The Knowledge-Based Design of Educational Technology

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Abstract. In the scientific literature, educational technology is often criticised as not being always optimised for effective teaching, as mostly technology-driven, not derived from knowledge as the basic key element of teaching. In this context, teaching is a typical knowledge-based process, which requires to deliver a concentrated educational knowledge within strictly limited time. Although digital technology should be knowledge-driven, a computer does not know what knowledge or educational knowledge is. An interdisciplinary definition of knowledge does not exist. Within the long-term research under an umbrella of technology-enhanced learning, this problem was solved by design of universal knowledge representation. This representation, so called- 'virtual knowledge', is both machine-readable and human-readable. It enables an individual user (teacher, student) to construct, transmit and share educational knowledge and content using all-in-one educational software in a user-friendly way and without a need of specific computer skills. This paper explains the essence of the design of the knowledge-based educational technology, which is based on the virtual knowledge and development of the educational software that enables the batch-based knowledge processing using the virtual knowledge and transfer of educational content through a shared infrastructure. The infrastructure consists of a combination of off-line (teacher's computers, classroom computers) and online (clouds, virtual machines) environments. The following sections present the use of the educational knowledge tables and modelling the educational packages and language corpora to support writing scientific articles to explain a way of the knowledge-based educational design.

Keywords: E-learning tools · Educational technology · Educational software · Technology-enhanced learning

1 Introduction

An integration of digital technology into education is a part of education policy from global to institutional levels. ICT support is commonly a topic of the research fields technology-enhanced learning (TEL) and educational technology. However, both these

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fields seem to be not sufficiently clearly defined. TEL is understood as being more of an informatics issue, while educational technology is understood as more related to teaching and learning (teaching). TEL was a part of the ICT calls that were put forward by the 7th Framework Programme of the European Union (2007–2013), where research priority was focused on 'how information and communication technologies can be used to support learning and teaching' (the authors participated in two calls — digital libraries, learning analytics).

The basis of the authors' research on the knowledge-based design of educational technology is the use of a defined, unique knowledge representation that, from a cybernetics point of view, functions as a switch between man and machine. This knowledge representation enables individuals (including lay people) to process unstructured and indefinite data in their natural language, and without the use of artificial semantic or relational schemes and machine languages. Such a knowledge representation or a similar research approach is not described in any scientific literature, not even for educational field. From a pedagogical point of view, the only limiting factor is how the teacher can bring their own educational content or implicit knowledge into this knowledge representation. From an IT perspective, the limitation is the need to use the Windows operating system, be it on a laptop or a virtual server.

In this paper, the principle of such knowledge-based design is presented including examples, with the focus on the latest authors' research approach using cloud services and virtual machines and working on an educational robot within an international project V4 + ACARDC-team. Only partially, the examples from teaching undergraduates are mentioned from solving the computer-supported collaborative learning. The following sections present examples of case studies from the authors' research, which are focused on:

- the principle of the knowledge-based design of educational technology
- use of educational software when teaching undergraduates
- complex research approach for modelling support of simulation and math
- modelling the educational packages for programming languages
- examples of using web source mining and language corpora.

2 Brief Review of the Relevant Academic Literature

This issue is presented in more detail in the TEL monographs [1, 2], surveys [3] or the article by Laurillard [4]. Goodman argues that learning, not technology, should be the driver of any educational innovation, as well as that new technological learning environments must be congruent with how individuals learn and the nature of the learning task [3]. In this context, Weston argues that TEL is a poorly conceived acronym which after more than ten years of trying 'has not produced any measurable improvements in teaching and learning' [5]. He identifies some problems with TEL as a term (e.g., 'technology' and 'enhanced' are too general; teaching — not learning — is what we do), arguing also that we should leave TEL behind and talk instead about 'education technology'. On the other hand, if one reads scientific journals or books related to education technology, he would find that technology is mentioned less, i.e. mostly a pretest-posttest design is preferred with focus if the use of technology results in better learning outcomes (it is an experiment where measurements are taken both before and after a treatment). This can be demonstrated in some scientific journals, which have in their title educational technology 'research' and 'development'. However, their content is more pedagogically statistical ongoing of a learning hypothesis. Technology tools are there described as something that exist separately from teaching (see e.g., ETRD https://link.springer.com/journal/11423). In the book 'Educational technology', state-of-the-art of educational technology is presented, where adoption of educational technology is explained as a highly complex process [6]. Oliver also identifies a significant gap in existing work within the field of educational technology—the failure to explain technology theoretically [7].

From a personalized teaching point of view, it results that a single teacher should use tens of technological tools, which is not possible in real teaching practice. In view of this, a universal knowledge-based solution is missing, e.g. an all-in-one educational personalized software is not specified in the book (although its need for learner-centered design is mentioned in general). In this regard, Martens declared an absence of software engineering for TEL [8], as well as little progress having been made in knowledge engineering as a methodology for designing tools regarding knowledge-based approaches in the practice of Learning Design, where such knowledge-based approach to modelling learning theory is considered essential [9].

