The Personalized Computer Support of Teaching

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Abstract—In comparison with the traditional learning, the computer support of teaching represents a combination of didactics and informatics approaches. This requires researchers to solve an additional design of specific educational software and suitable ICT infrastructure. This contribution describes a continuous progress under the umbrella of the research on technology-enhanced learning; and how the ICT integration is modelled for the collaborative teaching and appropriated activities when using an in-house educational beta-software BIKE(E)/WPad. The practical experiences are demonstrated with some examples of how it is applied within the teaching bachelors students and from the related research on computer support from a teacher point of view.

Keywords—technology-enhanced learning, computer supported teaching, CSCL, educational software, database applications

1 Introduction

Technology-enhanced learning (TEL) represents an interdisciplinary issue. As the key-term, TEL was used within the project calls of the FP7 EU funded research program. The research focus was more on the informatics aspects of computer support of teaching and learning than the didactics ones. There are many literature sources related to the TEL. One can find useful information especially in the "basic" books on TEL [1-3]. A specific computer support of academic teaching is described in [4], including the CSCL (Computer Supported Collaborative Learning), which is presented from a historical perspective in [5].

Nowadays, the computer supported teaching and learning covers many specific areas of education. The global goal of authors' research is to computerize teaching processes on a personalized level with focus on the complex computer support without a need to use global software solutions (see e.g. [6-8]- interdisciplinary approach, or [9,10]-CSCL/ICL Conferences). So, the educational software WPad was continually developed in the period of 2007-2016 (by one of authors). The specific goal is to test and modify the pilot version of the WPad also for collaborative teaching (WPad is a part of the beta in-house software BIKE(E)-Batch Information and Knowledge Editor and Environment). It supports various collaborative activities in engineering education, e.g. in the framework of the courses of study: Background of environmental protection; Occupational health and safety; Basics of Chemistry; Programming languages.

Fig. 1 illustrates the actual approach of authors to the ICT integration into the teaching and learning.

The education issues cover not only the educational content but also the teaching processes. The digital technology issues cover the technology infrastructure and the ICT tools. In this context, the pedagogical-didactic approach relates to the content and activities, and the ICT approach to the content and communication issues. This general approach more clearly illustrates the CSCL infrastructure in Fig. 2.

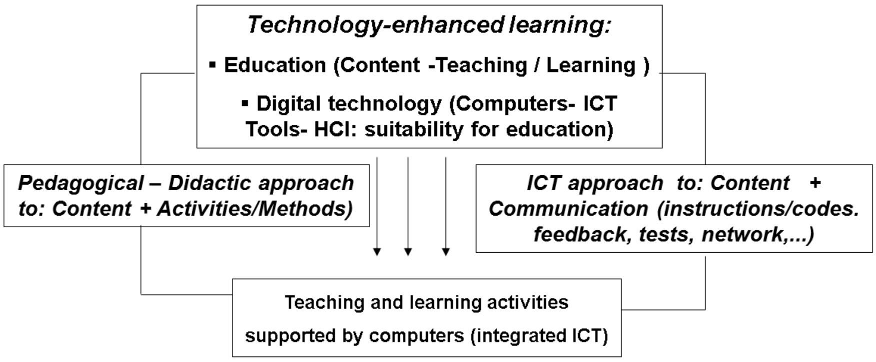

Fig. 1. Schema of the actual approach to the ICT integration into teaching and learning

