

eLearning After Four Decades: What About Sustainability?

Max Mühlhäuser
Technische Universität Darmstadt
FB20 – Telecooperation,
Hochschulstr. 10, D-64289 Darmstadt
max@informatik.tu-darmstadt.de

Abstract: After four decades of eLearning, we find a wide gap between the academic state of the art and commercially successful, broadly used eLearning in practice. To narrow this gap, we advocate a focus on sustainability in eLearning. To this end, the paper and keynote take the following steps: i) a brief review of the four decades of eLearning; ii) a rough categorization of eLearning concepts as a preparation of step three; iii) a strategy for realizing sustainability; iv) an inspection of the three top categories “augmented learning”, “distance learning”, and “ambient learning” with a focus on sustainability. Only the first of the three categories is treated in more detail as an example.

Summary of the Keynote

With four decades passed, we look back to the history of eLearning as an alternation of high hopes and deep depressions, frequently accompanied by deplorable gaps between “exciting success in the lab” and “way too little market penetration in the sequel”. Therefore, a look forward must put sustainability in focus: R&D and, in particular, deployment strategies, must emphasize evolutionary and re-usable approaches that exhibit broad coverage, high quality, and economic feasibility. Organizations and Universities can not afford expensive eLearning projects any more, they need truly sustainable eLearning strategies and programs.

The presentation starts by rephrasing the above basic statements. Next, the landscape of eLearning is set out, distinguishing three major categories at the top level:

1. Augmented Learning denotes attempts to support and advance classical on-site teaching and to use venues of physical encounter as a 'hub' for the eLearning approaches of category 2 below.
2. TeleLearning is used as an embracing term for the many approaches towards freeing learners from the same-time / same-place restriction;
3. Ambient Learning is a rather novel concept that aims at making learning disappear in everyday life, putting a first focus on manual business processes.

For each of the three categories, the overall focus "sustainability" is discussed with respect to pertinent approaches and deployment strategies. Only the first category is treated in a more elaborate manner due to time constraints: the R&D concepts and deployment strategies around "digital lecture halls" DLH are introduced, teacher support and learners-in-the-loop support are presented. DLH is a program currently driven by the author at his affiliate university, so that some of the results of an ongoing elaborate evaluation can be presented at the end.

The remainder of this paper gives additional background information on the topics addressed in the Ed-Media 2004 keynote speech.

Four Decades of eLearning History

The roots of eLearning go back at least to the mid 1960s i.e. four decades. In a simplified summary, each era was marked by hopes and deceptions as follows.

The first decade (about 1965-75) was marked by behavioristic approaches i.e. sequences of content presentation followed by tests and, correspondingly, re-iteration or continuation in the presentation flow. Limits of early host computers with simple monitors contributed to the disappointing results of this *dictatorship era*. Nevertheless, late multimedia-augmented remnants of this era like CBTs and WBTs – coined as **eTutorials** below – represent the only commercially successful eLearning category today.

The second decade (~75-85) brought a vast amount of model-based learning systems such as intelligent tutoring systems, role games and simulations, Microworlds and plan-based programming or help systems, summarized as **eWorlds** below. Poor reusability and cost benefit ratio prevented commercial success. Overstated promises, nourished by the AI and cognitivist communities (in the computer science and didactics/pedagogy camps, respectively), accelerated the rise and fall of hope for models that would suit the ‘brains’ of all learners including all possible misconceptions – due this ‘one suits all’ attitude, the second decade can be coined as *communism era*. eWorlds concepts were advanced since, but the key problems mentioned remain unsatisfactory.

Disappointing results with ambitious eWorlds resulted in overly modest pedagogic goals in the third era: instead of being guided, the learners were supposed to explore subject domains on their own. Constructivist research, much improved explicit representation of semantic structures (using the upcoming hypertext concepts) and improved presentation (as multimedia) all contributed to new – again exaggerated – hope for big success. But the era of explorative learning was way too much the *era of anarchy*.

Alas, the current decade (about 1995-2005) can be coined as *New Age* since old recipes are mixed with (once more exaggerated) new promises. The computer science camp jumped on the ‘virtual reality (VR)’ bandwagon just in time: serious budget problems in the private and public sector increase the temptation to believe that ‘virtual universities’ may be created where entire teaching departments can be replicated by means of keystrokes. At least the pedagogy/didactics camp tuned to modest expectations, despite two interesting advancements: firstly, an eLearning concept was shaped which we will call **eProjects**: support for discourse centered and project centered learning styles, applying computer and Internet based tools for project organization, cooperative work, etc. Secondly, adaptive hypertext was improved towards higher reusability and lower development cost for eTutorials and eWorlds; XML is likely to advance this field further.

eLearning Categories

Many taxonomies and classifications for eLearning exist, such as the distinction into local and remote, synchronous and asynchronous, isolated and cooperative learning. The categorization used below (cf. fig. 1) is not just another one, but was developed as a rationale for the importance of research strategies towards sustainable eLearning.

