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## Advanced Learning Technologies

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# A

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## 2 **Advanced Learning Technologies**

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### 7 **Synonyms**

8 Artificial intelligence in education; Intelligent tutoring  
9 systems; Learning environments; Technology enhanced  
10 learning

### 11 **Definition**

12 Advanced Learning Technologies (ALTs) are artifacts  
13 (*technologies*) that enable, support, or enhance human  
14 *learning*, emerging from the most recent *advances* avail-  
15 able in both areas. There are nowadays two real challenges  
16 to be faced when trying to outline in detail this definition  
17 of ALTs as a meaningful, full-fledged state of the art of the  
18 key concepts for future use, not just an historical overview  
19 of socio-technical approaches. The main technical chal-  
20 lenge is due to the unprecedented speed of innovation  
21 that we notice in Information and Communication Tech-  
22 nologies: ICTs; in particular: the Web. The educational  
23 challenge is a consequence of the technical one.  
24 An account of educational uses of technologies has to  
25 consider the impact of ICT innovation onto unexpected  
26 changes in human practices in any domain, modifying  
27 substantially the classical human learning cycle that since  
28 the nineteenth century was mainly considered to be  
29 managed within formal teaching institutions such as the  
30 schools. Therefore, our interpretation of *advanced* will be  
31 in the sense of *dynamic, experimental, to be implemented*  
32 *and evaluated* in order to limit the risk that what we  
33 describe today as advanced will be considered obsolete in  
34 a few months. This vision of ALTs, however, does not  
35 underestimate the interest for a reasoned analysis of past  
36 experiences. On the one side this analysis will guide us to  
37 avoid well-known pitfalls, on the other it will teach us  
38 lessons not only about how to exploit the potential learn-  
39 ing effects of *current* advanced technologies – the

applicative approach – but also how to envision, elicit, 40  
estimate, evaluate the potential promising effects of *new* 41  
technologies and settings to be studied and developed 42  
within human learning scenarios – the experimental 43  
approach – the last, enabling scientific progress both in 44  
Informatics and in Psychology of human learning. 45

### 46 **Theoretical Background**

Advanced Learning Technologies may be described and 47  
classified according to different criteria, such as their his- 48  
torical development (from the PLATO – TICCIT invest- 49  
ments in the 1960s in the US, to current wikis, semantic 50  
web and social networks) or their links with disciplinary 51  
works (Informatics, Psychology, Pedagogy, etc.). Each and 52  
all these classifications are widely available already (► ITS: 53  
Intelligent Tutoring Systems or ► AI in Ed: Artificial Intel- 54  
ligence in Education or ► IEEE ICALT: International Con- 55  
ference on Advanced Learning Technologies). What seems 56  
to us interesting here is to present a couple of *new* criteria 57  
that may offer a frame of reference for the years to come. 58  
Classification criteria should be now different because we 59  
are facing a totally different world that is globally 60  
connected through the Web where the role of ICTs 61  
becomes primary for science, education, and any socio- 62  
economic domain. In this sense, most of the remarks in 63  
this article are intertwined with the ones in the Web 64  
Science one. The core observation is that on the current 65  
Web, humans are both consumers and producers of Infor- 66  
mation and of Services, i.e., they have a bidirectional 67  
access to the Web. Differently said, the modern Web con- 68  
sists of some billions of machines *and* of connected peo- 69  
ple. In this context, previous definitions are challenged; 70  
for instance the classical distinction between technologies 71  
and humans (artificial and human autonomous agents) 72  
needs to be revisited. 73

Reflecting on each word on turn: let us start with 74  
*Technologies*. It is to be debated if current Information 75  
and Communication Technologies (ICTs) are just tech- 76  
nologies in the traditional term (artificial tools, artifacts 77  
that facilitate the human for the achievement of his/her 78  
goals) or rather, represent the modeling substrate of cur- 79  
rent and future reality. For instance: social networks are 80  
just tools or – by including the millions of humans 81

82 connected – are they a new natural phenomenon, as it is  
83 envisaged in the Web Science view? In the latter hypothe-  
84 sis: where is the equilibrium between a vision such that  
85 humans exploit technologies for their superior needs and  
86 the dual one: technologies influence humans in their  
87 behavior, an issue that may be classified under the topic  
88 of coadaptation? Are these technologies applications of  
89 previously defined principles and design rules or rather  
90 do they emerge as the evolution of a kind of natural  
91 selection process among thousands of options available?

