The Practice of Research on Technology-enhanced Learning

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Abstract—**The methods of programming in regard of Technology-enhanced Learning are not the same as in the case of programming for accountancy because teaching and learning are sophisticated knowledge-based activities. Moreover, these processes are unstructured and uncertain in respect of what is typical for living systems, e.g. people's mentality towards knowledge processing. Therefore, any informatics support is very complicated in this context. This paper presents how support is achieved in the practice of research on Technology–enhanced Learning in the teaching of bachelors. This is based on an in-house developed database application called BIKE that uses a batch knowledge-processing paradigm.**

Keywords-Technology-enhanced Learning; batch knowledge processing; database aplications; knowledge based processes

I. INTRODUCTION

Research on Technology-enhanced Learning (TEL) belongs to the priorities under the European Union's Seventh Framework Programme (FP7). According to European research, TEL investigates "how information and communication technologies can be used to support learning, teaching, and the development of competence throughout one's life". The actual FP7 TEL policy focuses on Educational Data Mining and Learning Analytics issues [1]. It is to be emphasised that in this research TEL does not mean e-Learning. More about the basics of TEL can be found in [2,3].

Within a participatory action research on the implementation of TEL in the teaching of bachelors, the in-house database application called BIKE was developed as a pre-programmed environment for "batch knowledge processing". Such participatory action research is typical for university conditions when a teacher investigates the impact of technology in ones teaching, see examples [2, 4]. In this case, the BIKE's author (Svetsky) is not only a teacher (instructor) and developer, but also a developer of technology according to real time needs in his teaching. Thus, such programming of TEL tools is based on a personalised bottom-up approach.

A basic idea for the computer supported teaching approach when teaching bachelors was presented at a Brokerage event in Warsaw 2006 with a focus on e-Learning (within the ATVN-EU-GP-Project). During that time, the approach was understood as e-Learning. This approach was modified to the TEL approach, due to the first FP7 ICT call, which was focused on TEL (2007). In the framework of the ICETA conference discussion, it was found that the method of programming within the conventional FPW 2.6a database platform considerably differs from the common relational database paradigm. In this context, precious advice was given to the author by one of the key lecturers - Abdel-Badeh M. Salem (he presented a lecture on the applications of data mining techniques in e-Learning [5]).

In the following years, the batch knowledge-processing paradigm was developed, which is performed by BIKE [6]. No similar paradigm was published in computer science literature. As the practice of research on TEL showed, the paradigm enables the teacher or students to work with huge amount of information and knowledge in a very user-friendly way without specific informatics skills. For instance, it enables one to perform an advanced desktop search, batch internet retrieval, knowledge and content management, creation of browsable teaching and study texts, and tutorials etc. A user with greater informatics skills can even develop applications analogous with applications which are categorised in the literature as "text mining", see examples [7,8,9], or artificial intelligence such as knowledge based systems and natural language processing.

The previous research on TEL evolved into the following three stages: (1) technology-driven approach, (2) education-driven approach, (3) personalised automation of teaching and learning processes. The practice of research on TEL required one to solve the following categories of computer support: (1) programming the personalised TEL system and a set of TEL tools, (2) pilot testing of TEL applications in teaching bachelors (created by BIKE and TEL tools), (3) testing the suitability of new technologies regarding common teaching. Examples are given in the following text.

II. OUTPUTS OF TEL FOR TEACING BACHELORS

The issue of TEL when teaching bachelors is relatively complex. The categories of outputs produced within previous years can be divided as follows:

- *TEL* tools - Internet: TEL system (including virtual learning environment/space), communication channels,

off-line - BIKE/WritingPad (students' version for the classroom), FPW2.6a applications and knowledge tables, cooperation with OPERA browser and MS Windows (advanced desktop search).

- *Programming* - FPW2.6a, MySQL, (DB2 - just rarely); foxpro, php, C++, bat, JavaScript, sql.
- *Support methods*: the automation of creating teaching texts and processes, communication (feedback), off-line working on a personal computer; and language support.
- *Application environments* - FPW2.6a (graphical browse); OPERA, Internet Explorer (default – also tested as browsers: Google Chrome, Safari, Firefox); Windows, faculty's server; private Internet domain.
- *Application formats* - texts (html, ASCII, PDF, doc); images (jpeg, gif, bmp); audio (mp3, wav).
- *Freeware, shareware, Open-source software, Office packages…* the core database application is adapted to actual software working in Windows.

