Technology Enhanced Textbook Provoking active ways of Learning

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ABSTRACT

With this contribution we want to present and explain the demonstrators of the »Technology Enhanced Textbook« (TET) that we developed during the last two years and discuss with the active PLE-community whether TET could be a useful component of a personal learning environment. Instead of using the term PLE to refer to the tool itself we prefer to use it to refer to the whole physical and virtual environment which can be influenced and designed by the learner.

Active learning and technological change

As we begin to let visions come true, we start creating new reality. During the process of implementation the new reality reveals to us as a whole of communicating and interacting individuals and the new product arising. In the process of realisation we use knowledge and tools which where handed over to us in varied ways by current or previous generations. These kinds of transmissions happen in personal and informal connections as well as in structured and institutionalized contexts like schools, universities, enterprises, theatres, concert halls, sports, museums, libraries and the Internet. Experiences, newly developed reality and the successively emerging externalised knowledge are passed on to the next generation in many different ways. In his 1916 published book »Democracy and Education« John Dewey referred to this process as “renewal of life by transmission” [Dew 16]. Humans as members of society develop and renew themselves in this manner as well as they influence the social infrastructure connected with them. In the digital age this recurring activity of handing over and renewal leads to a state of permanent innovation, because today production- and development cycles are becoming progressively shorter and more complex. This is what we experience in the food industry, furniture industry, in architecture, medical industry, in the development of our transport networks from aircraft, train to automobile, in the energy sector, in the supply and sewage networks, in media communication networks (television, computer, smartphone, tablets, mp3-player) as well as in the development of software and the Internet. Hereby, the combination of software development and Internet represents a catalyst function across all sectors of society. The handing over of externalised digital knowledge reaches large groups of people in a short time, because today methods of digital copying, networking and distribution are becoming more and more efficient. From the beginning of mankind to the invention of book culture, as well as from our digital age into the future ahead of us, our capabilities to renew the world are continuously expanding. Over the centuries our inventory of externalised knowledge has been stacked up, cross-linked and continuously developed in sediment-like layers of books, magazines, libraries, cultural assets and digital memories. “Bildung” as scientific term refers to this circular process of transmission and renewal [Neu 12a]. By developing solutions for learning we keep this definition of “Bildung” in mind. The psychological dimensions of learning are characterised by the change of behaviour through experience. Cognitivist, constructivist and behavioural models of learning acknowledge this fundamental view on learning [Lef 86], [Mie 07]. In the teaching-learning research, therefore, action-oriented concepts of learning play an important role [Neu 10].

The basis for the development of specific demonstrators during the TET project is a didactical design (the German term “Didaktisches Design” is different from the traditional term “instructional design” !) that overcomes the confines of traditional instruction-psychologically justified e-learning approaches [Neu 11]. With the design of a textbook of the future we focus on action-oriented educational contexts like “Learning in Context,” “project learning”, “self-organized learning”, “communities of practice”, “Problem Based Learning”, “Inquiry Based Learning” or “Location-Based Learning”.

Currently available mobile media devices, such as smartphones, tablets based on iOS or Android base already allow various forms of proactive interaction with the physical and digital environment beyond the usual communication oriented functions of these devices. You can manipulate experiments, tools, texts, images and other media elements by intuitive touch gestures. Built-in or add-on sensors facilitate measurements, audio and video recordings. You can carry out discussions with other learners and experts or make content available via the Internet. By using GPS, image recognition or augmented reality solutions, location-based phenomena and objects can be identified and individually experienced through interactive experiments and additional multimedia information [Bry 07].

Learning versus e-learning

Before discussing the technological enhancements of the textbook and its potential to provoke active ways of learning, we need to outline the problems that were carried into the educational sciences by the research field of e-learning. In an age of continuous innovation, e-learning seems to be too rigid and inflexible to keep up with the complex dynamics of the globalized development in our society. Numerous studies show that the expectations that many have placed in e-learning were rarely met. Three main characteristics can be found in the literature which could be the reason for the failure of e-learning:

