean geometry). The first criterion implied that, although any site in the web could be used as resource for learning, only sites explicitly defined by their developers as pursuing educational goals were selected for this study. The second criterion was defined to avoid the selection of “mega-sites”, i.e., websites that are in fact "umbrella-sites", or general-access-sites to conglomerates of educational projects or web pages.

Stage 4: websites analysis

In this stage the taxonomical instruments were implemented for the analysis of the selected sample of websites. Evaluation was conducted by simultaneous evaluators. Discrepancies among original assessments were solved by an additional evaluator. The creation of the database in each study was concluded when the criterion of at least 90% match between evaluators for all variables was met.

Stage 5: Actual state analysis

The analysis and processing of the data collected led to the mapping of the actual state of affairs in the WBLE landscape, concerning the studies' aspects of interest. Descriptive statistics tools allowed the composition of a profile of each aspect examined, (e.g., the kinds of didactic solutions implemented, the particular treatment of contents, or the use of communication means). Cross-tabulation of the data from the different categories examined provided useful comparisons of websites according to variables such as affiliation of the site developer, population targeted, or subject area.

Stage 6: Prospective analysis

Although the main purpose in all studies was to map the WBLE scene as such, in all cases an additional effort was made to identify specific aspects or exceptional examples of sites which may suggest potential lines of development or emerging trends. Therefore, specific attention was given to exemplary websites in which innovative and interesting ideas appeared (even if in early or raw format), indicating potentially important new educational directions.

Reflections on methodology

I should start by stating that it is not an easy endeavor to assess the state of WBLE at a given point in time. The web is a huge, loosely defined, and complex interlinked information base in continuous, rapid and unpredictable change. web entities are vaguely defined (a web page can include one sentence or a 5,000-word article) and the quality of the contents is uneven. Therefore it is only natural that, as in most educational studies so far, research including the used methodology focuses mainly on individual or exemplary websites. In contrast, the methodology developed for our studies provides a way to learn about WBLE as a whole phenomenon, as the entire space of resources faced by the educational community.

We have had several difficulties in applying this methodology. First, the WBLE population size is unknown (any number between one million and twenty million may be a valid guess). So what should be our sample size if we want to draw general conclusions? The answer to this question came from an unexpected (and pragmatic) direction. Since the analysis process of each and every WBLE by over one hundred variables is a time consuming task, the sample size was determined primarily - by the number of researchers that could be employed. About ten people participated in the research effort, and the number of websites analyzed was about one thousand. The initial assumption that this number would be sufficient for general conclusions was confirmed by the consistency of the results in all studies. For the sake of methodological rigor, these conclusions are considered valid for the point in time every set of data was collected. However, most results regarding many of the variables were surprisingly similar in studies done two years apart. This suggests that notwithstanding the perceived ever-changing nature of the web, in substantial educational aspects the life span of the main findings is considerable.

Do the studied websites represent all sites meeting the three selection criteria? In traditional quantitative studies the issue of representativeness is dealt with by random sampling according to defined criteria. The selection process of educational websites in the present studies was affected by many intervening variables, e.g., researcher's acquaintance with existing sites or portals, the quality of the specific search tools used, or the possibility to objectively state that a site was meeting the expected criteria. The result is that the sample is far from being random. However, it was encouraging that the five researchers who collected the websites in the first study, and who received similar training and used the same tools, came up with different websites. Less than 10% of the websites in the initial set were duplicates.

Finally, it should be noted that the methodology used in this project was intended for the study of the websites as educational entities. No attempt was made to look at students' or teachers' use of the websites. Clearly, the users' perspective (learning and teaching processes with WBLE) is a valuable research topic in its own right (and in fact we are currently engaged with this type of studies), but this is beyond the present scope.

SELECTED RESULTS AND CONCLUSIONS

The transition of web technology from its early, rudimental stages to the current “everyone-can-do-it” situation, has generated high expectations among educators. These expectations relate to the web’s potential impact on educational processes in three main domains: (a) the emergence of new pedagogical forms as a result of the unique features of the technology; (b) the development of improved information organization, representation, and handling capabilities; and (c) the enhancement of communication among students and teachers and support for collaborative learning. A brief summary of the findings of the WBLE studies regarding these three domains is presented in this section.

