Is e-Learning the Solution for Individual Learning?

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Abstract: Despite the fact that e-Learning exists for a relatively long time, it is still in its infancy. Current e-Learning systems on the market are limited to technical gadgets and organizational aspects of teaching, instead of supporting the learning. As a result the learner has become deindividualized and demoted to a noncritical homogenous user. One way out of this drawback is the creation of individual e-Learning materials. For this purpose a flexible multidimensional data model and the generation of individual content are the solution. It is necessary to enable the interaction between the learners and the content in e-Learning systems in the same manner.

Keywords: constructivist learning model, learning objects, e-Learning system, document generation

1. Motivation

> *“Learning through 'discovery' is best supported through the 'interactive' media of the field trip [...]. This is the richest mode of learning and, of course, the most expensive, requiring both the intimate involvement of the teacher, and the 'teacher-constructed world'“* (Laurillard 1995).

Already in the nineties a change in learning methodologies began to emerge in the US. Constructivist approaches started to replace instructional methods; the focus went away from the teacher and moved to the individual learner. A large number of trend reports and Delphi studies accompanied these discussions about e-Learning. In this golden age of e-Learning a lot of consulting companies presented a never-ending series of rather optimistic studies to the public. During this hype the primary motivation is a profitable motive. The acceleration of the ROI (“Return on Investment”) of e-Learning projects was moved into the centre instead to optimise the learning process. Mostly the e-efforts are reduced to the equation “e-Learning = e-business”. The usually quoted cost reductions should be the proper raison d’être of e-Learning. Also, the focus of activity has been mostly on mapping traditional educational processes one to one into a digital environment. Considerations of the learning process requirements and the needs of the individual learners have been mostly absent in practice. But, learning can only take place when heeding the specific context out of which learning activity is going to happen as well as making allowances for individual skills, interests, mental attitudes and abilities. Therefore we will suggest a learner centric point of view for all e-Learning investigations. Learning in this sense is an active, self-regulated, constructive and situated process (Duffy et al. 1992, Bransford et al. 2000) as well as a social one. That means learning has a procedural and active character, which must lead to construction of knowledge by the learner on the background of the learners individual experience and knowledge (Mandl et al. 2002, Sun et al. 2003). We will henceforth refer to this model as the *constructivist learning model* (Piaget 1977, Maturana et al. 1987, Clement 1989, Papert 1992). Furthermore, we will develop a new definition of e-Learning which takes this approach particularly into account.

A multitude of definitions of e-Learning already exists in literature. For many authors the adoption of electronic media in a learning scenario is already sufficient to constitute *e-Learning* (see e-Learning Consultant 2003). This definition is clearly too broad. For example the use of a microphone during a lecture should be excluded by a proper definition from being e-Learning. So, the simple use of electronic media is not enough. A proper definition should demand that the electronic media give specific support to the learning process itself, which probably could not be achieved by other media (else we would have a case of electronic media just emulating traditional media).

Many e-Learning projects seem to subscribe to the definition we just characterized as being too wide. Their program of action is just to import existing standalone mechanisms of content distribution and communication into a didactical environment without ever truly justifying their relation to and benefit for the learning process. Using hyperbole to make our point, we are tempted to say that a conflict which is being slugged out by throwing books does not constitute a literary contest at all.

An alternative definition of e-Learning has been that e-Learning is aggregation of all kind of learning which use the computer for medial support of the learning process (NRW Medien GmbH 2003). Similarly, Baumgartner, Häfele and Maier-Häfele (2001) suggest that e-Learning is the general term for all kind of software supported learning. Both attempts are not very useful because they are also too loose and do not demand enough.

In contrast, others only see e-Learning where all real business process of learning, teaching and organization has been migrated into the digital environment. According to Rosenberg (2001) e-Learning depends on internet technology and is typically a networked form of learning based on a more general concept of learning which transcends the traditional paradigms.

We suggest the following definition to emphasise the new and different aspects of e-Learning as compared with traditional learning:

> *We will call e-Learning all forms of electronic supported learning and teaching, which are procedural in character and aim to effect the construction of knowledge with reference to individual experience, practice and knowledge of the learner. Information and communication systems, whether networked or not, serve as specific media (specific in the sense elaborated previously) to implement the learning process.*

Thus, our definition is based on the constructivist learning model. Knowledge is no artefact and thus can not be conveyed to anyone. It must be constructed by the learner herself/himself. The paradigm of the moderate constructivism in which instruction and construction complement each other, seems to be especially appropriate for e-Learning. Here learning should be understood as a generative process which nonetheless needs to be initiated guidance by the teacher. In this reference frame constructive, autonomous learning always needs also instructional interludes coming from the outside.