It also seems that the transmission of the educational knowledge flow within teaching processes and technological infrastructure is not sufficiently solved in contemporary educational technology solutions, because mostly static technological are mentioned. In this respect, Francom presents his book as 'the first ever multiplatform digital textbook on educational technology designed for undergraduate university classes' [10]. The focus is particularly on the fields of student-centered learning technologies, project-based learning with technology, resource-based learning with technology, and distance learning. He specifies these features and characteristics of educational software: drill and practice packages; tutorials to teach new concepts; information retrieval systems; cognitive tools for learning are based on the constructivist principle; and productivity tools. The tools are, e.g., word processors, spreadsheets, databases, desktop publishing and presentation packages. He emphasizes that 'whilst these tools are not specific to Learning Technology, if used within a pedagogical framework, they can support learning by enhancing the quality of the learning process and by improving student productivity'.

In addition, although a term 'learning technology' is often used. It is understood as 'the application of technology for the enhancement of teaching, learning and assessment, and includes computer-based learning and multimedia materials and the use of networks and concussion systems to support learning' [11]. An essential component in a Learning Technology package is 'the ease with which the learner can interact with the contents. This is often referred to as the HCI, or Human-Computer Interface' (http://www.icbl.hw.ac.uk/ltdi/implementing-it/what-def.htm). Regarding learning technologies, the conference themes could be mentioned: Collaborative learning, Learning evaluation, Design methodologies, Learning innovation, Content design, Learning systems, and Learning analytics (https://www.learningtechnologies.co.uk/).

From the practical point of view, Heidi Hayes Jacobs is often cited on WEB that 'Teachers need to integrate technology seamlessly into the curriculum instead of viewing it as an add-on, an afterthought, or an event' [12]. So, if the integration should be 'seamlessly', then educational knowledge and teaching activities must be with technology treatments as twins. Keeping in mind that teaching, and education in general, is about knowledge and knowledge transfer (between educators and learners), all teaching and associated processes belong to knowledge-based processes. Thus, TEL or educational technology should be knowledge-driven. Such a knowledge-based approach is, however, not described in the scientific literature, and even if it is, knowledge is not defined. Some definitions of knowledge or knowledge representation can be found in the literature, but they are not interdisciplinary and universal. For example, knowledge is defined as 'a learner's collection of specific responses to stimuli that are represented in behavioral objectives' [13].

Regarding the term of knowledge, it should be emphasized that computers were invented for processing information in the form of zeros and ones as the information units. Therefore, a suitable knowledge representation is needed which would be acceptable by computers as a 'computer knowledge', i.e. as human knowledge which was converted to such information. The authors explored the scientific literature for some years, but it has been found that any universal interdisciplinary definition is used as a knowledge representation that is both machine and human readable. Nevertheless, only specific sources [14–19]. exist related to the question of knowledge that is not interdisciplinary.

Within a long-term research on TEL (2007–2014) and educational technology (2014–2019), the lead authors Svetsky and Moravcik invented a personalized knowledge-based approach for the integration of digital technology to teaching and associated processes. The breakthrough in their research was the formulation of the virtual knowledge, which is controlled and managed by its own educational software and resulted also in the registered utility model of the personalized technical infrastructure [20]. In the framework of this paper, the authors understand the knowledge-based educational technology as the integration of three components: educational software, technological infrastructure (off-line/online) and that it must function in the daily and real teaching and associated processes. In addition, the integration of digital technology into teaching must be synchronized, i.e. pedagogy and technology cannot be solved separately but must be solved in parallel. This is particularly important for informatics support of collaborative activities, because it is not possible to write source codes if pedagogical/didactic algorithms are not identified and formulated. From the practical point of view, teaching outputs are always directed to the screen of computers within the software environment, which is adapted to Windows functions or a set of html pages, and so the teacher can send it to WEB or the faculty's virtual learning spaces or the institutional academic information system (also off-line hypertext system is used). It is hard for a layman or common teacher who is not designer or educational technologist to understand. Perhaps it could be better understood when saying that even in writing this paper the authors' steps are indicated and new source codes were written and added to the software menu, also in connection with applying speech recognition (a part of the text is dictated by voice and written by the computer). Collaborative writing is a contemporary topic of research (see e.g. [21]), so a set of codes are written to automate just the collaborative writing.

Thanks to this approach, in principle nearly all above-mentioned cases of the state-of-the-art were covered by one multipurpose educational software (the actual public beta version is WPadV4). This affects around tens, maybe hundreds, of implemented case studies within university teaching till now. These were continually published and presented at conferences, where the software was presented as the all-in-one educational tool (see e.g. [22–27]).