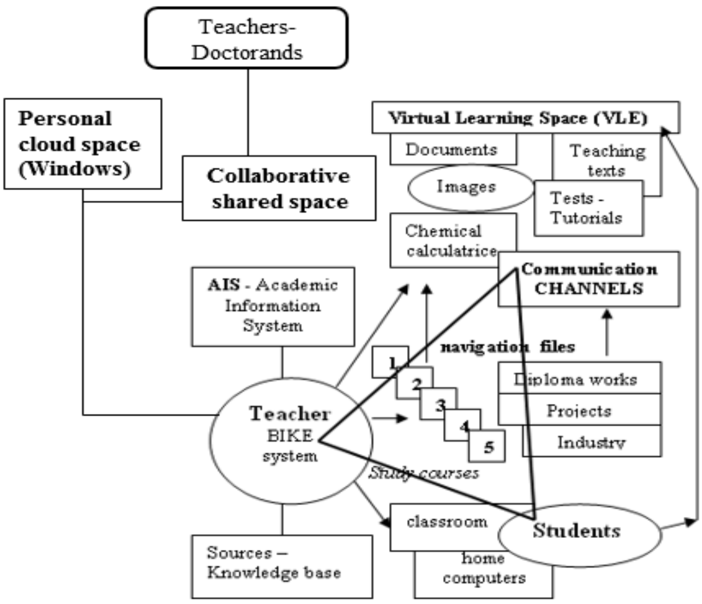

Fig. 2. CSCL infrastructure for the automation of teaching processes

In comparison with previous research presented in [7, 9, 10], the collaborative shared space and personal cloud space were implemented. The actual approach of authors' research on TEL is presented as the "automation" of educational processes" [11]. It should be understood as the integration of three key areas: (1) didactics processes running in classrooms, (2) informatics processes running during teaching, and (3) the adaptation of individual's activities related to using the Windows operation system, Internet browsers, software, hardware, clouds, networks (this affects the Human-Computer-Interaction). Authors' long-term research showed that the computer support must be strictly tailor made to the teaching activities, so not vice versa (teachers usually applied only a general software, e.g. office packages).

2 Examples of using WPad - Teaching

Any integration of ICT into education requires one to use an interdisciplinary approach. The issue belongs to the applied informatics, or applications in the field of cognitive science. This should be clear from the introduction, especially from the schemas in the Fig. 1 and Fig 2. In the context of this, the authors published their approach both from the didactics and informatics point of view (especially because one of them writes the educational software BIKE(E)/WPad).

For example, their actual IT approach is based on a theoretic background which was derived from Cybernetics approaches for automation of mental processes (teaching is considered as a knowledge based process). In our case, the WPad uses a so-called "virtual knowledge unit" which is both human and machine readable and isomorphically bridges mental processes with physical-computer processes [11]. So, the basic CSCL problems are solved by using the WPad in the framework of the combined off-line/online infrastructure (computers in classrooms/faculty's servers and open domain). This is illustrated by Fig. 3, i.e. the WPad, which is installed on computers in the classroom, virtual faculty's spaces and teacher's computers, represents a key IT tool for CSCL.

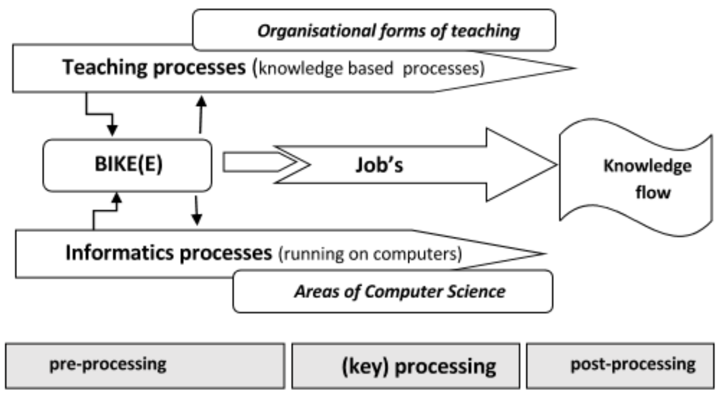

Fig. 3. The schema of the BIKE(E)/ (WPad) function within the research on CSCL

As was mentioned above, the supporting ICT infrastructure was implemented for modelling CSCL. The outcomes represent both the implemented collaborative methods (e.g. collaborative writing semester works) and the supporting IT background infrastructure (database application WPad, virtual learning space). It should be emphasized that the WPad tables are used by authors, teachers and students as the platform for sharing the same domain knowledge and to manage and move it via informatics paths (i.e. between classroom or home computers and faculty's server or internet).

Fig. 4 shows a screenshot of the WPad table. It represents an information exchange among teachers (see e.g. the note about Hopper's "Human are allergic to change", which was made from an e-mail).

One can also imagine the system BIKE(E)/WPad as a personal knowledge system or base which is empty at the beginning. Success in the processing of knowledge depends on the methods used for recording human or non-human knowledge into the knowledge tables. Fig. 5 illustrates examples of how various educational content is stored in the knowledge table. It can consist from strings and texts, e.g. personal notes, ASCII characters (e.g. a stored jpg- or mp3-file), or programming code which can be edited and launched directly from BIKE (here C++). The content and linked metadata are in one row of the knowledge table (see also output to html format).