- **The instruction paradigm of the instructional design:** E-learning transferred – since its inception – instruction functions of the teacher to the software (e.g. computer-based training, web-based training). This approach goes back to Robert Gagné who defined principles of instructional design based on his view on the psychology of learning, which stood in opposite to constructivist positions of learning psychology as described in the first section of this article [Gag 73]. Since the constructivist paradigm gained popularity in the psychology of learning, many authors from the field of instructional design made an effort to integrate this constructivist perspective. However, consistent approaches which considered construction as part of instruction were never formulated because: "If learning is primarily determined by the individual and not by the environment and knowledge is understood as individual construction, instruction as a »transfer of knowledge« is strictly impossible" [Blu 98].
- **The idea of controlling learning processes through software**: Until the early 1990s, core of the "Instructional Design" was the management and control of learning processes, e.g. [Mer 88], [Rei 91], even though there were also approaches to integrate context references and constructivist perspectives as seen in Reigeluth. The deficits that resulted from such a perspective in terms of human learning, were explained by Rolf Schulmeister in his book "Grundlagen hypermedialer Lernsysteme". In particular, he criticized the restricted view of Gagné regarding the human memory as a storage system which is a core part of the theory of "Instructional Design": "The validity of the assumption that defined knowledge is stored directly, the so-called "correspondence hypothesis" is rejected by constructivism and [..] been subjected to a detailed critique" [Sch 07: 137]. This dispute between authors of the field of "Instructional Design" and authors relating to the upcoming constructivism was comprehensively documented in [Sch 07].
- **The overvaluation of technology**: Summing up the results of their studies, Gerhard Tulodziecki and Bardo Herzig state that "Overall, the many studies on general media effects (as a comparison between media-based and labour-mediated teaching and learning processes) show that there can not be spoken of a fundamental superiority of learning with electronic media" [Tul 04: 81]. In further articles, Rolf Schulmeister, Gabi Reinman and Michael Kerres came to similar conclusions concerning the meaning of technologies in the context of teaching and learning [Sch 07: 362], [Rei 06: 32], [Ker 07: 3].

Many concepts of e-learning are designed to make learning "easier" for students. However, learning is only effective when the learner actively solves problems and such constructs knowledge. Therefore the "easy" way might not be the most promising one. To address this paradox of traditional e-learning, Joachim Hasebrook asked in a keynote speech in 2009 "Do computers still need humans to learn?" [Has 09]. In educational research it has long been known that there are challenging problems that, once they are overcome, lead to persistent learning and help to adapt existing mental models to new experiences. Encountering an inexplicable phenomenon, considering competing explanations, implementing goals and actively trying out possible solutions are all important activities related to the learning process but are not adequately considered by many traditional e-learning concepts. Therefore, we recommend to disengage from traditional e-learning. Instead of defining learning from the perspective of the electronic aspects of a learning environment, we believe that it is essential to find ways to encourage communication as well as active involvement with phenomena and learning objects to solve relevant problems. We then have to figure out which role media can play in these kinds of settings. In order to enable individual knowledge construction we need a “mediating” device – a medium – for communication and learning. To make these learning and communication processes transparent we use the German term “mediengestütztes Lernen” (media-supported learning). This term emphasizes that the media devices serve for specific functions especially as tools to communicate and facilitate reflection processes during learning [Neu 11].

Developing the Technology Enhanced Textbook (TET)

Our vision is an interactive textbook – as part of the personal learning environment – which provokes active ways of learning and grows with the learner’s experience. The designated user is an active learner who is the author and designer of his/her own personal textbook while going through the learning process. Today’s worldwide coverage of interconnected multimedia devices opens new educational perspectives to technologically enhance the traditional textbook. During last two years we had the opportunity to realise and validate our vision in a project fostered by the “Bundesministerium für Bildung und Forschung” (BMBF). The aim of the project is to validate the potential of innovation of our research and to fit our visions to the conditions of the market. Empirical data gained from focus group sessions with our partners of the educational field (schools, universities, educational publishers, museums, radio and television, vocational training) and data from surveys that were answered by experts in the field of learning (teachers, students, lecturers) helped to outline the demonstrators of TET. Instead of trying to promote learning through simply clicking through items on the screen, our focus lies on activities that use both, the physical and virtual environment. To offer students a wide overview, TET uses collaborative, interactive and sensitive media elements to provide opportunities for students to explore their physical environment through experiments, analyses, and measurements. TET also offers experiences for students to control photo-realistic virtual laboratories and “Interactive Screen Experiments” [Kir 07], which will be available on all current mobile devices with Internet access. Between the physical and the virtual world of experiences, learners construct their personal knowledge and become authors of their own personalized textbooks.

The focus groups

We chose to validate our projects using the focus group method. Compared to individual interviews, this method offers the advantage that the targeted solutions emerge out of the concrete experiences of the participants [Göl 05]. The results of the common communication and interaction of the focus group merge directly into the development of the desired product [Boh 03], [Man 60]. The focus group method emerged from research in the United States when it appeared economically reasonable to interview several experts at the same time instead of asking each of them individually [Boh 03], [Gre 98]. In order to generate a group opinion (as a product of collective interactions) discussion groups are compiled and provided with information [Man 60], [Gre 98]. Common applications of the focus group method include the development of new products, generating ideas, capturing user behaviour or the determination of attitudes [Gre 98: 9].