Such all-in-one multipurpose function is possible just due to the knowledge-based approach, because a computer understands and is able compute the virtual knowledge, where human knowledge is inserted in natural language, and thus it does not matter if the content of human knowledge is educational, engineering, personal, dedicated to leisure, etc. This simply enables one to simulate mental processes that are knowledge-based as well as teaching processes. In other words, the same principle — the same educational software — can be used for blended learning, e-learning, collaborative learning, or any kind of learning, including secondary topics such as learning analytics, educational data mining, online/offline retrieving of educational sources, multilingual support, etc. (Note: as was mentioned above, all this was designed and implemented within the authors' teaching and research). As the most important added value, it could be emphasized that the knowledge-driven approach is beyond state-of-the-art because the current ICT solutions are based on the data-driven approach, and it is well known that knowledge has a higher hierarchy level than simple data. To be understandable by orthodox informatics people, it could be explained as working with smart data which are in decision processes that are much more important than so called big-data. In addition, mostly our own smart data are used, not any training data from WEB repositories, as is often common in scientific literature.

3 Principle of the Knowledge-Based Design of Educational Technology

The knowledge-based design of educational technology is based on the representation of human knowledge as the virtual knowledge. This virtual knowledge is the key element of solving the integration of digital technology into teaching. From an informatics point of view, it is a specific data type in the form of a free database table. Therefore, a computer understands it as an information structure, i.e. a default set of zeros and ones. Similarly, as a calculator computes numbers, computing such as the virtual knowledge is performed in extremely high speed in comparison with velocity of human processes.

From a human point of view, the virtual knowledge consists of blocks of meta-information and content into which a user can insert his text, or ASCII text in general. A teacher can insert any educational knowledge or content directly into the virtual knowledge in his natural language without the need of using any other machine languages. Figure 1 illustrates the virtual knowledge as one row of the free database table when human knowledge was inserted into the table manually.

In this case, the meta-information identifies the content which is in the form of the manually written text. By adding other such rows, the knowledge table 'BJET' was created and used as a manuscript of this paper. Similarly, an individual user can create a set of such tailored knowledge tables.

For example, on the personal computer of the designer of the educational software, there are around two thousand tables nowadays. These knowledge tables can be

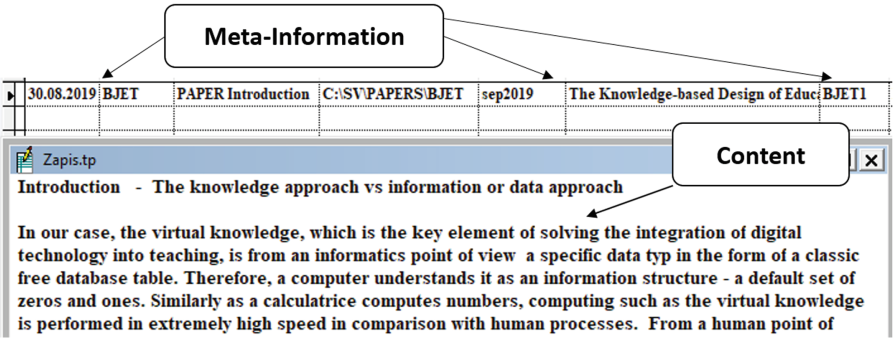

Fig. 1. Example of inserting the human knowledge into the virtual knowledge.

exchanged between users in the same way as the other formats are exchanged, i.e. as it is common by exchanging mail or documents. In this context, human knowledge before inserting into the virtual knowledge represents so-called tacit knowledge (the term from the knowledge management field), which is uncertain and unstructured from the computer science point of view. After its inserting, however, the human (educational) knowledge has the character of explicit knowledge, which is already semi-structured. This, thus, is already well suited for computing. By using a database technology platform, such a knowledge table can even have over a million rows. However, an individual user commonly works with tens to hundreds of rows, only rarely with some hundreds of thousands of rows.

Computing the virtual knowledge and the knowledge tables is performed by the database application WPad that is being developed by the main author of this paper. Because this educational software is based on the abstraction of the meta-information and content, it enables users to process any content in the default structure. So, the user can create knowledge tables for constructing the teaching texts, material for lectures, and exercises.

The design of the educational software was a part of the long-term research on technology-enhanced learning, and research outputs were continuously published and presented at conferences. Within teaching several courses of study, the software WPad has been installed on the classroom's computers and used for many categories of teaching activities. This means that to each category of the activities, tailored sources codes were written for processing knowledge flow while teaching undergraduates. For the repeating activities, the codes were added to the user menu, which contains around a hundred items, divided into some categories.