Pedagogical Characteristics of WBLE

It would be reasonable to expect that evolving educational websites reflect currently accepted pedagogical approaches such as the fostering of students active involvement in the construction of knowledge, their interaction with peers and experts, the adaptation of instruction to individual needs, and new ways to assess students’ knowledge and learning. Moreover, given the innovative character of the technology, new pedagogical forms based on the unique features of the technology could be expected to have arisen.

The results indicate that this is not the case. In the study of 436 websites reported by Mioduser , Nachmias, Oren, and Lahav (2000), only 28% of the sites included 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%) or rote learning (42%), fewer focus on analysis and inference processes (33%) and even less on problem-solving and decision-making (5%). Only some sites include student-modeling and adaptation mechanisms. In addition, and considering the fact that network technologies appear to be an ideal milieu for collaborative work, it is highly disappointing to find that only 3% of the sites support any form of collaborative learning. In the study of 95 websites focusing on atomic structure, hardly any facilitate inquiry-based, or collaborative learning processes. Similar results were consistently obtained in the other studies as well, conclusively showing that the pedagogical approaches favored (in theory) by educators and researchers for the development of valuable learning environments, are still far from being implemented in most educational websites.

Regarding interaction types, we found that most sites include browsing (76%) or simple forms of interaction (42%), and few sites offer complex (3%) or even on-line (6%) interactive activities. Few sites include any form of feedback, either automatically generated (16%) or human (5%). Most sites offer resources and means related to information handling (65%). Only few offer the student online tools (13%) or resources external to the site itself, such as materials in other sites (31%) or expert time (9%).

Pre-web digital educational materials present fascinating examples of the multiple ways educators succeeded in harnessing the new technologies to educational needs and goals (e.g., constructivist environments, intelligent tutoring systems, sophisticated multimedia learning environments). Against this rich background, the vast majority of educational sites at issue here prove to be the unripe yield of the promising but still immature web technology.

Therefore, this first stage in the assimilation process of the new technology by educators could be characterized as 'one step ahead for the technology, two steps back for the pedagogy'. As experienced educators we hold complex models regarding the varied facets of our practice (e.g., how to build a lesson plan, to assess a learner's performance or behavior, to 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 we replicate the known models by means of the new technology. Initially, while still assimilating computer technology, developers replicated the programmed instruction paradigm by means of the new technology, first, in the form of electronic worksheets and booklets which then evolved into sophisticated drill and practice and structured tutoring software (Venezky & Osin, 1991). This study reveals a similar transitional phenomenon regarding the vast majority of educational websites. The main component of most sites is the information base, built upon the hypermedia-CD model (even a feature that can be claimed unique to the web, as is the case with the linkage to external sites, is today included in many hybrid CD-web products). As for interactivity features based on the implementation of new technological resources (e.g., forms, Java applets, Shockwave), most online activities resemble the automatic-feedback (behaviorist-like) transactions of classic CAI (e.g., multiple-choice, select-correct-part, assemble-correct-configuration).

In light of these results one can adopt the skeptics' perspective and argue that web technology has little to offer to education. A more thoughtful perspective though would reflect on the potential outcomes of this transition stage and look for unique examples of emergent (and promising) directions in the research and development of educational websites. Such relevant directions will be briefly discussed to in a later part of this paper.

Information Representation and Handling

In our digital times the visual world (e.g., still images, icons, video-clips, animated graphics. movies) has re-entered the scene more powerfully than ever since pre-Gutenberg times. High-level and sophisticated integrated media is perhaps one of the defining characteristics of state-of-the-art websites today. But again, the present results showed that educational websites lag behind (it should be noted that we are not looking for educators' technical –and even pyrotechnical- use of imaging technology, but after their mindful use of visual languages). The vast majority of sites in our studies are still heavily based on text (over 90% of the sites include more than one text field in all their pages). More than half used still images extensively, and about one fifth of the sites do not include any visual materials. Most sites do not include interactive images (95%), animated images (83%), or sound (97%). It should be noted that in the later studies (e.g., in chemistry and geometry websites studies) showed that a more frequent and extensive use of visuals. However, it is not clear whether this is related to the subject domains or to the lapse of two years.