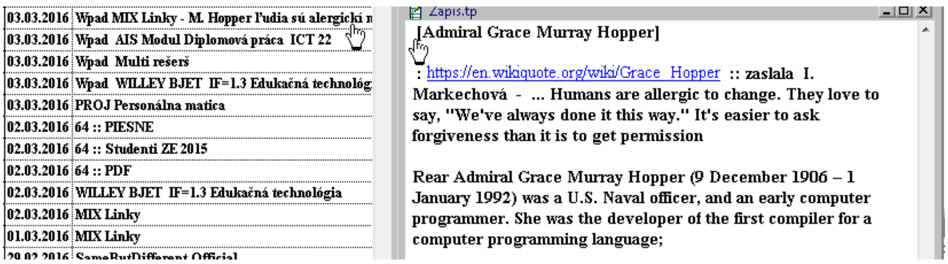

Fig. 4. Screenshot of the collaborative knowledge table for information exchange

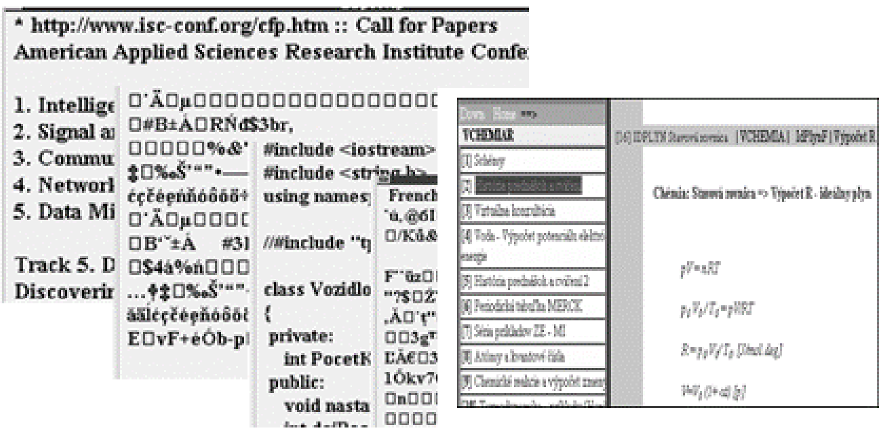

Fig. 5. Examples of content categories in a row of the knowledge table

Within the programming of WPad, an internet application was designed (the personalized TEL system) and placed on the virtual learning space. It functions as a communication channel for feedback and collaborative activities. So the collaborative teaching is performed in combination with the communication channels which connect the virtual learning space at the faculty's server with classrooms' computers, notebooks or mobiles. The communication channels work as a personal network where information, knowledge and instructions "travel" between teacher and students to be shared. They represent a sophisticated analogy to the Internet forums.

Fig. 6 illustrates how the teacher or students write information (ASCII-data) into the channel (on the left). It can be written by using keyboard or teacher can use a simple HTML text. For example, there is a comparison of emission and absorption spectrum of hydrogen from Wikipedia in the screenshot on the right.

While Fig. 6 represents one record (information) of the communication channel, while as one can see, the screenshot in the Fig. 7 represents the more complex communication content - in this case, an example of seven rows with instructions for students and links to an educational material (e.g. Windows 7 manual - created within a diploma work; computer speaks training material for photosynthesis – made by students).