The above-mentioned personalised paradigm for processing the educational content in the knowledge tables by using the in-house educational software enabled integrating digital technology into all kinds of teaching. This means that it is not a theoretical approach, but it was used for off-line teaching, e-learning, blended learning, learning analytics, formative assessment, writing semester works, self-study, computer-supported collaborative learning, and batch-retrieving from internet.

To the best of the authors' knowledge, there is no such all-in-one educational IT tool described in the scientific literature. Thus, it seems that the concept of the virtual knowledge representation is universal for solving the technological support and digitalisation of any knowledge-based processes. However, it must be mentioned that originally the WPad software and the knowledge tables were used for several years only at the empirical basis. In other words, it was used in real university teaching for teaching around two thousand students without any theoretical background. Despite using the database technology platform, it was even found that in comparison with the classic relational database paradigm (which uses E/R model, normalisation rules, index keys and does not allow any redundancy), the knowledge-based approach even represents an 'anti-paradigm', although very efficient and user-friendly (it was used by students and users with lower informatics skills). After more detailed analysis about why it works as an all-in-one educational technology system, it was found that the used informatics structure is in principle both machine-readable and human-readable. This means that it functions as a suitable universal knowledge representation, which could be efficient for processing unstructured data. This concept was also proposed to the Slovak Patent office, where it is registered (2016).

From the moment of realising the importance of the virtual knowledge, the authors' research is more systematically focused on building the complex knowledge-based educational technology consisting of the educational software and online/off-line infrastructure that contain knowledge repositories, expert and language corpora and educational packages. This additionally covers solving the transmission of the virtual knowledge and the files with the educational content within the infrastructure. Modelling these elements within a community of researchers ('community of innovations') is explained in this paper by giving some examples from the design of using a cloud service and a remote desktop as the faculty's virtual machine. Figure 2 illustrates the infrastructure for modelling the knowledge-based educational technology that was built for this purpose.

4 Use of Educational Software when Teaching Undergraduates

As was mentioned in the previous section, the multipurpose educational software was developed, tested and implemented in around ten categories of teaching (it could also be mentioned that ten diploma works resulted in the creation of small information systems, e.g. within the course of study 'Occupational safety and health'). This means that WPad functions in teaching practice as a dynamic and interactive system, which enables the teacher to support teaching activities related to how to use the selected parts/chunks of his personal teaching (digital) content directly during the teaching hours (lectures, exercises, classroom's instructions/communication, and uploading/downloading files by students from the faculty's server). Within several years of research on technology-enhanced learning, many such outcomes to teaching have been introduced into teaching. Perhaps it should be emphasized that the technology primarily supported the teacher's activities considering the teacher as the key player. This could by demonstrated by this complex example with added pedagogical and informatics values.

The pedagogical situation at the beginning was that the undergraduate students had very low knowledge in Chemistry, and it was continually needed to teach them

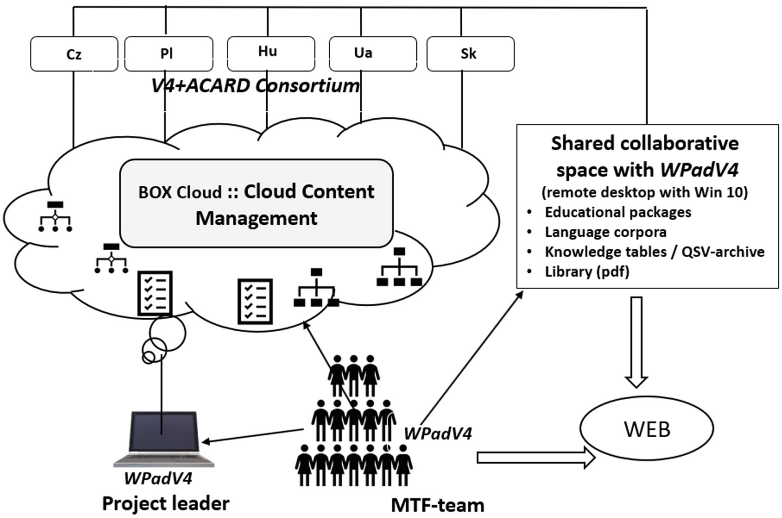

Fig. 2. The infrastructure for modelling the knowledge-based educational technology within the V4+ACARDC project team.

a basic Chemistry curriculum from pre-university schools. From the pedagogical point of view, the teacher decided to prepare teaching texts from the basic Chemistry collaboratively with students with the support of the WPad software. The following steps were performed.

