ABSTRACT
We present a classification of web-based education systems, tools and practices, focusing on the learning process and in particular on what the learner does while learning. The classification is based on six basic functions during the learning process: information storing/retrieving; written expression; communication and publication; experimentation including programming, simulation and virtual reality; administration; and what is today ‘advanced usage’. The paper also presents a brief overview of systems, tools and practices currently used in web-based education, including examples of actual usage characterized according to these learning process functions. Plotting learning functionality requirements vs web-systems functionality provided we can clearly see the needs and opportunities ahead.

KEY WORDS
Distance education, web-based education, classification, systems, tools.

1. Introduction

In this paper we present an overview and classification of the state-of-the-art in web-based education, including systems and tools currently used for web-based education, as well as a presentation of current practices. We treat ‘web-based education’ in the broadest context: ‘Web’ includes a wide range of Information and Communication Technologies (computers, the Internet, email, fora, etc.). ‘Web-Based’ does not imply predominant reliance to the web, -any utilization suffices for inclusion in this survey. Finally, the term ‘education’ encompasses any form of learning, be it formal or informal, organized or not, taking place in any setting, form university or school to home or on the move. On the other hand we restrict our overview to systems in ‘actual use’ meaning real life learning situations to serve numerous students in counterdistinction from ‘proposed’, ‘pilot’ or ‘research’ systems. Our experience in the Hellenic Open University, where web-based education solutions are starting to be deployed to serve approximately 20,000 students [1], has shown that there is an extensive, expensive and risky gap between pilot and large-scale deployment of solutions in real life situations.

What we expect from ‘web-based education’ is:
• Integration of all media in a single one, namely the web. This concept of multimedia –or media-independent- content includes not only present but also any future form of learning objects that can be digitally encoded and electro-optically stored and transmitted.
• Publication and distribution of educational content unhindered from temporal and spatial restrictions and with the cost of a ‘copy’ accessed becoming negligible compared with the value of the learner’s time.
• Individualization as regards to content and process (which is not the same as user-profile based personalization; rather we envisage content and access selected under the learner’s control and corresponding to his individual learning experience)
• Integration of the means for expression, storing, manipulation, communication, publication and dissemination data and information; all these are integrated as orthogonal axes (i.e. independent but interrelated).
• Dynamic content in the sense that it is not read-only for the learner, nor write-once for the author, and is interactive in the deeper sense of being transformed (not necessarily automatically) during and due to the learning process (technologically feasible but educationally very difficult to achieve when applied to non-trivial cases);
• Non-linear content, in that it has been designed for non-linear individual learner traversal. (Content and access related like data and program.)
• Conduciveness to an active learner’s position in the learning process. It accommodates and encourages learners’ activities additional to reading, viewing and listening.

The following text is structured in three sections. Firstly, a brief literature review is presented and a classification of web-based education is proposed. Then, an overview of
web-based education systems, tools and practices based on the proposed classification is provided. Finally, we conclude by spelling out the key points of the paper summarized in a table relating our classification with actual system functionality.

2. Classification of Web-based Education

A classification [2] of education, using the place and time parameters, is shown in Table 1. Our focus is placed on the last column that refers to distance education currently aided by (or based on) web technologies. Since 1874, when the University of the State of Illinois was founded offering correspondence studies, up to date, a number of technological means have aided distance education. Web technologies are not just the latest innovation but a large step forward whose promise will take a long time to be fulfilled in educationally non-trivial ways. This has happened before, when technologies passed by before they could be successfully utilized in education –at least formal education. For instance, radio was an innovative object of transmission of information in the 1930s, while later telephone, television and video were a substitute partially for the lack of communication between teachers and learners.

Table 1. Classification of education

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<th>Same place</th>
<th>Different place</th>
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<tbody>
<tr>
<td>Same time</td>
<td>Traditional</td>
<td>Synchronous</td>
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<tr>
<td>Different time</td>
<td>–</td>
<td>Asynchronous</td>
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It should be mentioned that since as early as 1997, roughly 70% of the certified US colleges offering four-year courses to their students, have added to traditional teaching, courses via the Internet [3]. (This should not be misread to imply that anywhere a comparable percentage of higher education is delivered through the web.) Nowadays, a number of web-based technologies has been proposed and utilized in many universities around the world [4]. Related bibliography includes numerous studies defining the characteristics and classifying web-based education systems [5, 6, 7].