Figure 1 briefly illustrates various categories of outputs into teaching bachelors for several courses of study - BIKE is only on the author's computer and its selected version of WritingPad is installed on computers in the classroom. Teaching and learning is performed by combining an offline (cca 80%) and on-line TEL approach (cca 20%). MySQL database and the php-environment are both on the teacher's computer with BIKE being on the faculty's server within a shared learning space.

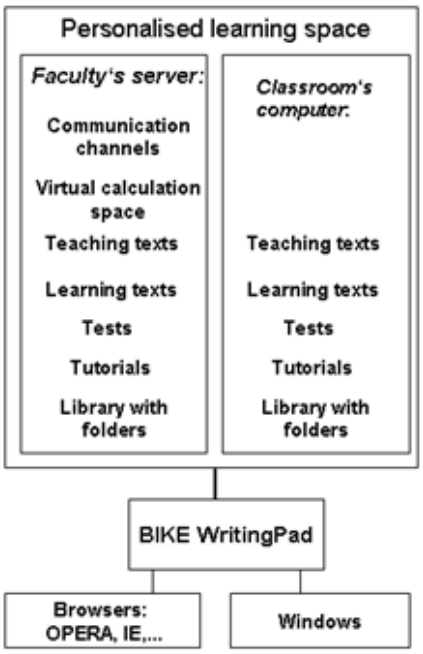
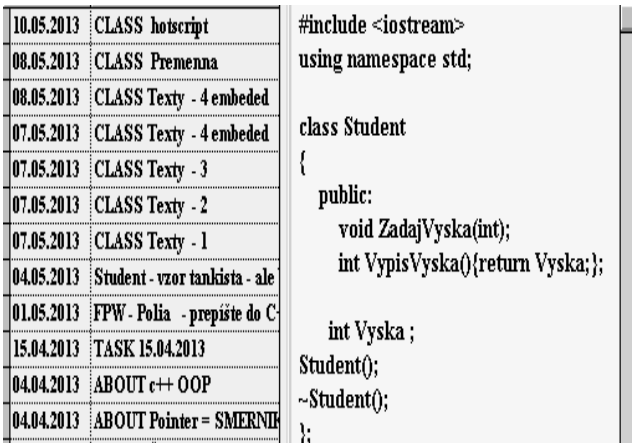


Figure 1. Schema of the personalised TEL system, how it works on the Faculty's server (left) and desktop computers in the classroom (right)

A. Construction of Knowledge (Content, Teaching Material)

BIKE works as a multipurpose pre-programmed knowledge system that enables individuals, i.e. teachers, researchers, and students to process information and knowledge in a very user friendly way because it only requires common informatics skills. The system solves the issue of processing information and knowledge based on batch knowledge processing that enables a user to work with huge amounts of knowledge in real time. Knowledge is processed in batches within the knowledge tables. According to BIKE terminology, knowledge is defined as being a set of structured and unstructured information, having a specified content stored in one row of the knowledge table within a default structure [6]. This enables an individual to utilize the vast power of database technologies and existing programming languages. When teaching bachelors all outputs related to the progress of knowledge processing, i.e. with a focus on a personalised approach, the automation of the teaching processes were continuously published, e.g. as shown in [10,11,12].

Because knowledge is the key element in teaching and learning, the success of knowledge processing depends on how the user designs the storage of knowledge into the knowledge tables. Figure 2 illustrates an example of how teaching content can be stored in the knowledge table. In this case, BIKE works as a C++ editor, i.e. programming codes are written and edited in the knowledge table and then directly transferred to an external C++ developing environment.



10.05.2013	CLASS hotscript
08.05.2013	CLASS Premenna
08.05.2013	CLASS Texty - 4 embeded
07.05.2013	CLASS Texty - 4 embeded
07.05.2013	CLASS Texty - 3
07.05.2013	CLASS Texty - 2
07.05.2013	CLASS Texty - 1
04.05.2013	Student - vzor tankista - ale
01.05.2013	FPW - Polia - prepiše do C
15.04.2013	TASK 15.04.2013
04.04.2013	ABOUT c++ OOP
04.04.2013	ABOUT Pointer = SMERNIK

```
#include <iostream>
using namespace std;

class Student
{
   public:
      void ZadajVyska(int);
      int VypisVyska(){return Vyska;};

      int Vyska ;
Student();
~Student();
};
```

Figure 2. Example of writing C++ code into the knowledge table

This example presented the utilisation of a graphical browse within the FPW 2.6a database platform environment. However, this use is more typical for a teacher. Students usually convert content of the knowledge table into a browsable html-format or they copy it to another environment such as office software packages.

