

INTELLIGENT LEARNING ENVIRONMENT (ILE) LEARNING ENVIRONMENT WITH AI SUPPORT TOOLS FOR TEACHERS AND TUTORS

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Abstract. *The present article describes an innovative approach to implement functionalities for e-learning based on artificial intelligence (AI) on existing LMS platforms. The following characteristics of the Learning Management System (LMS) involved in that process will be defined: flexible, ecological, autopoietic, enactive. Besides those dispositifs used for the design process (authoring tools), the knowledge building and tracking will be identified, to give support to the project team work and the activities of the Learning Entities¹ (LE).*

The ILE (Intelligent Learning Environment) architecture and the related functionalities aim to support the student in the first phase and, mostly, to support the teacher/tutor in the tracking activities, in the design phase and redefinition of the design of advanced learning paths focusing on a self-conscious learning and activities of knowledge building.

The LMS, on which the prototype was developed, is JAVA based and interacts with AI functionalities. The Multi Agent Platform can operate on e-courses dealing with different disciplines, that means, it is not bound to a specific subject matter.

Introduction

When we speak about the organization of a didactical path, two approaches seem to be antithetical: the situated one and the deterministic.

The situated approach refers to a didactic built around the context and inside the context, it is the result of the teacher's sensibility along with his/her listening attitude, his/her competence in drawing the process along the path and the valorisation of the event (Morin, 1974).

The educational relationship, meaning the continuous interaction between student and teacher, determines the quality of learning and teaching.

The deterministic approach refers to a path organization where all details are included since the beginning. All potential 'emergencies', difficulties, changes and the relative possible solutions are provided. Only one element is not predictable: the event (Morin, 1974). The teacher plays his/her cards in advance setting the environment. During the process he/she is absent or almost absent and can be replaced by the system.

If we analyze the AI supported learning as proposed by current standards (e.g. SCORM), only the deterministic approach is taken into consideration. The role of the teacher is limited to initial design while redefinition of the learning path, as the integration of new resources, is not foreseen during the course. Moreover, collective activities either don't exist or are merely accessories to the main path. Every process, where results cannot be envisaged, is considered a "non standard" and of minor relevance. Blogs and forums belong to this category since it is not possible to predict what will be negotiated, discussed and produced during the process.

In the 1990s, the constructivist view had questioned the positivistic approach by proposing a new circularity between theory and practice that overcame both the reductionist approach, typical of behaviourism, and the separation of cognitive, as well as meta-cognitive, processes from the context.

The complexity of the educational relationship progressively emerges along with the following relevant aspects, as the role of:

¹ The term Learning Entity (LE) stands for single student or work group.

- the relation between learning and teaching (Benner, Altet, Damiano)
- the LE in production of knowledge (Guba & Lincoln, 1995);
- the necessity of authentic tasks, problem-solving approaches (Jonassen, 1999);
- the self and narration in learning (Gergen, 2001);
- reflection-narration to acquire self-awareness of LE's own path in the learning process (Schön, 1983; Kolb, 1984; Le Boterf, 2000; Gergen, 2001; Gruschka, 2005; Korthagen, 2006),
- inter subjectivity and collaboration in the construction of knowledge (Wenger, 1998; Bereiter, 2002; Brown, 2005).

At the same time the society of knowledge (European Community, 1995) focused the attention on Lifelong Learning and on a kind of teaching centred on competencies in context (Samurçay e Pastrè, 1995; Rabardel, 1995; Pastrè, 1997, 1997; Rogalski, 1997; Rey, 2003).

Since 2000, the need to overcome constructivism is more and more evident, even if some elements of the constructivism have become common necessary heritage because of a variety of problems that progressively rise during the educational design processes. A constructivist teaching model doesn't necessarily come from a socio-constructivist learning approach, nor a complex process is always manageable and traceable in real time. As a result some theories integrate the socio-constructivism: teaching requires paths that implies both discovery and instruction (Lesh et Doerr, 2003; Wilson), a new relationship among theorists and practitioners is necessary (De Ketele, 1993; Altet, 1996; Laneve, 2003; Damiano, 2006), a push program approach is replaced by a pull platform (Brown, 2005), a stronger attention on the reflective and narrative processes for assessment drives to the development of the e-portfolio.

From e-I 1.0 to e-I 3.0

The evolution of e-I is parallel to the one of the education theories.

