Some Aspects of Teaching Processes Computerization

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***Abstract*—From the teaching processes computerization point of view, there is an absence of state-of-the-art approaches to their automation derived from "knowledge" as the key element of teaching and learning (including human knowledge transmission taking place in the framework of communication and feedback). This contribution presents such an approach, dealing with how the automation is solved when computerizing teaching processes. It has been developed within the published long-term research on the technology-enhanced learning and works in the teaching practice (it is applied to teaching bachelors students). The approach is based on the design of the "virtual knowledge unit", as the default data structure, which is both human and machine readable. This enables the teacher not only to process learning content but also to automate communication and feedback thanks to the possibility to transmit the knowledge, i.e. the teaching and learning content, between off-line and online environments by using the virtual knowledge unit. The virtual knowledge joins isomorphically the mental processes of humans with the physical processes of machines. From the practical point of view, the data structure is handled and controlled by the in-house software BIKEE. This database application enables a teacher to solve any kind of teaching and learning processes tailor made for him. Based on the teaching practice, this approach seems to be beyond the state-of-the-art. This can be concluded because a registered utility model, based on the use of virtual knowledge, is used for the knowledge transfer. Some aspects of teaching processes computerization are discussed regarding the automation of mental processes. In this context, the actual research is focused on development of an educational robot.**

Keywords—automation of teaching processes; knowledge representation; technology-enhanced learning; educational technology; Cybernetics

I. INTRODUCTION

The implementation of digital technology for automation of teaching processes was briefly presented by the authors at the previous FTC 2016 conference [1]. The automation was solved under the umbrella of a long-term research on technology-enhanced learning (TEL). This started around the year 2006 with an idea that each knowledge worker should be equipped with ITC tools for processing a large amount of knowledge similarly to the contemporary soldier who is equipped with high-tech tools.

At the beginning, the research was empirical with the technology-driven and educational-driven approach, and the results were continually presented at conferences and published. The following, already more systematic research, which was focused on the automation of educational processes [2], showed that to integrate ICT into teaching, i.e. to computerize all kind of activities of teachers and students, is not only about pedagogic (didactic) content, but also about transmission of this knowledge content and feedback. To automatize the teaching process (to write programming codes) many questions arose as was mentioned in [1], [2], for example, what is eLearning, what is technology-enhanced learning, what is "knowledge", the question of life cycles of hardware and software, and especially why the computer support in educational environments is often criticized not to have the suitable level to support teaching. Surprisingly, in the scientific literature related to integration of the ICT into teaching and learning, such questions are not considered. One could read hundreds of research papers concerning the research in TEL, educational technology, computer supported/assisted learning or in education in general, but important information (definition) - as what "knowledge" is or what "knowledge transmission" is - is missing.

It should be emphasized that when considering teaching as knowledge based process, the question of "knowledge" or "knowledge transmission" is absolutely crucial. To solve such issues, it was needed to go back to the literature from the Cybernetics era of the 1960's. At this time, the existence of isomorphic relations between mental processes and physical processes performed by a machine were considered as a basic assumption for the control of non-living systems. Therefore, the design of the "virtual knowledge unit", both human and machine readable in the natural language, as was described in [1], can be considered as a breakthrough in the presented research. Because the virtual knowledge unit represents a specific data structure, the "knowledge transmission" between off-line and online hardware and networks is possible, including modeling of feedback. The in-house developed software (by Svetsky) enables users to process, manage and transmit human (didactic/pedagogic) knowledge which is inserted into the "virtual knowledge unit". This actually works in daily teaching of bachelors students based on the utility model 7340/2014. So the problem of the knowledge representation was solved and it is a first step towards solving the automation of teaching processes.

II. Challenges for TEL Regarding the Automation of Teaching

The abstract concept of information and the absence of universal interdisciplinary knowledge representation seem to be behind the criticism of the lower level of integration of the ICT into education in scientific literature. For example, in [3] eight factors were described as student's barriers to online learning, but none of them was related to the "knowledge" as a crucial factor of any teaching. Stolar's paradoxes could be mentioned here: information smog, inflexible informatics environments and non-compatible domain ontologies in [4]. 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". Similarly, a prevalent technological approach to TEL research with a questionable educational impact is often more or less criticized in literature (see e.g. [5]-[7]). In [8], the TPCK framework (Technology, Pedagogy and Content Knowledge) is recommended as a "useful tool for the consideration of the interaction of technology with content and with pedagogy". This model should be helpful in "overcoming perceived barriers to the effective integration of ICT in teaching and learning".