Figure 3 represents an example from a diploma thesis of a pre-service teacher. The goal of the work was to test if a student would be able to construct teaching or training material by using the WritingPad. In this case, the student created a complete training tutorial and a manual of how to use Windows 7 functions. The manual was placed on the faculty's server and now bachelor students use it.

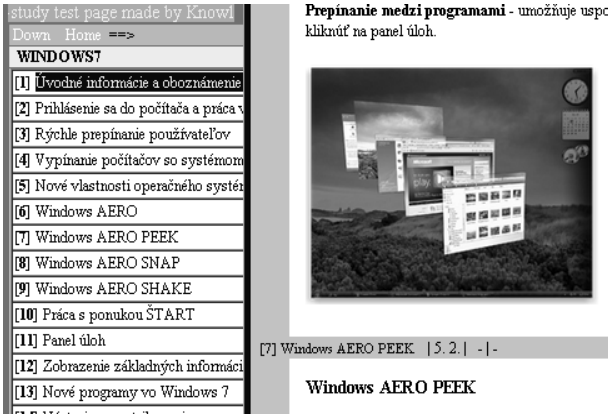


Figure 3. Example of the training material created by a pre-service teacher

Many teaching texts were prepared for several courses of study, each having their own communication channel (as illustrated in Figure 1). Figure 4 demonstrates an application for teaching technical English via browsable supportive texts consisting of a set of links to language translators, dictionaries, the BBC course on Slovak Radio, model sentences with prepositions used in technical German and sample sentences for writing English and German abstracts. The further phase was in facilitating cooperation with external software for Text-To-Speech, which supported the teaching of technical English. This means that the teacher wrote the teaching of study texts in English within the knowledge table of WritingPad and afterwards converted the content into the html-format (she obtained a browsable teaching material). After clicking on sentences, the machine spoke the English written text. Despite the fact that the teacher was able to prepare such outputs (with basic informatics skills), this was not very suitable for teaching in the classroom e.g. it required speakers for each computer and the machine's voice was not natural enough.

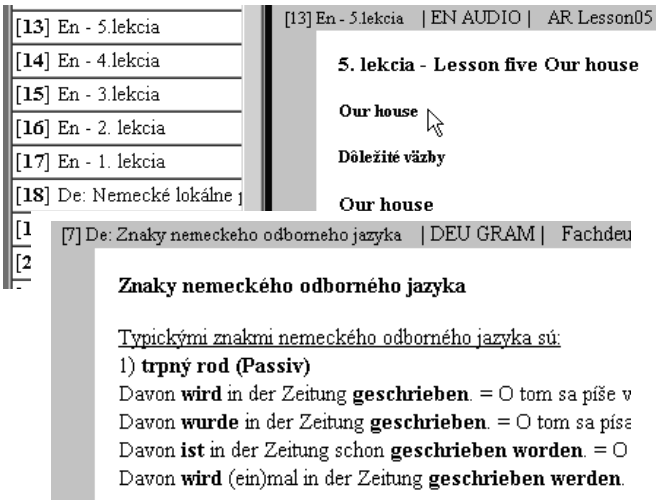


Figure 4. Example from the multilingual support outputs (English - on top: Text-To-Speech, German - below : grammar)

B. Education-driven Approach for TEL

At the beginning, research on TEL was focused on the building of a supportive infrastructure, the development of the in-house application BIKE and the creation of a set of informatics tools for active learning. This technology-driven approach for TEL was more focused on processing engineering content (acquisition, search, selection, creation, management, transfer, etc.). During this time, the so-called WEB 2.0 (internet) technologies represented the technology-driven approach for TEL. For instance, in [13] "Moodle" was evaluated as the mostly used TEL tool in EU universities. Nevertheless, it is a so-called Learning Management System, not a teaching tool suitable for classroom teaching, as it does not enable individuals to make retrievals, generate browsable formats, write desktop tutorials, or convert formats, etc.