1. The teacher had simply copied a list of around hundred students from the institutional academic system AIS into a knowledge table (so without using csv format).
2. Now, having the table with hundred rows, the teacher wrote a source code to assign for each name the keywords related to the basics of Chemistry, e.g. oxidation, reduction, periodic table, chemical laws, amino acid, DNA, genetic code, chemical equations, etc.
3. By clicking CTRL-F1, the table was converted to an html file and placed in the faculty's learning environment.
4. Into the teacher's application, a 'communication channel' was given to students to link to the html page with their names and tailored tasks.
5. Because WPad also enabled students to make retrieval, they performed a WEB search and copied results from search engines into their WPad tables in the classroom (WPad was installed on 10–15 computers in the classroom).
6. In some weeks, students of the study course 'background of environmental protection' worked out such 'encyclopedic' material. Their task was to insert this material into chapter 4 of their semester works.
7. The teacher joined the tables of students to one table, finalised it as a PDF file and placed it to the faculty's WEB page (in the virtual learning space).
8. The collaboratively prepared teaching texts were used also by students in the next semesters.

To be honest, the pedagogical level was not optimal, because students used also content with less quality (e.g. links to unofficial students' pages made by students for students) for WEB search. Thus, the teacher should check and correct this teaching material. But the result was useful, practicable and a set of interesting links were found.

Such an example of using WPad could be mentioned for some other kinds of teacher activities, i.e. when the teacher interlinked the AIS academic system pages (the institutional analogy to course management systems such as Moodle or Blackboard) and used it for assessment, instructions, and examining. In other words, WPad enabled him to concentrate institutional and personal digital content (including emails from students with semester works) to one or some WPad tables in a very quick way — beyond the state-of-the-art — and used it within the whole semester, even for some years (e.g., the teacher is now a researcher and can work out his case study from previous years). Figure 3 illustrates it schematically.

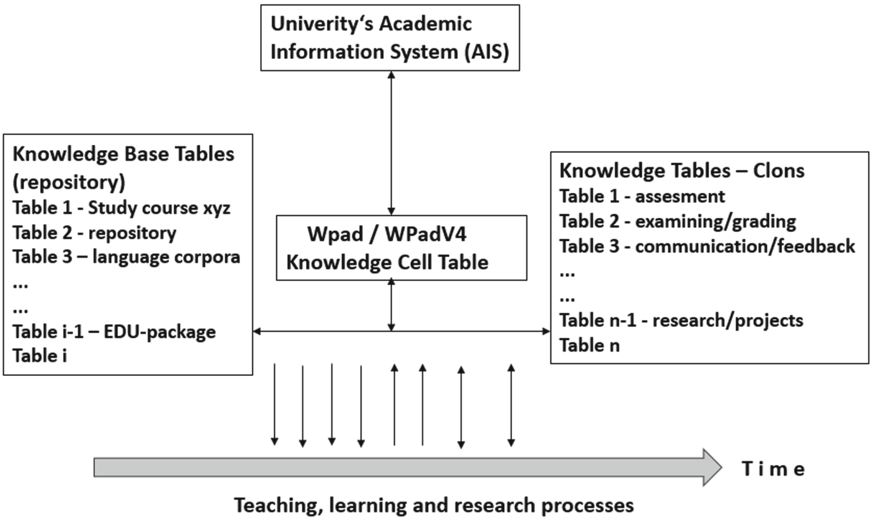

Fig. 3. A Schema for using the WPad Educational Software for Educational Processes.

5 Research Approach for Math, and Modelling and System Simulation

The research approach has both pedagogical and informatics levels because the personal software WPad was developed for supporting the teacher's activities within teaching undergraduates. In other words, it was an empirical participatory action research at the beginning, when the teacher designed their own technology tailored to his daily teaching needs (Goodman, 2002). After formulating 'the virtual knowledge unit', the research focus was on how to insert any educational content into the knowledge tables in natural language. This has required to design a new paradigm from an informatics point of view, such as how to create, manage, and process the knowledge tables containing teaching texts and content.

It was found, within solving the active and collaborative teaching, that firstly pedagogical steps must be identified and then algorithms must be defined to enable the teacher to write source codes for creating and managing content of the knowledge tables. Then the research focus was on how to process this content knowledge and how to transfer it (knowledge tables and files) to the virtual learning space, virtual machines and clouds, i.e. to the technological infrastructure which has been developed for this purpose. Keeping in mind this, personalized educational technology (software and infrastructure) was developed within daily teaching which did not previously exist (e.g., a utility model was designed). Basically, it is a pilot research to design educational technology and evaluate if it is suitable for teaching or not. Now, if any new technology exists, anyone could continue with a typical pre/post research, i.e. to compare two groups of students regarding learning outcomes when teaching with or without technology.