Generally the following four issues suggest themselves as being profitable as starting points for considerations about the requirements e-Learning systems must meet to support individual in the learning process.

- How can the teacher be supported in producing teaching material for standardized profiles?
- How should the material be presented to learner and which kind of interaction with the material will support learning?
- Which kind of feedback is useful and possible?
- How should teachers and co-learners be represented within the system?

We will now try to derive some desiderata for e-Learning systems from the constructivist approach we presently favour. It can be already perceived from our present state of discussion that we cannot focus exclusively on the learning process. In the moderate constructivist approach, the learner needs to receive additional instructions. To be in accordance with the constructivist idea these must be specific to the learner. So if we talk about a process supporting learning according to moderate constructivist theory, it stands to reason to extend our considerations to the question how the learner specific teaching material could be obtained or produced. We also need to consider the teaching process to certain extent.

Therefore, this work will elaborate especially the production and interaction with learning material for individuals. The paper is divided in three parts. First we will talk about the necessities of marking up texts according to target groups. Then, we will talk about synthesis of material from smaller components and reuse of components in this process. Last we will outline what interaction is necessary to enable the user to create an individual information landscape.

2. A multidimensional data model for learning material

Empirically the majority of existing e-Learning content has been produced by just transforming traditional "established" content into a digital representation. While the reason for this was usually lack of financial and temporal resources, this also implies that differentiation for different types of learner and adoption of constructivist philosophy could not take place. In consequence, this content does not offer any added value in comparison to traditional learning material.

To support the constructivist learning theory the learning material must be customized to the individual learner. Complete individual content is of course not viable. A coarse grouping of the learning community into various stages of advancement is necessary to reduce the number of learning material versions which need to be produced. Possible criteria could be the ability to concentrate, previous knowledge and interests. Dreyfuß (1986) and Baumgartner (Baumgartner 1993, Baumgartner et al. 2001) offer a system of classing learner into five levels.

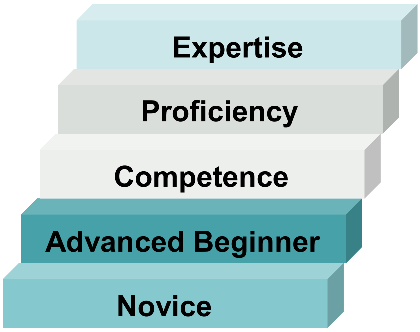

Figure 1: Learner Levels (Dreyfuß 1986)

The levels differ in various grades of intellectual and practical mastery of the subject in question. So systems to grade learners into various levels for defining target groups for the deployment of instructions of different difficulty degrees are already well known in the e-Learning community. The model quoted provides a one dimensional classification. In contrast we assert that a one dimensional model is not enough, i.e. more than one criterion is necessary in various degrees of intensity to characterize the specificity optimal to any given learner (Lucke 2002).

Multidimensionality, even when balanced against a low number of coordinates on each axis results in a huge number of potential variants of documents or learning objects deployed to the learner. Thus tool support is necessary to maintain all variants in a common source, mark-up sections of text or parts of learning objects for the intended target groups and extract the desired variants automatically. We will now introduce a document description language with associated tools to facilitate this process.

XML based document description languages have been proven tools for a time to achieve reusability and media independence of learning materials. The *Multidimensional Learning Objects and Modular Lectures Markup Language* (short <ML>^{3}, pronounced 'em-el-three', see <ML>^{3} 2003) is such an XML based description language geared towards e-Learning content which specifically provides methods of content markup supporting the creation of learner specific documents. This innovative document description language was developed by the German government project „Wissenswerkstatt Rechensysteme“ (in Engl.: „Knowledge Factory for Computer Systems“, see WWR 2004). Within this project twelve German universities are using this language to support teaching and learning in the field of computer engineering. The primary goal is to offer numerous fine-grained teaching and learning modules to combine easily with each other in order to fit on concrete educational objectives. These should provide for the matter that in many fields, several multimedia presentations for computer science have been created, but the combination of material is complicated by different presentation styles or just missing references (Lucke 2002). When using <ML>^{3} the subject matter will be structured into separate thematically self-contained modules. Every module could be structured subject specific as well as according to didactical considerations. The subject structure of a module provides the base for the content implementation proper and is equivalent to structuring in chapters and sections. The didactical structure is a complement to the subject structure. Its purpose is to divide the subject matter into parts, which can be easily handled by the learner. To achieve this, the module is being divided into lectures and learning steps independent from its subject structure. The latter are being classed into introductory, motivating, knowledge procuring, summarizing and applicatory learning steps. The classification of content into didactical structure is done exclusively by referring to content sections which have been implemented during the subject structuring. It must be emphasised that a given module can be furnished with more than one totally independent didactical structure. Furthermore, the given didactical structure template of lectures and learning steps can be replaced as needed by other suitable structuring schemas so that any module can be equipped with multiple structures, perhaps based on different structural schemas.