To start producing demonstrators of TET we discussed our ideas with experts of a television company who planned to enhance their educational program (Bayerischer Rundfunk alpha), with experts of museums in Berlin who wanted to give their visitors new ways of exploring their collections (Museum für Naturkunde, Technik-Museum, Spectrum), with experts of textbook publishing houses (DeGruyter, Cornelsen) and with experts in the field of learning (students and teachers of different schools and universities). Three main didactic functions emerged during the focus group discussions with our project partners. These will be the basis for further developments of the demonstrators of TET: (1) to experiment, (2) to communicate and exchange, (3) portfolio functions [Neu 12]:

- **Toolbox function**: Various sensors and technical interfaces are offered to measure, detect, experiment, photograph and record.
- **Communication function**: Learners communicate via chat or video call about their experiences and experiment together online.
- **Portfolio function**: Information can be researched and compiled from browsers, search engines and the cloud based IMPAL-market, the virtual backbone of TET.

Figure. 1: Acoustic measuring in the classroom

Learning scenarios

From a constructivist perspective the opportunity to actively carry out scientific experiments with mobile devices holds a special value because here direct action of learners and their initiatives come into focus. Appropriate ways of active learning were discussed with learners and teachers during the focus group talks of the TET project.

- **Measurement and Experimentation:** Current generations of mobile devices provide up to five different internal sensors: microphone, motion sensor, magnetic sensor, camera and GPS receiver. In addition, we developed a wireless interface which is able to process, analyse and visualize the data of external sensors that are usually used in schools and scientific laboratories. In an experiment for determining the speed of sound our students tested a scenario using the sensors of mobile devices In the hallways of our institute building the speed of sound was determined by the microphones of two iPads which were placed at 10 meters distance.

Figure 2: Measuring the speed of sound

With a pair of claves a synchronization sound was generated exactly in the middle of the 5-meter mark. Shortly afterwards, the actual measurement click was generated (spatially behind the iPads). Both clicks were recorded by the two iPads. The high resolution of the used sound editor allowed us to display the exact time interval between the two clicks. From the time difference between the two measuring points, the learner was able to determine the speed of sound (speed = distance / time) rather precisely. Several scenarios to promote active learning are documented on Blog Mediendidaktik (URL below).

- **Virtual Experiments:** Another exciting way to stimulate the learners curiosity is the use of interactive screen experiments (ISE) and interactive laboratories (ISL) as photo-realistic, interactive representations of real experiments and laboratories. They give learners the opportunity to make phenomena immediately tangible by using appropriate virtual experiments. Museum exhibitions, technical equipment and scientific phenomena that users experience in everyday life or appear on television can be discovered, investigated immediately and reflected through ISE and ISL. ISE and ISL can be stored in an individual manner using the portfolio function of TET and can be reused at any time. For TET-users ISE will be made available by the web-based media platform IMPAL [Kir 11].

- **Communication:** In the future, virtual experiments can be operated together, online. TET can provide information on who else is currently working with a specific experiment, or who has already worked with it previously. Users can contact these students via chat to discuss the

Figure 3: Inquiry into the centripetal force

implementation, assessment and evaluation of the experiment. To determine who is available online at a given moment, interfaces to common social Networks like Twitter, Facebook or Google+ will be integrated. Likewise, collaborations between classes from different countries or regions can be realized in the form of joint research projects in which measurements that were made in local environments can be collected and evaluated.

Figure 4: Video-analysis with the tet.folio

- **Portfolio use:** We designed TET as a personalized application on mobile devices which can also be accessed via any Internet-Browser on the web. The portfolio feature of TET allows to store personal externalized knowledge fragments, ISE, ISL, as well as individually collected web content. For this purpose TET offers the possibility to store content in an individually designed structure. Here the focus is put on a clean and intuitive handling, not comparable to the complicated functions of out-dated VLEs. Besides providing each user with the opportunity to individually design content, teachers or publishers are as well able to offer prepared contents that can be included in the individual portfolios of students. The portfolio function of TET allows to track individual knowledge construction with regard to design, as well as research processes by reflecting the personal development steps. All information available online such as “Open Educational Resources” content under Creative Commons License or paid media modules offered by publishers and knowledge brokers can be integrated into the portfolio.

