Design of All-In-One Technology-Enhanced Learning Software for Supporting Teachers' Personal Activities

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Abstract. *Computers cannot support all the activities performed by a teacher. Due to the lack of appropriate Information Technology (IT) tools, a teacher must adapt to existing technologies. The educational software WPad, developed within the framework of the authors' research on technology-enhanced learning (TEL), offers a universal solution. WPad controls the so-called virtual knowledge into which the teacher inserts content to simulate teaching activities. In this paper, TEL design in research and for publishing support are described based on examples from university teaching. The methodology of synchronising teaching and computing activities is also explained using the idea of building a personal information system.*

Keywords. Technology-enhanced learning, educational software, IT tools, synchronisation of pedagogical and informatics activities

1 Introduction

In practice, every university teacher participates in a large number of educational processes, which include not only teaching and learning, but also research, publishing, self-study, communication, international collaboration, e-learning, educational management, promotional recruitment, and various related administrative and economic activities. Thus, the integration of IT into education practically means that some software and IT infrastructure must be available for all these processes.

As far as IT support for education is concerned, learner-centred research is most often emphasised in the academic literature. One rarely encounters a focus on personal support for the teacher, even though the teacher is a key player in education. Even from the point of view of common sense, one can ask whether there can be any learner-centred approach without the involvement of the teacher. The requirement of IT support for the teacher as a key person in education is captured well in the TEL monograph by Goodman (2002). In the context of American universities, it is emphasised that every professor should have a team available to provide IT support. Although this monograph was published twenty years ago, it is still relevant to TEL. In this context, in a discussion on ResearchGate, it was said that while this works at US universities, in the EU, IT support is still left to the professors.

The integration of IT into education is generally covered mainly by research areas such as TEL, educational technology, and learning technology, which, however, are only synonymous from the teacher's point of view. Various studies (Balacheff, 2009; Roblyer, 2013; Bower, 2017), book series (Huang et al., 2021), and literature reviews (Walker et al., 2016) list a large number of IT tools. However, they are rather global and general solutions to which the teacher must adapt; the teacher must determine the suitability of each of these tools for his teaching activities. Examples of these tools are learning management systems (Moodle, Blackboard, academic information systems), Office packages, and tools for specific areas such as learning analytics.

It is necessary to realise that computer technology cannot support all the educational processes performed by the teacher. Therefore, it is logical that in the literature we find the argument that software engineering has little focus on educational software development (Martens, 2014), criticism of IT solutions or research approaches to education (Kinchin, 2012; Lundie, 2016; Kirkwood and Price, 2021), and a lack of theoretical approaches (Oliver, 2013). The importance and use of educational technology in the classroom has been discussed, including the question of 'whether schools and teachers themselves are ready for the use of technology in education and whether they are aware of its benefits' (Stošić, 2015).

Compared to the current situation, the authors' long-term research has brought practical solutions using computers to the classroom and online environments based on the development of their own all-in-one TEL software, which implements the paradigm of the mass processing of educational knowledge on a teacher's personal IT infrastructure. We did not find a similar solution in the literature.

The authors began researching TEL from 2006–2008, when they realised that teachers, researchers, students, and knowledge workers need to be equipped with personal all-in-one software. Users basically should not notice any differences between working on their own computer or online. This vision was presented as part of an e-learning solution for undergraduates at the ICETA conference (Svetsky, 2007). At the time, the authors assumed that as computer technology gradually improved, there would be such universal software on the market. To date, however, this has not happened, and, on the contrary, the authors have shown in recent years that they eventually programmed such a solution themselves.

Following this, the first author of this paper, as a teacher, wrote the source code for all the activities he performed, e.g., the creation of materials and tutorials for the teaching of undergraduates, the automation of multilingual searching, self-study, publishing support, and even grading and assessment, including linking these activities to the university's academic information system (AIS). For these purposes, he used a specific database structure in the form of tables. He processed the content of this structure by writing source codes from which he gradually built the WPad database application. Students had WPad installed on their computers in the classroom and used it in several study programs, e.g., the background of environmental protection, industrial management projects, occupational safety and health, programming languages, and the basics of chemistry. At the same time, several pre-service teachers tested WPad as part of their diploma theses concerning the production of e-learning kits.

Thus, the WPad software acted as a teacher's personal teaching tool and multifunctionally supported several teaching and learning activities. At the same time, WPad has begun to be used in research under the 7th Framework Program for the area of technology-enhanced learning. For this purpose, an advanced BIKE application was used; it ran only on the designer's computer. Its use in TEL research was first published as part of the IGIP-SEFI conference, when WPad template tables were created within the framework of international cooperation to support publishing (Divjak et al., 2010).