The European Commission which funded a series of large academic research projects into TEL explicitly recognized that there was a general 'absence of evidence' that the projects had achieved lasting impact" [9]. The conclusion was: "TEL is a poorly conceived acronym, a new approach is needed that focuses on *education-specific technologies*". Basically, it does not matter how the technology is named. More important is that the teaching is not considered as a knowledge based process. The same is true for the three monographs on TEL [10]-[12]. However, it must be emphasized, as argued in [12], that "a system design on the model basis has been widely ignored by the community" until now and "software engineering is missing in TEL system development". In contrast, the approach presented by authors is actually based on the TEL system design and development of the in-house software BIKEE. A selected part of it, the WPad, is used as the educational software which is installed on computers in the classroom or shared collaboratively within the faculty's virtual environment.

III. Cybernetics and Automation of Mental Processes

When looking back for any theoretical background in the Computer Science or ICT the authors found a certain analogy to the Artificial Intelligence [13]. More successful was the investigation of similar approaches from the early Cybernetics era. 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 [14]. Due to this isomorphy, 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 isomorphy in order to transfer some mental (thought) tasks into the physical area and vice versa. Fig. 1 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.

From the automation point of view, it is important that the "human" knowledge inserted into the "virtual knowledge unit" is both human and machine readable. Moreover, the machine (computer) performs the physical processes (i.e. those with the virtual knowledge) much more quickly and more precisely than humans perform their mental processes. It also enables users to transmit the "virtual knowledge" among computers, hardware and networks. One can imagine the "virtual knowledge" as a black-box, as the "pragmatic information representation" (see more in [15]). Fig. 2 illustrates other challenges where human knowledge is to be processed.

When solving these challenges (crucial for automation of teaching processes), one must be always aware of the uncertainty of knowledge based processes and a processing of unstructured data is required, too. In our case, it is solved 1) by the unification of content and algorithms; 2) programming the universal in-house software BIKEE; and 3) the knowledge representation is solved by the isomorphical functioning of the "virtual knowledge unit".

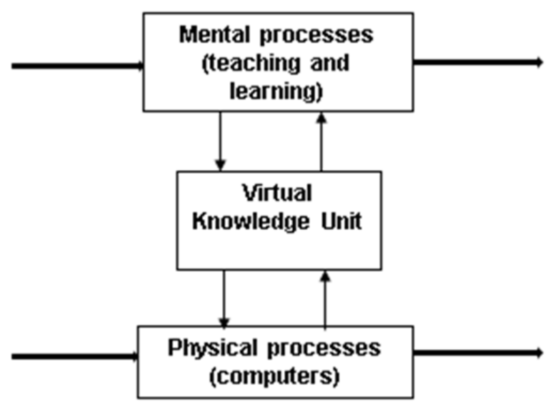

Fig. 1. Isomorphic relationship via the "virtual knowledge unit".

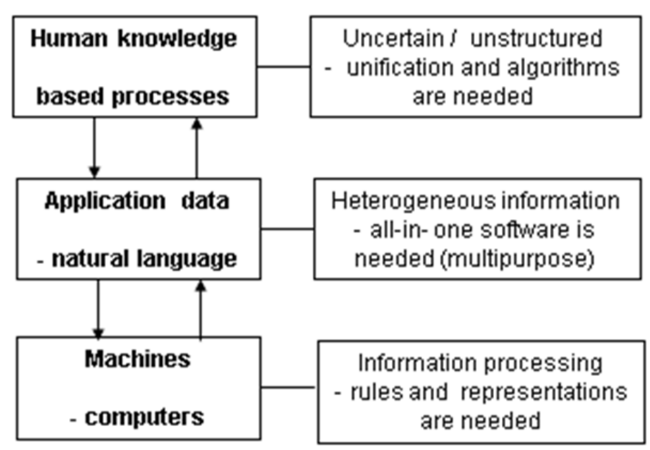

Fig. 2. The principle of the human knowledge processing [15].