Our classification proposal takes into account a number of attributes of the educational process including the learners, the learning purpose, the technology, the learners’ location, the teachers’ existence and roles, the learning material, etc., but focuses on the learning process and in particular on what the learner does while learning.

Therefore, rather than presenting some e-learning systems categories, we will set out a few basic functions, or attributes, of the learning process. We can characterize each particular case of web-based learning from the way in which it performs these functions, or else by the ‘value’ each of the attributes takes. Each attribute relates to a basic web-based learning function:

1. Using the web as a means for information storing and retrieval. In this case, information includes textbooks available on the web, educational videos and video-lectures (combination of lecturers’ videos with sets of transparencies), digital libraries, museums, etc. Questions related to this attribute are the extent of use, the type of the content, the ability of the content to evolve (versioning) or to be adapted (degree of personalization), the stakeholders and their actions (what the learner or teacher does).

2. Using the web as a means of written expression, where expression includes constructions and experimentation for learners and teachers such as e-whiteboards, shared (or not) web-based notebooks, e-laboratories (that allow the student to participate in experiments through web). Questions related to this attribute are the extent of use, the form of written expression (essays, tests exercises, projects, painting, music, etc.), the extent of the learner’s contribution to the evolvement of the educational content (which may vary from feedback to interactivity), the stakeholders and their actions (what the learner or teacher does).

3. Using the web for communication and publication. This compares to oral communication and includes e-mail, discussion lists and fora, as well as any system or tool that allows the student to publish his opinions on a subject, or to comment. Questions related to this attribute are the extent of use, the type of communication (synchronous, asynchronous), the content of the communication, the availability of this content for later review, the stakeholders and their actions (what the learner or teacher does).

4. Using the web for experimentation including programming, simulation and virtual reality. This includes web-based simulators, programming tools, educational games, virtual laboratories, etc. Questions related to this attribute are the extent of use, the degree of personalization, the collaboration among learners, the type of collaboration, the stakeholders and their actions (what the learner or teacher does).

5. Using the web for administration. This includes any learning management system (LMS), or any system used for administering tests, exams, and the educational process in general.

6. Advanced usage. This category includes all systems that are currently considered as advanced uses of web-based education and do not fit in any of the above 5 categories. Advanced usage of web is expected to change through time as new tools and systems shift from research to practice and networking speed and bandwidth improves. Currently, it includes interactivity of the learning material, personalization of the learning material, individualization of the learning process, allowing advanced learner activities, etc. Questions related to this attribute are the extent of use, the type of usage, the stakeholders and their actions (what the learner or teacher does).
Based on these learning process attributes, in the following section we present an overview of the current systems, tools and practices. For each \{(system | tool | practice), attribute\}, we discuss some of the questions set previously.

3. Overview of Web-based Systems Tools and Practice

In this section we present an overview of the systems, tools and practices of current web-based education, and we discuss how these relate to each of the aforementioned attributes. The order in which the systems, tools and practices are discussed below does not imply any type of strict classification, although it is somehow based on technological complexity.

3.1 E-mail, fora and discussion lists

One of the main communication instruments in today’s distance education is e-mail, which has a high value in attribute 3. E-mail can also be used as a means of written expression. Besides e-mail, the use of fora is also quite common in web-based education. Fora are mainly used for communication and publication, but can also serve as a means of written expression. Figure 1 presents part of a tutor-students discussion related to the 'Introduction to Computer Science Module' of the Hellenic Open University. Finally, discussion lists are quite similar to e-mail and fora.