Fig. 1 shows a fundamental distinction between computer-based improvements of existing, on-campus teaching/learning styles – called **augmented learning** – and the introduction of remote and possibly asynchronous eLearning which is not possible in classical schools and universities – coined as **distance learning**. A look at the first category reveals that **eLectures** i.e. on-campus concepts like electronic classrooms were omitted in chapter one. Current projects headed by the author concentrate on scaling up from classroom size to lecture hall size venues, so-called Digital Lecture Halls (Rößling, Bär & Mühlhäuser 2004), and on tight integration of notebook students i.e. learners equipped with mobile terminals of all kinds (‘learners-in-the-loop’).

Fig. 1 also points at the fact that eTutorials, eWorlds and eProjects can not only be applied in asynchronous and/or remote learning setups, but may be introduced in lectures and other on-campus teaching forms. Together with (multimedia) recordings of eLectures, they contribute to a seamless transition between classical yet augmented on-campus teaching and novel off-campus approaches.

The third fundamental category called **ambient learning** denotes an innovative field of eLearning that becomes possible with the pervasive, disappearing computing appliances considered as computers of the 21st century. Given such appliances, one may automatically retrieve much of the actual context (see Moran & Dourish, 2003) of users at work (or leisure). Based on this work context, not only just-in-time but *just-as-needed* learning (i.e. information provision) may be supported. Novel terminal devices, such as the location aware *talking assistant* for hands-/eyes-

free operation developed by the author's team (Trompler, Aitenbichler, & Rößling 2003), support presentation of and final navigation through the subject matter.

Ambient learning is a key to considerable innovation in manufacturing, services, and office automation. It may penetrate many areas of business and private life, thus the term **eLife**. In order to link this innovation with educational institutions, University labs must be transformed into **eLabs**. There is already a trend to link labs – the point were future work places are experienced in vitro – live to the Internet. Future concepts must go further and model ambient learning as described above.

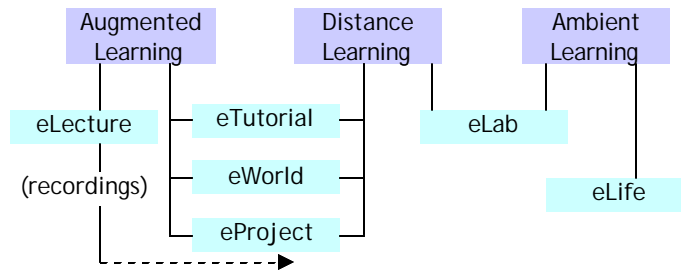


Fig. 1: eLearning categories

Sustainability in eLearning

Why did eLearning evolve at a different pace in academia and practice? In many in-depth investigations about prestigious eLearning projects – which were successful in academic, in-vitro terms –, the author found very similar patterns which hindered commercial success:

- The projects were undertaken with tremendous financial and temporal effort, wide-spread application with comparable effort was not feasible
- The projects depended heavily on the personal interest of the researchers involved, quite often a mix of expertise from several participants was necessary – unlikely to sustain in a typical volatile academic group and hardly found in the wide field of potential “users”
- Continuous adaptation and improvement of the results – in particular, the content – was not assured.
- Substantial dedication of the participants to the project was required; little attention was paid to future customers who might be busy subject matter experts, typically not inclined to invest a lot of dedicated effort to the development of new teaching material, let alone new teaching styles.

These findings lead immediately to the focal-areas towards sustainable eLearning:

- **Re-Usability way beyond material:** standards like LOM and SCORM already emphasize the – important – aspect of re-usable learning material, but that is not sufficient. Subject matter experts are quite often *not* pedagogic experts (especially, beyond K-12 education), let alone experts in eLearning or multimedia. Content creation processes, instructional processes and strategies, patterns and best practices, media expertise and similar domains must be made the focus of re-usability.
- **Quality centered processes, including tightly integrated short and long feedback loops:** feedback loops from the learners to authors and teachers have been a major subject in eLearning for years. Web forums and eMail channels have been established as short feedback loops complementary to oral feedback (questions, comments); evaluation of teachers and teaching material by students has become almost as common as student assessment and testing and examination. However, these feedback loops are still hardly coupled with the forward part of the loop: in order to refer to material, students usually need verbal explanation. As a consequence, the *true* feedback i.e. improvement of teaching requires pretty much a “hand-crafted data mining” effort, time-consuming, imprecise – and often not timely enough in the case of short loops that

