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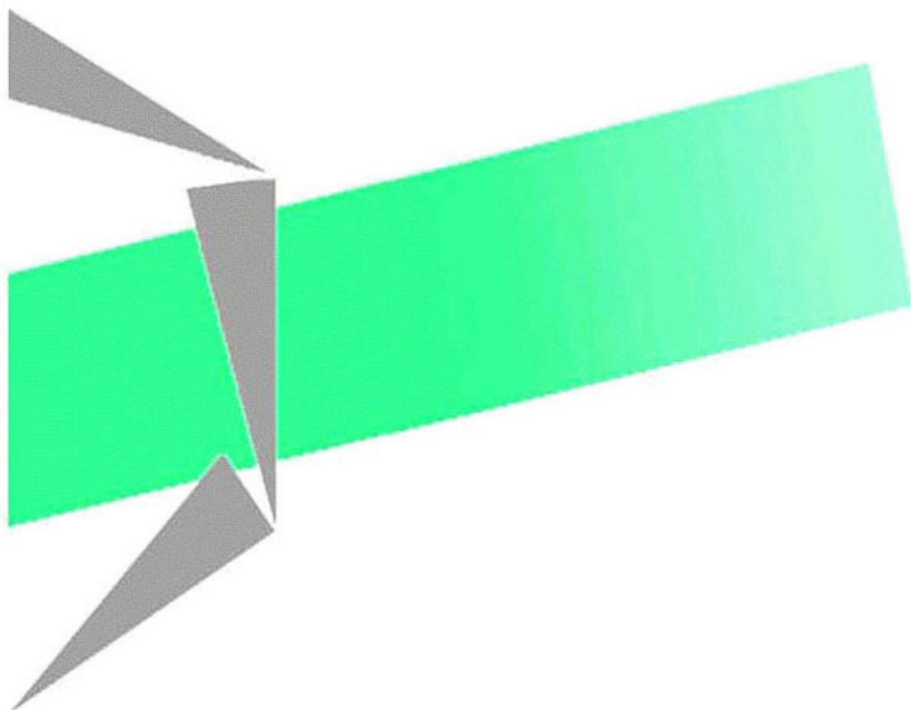
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a collective working paper

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1 The evolution of the “design and the use of technology for human learning” is quite clear: on the one hand a radical move toward a one-on-one model of ownership and use of computer-like environments—wireless, fully connected, mobile and ubiquitous—on the other hand an irresistible development of social practices which transform the technology into a means to learn collaboratively with other people, a mean to explore models and all kind of resources. At the same time the technology is more personalised (sense of ownership, 24/7 availability, adaptability) and more socialised (supporting communication and collaboration of all kind).

This introductory remark shows how intricate are the questions, issues and research *problématiques* in this domain. However, the approaches are still rather fragmented within disciplines (in computer science and technology, as well as social and human sciences), and across disciplines. We need evidence of an effective blend of theoretical frameworks and methodologies, being accessible to computational representation and epistemological evaluation.

The emergence of a stronger awareness of the social and cultural dimensions of learning, calls for a specific effort of **research on the design, implementation and deployment of technology being based on theories of learning as social and cultural processes**. This research must be combined with the research which has developed and proved its efficiency in line with the constructivist theories and their implementations (simulation, microworld, inquiry learning environment) and the emerging research on social constructive and mobile learning.

An ambitious **research programme combining collaborative learning, mobile learning and inquiry learning** would be an excellent case to question the concepts and theoretical framework underlying these sectors and to develop a comprehensive approach. This is certainly strategic for the future of TEL.

2 The development of professional software aiming at supporting the achievement of specific tasks or to the planning of them (computer aided surgery, car crash analysis, computer aided design, airplane piloting, etc.), calls for TEL environments able to address the learning of know how, controlled gestures, strategies of all kinds. This corresponds to implicit professional knowledge, which simulation can reify while not being accessible to comprehensive symbolic representation. In the same way, one can address through simulation and role play the training of “soft” skills such as negotiation skills, management skills, diagnostic skills, as well as meta-knowledge, even in academic disciplines, which are of the same nature: tacit, embodied, emergent from the activity. The combination of gaining explicit and implicit knowledge (for example by stimulating experiential and reflective learning) in one learning environment is one of the challenges we stand for.

Research is needed to address **professional learning and training, based on highly realistic and interactive simulations, microworlds and role-play environments**, allowing a deep immersion in virtual and/or augmented reality providing access to the acquisition of embodied knowledge. There is a need to develop more efficient and more relevant multimodal interface able to track and analyse learners behaviours and to provide symbolic, graphic and haptic feedback.

3 As well as providing rich and complex TEL, simulations, virtual reality, and microworlds also represent the current evolution of the development of learning objects. They extend the web of resources made available to learning, but they also increase the complexity of the task of integrating them in learning environments. They call for the definition of innovative models, **infrastructure and contents for experiential based learning**, especially when it requires complex virtual scientific objects and experiments.