At this time, the authors investigated how it is possible for WPad to function as an all-in-one teaching tool. This made it clear that the WPad data structure can simulate educational knowledge if content and related meta-information are inserted into it. Thus, it can function as a virtual knowledge macro-substitution and can be transferred between offline and online environments. The novelty of this approach was confirmed by the Slovak Patent Office (utility model Nr. 7340, 2016).

On this basis, the paradigm of the batch processing of educational knowledge was further developed, TEL software was designed, and a combined offline/online IT infrastructure was developed; within this infrastructure, virtual knowledge is transferred in the form of tables (as computer files). It therefore provides added value compared to the transfer of common computer files, because only reduced educational content is transferred. This significantly reduces information overload and entropy. The authors have continuously presented dozens of application outputs their long-term research on the integration of IT into education and academic research at scientific conferences and journals (e.g., Svetsky and Moravcik, 2014, 2016, 2017, 2019, 2021).

In the following sections, a demonstration of the research approach and examples of the use of the WPad software and tables in academic teaching and research will be described. The area of implementation of learning analytics, which was tested directly during the teaching of undergraduates, will also be mentioned. In a separate section, the principle of the synchronisation of pedagogical (didactic) and informatics approaches to IT support for publishing, which is a universal academic educational activity, is discussed. Such synchronisation requires the collaboration of the educational algorithms and IT algorithms, including adaptation to the operating system and online learning spaces and clouds.

2 TEL Design in Research

In TEL design, it is not enough to solve only content and pedagogical algorithms. Apart from the fact that the output must 'fit' on the computer screen, a separate problem is that computer files with educational content are in dozens of different and incompatible formats (PDF, HTML, DOC, TXT, PNG, MP3, etc.). This also applies to software and hardware and the entire offline and online infrastructure. A comprehensive approach to TEL research therefore requires solutions for various educational and IT categories. In addition, the teacher must deal with the management of the large number of computer files that teachers tend to collect over time.

2.1 Research Approach and Methodology for Teaching and Learning

In programming terms, this means that software adaptation to the operating system, networks, and the web must be addressed as a separate block. Therefore, a separate category of user menus must be programmed. Since educational content has to be selected and tailored for specific teacher and student activities, practically this means that it also has to be transferred between personal computer folders and online environments (virtual learning spaces, clouds, the public web).

The authors' long-term research has shown that it is not technically possible to cover such a huge number of variations of teacher and student activities and sub-activities, because if these activities are not defined in advance by algorithms, the computer does not know how to deal with them. It is important to note that current artificial intelligence can only process data that is hierarchically an order of magnitude lower than the information and knowledge that is formed from this data. Therefore, the challenge is to program an infinite number of TEL applications. In other words, first, a pedagogical algorithm is designed, source codes are written for its steps, and adaptive algorithms have to be programmed for software and hardware, i.e., a certain IT infrastructure, for the sake of compatibility.

The biggest challenge for human knowledge processing, however, is the synchronisation of the pedagogical and informatics steps. However, explaining this using the example of TEL design for teaching is practically impossible, because the reader would have to be familiar with the subject matter being taught. To explain how synchronisation should work, it is more appropriate to approach the design of IT support for publishing activities. This is because this is a general academic activity that involves teachers, researchers, and students. A practical solution to the TEL synchronisation of IT support for writing a scientific paper is described in a separate section.

2.1.1 Personal Learning Analytics

The authors were in the consortium of the 7th Framework Program L3Pulse, which submitted a project in response to a call for learning analytics (LA). As part of this, they tested a personalised solution to find out how to create a practical application to support the needs of a teacher teaching undergraduates. The result of the LA literature survey was that its essence is to analyse the visiting logs of online educational environments to learn how students use these environments. On the basis of calculating statistics for various online activities, educational institutions can then improve their learning strategies.

Such LA statistics, however, have no added value for teachers, because for assessment and evaluation they need to monitor how students receive and work with educational content. In this context, the writing of tacit knowledge in the WPad educational tables by students during lectures or exercises proved to be useful. Because the WPad tables of all students can be combined, it was possible to calculate statistics related to their human knowledge and not only to internet logs.

In addition, the statistics and visiting categories of the faculty educational environment were monitored in parallel by an external service during the testing of LA. Thanks to this, the teacher had an overview that included how many students used the connection to the faculty educational server during and outside of class. At the same time, he knew which WPad tables were being used. This feature was used when students were doing a WPad internet search. Since the Opera browser was in use at the time, it was possible to monitor on each computer which pages the students visited during the lesson and to evaluate the effectiveness of teaching.