[Aut]

92 In this reflection, the contributions of Eileen Scanlon  
93 and Tim O’Shea (2007) and Marc Eisenstadt (2007) are  
94 a splendid synthesis of the last 40 years of research, devel-  
95 opments, and practical implementations; successes and  
96 failures, directions to go and pitfalls to avoid. The main  
97 conclusions are that *we now have new topologies for learn-*  
98 *ing which have no direct analogues in past educational*  
99 *practice* (Scanlon and O’Shea 2007) . . . and *the essence of*  
100 *the problem is that new-tech disguising old ideas is almost*  
101 *certainly doomed to failure. Learning Management Systems*  
102 *and Learning Objects, for example, despite the noble inten-*  
103 *tions of many protagonists, can in fact conceal*  
104 *neobehaviourist drill-and-practice thinking* (Eisenstadt  
105 2007).

106 The subsequent word to be examined is *advanced*. This  
107 is rather self-explaining; however, the meaning of the word  
108 concerns more likely the exploratory nature of the infra-  
109 structures, tools, and practical implementations that one  
110 wishes to consider for enabling, supporting, or enhancing  
111 human learning. The issue is not so superficial, knowing  
112 that often people do not consider that the introduction of  
113 technologies in human life, particularly in Education or  
114 Learning, implies a profound modification of the human  
115 behavior. In principle, radical changes are regarded with  
116 suspect by the key actors. In our case, students (learners)  
117 are usually ready to accept, while teachers and adminis-  
118 trators resist to the introduction of changes as most pro-  
119 fessionals often do with respect to innovation (other  
120 historical examples being technologies for health or for  
121 the legal professions). Therefore, *advanced* suggests a life  
122 cycle of innovation that cares for an experimental part:  
123 similar to a spiral (software development) approach based  
124 on trial and error as opposed to the waterfall one, in order  
125 to *motivate and convince* the actors of their own interest to  
126 adopt changes in their practice. No major change in the  
127 work practice will ever occur if it is not preceded by an  
128 experimentation that puts the actors and their motivation  
129 and awareness at the center of the implementation itself.  
130 Some authors even reverse the argumentation by propos-  
131 ing to exploit the proactivity of humans in open partici-  
132 patory learning infrastructures – *serendipitous mashups*

133 *foster creative integration* (Eisenstadt 2007). Anyway, the  
134 classical concepts of ICT products optimizing the acqui-  
135 sition of knowledge and skills by interactive training are  
136 challenged by more modern concepts of peer-to-peer ser-  
137 vices adapting to the partner’s needs and collaborating in  
138 social networks in order to facilitate learning. More often  
139 as before, those modern socio-technical scenarios enable  
140 human learning that otherwise would be impossible to  
141 conceive, so that the administrator’s right question  
142 becomes more *what would happen if we do not use tech-*  
143 *nologies for learning* as the traditional question: *why should*  
144 *we use them?*

145 Thirdly, we are interested in *learning technologies* in the  
146 sense of human learning. However, we know very little  
147 about human learning. The relation teaching-learning  
148 (effects of teaching) is not always clear (see, e.g., *the no*  
149 *significant difference phenomenon* Web site: [http://www.](http://www.nosignificantdifference.org/)  
150 [nosignificantdifference.org/](http://www.nosignificantdifference.org/)). We are facing a kind of  
151 dichotomy between a natural process (human learning)  
152 and the practice supposed to facilitate it (teaching). The  
153 opposition is similar to the one of biology versus medi-  
154 cine: practicing medicine is not worth unless the patient is  
155 healed. Similarly, the only interest of teaching is in its  
156 effects: that learners indeed learn. Medicine is an art  
157 while biology is a natural science; we will never better  
158 our practices in medicine unless we better understand  
159 the underlying biological phenomena concerned. For  
160 those reasons, it is important to admit that technologies  
161 for teaching do not necessarily imply better or different  
162 learning. A vision of human learning may have  
163 a substantial influence on the priorities to attribute to  
164 the development of technologies for learning, the most  
165 radical difference being the one between behaviorism,  
166 constructivism and social constructivism which are  
167 treated extensively elsewhere in this encyclopedia.