In the first generation, e-I, the so called e-I 1.0, was characterized by the prevalence of an approach defined as "instructional" or positivist (Mason, 1998; Guba e Lincoln, 1994). It was based on study materials that were often well designed in their multimedia features and objective assessment tests. Materials and assessment activities are mostly embedded in Learning Objects (LO). The model, which takes into high consideration standardization and interoperability requirements, easily integrates with the SCORM standard and shows both its positive aspects and mainly its downsides (Friesen, 2006; Hodgins, 2006). It's suitable for instructivist learning paths but not flexible to fit processes directed to a significant and self-conscious learning (Buonaiuti, 2006).

In the last decade the research about online learning focused on the definition of a standard to enhance the quality level and guarantee the reusability and interoperability (ADL-SCORM, 1999-2004) but the didactical model used for that research doesn't always meet the different didactical process needs.

Other attempts to have a socio-constructivist approach in e-I have had in some cases relevant results, mostly for what concerns the community building and the chance to reach self-awareness learning thanks to a peer to peer review (Jonassen, 1999). In such experiences, communication tools already present in the web (e-mail, forum, chat) have been used without a focused searching on the creation of proper *dispositifs* to support the activities. Besides, tutors have had a central role and the positive results were mainly due to their balanced participation between scaffolding and fading. Tutors are required a great commitment and they do not always find easy to monitor the process in the due times. Taking in consideration the roles played by tutors, the necessary profiles are very high and imply to have disciplinary, relational and didactical competencies.

After 2003, web 2.0 takes a leading role in the web and marks a shift from the syntactic web to the semantic one. From a technological point of view, the web 2.0 introduces a set of utilities to enhance communication, resource aggregation, knowledge building and interaction among users. Such utilities have not only fostered the communication but they have also modified its modalities, as shown in the following examples: the roles of tags in folksonomies and the modalities through which they can be aggregated, organized and selected; the role of RSS as a selective alerting tool; the multi-author weblogs and the wikis as tools for communities but also as tools for new modalities of collaborative writing. The web 2.0 allowed the development of

communities and the member's active' participation in the creation of materials.

Is it possible to suppose that e-l 2.0 is rising from web 2.0 and Internet can become itself a learning environment? (Bonaiuti, 2006). Weblog, wiki, PLE, as any other real life object foster informal learning but the question is: how to integrate them in learning paths in order to get self-awareness of personal models or to be directed to the Zone of Proximal Development (Vygotsky, 1978)? In the majority of cases today wikis, weblogs, and different folksonomies are separated objects that connect each other through feeds and tags. Every object aims at being more and more complex and auto-sufficient by enhancing its utilities. But is it possible to suppose the learning/teaching process without an environment which makes explicit a learning path, organize it and map it in a conscious way? Thus, it's necessary to find models of learning environments that can take advantage of the previous experiences, specifically of the above mentioned web 2.0 objects, that can be flexible by overcoming the limitations of e-l 1.0 and keeping the learning environment structure

In 2004 the Journal of Educational Technology & Society publishes a special issue about "Ontologies and the Semantic Web for E-learning". In 2006 the issue n. 3 of the British Journal of Educational Technology is focused on "Advances of the Semantic Web for e-learning: expanding learning frontiers" (Lytras et al., 2006). The debate about the adaptive systems is also active, those systems propose automated methods for filtering and classification of information, systems that can define the interests of the users through a semantic representation (Tasso et al., 2002; Tasso, 2002; Pirrone et al., 2007). Artefacts for semantic filtering exist and they are able to label the main ideas of every text, to analyse the evolution of the discussion, to identify new concepts in a message (e.g. in a forum). The algorithms of the Latent Semantic Analysis and Carrot2, for example, guarantee those objectives.

Different projects aim at integrating e-learning and semantic web: Me-aggregator (Lundqvist, 2007), weblogs which include semantic tools (Cotterill, 2007), hypermedia adaptive systems (Brusilovsky et al. 2004), the ZZ-structures (Nelson, 2004), the kaleidoscopic tools (Rossi et al., 2006a), the dispositifs for reflection and the e-portfolio (Barret, 2001, 2005; Ravet, 2007; Rossi et al, 2006b, 2007; Attwell, 2007b), the "Pull platform" (Brown, 2005), the Pragmatic web (Schoop, 2006).

The above mentioned tools aims at the semantic analysis of texts, at a multi-level accurate tracking of the learner, at the efficient, exact and immediate visualization of data and information gathered and provide a wide and meaningful set of data. The need to know how to use those information arises, that is, the need of an "object" that can analyse those data, visualize them in order to provide an organic display of the system and that can organize them to facilitate the choices of the teacher/tutor: an artificial intelligence machine.