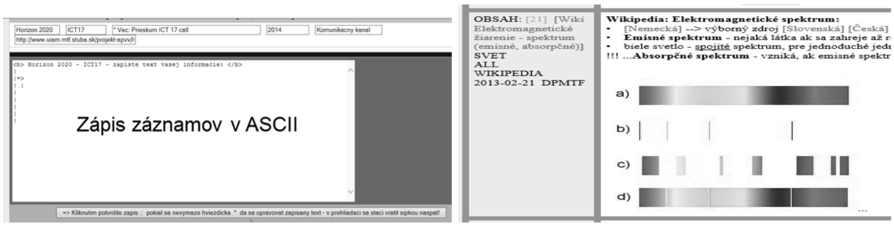

Fig. 6. Examples of screenshots of the communicational channel for Chemistry

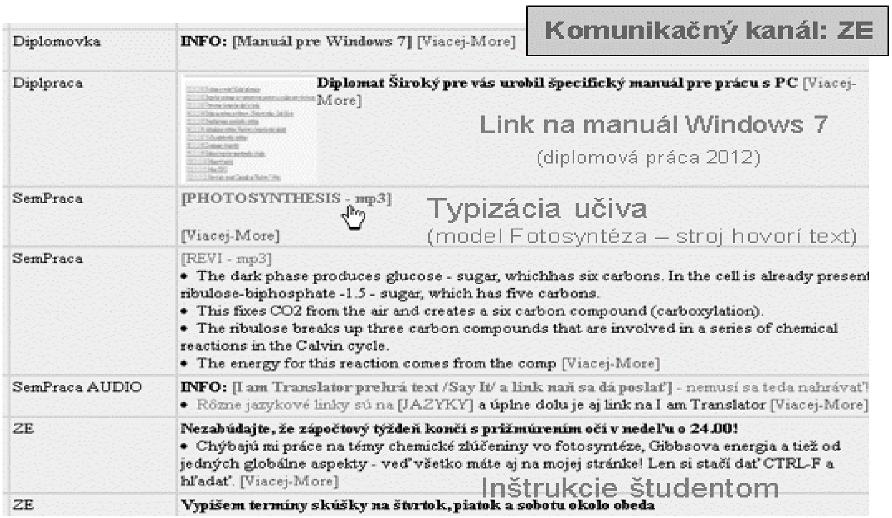

Fig. 7. Communicational channel containing educational content and instructions

3 Examples of using WPad - Research

In general, university teachers must perform such complex activities as education, training, formative and summative assessment, publishing (writing papers or conference contributions), even project solving, expertises, or other specific activities (international cooperation, partner search). To meet the mentioned drivers pressure in the workplace, where everything is focused on performance and performance is everything, a permanently formal and informal learning, and self-study of the teachers is required. To be sustainable it requires particularly for senior teachers to use:

- personal expert knowledge base with the huge amount of steadily updated educational information (in a computer-readable and human-readable form),
- generic information flow (e.g. from CORDIS, Wikipedia or other EU/Regional portals and databases),
- specialized expert information flow (e.g. concerning technology, standards, expertises, patents, case studies, information exchange, international collaboration,...),
- various information types and formats within their knowledge base (electronic, printed, audio, video, hand-written),
- various information sources (WEB-databases, online libraries, journals, books, standards, personal correspondence or records, educational portals, etc.).

In this context, the research performed under the umbrella of TEL is considered by the authors to be an automation of traditional "face to face" teaching. The software, a database application BIKE(E)/WPad, was written by one of the authors (Svetsky) who is both teacher, designer and researcher. Case studies on BIKE(E) implementation within traditional teaching were presented in [6-11]. Basically, it works as an all-in-one tool used by him for producing a set of teaching aid tools, i.e. from simple off-line tutorials to the complex virtual learning environment functioning online on the faculty's server. It is not simple to explain it in details because an atypical approach is used, which was patented as an utility model [12]. The database application is also unique, however it could not be patented because in the EU it is not possible to patent any software (only technical solutions).

The BIKE(E)/WPad as a multipurpose, “all-in-one” personal tool is also used for modelling interactive collaborative teaching as was mentioned above. However, it is possible to perform only a limited number of collaborative activities during the teaching hours (due to lack of time, when one teaches ten to fifty students). So under the "automation of traditional teaching" one should understand that computer support - with BIKE(E)/WPad as teaching tool - enables a teacher to solve new methodological approaches that could not otherwise be solved within regular teaching time. One can imagine simply that the computer works as a teacher's assistant. For example, the content from a computer - as illustrated on Fig. 4-7 - can be shared, evaluated, managed, i.e. used by the teacher for didactical purposes, summative or formative assessment, writing collaborative works etc.

To the best knowledge of authors, no such solution has been described in the literature. For example, several years ago, the learning management system Moodle was evaluated as the most frequent technology-enhanced learning tool used at European universities [13]. However, in contrast to Moodle, BIKE(E) works both off-line and online, allows the teacher to produce eLearning materials, perform internet retrievals or launch external applications in Windows operation system. Being a personal knowledge management tool, as published previously by authors [13], BIKE(E) could even be used to build a Moodle-like personal learning management system. For example, Fig. 8 illustrates integrating the in-house software BIKE/WPad within educational knowledge management processes.