## 168 **Important Scientific Research and Open** 169 **Questions**

170 The most important scientific research question concerns  
171 which discipline profits from the success of the interdis-  
172 ciplinary projects in ALTs. These profit from disciplinary  
173 competences of humans, and may produce advances in  
174 each discipline but in quite different proportions  
175 according to the choices made in the goals, plans etc.,  
176 adopted for the research process. In making progress in  
177 ALT, does one produce advances in understanding learn-  
178 ing, thus improving as a side-effect teaching practices, or  
179 rather the technologies experimentally developed in edu-  
180 cational or learning scenarios are significant for progress  
181 in Informatics? One of the most interesting paradigm  
182 shifts in current Web Technologies and Web Science is

183 that new usage-centered business processes do require to  
184 introduce interoperability among machines and people  
185 but reuse old technologies. Another is that social software  
186 success is hardly to be forecasted and may not be stable,  
187 will rather be dynamic, evolving, and volatile. So it is the  
188 case for the learning effect of informal learning situations  
189 such as those offered by the Web. The acceptance is also  
190 variable with the age: digital natives behave differently as  
191 digital immigrants independently from their role of stu-  
192 dents, teachers, or administrators. Within this totally new  
193 framework, the real open question concerns what are the  
194 established principles that we may assume as valid and  
195 how to progress.

196 For instance, in the Bioinformatics of genome it is well  
197 known that the main effect is a progress in understanding  
198 the genome; minor effects though exists in the availability  
199 of efficient algorithms for generic purposes (advances in  
200 Informatics). The opposite case considers the business  
201 domain (human learning in our case) as a *scenario* for  
202 the elicitation of new ideas (not as an application  
203 domain): an example being the seminal work done by  
204 Alan Kay around the Dynabook as well as Smalltalk in  
205 the early 1970s. Fundamental advances in Informatics  
206 research (the personal computer, the first real object ori-  
207 ented programming language, the window interface, the  
208 integrated environment including the language and the  
209 interface, etc.) emerged from observations about the needs  
210 of children (the dynamic book; the small talk for small  
211 children) with an enormous impact in the 40 following  
212 years. Similarly, the PLATO system conceived in the 1960s  
213 by Don Bitzer and Paul Tenczar for military and educa-  
214 tional purposes was a precursor of many currently  
215 used generic interactive technologies: the PLASMA flat  
216  $512 \times 512$  dot graphic display with images superimposed  
217 projected from a microfiche of color slides; an operating  
218 system with a kind of virtualization of student's variables,  
219 enabling in the 1970s the remote access of up to 1,000  
220 simultaneous users, the TERM-TALK option for chatting,  
221 the interactive TUTOR programming language that later  
222 became TENCORE for PCs, etc. On the opposite side,  
223 TICCIT was an early example of pure exploitation of the  
224 television for distance education with no real ambitions of  
225 advances in technologies.

226 In the case of ALTs, the most important advances  
227 concerned with modeling human learning have been  
228 obtained as a consequence of the need to tune (or adapt)  
229 interactions to individual learners. As Artificial Intelli-  
230 gence has demonstrated, modeling complex natural phe-  
231 nomena implies understanding them better. In the case of  
232 learner modeling, it means understanding better human  
233 learning. The domain of learner modeling, opened by the

234 foundational work of John Self (1974) has been at the core  
235 of years of quite profound research of generic impact for  
236 human-computer interaction, where models have  
237 represented human competence, human skills and, more  
238 recently, human emotions and personality traits. Adapt-  
239 able interfaces are now among the top priorities of any  
240 modern ICT application.