Artificial Intelligence (AI)

The evolution of AI from the Eighties of the last century till today is parallel to the changing of Weltanschauung in the educational field in the same period. The first generation of AI was based on the rationality principle and on the connection between knowledge and objective (Newel, 1982) when the AI system was defined as a *Knowledge Level*, that is a system providing all the knowledge defined in the *Symbol Level*, in the problem solving. In today's education process the mechanical dependence between teaching and learning is object of discussion mostly if we aim at significant learning (Reigeluth, ; Jonassen, ; Damiano,). In the Nineties Clancey (1993) states that "knowledge base is not a repository of knowledge extracted from one expert's mind (as in the transfer view), but the result of a modelling activity whose object is the observed behaviour of an intelligent agent embedded in an external environment".

There is another difference in the way the Intelligent Tutor plays his/her role (ITS). The technology proposed by Dick e Carey (1990), began with the specification of the instructional objectives – going through a more detailed analysis of the needed skills to reach the goals, the choice of the most adequate delivery strategy and the selection of the most appropriate materials – and ended with the qualitative evaluation/assessment.

The subsequent modality consists in following the student in the task and in providing some feedback and an adequate scaffolding at each step. In this second modality analysing the working styles and the cognitive processes that have been activated is possible (Beck e Stern, 1996; Corbett et al, 1997; Shute e Psotha, 1996). The second hypothesis can be applied only if

the process to start is structured in previously defined steps by the expert system (VanLehn et al., 2005). In this context the reply time of the ITS is a feature which characterise the system that can provide feedback at the end of each step or in a sommative way at the end of the task, according to the user's level.

But there's a further aspect. Among the implementations of carried out Intelligent systems we have **MyClass**, an environment for managers' training, created by IPS², **ANDES** (VanLehn et al., 2005), an environment which supports students in learning Physics, **Baghera**, a *multi-agent and web-based learning environment* to help students and teachers in teaching/learning Geometry. Baghera is constituted by two *multi-agent* systems (MAS) (Webber et al., 2002, 2004).

The above mentioned implementations are *subject matter oriented*, that is tied to a specific content and expressly built for a specific goal. The implementation of a knowledge base and the arrangement of such a course is time-demanding and requires a lot of energies. Besides such an implementation cannot be re-used for another discipline. The debate about how to overcome that problem is wide. VanLehn, for example, proposes to use in different domains components that has been carried out for a specific domain (VanLehn and Chi, 2007b) and he has verified that some meta-cognitive behaviours are transversal to domains (VanLehn and Chi, 2007a).

Intelligent Learning Environment

The hereby presented model is different. It is considered necessary to move from Intelligent Tutoring Systems (ITS) to Intelligent Learning Environment (ILE). While ITS are subject-based – enacting the human tutor and its liaison with students in a twofold teacher-expert system approach – the ILE is based on an environment where students and teacher-tutors are able to establish a dialogue and build knowledge. In other terms, the environment represents a cognitive space for a learning community. The environment is “intelligent” as it analyses interactions and connects them with the knowledge base in order to supply the tutor-teacher with information on groups and single students' status; this system is not meant to replace the tutor but its goal is to support the tutor relieving him/her from first level problems and suggesting known, viable solutions.

While at a first, instructional level AI operates on the basis of an external model, at a second level – that includes activities such as negotiation, regulation, design, reflection and where work is focused on open-end problems and the awareness of learning – AI takes as a reference its own system rather than an external model. Quality indicators are internal coherence and system balance. These indicators, together with students' tracking data, are used by AI in order to supply the tutor-teacher with a dynamic, easy to read snapshot of groups and students' progress.

Aim of AI is no longer the reconstruction of a deterministic process but the identification of new models useful to support the tutor-teacher in his activity and to improve the environment autopoietic characteristics.

Main goal is to build an AI-supported system which is content-independent or at least suitable for a wide range of subjects. First step is the design of an AI engine that could interoperate with a LMS so that platform modules (user authentication, profiling, activity tracking, course and materials editor) can work independently from a specific content. Two design requirements are to be met here: the former being a greater weighting of pedagogic knowledge in the environment design, and the latter as the strive towards the design of an AI system that is not going to replace the tutor-teacher while helping him with the initial design and running of the course. This obviously simplifies the implementation of system knowledge base while shifting focus on relieving tutor's effort and improving his effect on overall quality. For the above mentioned reasons, both teacher's and tutor's presence is required and absolutely necessary throughout the course in order to maximise results. More elements will be introduced later describing how we intend to set up specific courses using the herein presented system.