In terms of structure and organization of knowledge, the web is the realization of the hypertext (or hypermedia) model. Non-linear structure, complex linkage within and between information units, and appropriate navigation and search tools, are defining features of this model. The present results reveal only a shallow presence of these features in the evaluated websites. In the study of 436 websites reported by Mioduser , Nachmias, Oren, and Lahav (2000) only 61% of the sites included within-the-site linkage to a reasonable extent (one link per page and more), and about 18% of the sites referred to other sites (external linkage) at the same extent. In the study of 95 chemistry websites that took place about two years later, the results were similar: 72% and 16% respectively (Tuvi & Nachmias, 2001). In both studies more than half of the sites (58% and 53%) included no external links at all. In summary, the basic defining properties of the technology (e.g., nonlinear structure, hyper links) have still to find their way into most of the learning materials developed for the Internet.

Communications

The results of all studies show that most websites exploited limited communication resources. The most prevalent (and almost sole) resource in the sites is electronic mail (about two-thirds of the sites). Other tools such as discussion groups, chat, or any form of distant work (e.g., tele-manipulation, tele-creation) were found only in a few sites. Moreover, features aimed to support 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 communications domain than in the previously discussed domains. The main reason is that the technological resources do exist and are being successfully implemented in other areas of life (e.g., work, professional training, banking, shopping). In addition, transactions among humans, and 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. As for today's reality, this support is not yet a function in most educational websites.

PROSPECTIVE ANALYSIS OF EMERGING TRENDS

The web is a dynamic environment, with a rapid rate of both growth and decay of websites and web pages. WBLE are not an exception. Many promising educational websites disappeared or linger unmaintained on the web, and many others make their appearance every day, if not every hour. At a growing pace, a great variety of ideas and didactic solutions find their way into the web - from single web pages to complex web-based collaboration projects. Out of this "primordial digital soup" which is in continuous transformation, the present paper tries to sift types of work that represent significant and innovative trends in the educational use of the web. In the following discussion, these trends are elaborated in terms of their focus on macro, meso, and micro level educational issues.

Macro-level trends: models of implementation

The macro-level is concerned with the overall models which are gradually becoming main implementations of the web for teaching and learning. According to one model, the web is conceived as a resource center, or a "digital pedagogical center", encompassing numerous learning units of varied scope and content. Typical examples of this model are websites focusing on learning activities in a particular topic (e.g., embryology for children, http://chickscope.beckman.uiuc.edu/ or on bird migration, http://www.birds.org.il); collections of teaching ideas, aids and demonstration units (e.g., in science and technology, http://www.sln.org), or organized databases (e.g., texts, pictures, video clips) on specific subject areas (e.g., chemistry, http://www.shef.ac.uk/chmistry/web-elements ; or in astronomy : http://education.nasa.gov). This use of the web usually does not pretend to replace, but rather complements, regular classroom activities.

In contrast, a second model gaining growing presence on the web aspires to create an alternative to time and space constrained learning, by offering all-digital and all-communication-based courses. Although it comprises many different modes of work, this approach is usually referred to as the e-learning model. Its main goal is to supply all necessary resources enabling a student to learn a complete course "anywhere at anytime". Nowadays a student can find on the web a wide range of e-learning possibilities, from an individual course on a topic of interest, up to complete degrees with full accreditation granted by recognized educational institutions (e.g., The World Lecture Hall site, http://www.utexas.edu/world/lecture/ ; virtual high school, http://vhs.concord.org).

A third model emphasizes the potential role of computer mediated communication (CMC) as a key resource for the creation of learning communities. A learning community can be defined as a novel educational system based on the combination of three components (Oren, Nachmias, Mioduser, & Lahav, 2000): a virtual community (social dimension), hosted by an appropriate virtual environment (technological dimension), and embodying advanced pedagogical ideas (educational dimension). Detailed analysis of many websites that claim to be learning communities showed that most of these lack the essential features to sustain these claims. However, good examples of educational websites that succeed in realizing the learning communities rationale are gradually emerging (e.g., MATAR a virtual learning community of elementary science teachers in Israel, http://www.matar.ac.il ; Teachers Helping Teachers site, http://www.pacificnet.net/~mandel/). Among the defining features of these websites are: these sites explicitly present the building of a community as a goal; they stand independently (rather than as supplements of real institutions); their structure motivates social immersion; they offer multi-user learning situations; they provide management and moderating functions to support social definitions (e.g., status, roles) and transactions; and they promote learning processes based on members' personal interests, willingness to participate, and motivation to interact with peers, teachers and other knowledge sources.