241 However, the fundamental question on ALTs still  
242 remains, after more than 50 years of research and practice.  
243 The question is if ALTs are concerned with a more efficient  
244 production of teaching material by using technologies, as  
245 it was the case for the CAI (Computer-Assisted Instruc-  
246 tion or its synonyms) that basically attempt to mimic the  
247 schoolteacher in transmitting content and examining the  
248 acquisition of the subject matter, or rather are called for  
249 stimulating learning by dialogue and interaction in any  
250 area (learning environments), such as it is the case for  
251 (serious) games, social networks, communities where  
252 learning may occur as a side effect of social interaction.  
253 In order to have once more a direct answer, one may refer  
254 to the arguments of one of the pioneers: John Seely Brown.  
255 Related to this question, the distinction is sometimes  
256 made between formal and informal learning. In the first  
257 case, today's focus is ontologies (the intensional represen-  
258 tation of concepts and relations for reasoning, problem  
259 solving, and search), instructional design and experiments  
260 on the learning effects due to teaching strategies. In the  
261 second case the issues are interaction design, dialogue  
262 management and the evaluation of the success by other  
263 parameters such as motivation, implication in social net-  
264 works, and professional impact of the actors. It is certain  
265 that both approaches are synergic to one another.

266 While Artificial Intelligence may pervade each of the  
267 approaches, it does it in very different ways. In order to  
268 understand how pioneers paved the way for radical  
269 changes in the research and practice on ALTs, we refer to  
270 the inspiring paper of Jaime Carbonell (1970): the notion  
271 of mixed initiative dialogue has introduced a shift in the  
272 conception of classical, previous educational software  
273 (such as the one produced on PLATO) by requiring the  
274 *automated tutor* to understand the learner's question,  
275 needs, and statement. While in the beginning this was  
276 supposed to require just some natural language software  
277 able to recognize *WH- questions*, later the approach  
278 opened the research agenda on user models and, in gen-  
279 eral, on dialogues including models of the pragmatics of  
280 conversations such as those typical of modern Agent  
281 Communication Languages (performatives, speech acts).

282 As a conclusion, ALTs are at the core of questions and  
283 answers that have challenged informaticians since the  
284 1960s. ALTs have historically been prototypical for most

285 innovations in interaction models and technologies as well  
286 as, nowadays, in interactive, multi-centric, heterogeneous,  
287 asynchronously communicating service-oriented business  
288 (learning) processes (Cerri et al. 2005; Ritrovato et al.  
289 2005). In its essence, the question concerns how to *design*  
290 *interactions* suitable to have effects on a human partner in  
291 conversations where the meaning of design is far from the  
292 rigid definition of classical workflow and more in the sense  
293 of exploiting open interactions for enhancing learning.  
294 This scientific question fits well with very modern issues  
295 (service-oriented computing: semantics, processes,  
296 agents). A service is different from a product in the sense  
297 that it is produced on the fly when required by the con-  
298 sumer (dynamic) and its effectiveness is measured by the  
299 consumer's satisfaction, not just by its intrinsic perfor-  
300 mances. This recent paradigm shift in Informatics fits  
301 better with the above mentioned concepts of conversa-  
302 tions among autonomous agents (such as teachers,  
303 learners, or other actors in the community of practice)  
304 where the dimension of heterogeneity of knowledge, com-  
305 petence, skills and motivation, the distribution of  
306 resources and interests, the asynchronous communication  
307 channels and patterns, the coexistence of artificial and  
308 human agents in the collaborative efforts, the ubiquity of  
309 bidirectional access worldwide ought to be considered  
310 components of a Web Science scenario where learning  
311 occurs everywhere at any time rather than classical ICT  
312 products in a traditional classroom equipped with some  
313 computers.

## Cross-References

► Interactive Learning Services	314
► Learning as a Side Effect	316
► Serious Games	317
► Social Networks	318
► Web Science	319

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