But only the scaling concept integrated into the <ML>[3] data model allows the definition of learner specific content and enables, in combination with the features previously described, the production of high-quality content for e-Learning. A module can be scaled within three dimensions: *intensity*, *target group* and *usage scenario*. The first dimension, intensity takes three possible values. These are according to the steps in figure 1 *novice*, *competence* and *expertise* and mainly mark the complexity of the subject matter and thus the amount and depth of material produced. Presently the second dimension, target group differentiates only between learner and teacher. Using this parameter it is possible to define content section specific for a target group. This is useful in example for self-testing exercises, interactive components or virtual experiments from which mainly learners can profit, whereas teaching assistance and sample solutions are mainly of interest to the teacher. Finally the third dimension, usage scenario determines how the material is going to be presented. Presently documents can be produced to be used as a slide based presentation (e.g. within a lecture), as a printable version (e.g. lecture notes) and online version.

3. Generation of individual learning documents

This data model has been introduced as a pretty good example which offers the options to allow for the individual needs of the learner. The flexibility of <ML>[3] is restricted by the variability of the content. To achieve this flexibility the *reuse of learning objects* is an often quoted buzz word. Essentially this would mean to be able to create new learning objects flexibly, adapted to the individual experience and knowledge of the learner. Baumgartner question this idea by asking exaggerating, why anybody should book an online course of some hours if 15 minutes could be sufficient?

This criticism must be considered founded insofar as the idea of reusing learning objects has not had the desired results yet. The original idea has been to modularize documents into single building blocks which can be reassembled to documents again similar to the children's toy LEGO (see Fig. 2). The IEEE has recently formalized this idea by the defining a learning object as „*any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning*" (IEEE, 2003). According to this definition, a learning object could be almost anything: a single picture, some graphics, a text, flash animation, a short tutorial text or a multiple-choice-test (Baumgartner 2001).

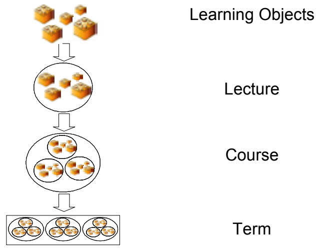

Figure 2: Building blocks principle applied to learning objects

> *Consequently, „what has followed since the introduction of the term learning object has been a flurry of technical activity, financial speculation, and international standards efforts. What has not followed is a flurry of principled instructional design work utilizing the new instructional technology"* (Wiley et al. 2000, p. 1).

Designing such a system of building blocks makes it necessary to take some decisions which have fundamental implications. The choice of a granularity, that is the size of the smallest components, is such a decision. It brings about the controversy between the proponents of the constructivist and instructivist paradigm. For example, if the smallest component encompasses a full course its reusability would then be rather restricted and context specific. This would mean a reification of the knowledge in question and would emphasis the instructivist element. In the other extreme reducing the granularity to single sentences would be rather nonsensical. It would be quite difficult to present in coherent way anything meaningful in such an *atom of information*.

Constructivist learning models depict the context of a learning scenario that is situated learning, as one prerequisite that meaning can be constructed (Bruhn et al. 1996, Bannan-Ritland et al. 2000). The best choice of granularity should therefore lie somewhere between two extremes. A size too small would let the learner loose herself/himself in the information nirvana, i.e. the granularity is too small to allow a constitution of meaning within the single element. A size too large would mean a fixed sequence of segments of information which would allow neither retrospection nor preview and would also be much too inflexible in a constructivist learning process.

AMG (Automatic Manuscript and Course Generation, see AMG 2003) is a project which is building on <ML>^{3} and consequently has chosen the <ML>^{3} module as the unit of granularity. Accordingly, a module is a composite of textual sections and other media objects. The automatic composition happens in several processing steps. The first step finds modules suitable for the generation process. The result of this search is a graph of relations, which will be used in two ways. Firstly, to create learning documents for standardized profiles (like novice, competence and expertise). Secondly, to synthesize an individual document for a single learner. Since standardized profiles can only describe a learner in a rather general way, a certain minimum mismatch between the actual abilities of the learner and the presumed target group necessarily results. Furthermore, the teachers have additional work generating all necessary document variants. Therefore within the second scenario every single user can herself/himself generate documents adapted to her/his personal profile.

Using the user profile and a given learning objective, the system can selectively determine an appropriate learning path. So, single nodes can be removed from the graph either because they are providing instruction that is already being covered by previous knowledge or because they are not imperative to the objective. On the other side, some nodes can be weighted more heavily to cater certain user interests. Even more, generation of personalized documents could adapted to the learner with respect to content, form of presentation, time needed, difficulties and arrangement of subject matter.