When a teacher programs technology, the participatory action research on TEL showed that, any excellent technology or knowledge base, would be "dead" if the teaching content was not transferable into the classroom environment. Namely, actual practice required that the focus should be more concentrated on an education-driven approach. This finding from the practice of research on TEL complies with actual state-of-the art where emphasis is on the teacher's key role in teaching. In other words, any computer support should be education-driven, as shown in [2] and [3]. In [14]-[18] the topics were discussed regarding the role of knowledge [14], challenges for digital and learning technologies [15], and informatics aspects of pedagogical innovation [16]. In [17], gives emphasis to a teacher's role being central. Four myths were discussed by Dillenbourg concerning the limitation of technology in education, e.g., the overestimated effect of the use of media in education, stressing the fact that media itself does not bring pedagogical innovation, or in regards to the upcoming 'success' of e-learning applications. He argues, "teachers' current technological skills are fairly well developed therefore the lack of skills no longer counts as an excuse for the poor development of TEL practices". Similarly, some "paradoxes" are discussed in [18] together with information smog, inflexible informatics environments which have an impact on individuals that are extremely overloaded, and non-compatible domain ontologies. These should be resolved by simplified navigation and the transformation of "rigid sophisticated artifacts" into a natural language in order to be closer to the humanistic principles of education.

The practice in teaching bachelors showed that to revive the flow of knowledge (teaching content), the examination of teaching in sequenced steps, content unification and the use of specific communication channels for each of the courses of study are needed. In other words, another field of programming must be solved in order to automate learning processes and communication between the teacher and students. In this context, the unification of teaching content and educational processes can help a computer to computerise them. If this all works together, then the teacher can select and mix the content of teaching, informatics tools, communication, and didactic elements according to the actual requirements of the teaching process in the classroom [6]. More details are in [19].

The enlarged technology-driven approach to the education-driven approach is illustrated in Figure 5. In principle, the education-driven approach deals with the: (1) programming a personal network "teacher – students" on the faculty's server (in the form of communication channels), (2) solving how to put forward instructions, teaching tests and information exchange into these channels (so called Forums – see the schema in Figure 1), (3) how to innovate teaching when using existing and emerging technologies, as these are not usually automatically suitable for teaching bachelors (e.g., as shown in Figure 6 and Figure 7).

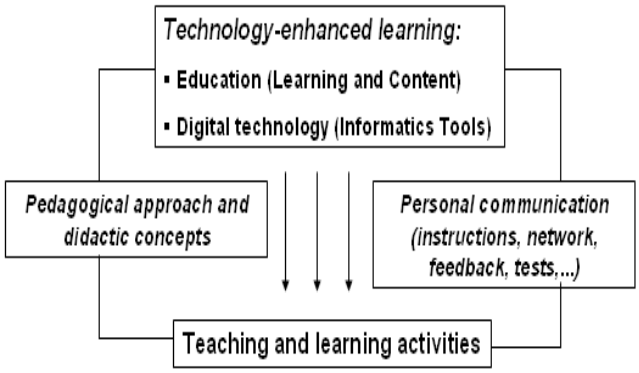


Figure 5. Schema of an education-driven approach for TEL (showing what is to be programmed in teaching and learning processes)

Figure 6 presents a screenshot of a communication channel for the course of study - *Background of Chemistry*. This represents how the personal network "teacher- students" was tested in the area of how to exam students by using the communication channel. As you can see, students had three images at their disposal without viewing any interface, i.e. a hand scanned image from the teacher, another from a printed source (an image regarding a chemical bond), and the last from an on-line source which was an image of a Daniell's electrochemical cell from Wikipedia. Students had to explain these by writing in the channel (Note – SKUSKA means "exam" in English).

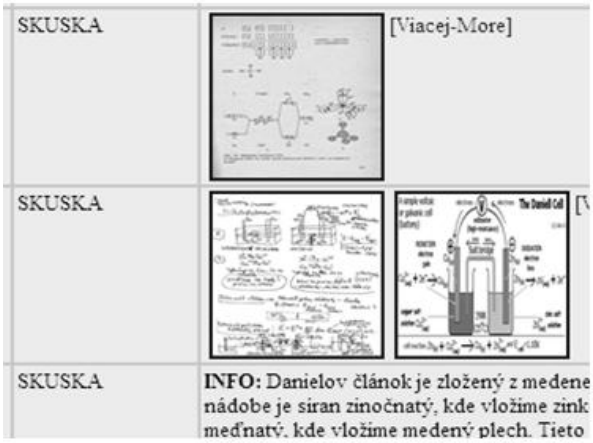


Figure 6. Screenshot of the communication channel for teacher and students on the faculty's server (an example from the final semester exam)