would demand immediate adaptation of the teaching process. In order to change this status, feedback must be designed in much more explicitly during the authoring stage: if learners can refer to the semantics (concepts, topics etc., in a machine-readable way), physical material (by machine-readable reference), and process (by generally applied timestamps), then authors and teachers can easily refer authoring issues (material, presentation, didactics, etc.) and feedback to one another, both for dynamic adaptation (during ongoing lectures) and for long-term improvement (from one cycle to another); statistical analysis and other computer-assistance in the feedback loop

- **Seamless, gradual development/deployment processes:** good teachers are usually experienced teachers, which means that a) they don't want to leapfrog into novel teaching approaches (which would make them unexperienced) and b) they are most likely too busy to dedicate a lot of effort into revolutionary new processes such as eLearning, in particular. In the commercial world, teachers (often: trainers) have slowly moved from blackboards and overheads to Powerpoint™ like tools. Being busy and successful, they are reluctant to huge efforts and "unknown" teaching style. In the academic world, teachers are mostly researchers, for whom teaching is often only a secondary interest. In any case, seamless and gradual introduction of new styles is crucial both in order to keep the introduction effort feasible and in order to let teachers experiment and gain experience with new teaching styles.
- **eLearning programs, not projects:** mostly orthogonal to the conceptual requirements stated above which must be materialized in ("technical", "pedagogical") processes, methods, and tools, educational institutions (and the strategically and financially responsible) must decide to move from eLearning projects to eLearning programs. With the term programs, we want to emphasize the move away from efforts of rather limited scope in time and reach (of people involved). Programs, in contrast, must target all teachers and learners and qualitative criteria that may effect budgets, evaluations, strategic decisions, and the like.

In the remaining chapter, we will take the example of Digital Lecture Halls, a project headed by the author, in order to explain in an exemplary way how sustainability can be introduced into eLearning tools and approaches.

Sustainability in the Digital Lecture Hall

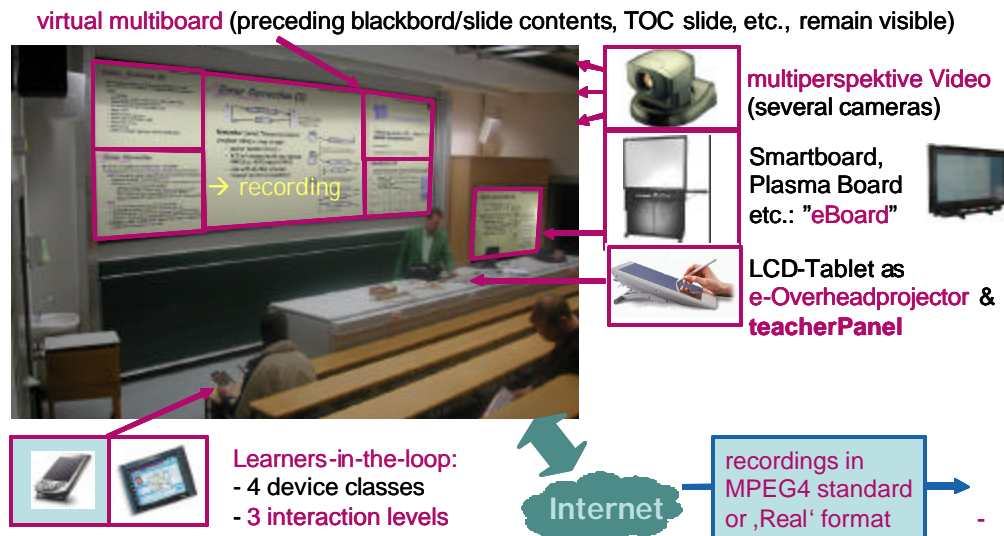


Fig. 2: Medium-Size Digital Lecture Hall, Excerpt

As mentioned before, we will inspect only one of the three eLearning categories briefly as an example, mentioning only some of the possible efforts toward sustainability. To this end, we will pick *Augmented Learning* i.e. computer support for traditional teaching venues.