Figure 5: tet.folio page on a computer screen

- To get some impressions of the learning scenarios that we are experimenting with, visit the Blog Mediendidaktik and choose category Lehrszenarien: http://www.mediendidaktik.org/category/lehrszenarien/

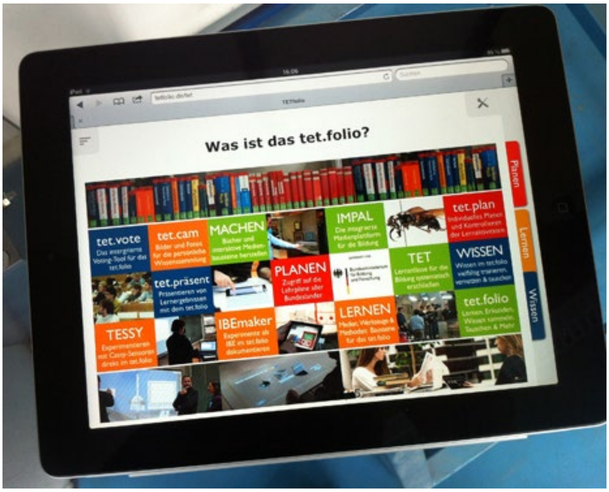

Figure 6: tet.folio page on a tablet

Existing Demonstrators of the TET

TET as a mobile, interactive textbook supports its future users with didactic-technological extensions of reality, through a high degree of modularity of the content and by a variety of tools for the individual and joint construction of knowledge. TET links proven elements of the textbook with new references to the real life: interactive media modules enable experimentation and exploration in space and in situations that are not available in reality. The following demonstrators of the TET are available for demonstrations:

- **tet.folio:** With the tet.folio learners have access to tools, study materials and the whole Internet. They can bring all of these elements into their own intuitive order, carry out evaluations and make those individually prepared items available to other students and teachers. Active, self-determined forms of learning can be optimally stimulated and supported with the tet.folio. In the tool-area instruments are made available, which are able to record data from external or internal sensors of the mobile device. These records can be evaluated, visualized and processed directly within the tet.folio.
- **IMPAL-Server:** The tet.folio offers access to elements and learning objects of different learning media providers via a cloud-based Internet server (IMPAL) . The user gets access to Open Educational Resources, Creative Commons Licensed media as well as fee-based, high-quality media products of renowned educational media publishers.

- **Interactive Screen Experiments:** Interactive screen experiments (ISE) as photo-realistic, interactive representations of real experiments are no movies and no mathematical simulations. The production of an ISE is based on photo-shootings, during the execution of the experiment, recorded in stop-motion, similar to the production of cartoon animations. Audio and video elements as well as measurement data are inserted to the ISE to enable a realistic perception.
- **ISE-maker:** The ISE-maker allows you to produce Click & Slide animations in an intuitive way. There are no programming skills required. An HTML-based interface allows the user to take photos, to define interactive areas and to animate the resulting ISE. This works on a computer via mouse click, as well as on mobile devices using touch gestures.
- **Tessy:** The "Tessy" sensor interface of the TET enables the user to record values of external sensors wirelessly. It allows you to stream data directly to the digital teaching materials of the tet.folio. The measured values can be streamed in real-time to any place in the classroom. Real experiments can be demonstrated. The measured data of an experiment will simultaneously play the resulting graphics on a Smartboard. Other mobile devices are able to track the live data also, so students using the tet.folio will be able to edit these data streams directly.

These demonstrators help to enrich the personal learning environments of any learner. Aside to these "educationally" demonstrators we developed some more technically driven demonstrators, such as Interactive Screen Laboratories, which offer interactive panorama-views of a real laboratory, the tet.table which offer visitors of a museum ways to interact with real and virtual objects at the same time as well as automation and production systems to realise new media formats for educational television and museums. To get some impressions of the status of the TET-demonstrators and its context visit the tetfolio.de Homepage: http://tetfolio.de/home/index_engl.shtml .

Conclusions

The TET project reached a status now where we want to spread the results of our validation process and find partners to go live with the project. Aside to the fact that the developed demonstrators seem to fulfil the needs of the different target groups which were explored, the core results of the validation are: there are three relevant business segments to earn money with our solution: production (service, customization), sale (IMPAL products, multimedia elements and tools) and resale (marketplace, publishing houses). The central idea around the business model at the moment is, to offer the tet.folio free of charge for all systems and to earn money with high quality products around it. In a next step we look for the financing to produce the prototypes of the tet.folio and the IMPAL-server. A beta test phase and activities to build a lively learning community around it will follow. People and institutions who want to collaborate are always welcome. Up-to-date information about the TET project you can find on our homepage: http://didaktik.physik.fu-berlin.de/projekte/tet/index_en.html

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FIGURES

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