These highly interactive and distributed learning objects are creating new learning ecologies, including mobile distributed team learning, technology-enhanced field studies, augmented reality learning, and asynchronous collaborative learning in the workplace. There is a growing understanding that **context should be reconceived as a construct that is continually created by the interaction of learners, teachers, physical settings, and social environments**.

A strategic research agenda should **cover all cognitive and technological issues related to the design and compatibility of highly interactive learning objects, as well as their use and the development of a new ecology of learning**. There is a need to **develop implementable models of context-as-construct** that can inform the design of future TEL.

4 This development of TEL open the possibility to fully exploit the phenomenological nature of knowledge, being the emergent outcome of the interactions of the learner with his or her environment in a socially meaningful situation. However, learning is a personal process although shaped and supported by social and digital interactions. It requires that TEL environments are more and more **socially relevant** and epistemologically

valid, that they **provide support to the interactions between learners and to the learners individually in their learning process.**

To ensure a better adaptation to the needs and specificity of learners, **TEL must reflect cognitive styles and population diversity.** Research must develop a greater understanding of how individual differences such as cognitive style, gender, personality and learning styles affect the effectiveness of specific functional and interface components of digital learning systems. The role of age on these same must be investigated as well. This latter theme is related to recognition of the increasing average age of populations within Western Europe and the need to recognize the needs and requirements of this older population in terms of accessing digital learning systems effectively. It is also related to the idea that we may benefit from identifying trends among young people (chat, material exchange, gaming, etc) and find translations into learning

In relation to personalisation it is now time to come back to old and resistant problems, although this must be done from a different angle and with different approaches making benefit from the advances in Artificial Intelligence and cognitive science: advanced learner modelling techniques and models, repair of misconceptions, generation of helpful and cognitively adequate feedback (which has been proven to improve learning). When learner modelling and diagnostic techniques are not efficient enough, **technologies must be developed for providing learners with insight in their learning process and knowledge during the learning process:** reification of interaction pattern and interaction analysis tools, learning trails, collaborative diagnostics.

We need to understand how such insights into human cognition can be shared and used to develop collective competence. Research should focus on **how collective cognition can be developed** and to what extent such processes result in accumulated insights that exceed the sum of individual efforts. The focus will be on groups of learners and working teams that execute tasks and assignments that demand complex and non routine expertise.

Moreover, research targeting personalization of learning must explore **how learning is grounded in social and cultural processes.** It implies work on developing conceptual models for TEL processes, and on cognition and learning in its social context. Research should be focused on specific learner situations (ages/groups of learners or specific subjects) but should demonstrate how approaches can be sensitive to other contexts, situations and conditions that influence students/workers learning trajectories. Looking to the longer term, it should advance the basic understanding of specific issues pertaining to the interplay between the various dimensions of learning, including emotional and affective aspects, on the one hand and technology on the other hand (e.g. physiological, psychological, social, cultural and cognitive aspects).

The TEL research agenda should include the search for **models accounting for learning as an emergent process in complex systems which ecology is shaped by social, epistemic and technological factors.** These **models must be empirically valid when confronted to actual use, and computationally tractable** to ensure cost effective and efficient transfer.

5

It is no longer relevant, nor visionary, to consider TEL environments as purely digital environments. Both for pragmatic reasons and for technological reasons, for example in the case of augmented reality, learning environments of the future will blend digital and non digital learning objects and environments, as well as a range of possible learning and teaching models. Already, a pragmatic approach to blended learning is combining human tutoring and a software applications; this could be extended to combining books and classical learning material with software and digital resources. Eventually, this will lead to ambient intelligence, allowing a mix of real life events with virtual ones, improving the perception of affective, emotional and social factors.

Blending should also be considered across technology and a variety of TEL strategies and applications. Among examples, one can mention **ePortfolio technology in connection with learning environments**, the **integration of “intelligent” modules to current LMS systems for language learning** (taking full advantage of advances made in the automatic analysis of natural language) and for the tracking and analysis of non-digital or complex (collaborative) learning situations, the **integration of video conferencing with advanced computer supported learning scenario**, the exploitation of synergies between learning and knowledge management systems in complex educational contexts.

Compatibility and adaptability is at the core of the feasibility and efficiency of such blending. While much progress has been made on the side of standard and norms for learning management systems, not enough has been made in general either for ensuring the compatibility and good communication of applications and material targeting learning, nor for ensuring the coherency and possible cooperation between the possible models and scenarios of learning, teaching and training.

Blended learning, from a practical and theoretical perspective, needs concepts and models to support its development and ensure its efficiency. These concepts and models must allow to address all the issues of compatibility, applicability/interoperability and validity of the de-facto standards and specifications of the large variety of learning objects and environments likely to cooperate in more and more complex learning situations.

6

Whatever is the richness of the social and technological environment, the effectiveness of learning will be measured against the capacity of learners to cope with new situations, to solve problems efficiently or to achieve tasks which are ruled by specific criteria of success. The content at stake in the learning process can not be directly delivered, as is now well known, but will be the property of the interaction of the learner with his or her environment. The quality and relevance of the feedback, the possibility to customise it to the learner needs is critical. The **adequacy of the representation and of the feedback to the content specificity** is crucial as well. Research programmes are needed to explore these issues in a variety of domains. Some priorities can be considered like: **basic skills in arithmetic and reading, language learning, natural sciences and experimental reasoning**, as well as **knowledge and know-how related to specific professional practice** (management, surgery, decision in emergency situation, piloting and driving, etc.)