Finally, a fourth model which should be mentioned is built on the idea of web-based collaborative projects. The core aspect of this model is the collaboration of individuals, groups, even schools, in the planning and implementation of large scale communication-based projects. Examples of these projects are: students from different parts of the world collaboratively work on real-time updated data (e.g., Globe, http://www.globe.gov ; I*earn, http://www.iearn.org/); students from different national, cultural or ethnic groups with an history of conflict elaborate, discuss and advance activities aimed to support mutual comprehension and fruitful collaboration (e.g., SOLAM, http://netdays.org.il/rtf-

2000/p023solamreg.rtf ; Peace Network, http://www.geocities.com/reshetshalom/); students from different geographical locations facing similar environmental or ecological problems work together in search for suitable solutions (e.g., Since Learning Network websites, http://www.sln.org). In this model, the web and its tools serve mainly as the communication platform for project implementation, and as the virtual common space for students to meet, interact, and accomplish the learning tasks.

Meso-level: the organization and delivery of contents

One of the key constructs in education is the curriculum. Far from being unequivocally defined, it relates, nevertheless, exactly to how we define, organize, deliver, and assess the acquisition of learning contents. At the meso-level, the present focus is on emerging perceptions of the curriculum of the digital era.

A great deal of theoretical and practical knowledge has been generated regarding curriculum research and development based on print technology (e.g., see Tyler, 1949, or Jackson, 1992). The shift towards representing and delivering knowledge by means of digital technology (alongside the textbook? Instead of the textbook?) is an unquestionable reality, and it represents profound changes regarding key curricular issues, such as the nature of curricular resources (e.g., from limited-media to multimedia); the knowledge-organizational template (e.g., from linear and hierarchical structure to web-like and multiple-layer structure); the locus of responsibility for the creation of significant curricular packages (e.g., from developer/teacher generation of structured learning units to learners' personal curriculum and ad-hoc chunking of knowledge units).

Considering the principles underlying the print technology curriculum versus the digital technology curriculum, how can we relate the later to the former: natural continuation? gradual evolution? break through? The preliminary answers embodied in current quality websites tend to be instances of pragmatic decision-making rather than of theoretical formulation of new curricular principles. The challenge is thus twofold. First, we should identify, analyze, and categorize these pragmatic solutions as a first step in the definition of a more general body of curricular principles. And we should elaborate, focusing on the unique characteristics of the new technology, on new directions and models which appear to be promising for supporting innovative teaching and learning processes.

Micro-level: specific aspects of learning and teaching on the web

This is a level at which many interesting trends can be seen to evolve. What we have here are not complete models or comprehensive solutions, but emergent lines of development of specific issues which may very well contain the seeds of significant future transformations. These seeds, usually taking the form of a component or feature of an educational website, are various in kind, for example: a particular inquiry learning template, a novel communication configuration, or an audio interface as a learning solution. Many of these early signs of innovation occur on the web all the time. The following examples illustrate these developments in three distinctive areas: visual languages, collaborative learning, and producer-oriented materials.

Visual languages

The use of visual materials to represent aspects of the world, ideas, and emotions has been an essential component of human experience since the beginning of humankind. For several centuries however, the written and printed word have been the main conveyors of information, and the main representational means serving educational purposes as well (Baron, 1997). During this period, images were incorporated in texts mainly for illustration or for ornamental purposes. In the previous century, image-based technologies (e.g., cinema, television), and more recently digital multimedia, brought visual representation back into the centre of the scene with unprecedented strength.

Educational websites play an active role within this trend; the following represent are among the promising developments:

- Comprehensive symbol systems for use in digital learning and working have been developed. These developments include the <u>informal consolidation</u> of conventions as part of the evolving Internet culture (e.g., the adoption of conventions in e-mail and chat environments), or the design of icons for common functions in web pages), as well as the <u>formal definition</u> of complete visual languages for accomplishing programming or design tasks (e.g., icon-based programming).
- The representational resource repertoire is expanding. Visual materials are no longer restricted to still images. Alternative representational forms (e.g.,

static, dynamic, 2D, 3D, pre-made or rendered in real-time) allow learners to access information in ways other than decoding it from still images (e.g., use of scientific visualization tools with real-time data, acting virtually within immersive environments). These alternative forms also contribute dynamic and interactive dimensions to the digital learning environments.