To describe a ‘sub-focus’ on all kinds of teaching and associated processes in more detail is beyond this paper. In the ideal case, the pedagogical research must be solved with informatics research in parallel. The main reason is that the teacher works as an educational technologist and research results generate new ideas for modelling pedagogical and informatics approaches. This could be illustrated by developing the educational packages for math and simulation courses of study. Originally, WPad was developed within teaching courses of study, e.g. Background of environmental protection and Occupational Health and safety, that required mostly processing texts and images. In contrast with this, teaching Chemistry, Math and Simulation require processing formulas and equations, where paper and pen are more suitable than heterogeneous and incompatible computer formats. In view of this, a key point of programming is how to link educational content from heterogeneous formats. For this purpose, a screenshotting method was worked out for the creation of educational packages. This term means that many heterogeneous files are linked together into a raw package and then texts, comments, and navigation links are added as needed. Figure 4 illustrates such an example of the raw package.

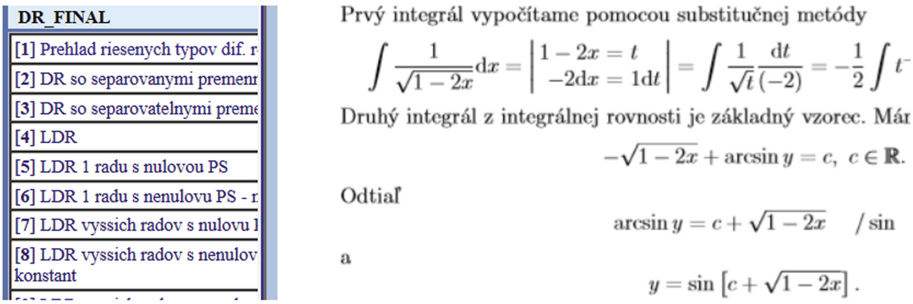

Fig. 4. Screenshot of the raw educational package for a differential equation

To better explain the need to synchronize pedagogy and technology, it should be mentioned that such raw educational packages were modelled by two teachers for the first time. Namely, the raw packages are a technological result. This inspired the teachers to design a set of potential pedagogical applications, which could be a key topic for the following development of WPadV4, i.e. for each planned activity, sources codes can be written. In this context, they propose the following future work.

A potential future research work for MATH could be as follows:

In mathematics, the application can be used as a supporting tool in home preparation of students for the teaching process. The application can supplement the prescribed study literature with tasks to deepen the subject matter, and it can contain additional materials for preparing the student for a new exercise so that the student gains an 'insight' into the subject covered. This can be done in the form of:

1. a list of recommended tasks for practising the subject matter, providing solutions or appropriate procedures;
2. a graphical solution that gives students a visual idea of tasks that were solved separately at home or at an exercise where this step was omitted for time reasons;
3. test tasks to verify understanding of the curriculum;
4. links to interesting materials from other universities, free teaching materials from these educational institutions, and motivational examples from practice.

A potential future research work for MODELLING AND SYSTEM SIMULATION could be as follows — the teacher understands it as an information and self-study educational system:

1. Sequence of steps to create educational package for work with the Witness simulator within the course of study Modelling and simulation of systems:
2. design and creation of the content of educational materials in the form of images, videos and textual information;
3. linking the created files into the knowledge tables of WPadV4 database environment;
4. user-friendly automatic generation of website by users;
5. internal testing of quality and comprehensibility of information of the generated educational material;
6. revisions and improvements;
7. testing on the control group of users and finding out the level of their satisfaction;
8. evaluation of benefits.

From a pedagogical point of view, it is essential that there is: clarity and good orientation in the information offered; and appropriate continuity of the materials and the possibility of their potential modification, updating or gradual completion, which would enable the educational package to be updated and expanded. For the subject Modelling and Simulation of Systems, this means especially the creation of web pages dedicated to teaching working with the simulation software Witness. The elements of interactivity and personalised learning provide the opportunity to learn through self-study and self-controlled working within exercises in an effective and interesting way.

From the use of educational packages point of view, we see a perspective in introducing interactive elements into the supporting means of the self-study process when working with the Witness simulator.

The main contribution of educational materials in the form of automatically generated web pages would be supplemented and updated study materials (teaching texts in pdf files and complete templates of the simulation and optimisation models), which are published in the Academic Information System of the faculty.

The target group is mainly students who study the course of study subject in individual mode. Here, a multilingual (preferably English) version would be useful, especially for students from other universities participating in exchange stays (Erasmus).

The second group for which the educational package would have its significance within the course of study are so-called DKM students (distance students). They should have the opportunity to follow the individual steps of model building at their own pace, taking into account the choice of specific thematic areas.

Similarly, for full-time students, the proposed educational package offers the possibility to complete skills in the mastering of the selected simulation environment in the home preparation, or in exercises in the following weeks of the semester as part of controlled individual work.

6 Modelling Educational Packages for Programming Languages

The presented educational software enables teachers or educational researchers to construct teaching material in various kind of outputs, moreover in the form of multipurpose concentrated forms (the WPadV4 version). The best results are obtained in the case of teaching programming languages because WPadV4 can be modified or directly used as the editor of the source codes.