It would be very productive to **create a collection of domain specific evidence and research based recommendations**, in order to inform practice and actual use, but also to explore the differences and commonalities with respect to design principles and use of TEL

environments and **get a better knowledge and understanding of the challenge of TEL from an epistemological perspective** (computational transposition, new epistemological structure of communication and social interaction, fundamental question of the philosophy of TEL and the evolution of education and cognition).

7 The development of TEL over the past decade has stimulated an understanding that we need a **focus on informal learning**. This evolution means that school and the work place are no longer the only focus of TEL, but it also includes all the situations and context in which human beings may want or need to learn, to develop understanding or skills for practical reasons, intellectual satisfaction or pleasure. This is a recognition that learning is a human activity dense everywhere, across space and time. **The way is open to blending formal and informal learning** in a much stronger way, questioning our relationship to learning. Such a movement implies a larger involvement of the society in the investigation of the impact of this generalisation of the access to TEL: school directors, inspectors, decision makers in the educational systems or from human management units in companies, as well as the general public, and the parents must be involved—in the end they are the end-users.

In addition to understanding how social and cultural aspects create affordances and constraints for use of information and communication technology, **we must understand the relationship between institutional norms and use**. Here, the issue of what counts as knowledge becomes transparent and a possible source for change.

This evolution brings to the fore a problem known although it has not received the attention it deserves: **on-line certification**, academic evaluation of learners productions, knowledge and know-how, diploma delivered at a distance, accreditation of virtual schools and training entities. At the core of these are difficult issues of **trust and security, tracking of plagiarism, recognition of individual competences acquired in collective situations**, as well as the capacity to make actual **evaluation of learners' competences and understanding against accepted practices or institutionalized knowledge**.

The use of digital technology for the certification of knowledge and skills will be a driving force for the deployment of TEL. Research must contribute to the **“decompartementalization” of learning practices and examinations and assessment** either at school or on the work-place or to validate informal learning.

8 The design of a learning scenario based on digital technology, the organisation of a teaching or training session or the **optimal organisation of learning resources** of any kind call for specific tools and support. Research must contribute to supporting new forms of access to **learning services relying on advanced techniques** for learning material arrangement according to user needs, learning objectives and approaches (multimodality) able to fully exploit new forms of interactive digital content. In this respect, authoring tools for semantically represented content are a real bottleneck, especially all problems connected with **collaborative authoring**, including proper versioning.

Support is needed for **technology-enhanced innovative authoring and learning systems**, tools and services, organised in flexible software architecture enabling the creation of domain specific platform that take into account the context and allow dynamic adaptation to different learners based on substantial advances in pedagogical theories and knowledge models.

9 Research on TEL makes **progress by a constant interaction between theoretical frameworks and experimental investigations** based on either rigorously planned experiments or on empirical in-the-field observations. It requires the coordination of a technical-technological evaluation and of a cognitive and epistemic evaluation, as well as an evaluation of the learning settings and circumstances either institutional or informal. However, the current situation is rather weak, the experiments being often carried out in contingent situations (depending on availability and willing of volunteers—often not representing the most general case).

Managing an experimentation and collection of data is often a complex problem in itself. Research on TEL is very far from the point where the results of experimentations can be shared reliably given the contingent circumstances of data collecting and the lack of a standardised way to report on the experiments themselves. Hence, TEL research misses the capability to share the results between different disciplines to produce new outcomes coming from different research perspectives.

In short, it is urgent to react to the fact that research on TEL (i) is still based on too weak **bridges and interactions between technology research and research on learning**, (ii) is at a low level of **infrastructure in support to the sharing of means and results at the conceptual, technological and technological level**.

It is critical to **enhance the support of the experimental dimension of research in TEL** in the following directions:

- To provide frameworks for the **description of the experimentation settings** and processes. A sound experimental setting can be considered as a first class outcome that can be shared and reused with profit → **methodological standards**
- To provide frameworks for the **description and annotation of experimental data** in order to enhance the capability to share, manage and compare data, taking up the challenge of combining multiple disciplinary frameworks → **benchmark...**
- To provide **tools and means to instrument the experimental situation** so as to gather experimental data in a meaningful way (i.e., the right data set and in a coherent manner, with respect to the chronology for instance) → **testbed...**

providing the infrastructure for the management and sharing of all these information as well as the support of the collaboration of the researchers in every phases of the experimentation process.

10 Technology, pedagogy and cognition do not exhaust the research agenda, since there is a major implementation gap to cover that can only be addressed when organisational, economic and socio-institutional issues will have full citizenship in research on TEL, and when a higher degree of integration and system view will be achieved among the different discipline perspectives.

The **complex process of adoption of TEL in the different learning contexts** is at the centre of where we should concentrate research efforts in the near future.

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