3.2 Digital textbooks, libraries, galleries and museums

It is common practice among universities to offer online course textbooks (c.f. MIT Open Course Ware at: http://ocw.mit.edu/OcwWeb/). In most cases, such educational content lacks interactivity and is not suitable for distance learning. However, there are cases of truly interactive or personalized textbooks that offer students the means to comment on the textbook, as well as interactive exercises and self-assessment tests. Some even propose suitable study methods based on the student’s scores in the self-assessment tests. Digital textbooks can also be organized using a Learning Content Management System (LMCS) such as Atutor at: http://www.atutor.ca/. All textbooks score high in attribute 1 and, provide that they are truly interactive or personalized, they are also characterized by a high value in attribute 2. Similarly to digital textbooks, digital libraries also score high in attribute 1. Some of the best-known digital libraries are these used by the academic community to publish research results. This kind of use also scores high in attribute 3. Similar characteristics can also be identified in the case of digital galleries – such as the NASA JSC Digital Image Collection at: http://images.jsc.nasa.gov/ that offers 9000 NASA press release photos from the space program– and in the case of digital museums.

3.3 Chat, net-phone and net-meeting

The use of chat (realized, in most cases, with the help of instance messengers) is a well-known communication means in web-based education. Most instance messengers incorporate additional net-phone and net-meeting facilities and can therefore be used for lecturing purposes as well. Such is the case of Buddy Space [8], a tool used in the British Open University (found at: http://kmi.open.ac.uk/projects/buddyspace/), that allows optional maps for geographical & office-plan visualizations, as well as build-in tools for web casts and video communication (see figure 2). All of the above score high in attribute 3.

3.4 Online lectures and web casts

Some universities offer online course lectures to distance students. An example of such lectures is shown in figure 3 that illustrates a screenshot from a lecture in Harvard University. Online lectures are usually quite long and
resemble to traditional university course classes. Usually, online lectures are stored for later review.

3.5 Learning management systems

In our definition of Learning management systems (LMS) we include only the set of tools used solidly for administrational purposes. However, most of the current LMS, apart from enabling management of educational content, also integrate tools that support most of the aforementioned web-based technologies (namely fora, online lectures, virtual classrooms, etc.). Some widely used LMS are the commercial Blackboard (found at: http://www.blackboard.com) and the WebCT (found at: http://www.webct.com), as well the open source Moodle (found at: http://moodle.org/).

3.6 Remote and virtual laboratories

Remote laboratories are laboratories that allow students to participate into a real experiment (an experiment that takes place in an actual laboratory) remotely. In this case, student participation varies from defining a set of parameters and receiving the results to actual remote control of the experiment. Figure 5 shows the entry page (where students log on to participate into an experiment) of the Remote Dynamical Systems Laboratory at Stevens Institute of Technology (http://dynamics.soe.stevens-tech.edu/). Remote laboratories score high in attribute 4, but are also characterized by a value in attribute 6 (depending on their nature) and in attribute 3 (provided that they allow student collaboration and communication).

Web casts constitute an approach similar to online lectures. Web casts are smaller size (normally 5 to 15 minutes) ‘video-lectures’ that combine a series of slides with narration and simple video (showing mostly the speaker). Their goal is to clarify specific points of a course (usually spotted based on student queries) and are made available through the web using streaming video technologies. Figure 4 illustrates an example of a Hellenic Open University web cast. Web casts carry a high value only in attribute 1.

Unlike remote laboratories, virtual ones do not require actual establishments. They simulate laboratories allow students to practice. In most cases, students act individually and are able to simulate (using from simple graphics to virtual reality tools) a real experiment by interacting with the system. Figure 6 illustrates an example from the Virtual Laboratory, Department of Chemistry of the University of Oxford (found at: http://www.chem.ox.ac.uk/vrchemistry/). Such virtual
laboratories score high in attribute 4, as well as in attribute 6 (depending on their complexity).

It should be noted that this category also includes all simple tools (such as a programming tools, compilers, etc.) that allow students to work remotely in a laboratory-like manner. Finally, another tool that is currently used for learning purposes is collaboration games. In such games, students are assigned roles in real life situations and take part remotely. Such tools carry a high value on attribute 4 and a value on 6, depending on their complexity.

3.7 Shared blackboards and virtual space

Shared blackboards have similar functionality to classroom blackboards and enable two or more students to write (either by exchanging a key, or simultaneously). As already mentioned, blackboards are integrated in most LMS and constitute a means of written expression that also allows for student-student collaboration, therefore carries a high value in attributes 2 and 3.