Research hypothesis

The research hypothesis is ultimately to implement an AI system that, interoperating with an LMS, could support teacher's and tutor's activity.

² L'IPS is a private enterprise (<http://www.ipslearning.com>) specialised in the private sector.

The suggested system includes three elements:

- open source LMS with specific characteristics (to be described later);
- LMS-integrated Knowledge Management tools for semantic analysis, monitoring, and aggregation of platform data;
- AI system capable of analysing data supplied by the two above mentioned elements, interoperate with the platform and provide feedback to teacher and tutor (T from now onwards).

Let us define E-L 3.0 as a system based upon an LMS where KM and AI elements retain a relevant role.

Learning Management System for ILE – Pedagogical characteristic

Main restrictions of first-generation LMSs were rigidity and non openness. These limits result from the pedagogic and technological structure of LMSs and are not internal within the concept of LMS. In reality we do not believe that features like guidance and learning support – of the kind that are specifically designed for an LMS – can be overlooked. As matter of fact the LMS is responsible for supplying the learning process with consistency and with a clear, mapped display of the path in order to provide awareness of process, motivation and guidance to students. These objectives require an LMS to be flexible, ecologic, autopoietic and enactive.

Flexibility has two sides. The former allows teacher-tutors to design and re-modulate the environment on the go by means of authoring tools that do not require specific competences. The latter allows learning entities (LE) to personalise the environment accordingly to one's own profile and learning style while keeping coherence with the process. Modules organisation in the chosen LMS presents a narrative XML outline, constantly displayed, that can be modified on the go by automated routines or by tutors' direct intervention.

The **ecologic** feature of the environment is given by the possibility to connect different system sections. The LMS can be described as an overlay of three networks (Rossi, 2007):

- the **dispositifs** network: tools are not isolated but inter-connected in order to function either diachronically or synchronically;
- the **writings** network: students' written inputs – either in forums, blogs, wikis – and materials added by teachers can be connected during the process;
- the **relations** network: interactions established among students and tutors during the learning process trigger the development of a cognitive, emotive connections that dynamically evolve in time.

These networks may not origin spontaneously but can be the result of an initial, as well as an on the go, design. The networks are purposely focused and aware of the fractal structure of the LMS. The dispositif independence integrates with the general structure as each dispositif implements, and extends with more specificity epistemological choices, general objectives and pedagogical patterns.

In addition learning materials stored within different tools and repositories benefit of a single indexing ensuring reticular connection. Multiple, effective visualisation tools (for contents, networks, relations) allow for a systematic awareness of T and LE.

The three networks reveal the **autopoiesis** of this system as the writings network and the relations network expand on the go with a growing in number of self-referencing connections as the process develops through LMS internal tools. The system is a non-static one just as LE's profiles, motivations and expectations are.

Finally the LMS in **enactive**³, meaning that interactions LE-environment contribute to the construction of symbols, of knowledge and of learning processes.

The ILE project chosen LMS presents an XML-based course hierarchy displayed to both T and LE as a branched structure. This allows the AI engine to interact with it and modify it in real time, the holistic branched structure allows for a screenplay-like pedagogical design and the visualisation ensures awareness and motivation to T and LE.

³ "It is not sufficient to keep a connectionist approach only because it matches the biological reality, instead it is necessary to revise the notion of representation, of symbolic sensing. An attribute observed in reality – space, colors, shapes – it is not something pre-existing, rather it is configured through relations that the organism establish with the environment. This does not contain any attribute; it is history on its being cycling and recurring that brings up world's attributes" (Varela, 2007, pg. 132).

Furthermore, the LMS is not pedagogically neutral but, at the same time, must ensure the possibility to implement different pedagogic models to different professors. The used model includes several cronotopos/dimensions that are independent and connected through artefacts. Each pedagogical dimension uses own **dispositifs** (that is the connection between technology and activity to reach a task) pedagogically characterised by own evaluation models and own structures. It is teacher's task to connect them within a coherent and organic process. Artefacts that are included, or produced in the process are boundary objects implementing connection among the three dimensions. The model (Fig. 1) includes three macro dimensions (Rossi, 2007; Rossi et al., 2008):

- an instructional dimension where resource provision and objective assessment prevails;
- a group dimension for regulation where students are asked to work on authentic tasks, to solve open-end problems, to carry out problem posing, to make decisions and design choices. These are usually collaborative activities that include group negotiation and design;
- a personal dimension for reflecting on activity, on own profile and identity. E-Portfolio and web 2.0 tools are significant in this dimension.