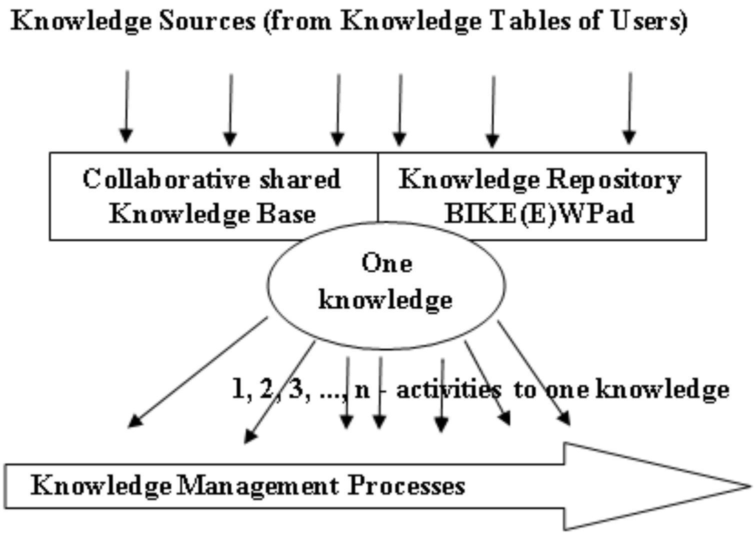

Fig. 8. Relationship between knowledge (content) and activities (knowledge flow within knowledge management processes)

In principle, a systematic research on technology enhanced learning started within the FP7- ICT proposal KEPLER (Knowledge-Enhanced Proactive Library Learning) [14]. The focus was on the ICT Objective ICT-2007.4.1-Digital libraries and technology-enhanced learning, and aimed at the crucial processes of the selective capture, preservation, accessibility and usability of multilingual, multimedia websites. The virtual federated grid services should have been used on the basis of the elaborated use cases, and the R&D innovations demonstrated within a new kind of grid-based Federated Digital Library. Basically, this grid-based Federated Digital Library would had been a source of learning content for engineering teaching and learning. This required, inter alia, to design a system of keywords for multilingual content indexing and retrieval.

The following text illustrated a planned content of such work-package (Slovak University of Technology was a leader of this task) as was in [14]:

Work-package title: MULTILINGUAL CONTENT INDEXING AND RETRIEVAL

[STATE OF THE ART]

1 WEB-Monitoring (investigation and testing of content sources for indexing and retrieval, multilingual tools and services, testing of on-line applications)

2 State-of-the-art Study

[SUBTASK 1] : KEYWORDS STRUCTURATION FOR M-CONTENT INDEXING

1.1 GENERIC meta content keywords
Deliverable: M-Database 1

1.2 SPECIFIC R&D meta content keywords
Deliverable: M-Database 2

1.3 DEFAULT R&D content keywords (standards or international classification)
Deliverable: M-Database 3

1.4 Keyword based BATH SEARCHING SYSTEM modelling
Deliverables: Set of retrieval templates

1.5 Reporting
Deliverable: Report

[SUBTASK 2] : MULTILINGUAL RETRIEVAL MODELLING

2.1 Mono- and multilingual RETRIEVAL with refining
Deliverables: Set of databases

2.2 Knowledge based RETRIEVAL LIBRARY BUILDING
Deliverables: Partial libraries

Another focus on the Learning Analytics field was within the FP7 ICT proposal L^3-Pulse (L^3-Pulse: a Scalable Cloud Platform for Interactive LongLife Learning Data Mining for a Sustainable Future). The topic of the proposal aimed to develop an innovative eLearning toolkit for collecting, storing, exploring and reasoning on large-scale educational data to better understand learners' knowledge, assess their progress and evaluate environments in which they learn. This toolkit should have been equipped with intuitive interfaces for visualizing and interacting with the data in order to ease their integration into the practice of teaching and learning. L^3-Pulse would had been research new techniques for automated improvement of learners models, assembling a technology platform to support a free and open source learning analytics toolkit for sharing hypotheses and integrating, analysing and visualizing data creating innovative training scenarios for such developments that are supported by the toolkit to be constructed. Expected Impact was: more efficient use of ICT for learning through the exploitation of learning analytics tools, and increased awareness on the benefit of the adoption of learning technologies.

Fig. 9 illustrates a schema of modelling the learning analytics by using the in-house software BIKE(E). In this case, the objective intended to be attained is the modelling learning analytics in the classroom conditions. However, in comparison with state-of-the-art in the field of Learning Analytics this approach is focused directly on “human knowledge”, i.e. educational knowledge flow during real teaching, not only on monitoring of activities of students in online learning environments.