One advantage is, that in this way personalized documents, which lead the learner without needless detours directly from her/his current base of knowledge to the desired learning objective, can be generated automatically and every time. A further point to consider, which might seem less essential but nonetheless might prove rather disruptive when not heeded, could be the use of heterogeneous data formats for the fundamental building blocks. It might be a desirable vision to bring together any kind of data formats but the resulting differences in presentation and handling might also distract the learner from learning. Therefore the separation of content and layout is a necessary prerequisite. Since <ML>^{3} is a semi-structured data format it is possible to compose content first and only then decide on a uniform representation by selecting a stylesheet.

4. Interaction with learning content

In the last two chapters the focus has been on the creation of learner specific content. But only the creation of content, how good ever it might be, can not be a purpose of itself. Everyday handling of such content in the communication to the learner is a significant part of the learning process. We will now undertake a short survey of the state of practice as found in contemporary e-Learning systems by an evaluation at the University of Rostock, criticize that practice and from that derive some requirements for how e-Learning systems should interact with the user.

As part of the project Notebook University Rostock (NUR 2003) more than 15 e-Learning systems have been checked against a previously compiled catalogue of criteria in spring 2003. In summer 2003 three selected systems have been evaluated against each other in actual operation to test the suitability for long-term usage at the University of Rostock. Whereas a system could be selected which caters for the (currently primarily organizational) needs of the users, none of the systems has any significant support for the constructivist aspects of the learning process. Mostly these systems serve only as data containers into which the teacher or tutor can upload files. But such files of arbitrary format must remain opaque to the system and therefore can not be filtered during the rendering process according to the users profile and history. The user can not leave traces in the document. Basically, all investigated systems just try to map traditional learning objects of the physical world like a book or lecture notes into a digital environment. But only certain major properties of these objects are actually modeled, like that books are made up of pages, can be read etc. Other more accidental properties of the physical counterpart got only minor importance attached by the systems designers and were lost in the digital world, but are actually essential to constructivist learning. For example, books and lecture notes in the physical world can be annotated, but their electronic counterparts can not be. Any effort to create a personal portfolio of documents is also badly supported. The learner find herself/himself restricted to static folders created by the teachers, his only option to group documents differently is, to download them. But then e-Learning does not happen in the system anymore, the e-Learning system degenerates simply to a distribution platform for electronic documents.

Learning with “real paper”, that is text books, lecture notes and photocopies provide an opportunity for autonomous and self-controlled learning. The learner can put together her/his own reference library, their own portfolios and folders for every topic. She/he can annotate and cross reference documents and thus forge a knowledge and information landscape in which she/he is at home and can navigate expertly. In this point the digital environments provided by all the investigated e-Learning systems fall short of their originals, since they model the paper objects only incompletely, and must thus be considered rather useless when judged from a constructivist perspective.

In the criticism just voiced from a constructivist point of view some corner points of requirements to a useful e-Learning system become already apparent. The e-Learning system must enable the learner to create the aforementioned personal information landscape while working with the provided learning materials. The means are individual compilation and topical rearrangement of learning material, creating “pools” of especially important documents as well as the possibility to annotate and cross-reference material.

5. Conclusions and further works

As we pointed out despite the fact that e-Learning exists for a relatively long time it is still in its infancy. The focus on technical gadgets and promising business models have influenced the development into the wrong direction, at least as perceived from a constructivist point of view upon learning.

To provide a new point of orientation we first suggested a new definition of e-Learning and than tried to at least partially derive requirements for e-Learning systems from the necessity to support constructivist learning processes. We found that individual content and learner specific interaction are the media specific value software based systems could contribute to learning. Methods to maintain and reuse learner specific content have been introduced with the *Multidimensional Learning Objects and Modular Lectures Markup Language* (<ML>[3]) data model and the AMG project. This data model was developed in context of the WWR project. An XML based approach was deliberately chosen in order to achieve for e.g. interoperability, reusability, human-machine understandability, ease of use, etc. The foundation is therefore a modular, scalable description format that enables the separation of content, presentation and didactics. That means parts can easily be exchanged. Based on this features in combination with the generation of individual learning materials a maximum of individual content is possible. The automatic generation of documents is the subject-matter of the AMG project. Obviously a better understanding of the learning process can provide a strict reference frame for designing e-Learning systems.

From that experience our demand to designers of e-Learning systems can only be to drop their occupation with technical gimmicks and instead try to achieve a true understanding of the learning process. Fortunately this insight has already arrived at least at a part of the e-Learning systems designers community, as evidenced by some reviews of the last e-Learning trade fair LearnTec at Hamburg in spring 2003 (Schneller 2003).

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