Materials resulting from different dimensions can be reused in other areas where they assume different meanings and functions: a learning resource provided in dimension 1 can become the subject of discussion in dimension 2 or an element in the personal portfolio selection.

The central role of dispositifs in their dimensions ensure synergy between didactic and contents.

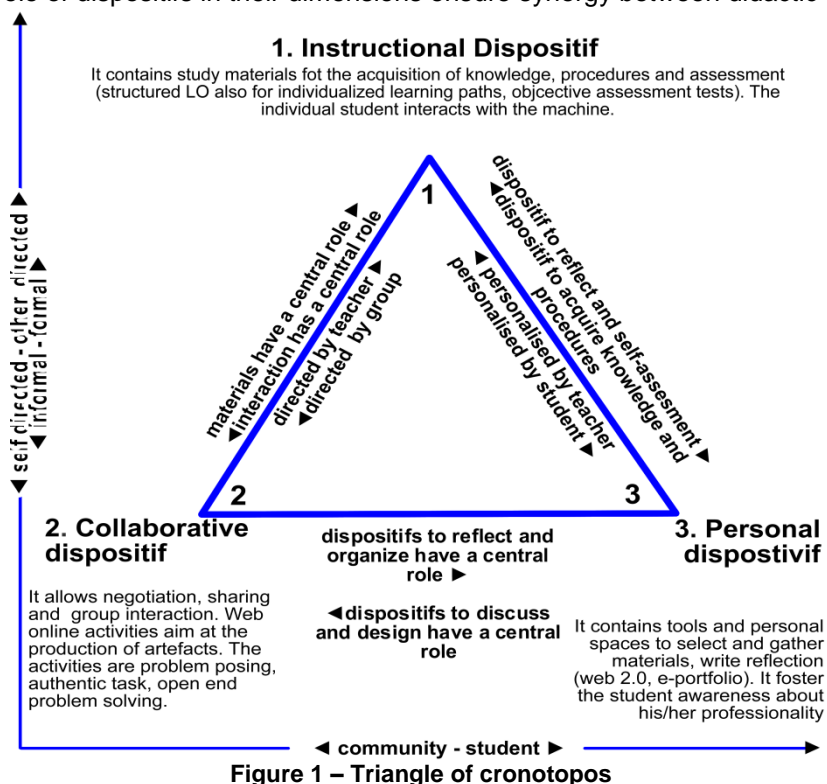


Figure 1 – Triangle of cronotopos

The objects of Knowledge Management

The construction of the three networks is ensured not only by features embedded in each tool (like tagging within each forum) but also from specific devices enabling the interaction of data originated from several environment tools. Hence the twofold need to collect data and to build tools for its interaction and visualisation.

The first tool is aimed at the semantic analysis and tagging of texts; for this purpose three possible solutions seem viable:

- top-down processes: starting from an ontology to map contents (Pirrone et al., 2007) and to personalise learning paths (Cantone, et al. 2007);

- bottom-up processes with user intervention: users tag resources and texts that are organised and retrieved through folksonomies;
- automated bottom-up processes: texts are filtered by routines that assign tags used for their organisation and retrieval (Rossi et al., 2006a).

Our own-developed prototype features a specific object in charge of collecting user-added tags, assigns tags to other resources, and displays through a number of possible visualisations (maps, networks, trees).

The second class of objects is functional to aggregation of resources, to multiple-source production, to group production. Tools are aimed at the construction of kaleidoscopic resources that are the product of integration among different pieces coming from materials in different dispositifs (as previously mentioned, artefacts are boundary objects). As networked, collaborative, multiple-source constructions are becoming more common we need to refine tools going in this direction (e.g. Wiki). The object in our design allows to retrieve pieces, scraps from resources within the LMS and compose "patch-works" (Rossi et al., 2007). A well connected and integrated e-portfolio (Barret, 2005; Rossi, 2006b) can be included in this class of objects. These objects aim to support a didactics, where the LE's networked/kaleidoscopic productions are important, and to activate multimedia narration paths.

The third category is related to monitoring. Nowadays most LMS can store every single user click collecting a large amount of data. In addition to that, data from semantic text, e-portfolio, analysis are useful to assess individual user activities. Hence the need for tools capable of analysing this massive collection of data, of displaying them in a clear and understandable way useful for monitoring purposes (Rossi et al., 2008). This data allows for the construction of individual, as well as group, LE profiles. Algorithms of SNA (Social Network Analysis) can be utilised to produce this kind of analysis and to supply information on group activities. As individual data does not retain an absolute significance, an intelligent system is necessary to compare and cross-examine data with regards to specific objectives.

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