A more complex form of blackboard is the virtual space, a system that enables a number of students to share a common virtual space providing at the same time other communication tools as well. Virtual spaces are usually organized for an explicit learning purpose, i.e. collaborative design. A representative example of such a system is Synergy [9], a peer to peer application that allows students of the Hellenic Open University to manipulate a number of developed diagrams in a shared activity space and to communicate directly through a chat tool, while offering measurements related to the degree of collaboration (for the tutor or the researcher). Figure 7 illustrates the result of the collaboration between two distant partners using Synergy. Virtual spaces carry a high value in attributes 2 and 3, as well as a value in attribute 4 (in cases where programming is involved).

3.8 Virtual classrooms

Virtual classrooms are currently used in distance education to emulate real classroom lectures. In virtual classrooms students log on to the system and attend a lecture, while interacting with the tutor and with each other. Virtual classrooms allow students to interact with the object used (i.e. to write on the slides, to share their computer desktop or view, etc). Virtual classroom courses may be recorded and stored for later review. An example from a virtual classroom lecture in the Hellenic Open University is shown in figure 8. Since virtual classrooms integrate many tools, they carry a value in attributes 1, 2, 4, 6 and a high value in attribute 3.

4. Conclusion

Based on the discussion of Section 3 and the learning process attributes defined in Section 2, Table 2 presents
an overview of the values of each system, tool or practice for each attribute. We have used two values, namely ‘Barely’ and ‘Substantially’ (indicated as ‘B’ and ‘S’), while no value marked means that this system, tool or practice has no significant value for the specific attribute. Value ‘B’ means that this system, tool or practice may or may not carry a value for the specific attribute depending on the technical or application particularities; it may also mean that the system, tool or practice does carry a value although not a very high one. Finally, value ‘S’ means that the primary goal of the system, tool or practice in question fits in the description of the particular attribute.

One conclusion deriving from the discussion in the previous sections is that although there are many systems and tools available, widespread practices still do not exist. Although many education providers offer web-based education to distance learners, few of the aforementioned attributes of the web-based education are fully used in practice. In fact, most education providers focus only on some attributes, for example they use the web as a means for information storing and retrieval, with limited interaction and personalization. The use of these available technologies in a learner-oriented manner will surely facilitate distance education.

Table 2. Overview of web-based systems, tools and practices

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<thead>
<tr>
<th>Systems, Tools &amp; Practices</th>
<th>Attributes</th>
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<tr>
<td>E-mail</td>
<td>B S</td>
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<tr>
<td>Fora</td>
<td>B S</td>
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<tr>
<td>Discussion lists</td>
<td>B S</td>
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<td>Digital textbooks</td>
<td>S B</td>
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<td>Digital libraries</td>
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<td>Digital galleries</td>
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<td>Digital museums</td>
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<td>Chat and instance messengers</td>
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<td>Net-phone</td>
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<td>Net-meeting</td>
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<tr>
<td>Web lectures (online)</td>
<td>B B S</td>
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<tr>
<td>Web casts</td>
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<tr>
<td>Learning management systems</td>
<td>B B B S B</td>
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<tr>
<td>Remote laboratories</td>
<td>B S B</td>
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<tr>
<td>Virtual laboratories</td>
<td>S B</td>
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<tr>
<td>Programming tools</td>
<td>S B</td>
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<tr>
<td>Collaboration games</td>
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<tr>
<td>Shared blackboard</td>
<td>S S B</td>
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<tr>
<td>Virtual space</td>
<td>S S B</td>
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<td>Virtual classrooms</td>
<td>B B S B B</td>
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In conclusion, if the textbook and the lecture have been the main educational instruments for the past three centuries, and if we view the Web as that set of technologies which will give us the chance to extend these instruments in the future in the directions of:
- Dynamic content (not read-only for the learners)
- Continuously developing educational material (not write-once for the authors)
- Non-linear individualized learning experience (through personalized content and differentiated access to it)
- Seamless integrated multimedia
- Interactive educational material in the deep sense of responding to the learning process and developing accordingly
- Unobstructed dissemination of educational material and independence from the need of synchronous presence of learners and teachers

then it is clear to us that we still have a long, fruitful and interesting way to go before educational needs meet the technological opportunities.

References: