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Advanced Learning Technologies

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Synonyms

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

Definition

Advanced Learning Technologies (ALTs) are artifacts (*technologies*) that enable, support, or enhance human *learning*, emerging from the most recent *advances* available in both areas. There are nowadays two real challenges to be faced when trying to outline in detail this definition of ALTs as a meaningful, full-fledged state of the art of the key concepts for future use, not just an historical overview of socio-technical approaches. The main technical challenge is due to the unprecedented speed of innovation that we notice in Information and Communication Technologies: ICTs; in particular: the Web. The educational challenge is a consequence of the technical one. An account of educational uses of technologies has to consider the impact of ICT innovation onto unexpected changes in human practices in any domain, modifying substantially the classical human learning cycle that since the nineteenth century was mainly considered to be managed within formal teaching institutions such as the schools. Therefore, our interpretation of *advanced* will be in the sense of *dynamic, experimental, to be implemented and evaluated* in order to limit the risk that what we describe today as advanced will be considered obsolete in a few months. This vision of ALTs, however, does not underestimate the interest for a reasoned analysis of past experiences. On the one side this analysis will guide us to avoid well-known pitfalls, on the other it will teach us lessons not only about how to exploit the potential learning effects of *current* advanced technologies – the applicative approach – but also how to envision, elicit, estimate, evaluate the potential promising effects of *new* technologies and settings to be studied and developed within human learning scenarios – the experimental approach – the last, enabling scientific progress both in Informatics and in Psychology of human learning.

Theoretical Background

Advanced Learning Technologies may be described and classified according to different criteria, such as their historical development (from the PLATO – TICCIT investments in the 1960s in the US, to current wikis, semantic web and social networks) or their links with disciplinary works (Informatics, Psychology, Pedagogy, etc.). Each and all these classifications are widely available already (► ITS: Intelligent Tutoring Systems or ► AI in Ed: Artificial Intelligence in Education or ► IEEE ICALT: International Conference on Advanced Learning Technologies). What seems to us interesting here is to present a couple of *new* criteria that may offer a frame of reference for the years to come. Classification criteria should be now different because we are facing a totally different world that is globally connected through the Web where the role of ICTs becomes primary for science, education, and any socio-economic domain. In this sense, most of the remarks in this article are intertwined with the ones in the Web Science one. The core observation is that on the current Web, humans are both consumers and producers of Information and of Services, i.e., they have a bidirectional access to the Web. Differently said, the modern Web consists of some billions of machines *and* of connected people. In this context, previous definitions are challenged; for instance the classical distinction between technologies and humans (artificial and human autonomous agents) needs to be revisited.

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

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

In this reflection, the contributions of Eileen Scanlon and Tim O'Shea (2007) and Marc Eisenstadt (2007) are a splendid synthesis of the last 40 years of research, developments, and practical implementations; successes and failures, directions to go and pitfalls to avoid. The main conclusions are that *we now have new topologies for learning which have no direct analogues in past educational practice* (Scanlon and O'Shea 2007) . . . and *the essence of the problem is that new-tech disguising old ideas is almost certainly doomed to failure. Learning Management Systems and Learning Objects, for example, despite the noble intentions of many protagonists, can in fact conceal neobehaviourist drill-and-practice thinking* (Eisenstadt 2007).

The subsequent word to be examined is *advanced*. This is rather self-explaining; however, the meaning of the word concerns more likely the exploratory nature of the infrastructures, tools, and practical implementations that one wishes to consider for enabling, supporting, or enhancing human learning. The issue is not so superficial, knowing that often people do not consider that the introduction of technologies in human life, particularly in Education or Learning, implies a profound modification of the human behavior. In principle, radical changes are regarded with suspect by the key actors. In our case, students (learners) are usually ready to accept, while teachers and administrators resist to the introduction of changes as most professionals often do with respect to innovation (other historical examples being technologies for health or for the legal professions). Therefore, *advanced* suggests a life cycle of innovation that cares for an experimental part: similar to a spiral (software development) approach based on trial and error as opposed to the waterfall one, in order to *motivate and convince* the actors of their own interest to adopt changes in their practice. No major change in the work practice will ever occur if it is not preceded by an experimentation that puts the actors and their motivation and awareness at the center of the implementation itself. Some authors even reverse the argumentation by proposing to exploit the proactivity of humans in open participatory learning infrastructures – *serendipitous mashups foster creative integration* (Eisenstadt 2007). Anyway, the classical concepts of ICT products optimizing the acquisition of knowledge and skills by interactive training are challenged by more modern concepts of peer-to-peer services adapting to the partner's needs and collaborating in social networks in order to facilitate learning. More often as before, those modern socio-technical scenarios enable human learning that otherwise would be impossible to conceive, so that the administrator's right question becomes more *what would happen if we do not use technologies for learning* as the traditional question: *why should we use them*?

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

Important Scientific Research and Open Questions

The most important scientific research question concerns which discipline profits from the success of the interdisciplinary projects in ALTs. These profit from disciplinary competences of humans, and may produce advances in each discipline but in quite different proportions according to the choices made in the goals, plans etc., adopted for the research process. In making progress in ALT, does one produce advances in understanding learning, thus improving as a side-effect teaching practices, or rather the technologies experimentally developed in educational or learning scenarios are significant for progress in Informatics? One of the most interesting paradigm shifts in current Web Technologies and Web Science is that new usage-centered business processes do require to introduce interoperability among machines and people but reuse old technologies. Another is that social software success is hardly to be forecasted and may not be stable, will rather be dynamic, evolving, and volatile. So it is the case for the learning effect of informal learning situations such as those offered by the Web. The acceptance is also variable with the age: digital natives behave differently as digital immigrants independently from their role of students, teachers, or administrators. Within this totally new framework, the real open question concerns what are the established principles that we may assume as valid and how to progress.

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

In the case of ALTs, the most important advances concerned with modeling human learning have been obtained as a consequence of the need to tune (or adapt) interactions to individual learners. As Artificial Intelligence has demonstrated, modeling complex natural phenomena implies understanding them better. In the case of learner modeling, it means understanding better human learning. The domain of learner modeling, opened by the foundational work of John Self (1974) has been at the core of years of quite profound research of generic impact for human–computer interaction, where models have represented human competence, human skills and, more recently, human emotions and personality traits. Adaptable interfaces are now among the top priorities of any modern ICT application.

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

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

As a conclusion, ALTs are at the core of questions and answers that have challenged informaticians since the 1960s. ALTs have historically been prototypical for most innovations in interaction models and technologies as well as, nowadays, in interactive, multi-centric, heterogeneous, asynchronously communicating service-oriented business (learning) processes (Cerri et al. 2005; Ritrovato et al. 2005). In its essence, the question concerns how to *design interactions* suitable to have effects on a human partner in conversations where the meaning of design is far from the rigid definition of classical workflow and more in the sense of exploiting open interactions for enhancing learning. This scientific question fits well with very modern issues (service-oriented computing: semantics, processes, agents). A service is different from a product in the sense that it is produced on the fly when required by the consumer (dynamic) and its effectiveness is measured by the consumer's satisfaction, not just by its intrinsic performances. This recent paradigm shift in Informatics fits better with the above mentioned concepts of conversations among autonomous agents (such as teachers, learners, or other actors in the community of practice) where the dimension of heterogeneity of knowledge, competence, skills and motivation, the distribution of resources and interests, the asynchronous communication channels and patterns, the coexistence of artificial and human agents in the collaborative efforts, the ubiquity of bidirectional access worldwide ought to be considered components of a Web Science scenario where learning occurs everywhere at any time rather than classical ICT products in a traditional classroom equipped with some computers.

Cross-References

► Interactive Learning Services
► Learning as a Side Effect
► Serious Games
► Social Networks
► Web Science

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