Figure 5-3 illustrates such a case of how the teaching elements can be concentrated into the computer screen and used for many categories of teaching the PHP programming language, e.g. in a classroom or for self-study. The teacher uses the knowledge table (XAMP_HP) which functions as his personal repository containing source codes for PHP in the table rows — see Fig. 5-1. Using the user menu of WPadV4, the teacher launches that source code from individual rows of the table, which the mouse cursor is just on. The result of the launched PHP code (mocniny.php) is automatically visible in the IDE environment — see Fig. 5-4. This is a situation when the teacher teaches students to programme a math exercise for powers in the PHP language. Such tables can be produced by students in the classroom with WPadV4 and the PHP software XAMPP (or other PHP software) installed, including uploading and downloading the source codes from the faculty server or web-hosting page. By using the WPadV4 menu (CTRL-F1), the teacher can convert it to HTML format — see Fig. 5-2 and Fig. 5-2 — and place it on WEB. The navigation is solved in such a way that by clicking on the record number, i.e. [16] in this case, the source code is visible both in the default text editor and in the browser in off-line mode.

It should be clear from this example illustrated by Fig. 3 that the added value is obtained both from the informatics and pedagogical (didactics) points of view. Technologically, this all-in-one system spares much time due to concentrating the outputs (fewer interfaces, windows, screens, and the radical minimising of number of clicks). However, it means pedagogically that teaching material is concentrated and the user sees the teaching texts, source codes and results at that same time without the need to switch between interfaces. In other words, teachers, researchers, and students can write and launch the source codes without knowing that any PHP software is used. This way represents a very effective support system for the training of writing the PHP source codes in order to obtain routine programming skills, and it is not a static material as it is common in general. In addition, teaching and technology are synchronised as ‘twins’.

In the case that students have the WPadV4 application and PHP software installed on their computers, they can collaboratively perform teaching tasks and train many more PHP source codes within one teaching hour than without the using WPadV4. So, after time the knowledge tables function as a repository of the launchable source codes, which can be used by other students in the next semesters. Of course, the knowledge tables can work as the smart repositories which are filled from the WEB educational resources.

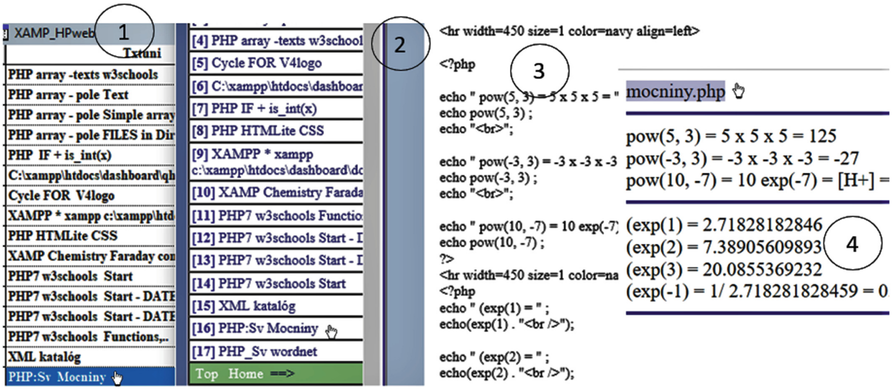

Fig. 5. Example of concentration of the teaching material using the PHP source codes repository

7 Examples of using WEB Sources Mining and Language Corpora

The WpadV4 educational software also enables one to work with a huge amount of information stored in WEB databases for analytical work or to build multilingual support. Two examples could be mentioned. For example, a list of projects solved within the 7th Framework programme from the European CORDIS database was inserted into the WPadV4 table, which resulted in the creation of a table with over six thousand rows. By using the user menu, around three hundred ICT projects were found in which one can browse and analyse a research focus of the projects. It can be converted to html format, as Fig. 6 illustrates.

Similarly, the knowledge tables containing useful English sentences can be used for personal support of users when English is not their native language. Figure 7 illustrates such support just when this paper was written. In this case, the teacher was not sure how to use words ‘point of view’. He has simply used the knowledge table TACITKW and chosen from WPadV4 menu ‘Search in the table’. This resulted in the creation of the temporary table and html output with all sentences containing these words.

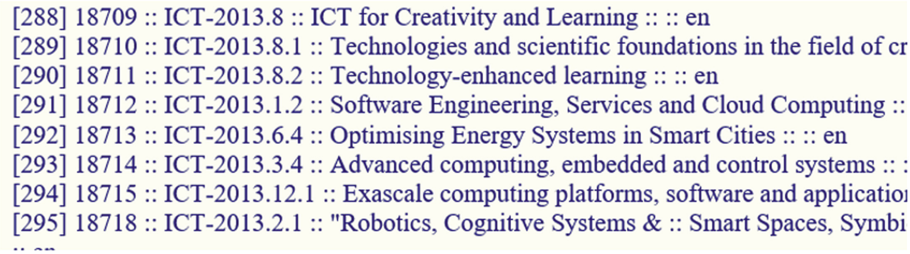

Fig. 6. The selected ICT projects from the list of solved projects from EU-CORDIS.