It should be also mentioned that the automation of teaching and learning is a complex interdisciplinary issue. The Cybernetics (within which computers were invented) represents the basic theoretic discipline focused on the automation (regulation, control) of non-living and living systems with focus on the information, information transfer and processing [16]. Teaching and learning processes are considered as cognitive processes, i.e. they are human knowledge based, and connected with thinking and intelligence. Within psychology, behaviorists understand thinking as a “process of solving problems” (as an adaptation to the changes in environment), while in the Cybernetics it is a process of “processing and using information” [17]. From the educational psychology point of view, teaching can be considered as “acquisition of concepts, problem solving, intellectual operations shaping, or acquisition of algorithms” [17].

Within the presented long-term TEL research it was found that three categories of algorithms are crucial: didactic, informatics and integrated. The automation practice shows that the design of the algorithms is especially important in the case of the so called Computer Supported Collaborative Learning. Namely, if no didactic algorithm (method) exists, there is not any possibility to write informatics algorithms. In addition, the didactic algorithms and the above mentioned aspects of the presented approach are not described in the actual scientific literature. One can find more information rather in the older literature resources, e.g. about the Cybernetics - Information-theoretical Didactics [18]. Interconnection of the particular systems S1 (teacher), S2 (brains of students) and S3 (facial expression) was described in [14] as interconnection of informatics-technical nature. S1 sends sound waves (as information carriers) to S2 which influences S3 via neural connections and S3 influences S1 as optical feedback (teacher regulates his lecture based on facial expressions of students).

IV. Practical Solutions in the Teaching Practice

As was mentioned in the abstract, the virtual knowledge is handled and controlled by the in-house software BIKEE (WPad). In addition to Fig. 1, the following Fig. 3 illustrates the function of the software as a tool that adapts human thinking to the environment.

The schema was made during testing suitability of a digital pen for the computer support of teaching. This is in accordance with the common approach of psychologists who accept the human thinking as an adaptation to the environment [17].

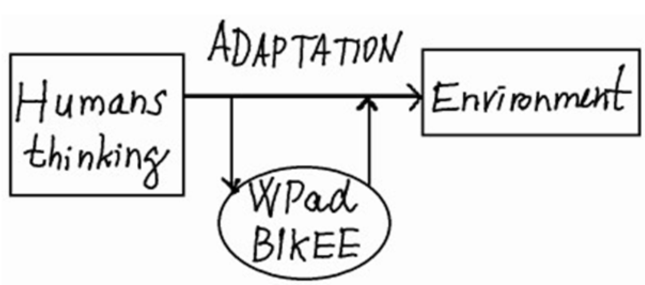

Fig. 3. Function of BIKEE (WPad) in adaption of human thinking.

It is very important from the practical point of view, that the data structure is both machine and human readable (the ASCII coding is used). Thus, knowledge can be transmitted between the off-line devices and online virtual spaces (virtual computers, clouds) simply as is, i.e. in the form of “knowledge” tables that are created on a common database platform. This is a different approach than in the state-of-the-art where other formats are used for file transfer, e.g. xml, csv, doc, pdf …. Moreover, data conversion or using other languages is needed as well.

The mentioned research on TEL was performed as an academic research. Despite the fact that the focus of this contribution is not on giving a theoretical explanation or literature review, to the best of authors’ knowledge, this contribution seems to be the first attempt to publish the above mentioned approach to knowledge representation and automation of mental processes.

In addition, this approach is built on using own software BIKEE which is already functional in the daily teaching. No such approach was presented on academic conferences focused on engineering education or directly mentioned in the EU research agenda. For example, in the Geographical ICT Survey Results on ICL conference [19] 14 categories of academic research were identified, however none of them is related to our topic (see details of the key presentation [19]).