It is yet to be emphasised that computers were not invented directly for education; hence, new technologies are not automatically suitable for teaching and learning. Therefore, an important role within research on TEL is in investigating how emerging technologies and software can be adapted to actual teaching in a classroom. In this view, some technologies were tested, especially the possible audio application (Text-To-Speech, Speech Recognition). For example, students had to deliver a part of their semester work as an mp3-file spoken by the computer. It was found that this support had very good results regarding the elimination of plagiarism. On the other hand, it was time wasting due to the existence of many audio formats, their incompatibility, and a diminished quality of the machine's voice. Another example is mentioned in the solution for the automation of language support. Figure 7 represents a transfer of printed content on conjugation from a French book for autodidacts to BIKE as a html – output.

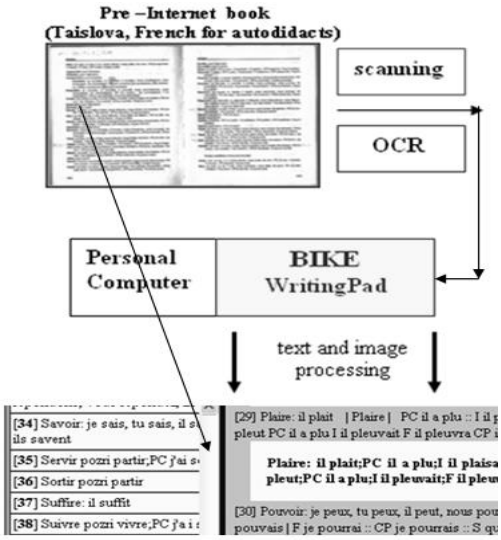


Figure 7. Example of a transfer of printed content into html-format content for self-study purposes (French conjugation)

III. CONCLUSION

This paper discusses several informatics and didactic aspects from the practice of research on TEL in relation to the results of a long-term participatory action research. A specific feature of the research is that an individual teacher (instructor), researcher and developer, has programmed the multipurpose, user-friendly system of BIKE to enable teachers and students to process huge amounts of information and knowledge regarding teaching and learning content. The results from the practiced research on TEL were explained by the examples of the implemented personalised TEL system. As shown, TEL works as a personal learning environment which allows for the construction of knowledge (teaching material and study content), including various categories of outputs used in teaching bachelors. Specific emphasis was given to the education-driven approach for TEL. It is to be noted that, the *unification of teaching content, processes* and *communication* (feedback, personalised network of "teacher – students") was focused on in order to improve computerisation of knowledge

based processes that are typical for teaching and learning. However, this part of the participatory action research, related to teaching some courses of study, represents "one man's research." That is, there is no feedback from other instructors or experts. The main goal is to write computer programmes, to build informatics' tools for TEL and to investigate if they are suitable for knowledge processing in real time when teaching bachelors. It is based on a combination of both a desktop solution (cca 80%) and programming internet applications, i.e. the personal social network of teacher - students (cca 20%). This research does not cover pedagogical elements such as "teaching plans in a classroom". However, BIKE can be used to generate teaching plans if needed. For example, some students and pre-service teachers utilised it in their diploma works for constructing personal preparations. A part of the research deals with solving how to adapt existing audio technologies to teaching because they are not yet automatically suitable for computer support in classrooms (thus, there is a limitation in the research on TEL).

Actual research on TEL is understood as an *automation* of all categories of educational activities. This strategy does not solve if something is in the category of e-Learning, construction teaching material, data mining, text mining, learning management system, knowledge management, etc. A solution is in the automation of knowledge-based processes where *knowledge* is a key element and BIKE works as an all-in-one software for knowledge processing - it has seven hundred items in its user menu. Within the research on TEL, the following knowledge processes were identified: (1) working with educational content, (2) communication processes, and (3) processes related to a teacher's instructions. In this line of approach, further research on TEL will be oriented towards investigating the creation of knowledge templates, production and transfer of educational data, programming support of teachers' teaching (instructions, communication, feedback), and the "synchronisation" of these issues within Learning Analytics. Research on TEL is limited in respect of a low concentration of students, technical equipment, didactic aspects such as language barriers regarding English and changes to the content of a syllabus. The opinion of BIKE's authors is that BIKE's limitations are due to a low performance of desktop computers, available software, too many incompatible formats, time consuming co-programming in Windows, internet browsers and office software packages.

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