The Digital Lecture Hall (DLH) is the first known attempt to augment *large* venues, i.e. 150 thru over 1,000 seats, plus remote participants, towards systematic e-Learning. (While our concept scales back to classroom size, electronic classrooms like our predecessor project Ccf (Mühlhäuser 1996) or the Classroom2000 project (Abowd 1999) do not truly scale up to large venues.) For the sake of brevity, only some key features of DLH are mentioned here. Among others, we turn venue walls into ‘virtual multiboards’ based on an affordable beamer-array approach, and improve telepresence experience for remote participants by use of multi perspective video. Our teacher software offers a comfortable mix of dynamically annotated prepared material (Powerpoints, WebPages, simulation software, or whatever) and ad hoc slides, and integrated teacher access to all of the following functions. Local and remote learners-in-the-loop are supported in four mobile device classes (Smartphone, PDA, Laptop, Tablet PC) with three interaction levels: 1. *TVremote*, a minimally distracting, non-obtrusive mode of mobile device usage; 2. *ToGather*, a novel support software for comments and questions, digital note-taking / annotations (locally based on wireless broadcasts of virtual multiboard contents), learner groups, etc.; 3. *Assignment*, an integrated approach for planned interactions, with automatic projection / dissemination of assignments, collection and anonymous (statistical) or personalized evaluation of results. The picture below illustrates just one possible setup, in this case for a retrofitted 150-seat venue. Other venues in regular DLH use comprise, e.g., some 600 students per class.

Looking at the key requirements stated above, we find the Digital Lecture Hall respond to these in the following way:

- *Re-Use way beyond material*: although this requirement is more pertinent to the “distance learning” category of eLearning, DLH covers it to the extent possible. DLH suggests a customizable, modular teaching process which is “coded” into the tool set, enabling teachers with classical yet computer based teaching material to embed this material readily into the DLH-supported process; the process itself is intuitively adapted to a teacher’s and to learners’ needs. The open interface (compatible with any presentation and Internet tools, open for integration with any feedback and learners-in-the-loop tools and concepts) allows for integration of existing material, tools, and processes.
- *Quality centered processes, including tightly integrated short and long feedback loops*: regarding this requirement, DLH-module *TVremote* (see above) provides already a high degree of support, with further improvements under construction. Today already, the short feedback loop includes textual questions as well as customizable short-term evaluation (e.g., regarding the speed in which the teacher progresses). A question counter is visible at any time and doubles as access point to the question-handling module of DLH, where questions can be selected for public discussion. Using timestamps, they can later be related to teaching material for easy consideration in the improvement cycle. The same applies to “comments”, an alternative means for students to submit textual feedback, when they consider it relevant for non immediate consideration only. The short-term evaluation is immediately statistically evaluated and displayed: e.g., a very condensed color-coded quick feedback is available with minimal cognitive distraction at any time; by selecting the corresponding tool bar, teachers receive detailed analysis of the evaluation. The *Assessment* module of DLH, too, supports immediate statistical evaluation such that teachers can immediately infer adaptations to the teaching process from the test results of interactive quick tests. In the near future, DLH will be augmented to support semantics of subject matters in its modules. For instance, this will allow students to refer to generally agreed subject matter ontologies during their feedback, providing even tighter coupling of the forward and backward path of the process loop.
- *Seamless gradual processes* are maybe the single most important feature of DLH: teachers can migrate from Powerpoint™ like, Internet based, or blackboard based teaching to the DLH based teaching process with absolutely minimal effort. With the recently released version of DLH, we have experienced (non computer science, non pedagogy) teachers adopt DLH easily with a 30 minute introduction – of course, only in a mode that resembled their existing teaching style to a large extent. From that point on, the seamless transition into true eLearning can be carried out at the pace suitable for the teacher; e.g., the introduction i.e. sub-steps of “learners-in-the-loop” (after-hours comments first, then immediate feedback, then interactive quick tests, etc.) can be paced individually, even concerning the “degree” (e.g., number and

length of interaction/test phases) within each sub-step. “Distance Learning” modules can also be introduced in small steps. For instance, we introduced in the course of our DLH-based lectures simulation applets, algorithm visualization tools, knowledge bases, and other ‘modules’ suitable for self-study. This provided seamlessness with two respects: i) with respect to the in-class teaching process (these modules could be developed and introduced at a pace suitable for the learner; e.g., in one term of one of the lectures, only about one hour worth of teaching was converted); ii) with respect to the introduction of distance learning as an addition to augmented learning.

- *Programs, not projects*: details of this aspect of sustainability will be provided at the keynote directly since late-breaking success is expected to be reported.

Conclusion

We have advocated sustainability as the central requirement of eLearning research, in an attempt to narrow the gap between eLearning research/experiments and wide-spread practice. Sustainability was further expanded into three crucial requirements. We identified the areas of eLearning for which sustainability has to be considered, and reported about experiences in one of these areas, augmented learning. The example has also indicated that sustainable approaches in one area may help to provide better integration among the three areas.