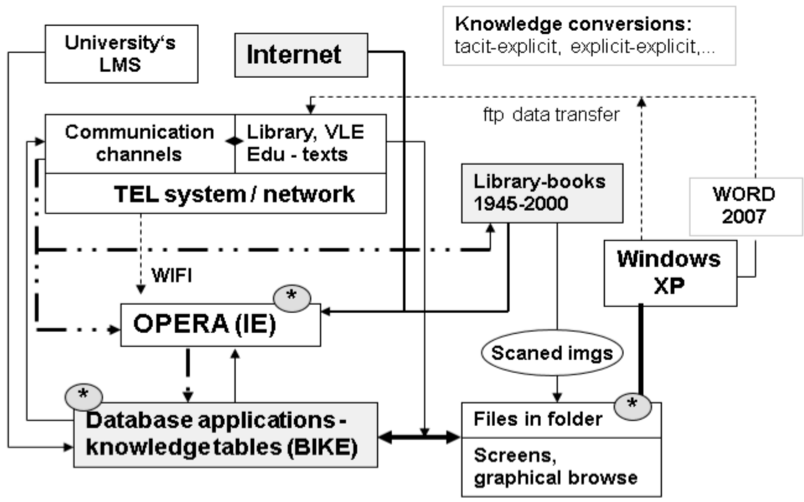

Fig. 9. Schema of modelling Learning Analytics by using the in-house software BIKE[15]

In the Cybernetics, it is common that some thought problems and processes can be investigated by their physical representatives. A necessary condition is that isomorphic relationships exist between the specific system abstractions and real physical systems [16]. Due to this isomorphism, the result of physical processes can be translated into mental operations, i.e. into the "intellectual" result. Because the mental processes are knowledge based, one can design a physical model based on the isomorphism in order to transfer some mental (thought) tasks into the physical area and vice versa.

Fig. 10 illustrates such isomorphic relationship between the mental and physical processes, which is represented by the "virtual knowledge unit" as the key element of the presented approach. A concept of this "virtual knowledge unit" is explained in [17]. In our case, just this can be used for monitoring the "educational" knowledge flow when solving learning analytics issues as was mentioned above (it is also used within the registered utility model for processing unstructured data in the Slovak Patent Office).

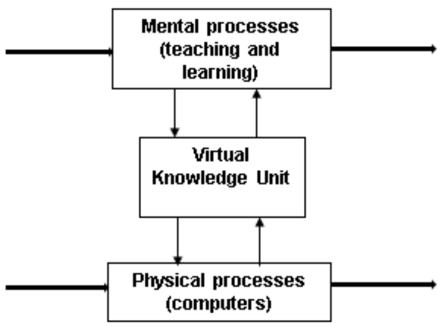

Fig. 10. Isomorphic relationship via the "virtual knowledge unit

4 History of the in-house research on TEL

Within a period of around ten years of empirical research on Technology Enhanced Learning (TEL) implementation in teaching at the Faculty of Materials Science and Technology of the Slovak University of Technology, a pre-programmed environment for "batch knowledge processing", was developed. This includes the about mentioned in-house educational software BIKE(E), a personalized Virtual Learning Environment and a set of tailored WEB-pages for several engineering courses of study. This was tested and directly applied in the teaching of bachelor students. The field of TEL was a part of the calls put forward by the 7th Framework Programme (ICT research in FP7), where the research priority was focused on "how information and communication technologies can be used to support learning and teaching“.

At the beginning, there was an idea to equip research and development staff (knowledge workers) with informatics tools for personalised working with huge amount of information, e.g., for "self-eLearning". Thus, a knowledge base and information sources structure, associated activities and outputs were designed to be solved. For this purpose, the database application BIKE(E) was developed as an "all-in-one" support tool for generating browser-based eLearning applications, performing personal internet retrieval, creating a combined virtual online / offline learning environment and the support of content management, etc.

In this context, the introduction of an entirely new paradigm of batch processing of information and knowledge was needed, because in a conventional DBMS (Database Management System) the data are processed in another way based on a relational E/R model. This gradually resulted in the development of the pre-programmed environment of the BIKE (Batch Information and Knowledge Processing) that was used for support of the engineering education of bachelors. For students and other teachers it is available as a standalone WPad (Writing Pad), which is installed on computers in a classroom. The existence of such an informatics tool allowed for teachers to solve the first stage of processing the knowledge flow between information sources and the "knowledge" database tables. In this stage various types of learning materials and libraries with browsable pages and documents were produced to support daily teaching.