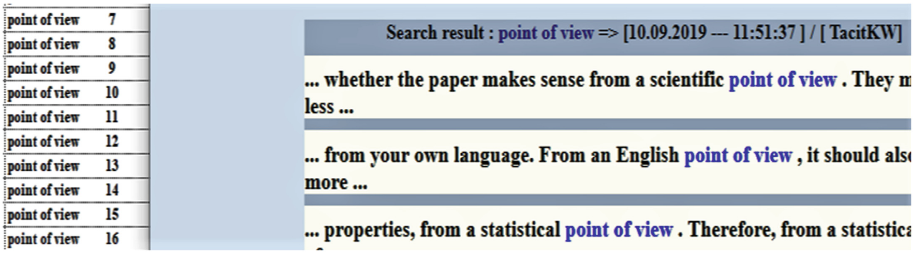

Fig. 7. Screenshot from the result of a search for English sentences from the language corpus TACITKW.

8 Example of the Educational Design for Collaborative Teaching

In the case of educational design for collaborative teaching, it is crucial that the teacher must design pedagogical steps related to a collaborative activity firstly and then write informatics algorithms. The computer program must be synchronized with any pedagogical method, so as to be more than a simple teaching aid. This can be illustrated in the case of how the WPad application was useful within teaching the course of study of ‘Background of environmental protection’, for explaining electromagnetic radiation. For this purpose, the teacher has designed their approach using the methodology of computer-supported collaborative learning (CSCL). It can be briefly described by the following pedagogical and informatics steps.

From a pedagogical point of view, it was important to explain to students that the electromagnetic spectrum consists of radiation with a wavelength from 0.001 nm to 1 km, keeping in mind that the wavelength is associated with a certain level of energy. Each student was assigned a random wavelength to calculate the radiation energy. The result was a shared table. So, if every student sees that the energy of radio waves is practically zero and that the energy of ultraviolet, X-ray or gamma radiation goes up to millions of values, it is logical that they will better understand the context from a didactic point of view. In other words, if radio radiation falls on us, it will do nothing to us, whereas this radiation can already more or less disrupt the structures in living organisms (molecules, atoms).

From an informatics point of view, a list of students was copied from the Academic Information System of the faculty into the knowledge table, and a source code was written which randomly assigned students the wavelengths for calculating. Teaching content related to electromagnetic radiation was on the virtual learning space (a student saw for each kind of radiation/UV, X-ray, infrared/linked energy level). Using the teacher's tutorial, students only inserted a number (the wavelength), and the result was the energy level, which was written on the classroom's table by each student.

In the next teaching, this approach was used for some courses of study, e.g. students used the WPad tables (WPad was installed on the classroom's computers). Instruction was face-to-face or via communication channels to the students' virtual learning space of faculties.

9 Conclusion

In this paper, a specific paradigm for the design of the knowledge-based educational technology was presented, which in comparison with the state-of-the-art is based on the real educational knowledge representation, not only on an artificial construct of knowledge. The authors' knowledge-based approach enables a user to produce and process their own machine-readable knowledge sources in their natural language, thus not using any training datasets from the internet, as is common. The educational technology has been presented as a personalised system consisting of the collaboratively shared offline and online infrastructure (clouds, virtual machines, WEB) and own in-house developed educational software. Within the V4+ACARD consortia, the multipurpose WPadV4 database application was developed for modelling educational packages, multilingual support, text corpora and various categories of associated outputs. The educational 'prototypes', which were described in several examples, were designed in the cloud/off-line infrastructure collaboratively by a community of researchers of six academics subjects from five countries. In the context of information and knowledge management, the presented research showed that the integration of the database technology, robotics and human language technology is particularly suitable for processing the heterogenous content in a user-friendly way and much shorter time than is common. There are also some limitations regarding human and technological factors and the time factor, e.g., willingness of teachers to use the developed knowledge-based technology; non-compatibility of software formats; teaching topics can be very well supported by a personalised knowledge - base, but lectures and exercises are strictly time-limited. It should also be mentioned that another modification of the teaching and informatics paradigm is to be solved within the future work. It will be focused on testing and implementing results into teaching engineering courses of study and academic research (e.g., the prototypes of educational packages for maths and multilingual support will be divided into some categories and tested for teaching). From a theoretical point of view, it can be stated that the pilot and empirical research presented by real outputs into the teacher's practice shows that the unique knowledge representation understood by man and machine allows to solve personal computer support of practically all activities performed by the teacher.

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