The same is true of the reports of STELLAR (the European Network of Excellence in TEL) and HoTEL (FP7 project), in which new innovative TEL methods were investigated [20], [21]. However, regarding authors’ approach to knowledge abstraction and representation, it was emphasised in the STELLAR report that “The challenge of the coming decade is to break the barrier of knowledge representation”. This challenge requires “passing from knowledge modelling to interactive modelling when an explicit representation of knowledge is not available or even not accessible.” However, this “passing” does not comply with authors’ findings in which the knowledge is considered as the crucial parameter of the teaching processes, i. e. including knowledge modelling. And it is commonly written in all didactic books that teaching is about knowledge (see e.g. [22]). The proposed “interaction modelling” seems to comply with authors’ understanding of the processing dynamic knowledge flow which automatically supports any interaction.

Similarly, in the EU research programme HORIZON 2020 (Work programs 2014-2017), only the topics “Technologies for better human learning and teaching” or “Technologies for Learning and Skills” are mentioned in general.

As long as BIKEE (WPad) is a database application, the authors’ approach can be characterized as a specific use of databases in contrast with the classical data processing. Authors do not use the Entity-Relationship model but a logical model, based on records (not objects). Authors also wanted to apply for a patent application for the BIKEE software, but in the European Union it is not possible. It is only possible to apply for technical solutions but not for software. Only the utility model - technical solution, related to the unstructured data processing using a specific data structure - was applied for.

As regards the practical aspects of the computerization of teaching processes, by using BIKEE or beta-WPad, tens of applications were implemented in order to support the daily teaching or individual teachers. Some of these applications were presented in [1]. All these applications were basically designed by combining the different menu items in the BIKEE software. In this context, a research idea was born to design database applications for modelling the automation of mental processes. As a consequence, an academic project was proposed with the intention to develop an "educational robot". This is illustrated by Fig. 4.

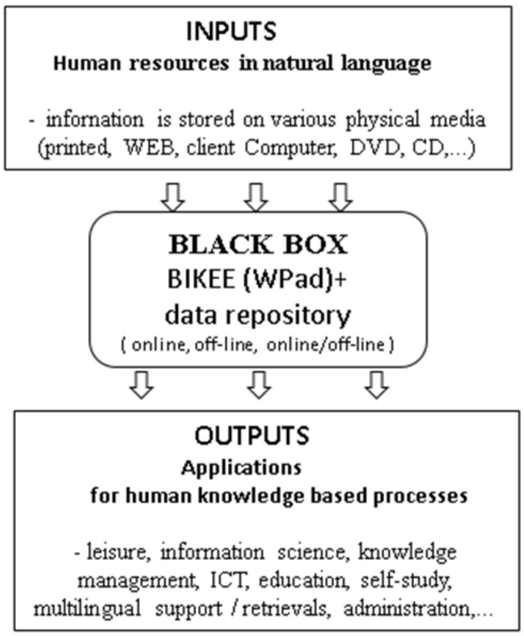

Fig. 4. Schema of the design of database aplications for modeling the automation of mental processes.

V. Conclusions

In this contribution some aspects of computerization of teaching processes were discussed regarding the principle of how the computer support is solved when teaching bachelor students, and how the knowledge and its transmission is processed and exchanged between off-line and online environments. Challenges for technology - enhanced learning are discussed, including automation of mental, i.e. knowledge based processes, from the Cybernetics point of view.

Authors' approach to automation is based on the "virtual knowledge unit", a specific data structure which isomorphically bridges mental processes of humans with physical processes of computers. An in-house software BIKEE is used for the modelling of the automation. Authors in this contribution explained the differences in contrast with the state-of-the-art:

- The designed virtual knowledge - as a specific data structure - solves the problem of knowledge representation (both machine and human readable).
- The use of a specific database application - own in-house software BIKEE (WPad) for knowledge processing was developed.
- The registered utility model 7340/2014 for knowledge transfer which solves the knowledge transmission.
- The specific database platform use (because Entity-Relationship model is not used).

This approach enables one to model all kinds of teaching and learning processes in the future. In addition, an institutional academic project was proposed, aimed at the design of database applications for modelling the automation of mental processes, including the intention for developing of the "educational robot".

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