Extended References

G. Abowd (1999); Software engineering issues for ubiquitous computing; Proceedings of the 1999 international conference on Software engineering, 1999, pp. 75 – 84.

G. Abowd, C. Atkeson, A. Feinstein, C. Hmelo, et al. (1996); Teaching and learning as multimedia authoring: the classroom 2000 project; Proc ACM Multimedia 1996, pp. 187 – 198.

D. Brown, J. Burg & J. Dominick (1998); A strategic plan for ubiquitous laptop computing; CACM 41, 1, pp. 26-35.

T. Duffy & D. Jonassen (1992) (Eds.): Constructivism and the Technology of Instruction: A Conversation. Hillsdale, New Jersey: Lawrence Erlbaum Associates, Inc., 1992.

D. Fellner & A. Hopp (1999): VR-LAB--a distributed multi-user environment for educational purposes and presentations, Proc. VRML 99 4th Symp. The virtual reality modeling language, February 23 - 26, 1999, Paderborn Germany, pp. 121-132.

R. Ginsberg, K. Foster, (1998): The Wired Classroom. IEEE Spectrum, Aug. 1998, pp. 44–51.

T. Hampel, F. Ferber, R. Keil-Slawik, & W. Müller (1998): Hypermedia teaching of mechanics--MechANIma; Proc. 6th Conf. teaching of computing/3rd Conf. integrating technology into computer science education, 1998, pp. 112 – 116.

V. Hilt, M. Mauve, J. Vogel, W. Effelsberg (2001): Interactive Media on Demand: Generic Recording and Replay of Interactive Media Streams. ACM Multimedia 2001, Ottawa, Canada, 2001.

V. Hilt, C. Kuhmünch (1999): New Tools for Synchronous and Asynchronous Teaching and Learning in the Internet. Proc. ED-MEDIA and ED-TELECOM'99, Seattle, USA, 1999.

C. Hornung, J. Hornung (1999): Knowledge Management in Learning Organizations, 19th World Conference On Open Learning and Distance Education, Wien Jun 21, 1999.

R. Jackson, W. Taylor, & W. Winn (1999): Peer collaboration and virtual environments, Proc. 1999 ACM Symp. applied computing, Feb. 28-Mar 2 1999, San Antonio, TX USA pp. 121-125.

- R. Jain & K. Wakimoto (1995). Multiple Perspective Interactive Video. Proc. Intl. Conf. Multimedia Computing & Systems, pp. 202-211, IEEE Computer Society Press 1995.
- B. Kahn (1997) (Ed.): Web-Based Instruction. Englewood Cliffs, New Jersey: Educational Technology Publications, Inc., 1997.
- T. Moran & J. Dourish, (2003) (Ed.): "Context -Aware Computing". *Human Computer Interaction 16, 2-4*, Erlbaum.
- M. Mühlhäuser (1996): Interdisciplinary Development of an Electronic Class and Conference Room. Journal of Universal Computer Science, J.UCS 2 (10), Springer Heidelberg, Oct. 1996.
- E. Mynatt, T. Igarashi, W. K. Edwards & A. LaMarca (1999): Flatland: new dimensions in office whiteboards; Proc. CHI 99: the CHI is the limit, 1999, pp. 346 – 353.
- T. Naps, J. Bergin, R. Jiménez-Peris, et al. (1997): Using the WWW as the delivery mechanism for interactive, visualization-based instructional modules; Suppl. Proc. Conf. Integrating technology into computer science education 1997, pp.13–26.
- G. Rößling, C. Trompler, M. Mühlhäuser, S. Köbler, & S. Wolf (2004): Enhancing Classroom Lectures with Digital Sliding Blackboards. In: Proceedings of the 9th Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE 2004), Leeds, UK. (to appear), ACM Press, New York, 2004.
- G. Rößling, H. Bär, & M. Mühlhäuser (2004): Interaction Support in Large-Scale Lectures. In: Proceedings of the 9th Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE 2004), Leeds, UK. (to appear), ACM Press, New York, 2004.
- K. Swaminathan, S. Sato (1997): Interaction design for large displays; interactions 4, 1 (Jan. 1997), pp. 15 - 24.
- C. Trompler, E. Aitenbichler, & G. Rößling (2003): "Intelligent Headsets for Supporting Digital Lecture Halls". Proc. WOMTEC'03, *JDET Jrnl.*, Idea London.
- A. Tucker (1996); Strategic directions in computer science education ; ACM Comput. Surv. 28, 4 (Dec. 1996), pp. 836 – 845.
- Virtual Campuses (1998). CACM special edition, January 1998, Vol. 41, No. 1.