However, the creation of tools and solutions only for processing the content was not sufficient for the needs of teaching, because this technology - driven approach, did not take into account the pedagogical aspects of education and the key role of the teacher. It was found that the processing of knowledge (engineering content) also needs to address the flow of knowledge between the produced learning materials (tailored for courses of study) and between individual educational activities. This required more education - driven TEL approach than the previous technology driven one. In other words, the technology-driven approach for TEL was expanded with educational aspects. From an informatics point of view, the next solution showed a need to understand the information and knowledge processing in order to support teaching and learning activities such as "automation." When programming is focused in this direction, it became clear that when dealing even with the simplest of activities a large amount of alternatives are available. If one takes "the automation of teaching and learning activities" into account as an individual interdisciplinary issue, the solving represents a "never-ending story". In this paper, some examples, i.e. applications of personalized support of teaching, were presented.

Currently the BIKE environment allows individuals (teachers, students and researchers)]:

- to design and produce a large amount e-Learning of training materials from one's own personal know-how, such as, printed materials, electronic media and also the multilingual Web environment by the use of educational content and internet services,
- to solve the support of teachers in developing their personal preparation for teaching and related e-Learning tools (tutorials, self-evaluation tests, interpretation of the scheme, a personal information system, the digitization of printed books and the transfer in teaching material for a given study program),
- to automate all kinds of educational activities - teaching, testing, evaluating and grading of students, publishing, making retrieval, administrative activities, the data transfer from Academic Information System,
- to create a personal Virtual Learning Environment and use a communication forum that acts as a personal social networking among students and teacher for feedback, sharing information, instructions, but also for a common research space where participants can store information from the survey of literature (particularly students working on diploma theses),
- to automate, i.e. streamline the activities of individuals in the Windows environment (the additional features to the operating system, searching in the database, directories and files, to archive files by incorporating certain features of the File Manager and editing programming languages – HTML, PHP / MySQL).

With the multi-purpose environment of BIKE (it is only on the author's computers), or it's part WPad, which is installed on personal computers, teachers and students can use all five categories and all possible types of learning (face to face, blended learning, informal learning to life-long self-study). For these reasons, it can be understood as a specific type of personal "Mindware" (personal external memory), but also as a supplement to the operating system of Windows.

It may be noted that despite several years of intensive research, there could not be found in the literature and on the Internet described, a similar paradigm of batch knowledge processing when working with conventional RDBMS (relational database). No identical or similar multi-purpose software package that provides many activities at once, such as dozens of dedicated software routines, can be found. This multifunctional environment of BIKE(E) gives added value to traditional teaching, which brings a synergic power factor in terms of educational materials for the creation of new materials, new innovative ways of teaching and self-study. By BIKE(E) from beyond the established computer and pedagogical practices, it is quite difficult to explain its function. This is one of the reasons for the differences of evaluators when peer-reviewing, where someone classified it as a tool for knowledge management, eLearning, and even soft-computing.

5 Conclusions

The real computer support of teaching represents always a mix of various kinds of teaching and learning processes and areas of ICT. Some practical experiences with the in-house developed educational software BIKE(E)/WPad for modelling the interactive collaborative teaching were briefly described via examples from teaching bachelors students (e.g. how communication channels "teacher-students" function and how the computer support of collaborative writing is solved by using the WPad tables). From the collaborative teaching point of view, both teacher and students can use the same knowledge, including transfer of the domain knowledge flow via digital paths. The teacher designs collaborative methods, in addition, the described informatics background infrastructure is hierarchically subordinated to those methods. The communication channels were also tested when examining bachelors students (on their classroom or home computers they see the communication channels, located on the faculty's shared virtual space).

The interdisciplinary research on CSCL actually continues in the framework of an institutional project. For instance, teachers and PhD students test collaborative methods for sharing their personal data (in their WPad tables on their devices) with the shared central WPad table (localized on the faculty's server). A future work is aimed at the design of database applications for modelling the automation of mental processes (based on the utility model), including solving the CSCL visualisations. It should be also emphasized that modelling the computer supported collaborative teaching and learning requires in parallel a combined pedagogic (didactic) and informatics research (because it is not possible to write programing codes if no teaching steps exist).

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