· Cognitive processes based on the use of raw visual materials are encouraged, promoting new forms of visual reasoning (e.g., mental modeling of processes, reasoning with visual metaphors).

· The communication resource universe for learning-disabled persons is expanding. Visual materials, metaphors and languages enable people to use alternative channels (besides the text-only and formal-analytical-only characteristics of the print technology) for learning and working.

Examples of WBLE presenting interesting visual solutions are Knowmagine - A Virtual Knowledge Park of Science Technology and Human Culture, http://muse.tau.ac.il/museum/kc-muse-heb.html (See also Mioduser & Oren, 1998); in one of the San Francisco Museum of Modern Art virtual exhibition http://010101.sfmoma.org or in The Alphabet Superhighway, http://www.ash.udel.edu/ash/ .

Collaborative learning

Undoubtedly one of the defining features of the web technology is that it enables people to interact with (distant repositories of) knowledge as well as with each other - that is in facilitate communication. These two within-group events, knowledge manipulation and interpersonal transaction, were extensively studied in the context of group learning processes (e.g., Sharan, 1994). However, in the context of the web, in contrast to traditional group learning situations, some significant changes take place regarding group functioning. The following are examples:

· Group functioning is not limited by place or time boundaries. The usual face-to-face and simultaneous action characterising group work does no longer exist.

- Group members can assume varied roles and even (in less formally defined situations) varied identities according to changing situations.
- Interpersonal transactions are mediated by the technology (e.g., massive use of writing and other symbolic resources).
- In activities involving asynchronous work, members' participation proceeds by stages which may be separated in time: reading, elaboration, production, delivery, feedback supply or feedback recollection stages. A crucial implication is that a member's input to the group's work can be elaborated without the pressing immediacy or demands so typical to real-time face-to-face communication situations. There is opportunity for more reflection, reconsideration and refinement of a learner's contribution to the collaborative task.

Interesting examples of novel collaborative configurations can be found in ThinkQuest, http://www.Thinkquest.org/tq/) for high schools ; or in Nachmias, Mioduser, Oren & Ram, 2000, for higher education.

Producer-oriented materials

Learning materials of the print-technology era, almost by definition, are meant to be consumed. The vast majority of printed learning materials (e.g., textbooks, readers, worksheets) are made for this purpose. The production aspects of learning processes usually occur elsewhere, for example, in the science lab, in the creative workshop, or in the learner's notebook. Digital technologies offer, for the first time, the possibility of an integrated environment, in which the same working space and tools (namely the computer, the web) serve both for consuming ready made materials, and creating new ones. Some interesting websites integrate knowledge creation tasks at different levels. In the very basic cases, the recycling mode, an opportunity is given to use existing materials for the creation of personal versions of a topic. The learner is supplied with tools allowing reorganization and recombination of content components (e.g., a piece of text, a picture, a sound file) in to a personal product. At the other extreme of the continuum, the integrated use of web-page editors, text and image processing tools, presentation software, and search engines, allows the learners to create entirely new materials. By the inclusion of these features, the production/consumption functions as regards the flow of knowledge in the educational process is not longer confined to the traditional "division of labor" between developers/teachers (the producers and deliverers) and students (the consumers).

Examples of websites fostering learners' creation of knowledge can be found in the WISE science curriculum project, http://wise.berkeley.edu/WISE/index.html ; or in innovative schools websites (e.g., an Israeli school in the Arava desert in which students and teacher are creating together websites describing their surrounding http://shaharoot.kfar-olami.org.il).

CONCLUDING REMARKS

The major conclusion of this project is that we are in a time of transition, that the technology in use is far from being definite and stable, and that we are only in the preliminary stages of redefining and devising pedagogical solutions to the appropriate educational implementation of the new technologies. The members of our group feel part of the community of educators dealing with the problematic involved in the assimilation of web technology to education. In this study I have referred to the educational websites population in quantitative terms, as well as to number of examples of high pedagogical-quality sites that already exist on the web. The main purpose of our research project, was to focus on the exceptions as well as to map and learn what most existing sites and current trends, as they are delivered to cyberspace, have to offer to educators and learners. Based on the outcomes of this project and similar studies, the next steps should focus on the research and development of novel web-based educational models (Windschitl, 1998; Dede, 1997). By this, we hope to make two steps ahead for the pedagogy/technology and one step back for reflection and mindful planning of subsequent steps.

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