In this way, the methodology for using WPad for LA was developed. Its added value was that the LA statistics obtained were directly related to the students' knowledge in the classroom; it is not possible to obtain such statistics from online clicks (compare with Martin and Ndoye, 2016). From a practical point of view, the teacher gained a useful tool for formative assessment and, thanks to the feedback obtained, he was able to better manage his teaching.

2.1.2 Multi-search (online/offline)

WPad has a rich user menu, which also includes internet search items. Since the keywords to be searched by a search engine are entered directly into the text window of a WPad table, the user does not have to open a web browser and enter the keyword. Instead, the user just chooses the menu item of interest, and then the browser opens a window with the search results. There is a specific option in WPad, which conventional software does not have, allowing the user to type several keywords in a text window; closing the text window will cause WPad to open a browser window with search results for each keyword. This multi-search is automated, so that if 50 keywords were typed or pasted at once, the Opera browser would open 50 windows that would cover the entire computer screen.

The literature does not discuss the fact that, after a few years, a huge number of computer files accumulates on teachers' computers. In other words, the teacher also needs to deal with offline search on their own computer, CD-ROMs, DVDs, and USB drives. WPad has some menu items for these purposes. A teacher who uses virtual environments or even virtual machines on clouds needs to search for files in these environments as well (in other cases, file managers are used for this purpose).

2.1.3 Big Educational Knowledge vs Big Data

The purpose of this paper is to point out that a regular teacher has a 'small internet' on his computer. Thus, he needs a way to process such 'big educational knowledge'. From the individual point of view, the teacher has a huge number of files in which learning content is stored on his home and work computers or in online clouds.

Table 1 shows the number of files that the teacher had on disks C and D of his desktop computer in 2017 and on his HP notebook in 2022. The table shows that the total number of computer files is on the order of half a million to one million. Of course, this number also includes all the files in the Windows and

software folders. He personally 'collected' tens of thousands of files in various formats (TXT, DOC, PDF, HTML). There are also about 9000 PNG files, i.e., image files, in the table. In this case, these image files are almost exclusively screenshots that were taken for visualisation modelling and literature searches. This has led to the finding that creating screenshots is easier than making manual notes; in this case, mass image processing is performed.

It should be emphasised that the teacher works on his computer not only with a large number of files but also with folders. From his point of view, this data represents big educational content. Artificial intelligence is currently popular; it can process big data, which basically consists of short pieces of texts or numbers, but it cannot work with the range of content included in big educational content, i.e., it cannot work with knowledge, which is hierarchically higher than data. WPad also allows such 'big educational knowledge' to be processed multifunctionally at the level of the individual, and thus it acts as a container for the individual's information and knowledge.

Table 1. Number of files on the teacher's computer

	C (2017)	D (2017)	HP (2022)
Files	448891	656744	532183
TXT	5831	6410	8569
PDF	8693	13978	14812
HTML	42285	75983	25590
DOC	13568	19059	33141
PNG	-	-	9088

Although both Windows Explorer and file managers (e.g., Total Commander) allow one to work with many files and search for files in an offline mode, they only partially address the teacher's needs. This is due to the fact that these programs do not know exactly what the teacher needs. If a teacher wants to look up something he did years ago, he does not know in which files it is stored. Using WPad enables a teacher to automatically insert a list of files from folders or disks (including USB drives and CD-ROMs) into the WPad table and to filter, search through them, or open them directly as needed. In other words, WPad has several menu items that provide tailored activities related to files and folders similar to the services that file managers provide.

For example, the number of rows in a WPad table could be exactly equal to the number of files in the inserted list, as illustrated in Table 1. For example, on the HP notebook, the table had 532183 rows, and after filtering it for PNG files, it had 9088 rows. The important result of this test is that through purposeful filtering, the teacher could find what he was looking for. Fig. 1 illustrates such a search for PDF files with papers from the British Journal of Education Technology. Importantly, the teacher can also open the files directly from the table without a need to switch to Windows Explorer or Total Commander. In practice, this method was developed as part of the V4+ACARDC project: teachers from the V4 countries and Ukraine modelled the automated creation of educational packages (this is not the subject of this paper).

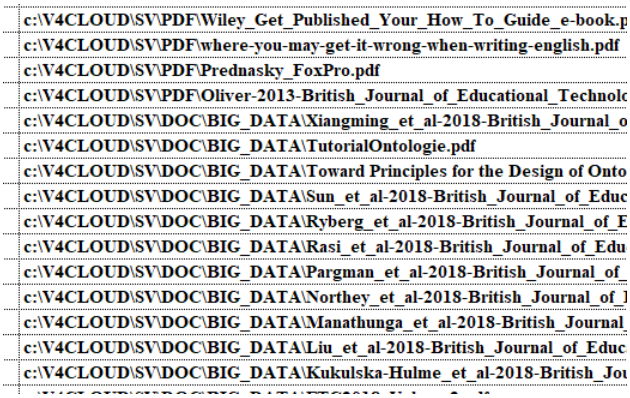

Figure 1. Results of searching for PDF papers in the table with 532183 rows

2.1.4 Personal TEL Infrastructure for Teachers

Fig. 2 illustrates the personal TEL infrastructure for teachers that the authors used in their research. It enables the teacher to combine offline and online activities. The basic TEL level requires only Windows and the installation of the WPad software on the computers of the teacher and students. This level is very user friendly because it does not require the users to have any higher IT skills. The advanced TEL level additionally includes many TEL online solutions, such as the ability to access the web, clouds, virtual learning spaces, virtual machines, academic information systems of universities, and PIKS channels (this requires routine IT skills).

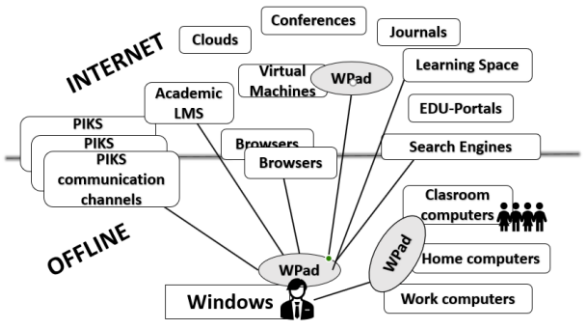

Figure 2. Personal TEL infrastructure for teachers

2.2 TEL Design for Publishing Support

The authors' most recent TEL research focuses on the synchronisation of learning and informatics activities. In practice, this means that the final algorithm that combines the sub-activities of the learning activities is

written simultaneously with the WPad source codes. It is important that the user identifies these learning activities and defines the sequence of steps. As a result, the WPad application menu is extended, and potential research topics are profiled. In this context, it should also be understood that the teacher needs to process knowledge as quickly and easily as possible. As a result, the teacher adopts IT support as a routine activity to automate his teaching processes. Interestingly, the issue of the speed of knowledge processing is not mentioned in the educational literature.

Explaining the synchronisation of pedagogical and IT steps to the ordinary reader is quite difficult, but it is also difficult to explain to IT specialists. The problem is that IT support is related to dozens of subjects and social or technical areas, and each TEL solution is different. Therefore, it seems to be an optimal starting point to describe the principle of synchronisation using the example of applying TEL solutions to writing scientific papers, because this is a general academic activity carried out by teachers, students, and researchers. A teacher who publishes regularly or more frequently will find, over time, that he has certain resources available and that certain activities in publishing are repetitive. The process of writing a scholarly paper can be described as follows:

- choosing the right conference or conferences;
- reviewing the requirements for authors;
- submitting an abstract or extended abstract;
- submitting a paper for review;
- having a native speaker of the language the paper is written in proofread the paper;
- editing the paper according to the reviewers' requirements;
- submitting the final version (camera ready) of the paper;
- registration and payment;
- creating a video presentation for a virtual conference;
- communicating with the organizers throughout the process via emails, automated emails, and online paper submission systems.

2.2.1 Literature Resources

The most time-consuming phase of writing a scientific paper is writing the introduction, which allows readers and reviewers to classify the presented topic into some well-known category. This is due to the fact that the field of IT or computer science is very atomised in the literature. If the research topic is interdisciplinary, it is almost impossible to find similar works or research approaches. This is the case for the topic of this paper. By using WPad, a teacher does not have to use a dozen pieces of software for the same purpose; however, IT journals specialise in the individual software products.

Therefore, the key question is the following: what should the authors' TEL design be compared with, if there is not any software on the market that covers several teaching and learning areas? In this respect, WPad tables can be applied to all of the following categories of resources, which are used by practically every publishing teacher (a teacher can create their own information system for this purpose):

- educational internet and e-learning portals;
- university information systems for publishing;
- a teacher's folders and files on his own computers;
- archived papers on clouds used by teachers;
- online repositories with scientific literature;
- the teacher's own knowledge base (e.g., WPad tables);
- internet search using search engines;
- many other e-media sources (USB drives, CD-ROMs, DVDs);
- archived e-mail communication.

Integrating IT into teaching is also related to teacher support, so part of the TEL design needs to address this support as well. WPad can be used for this purpose. From the WPad tables, the user can switch between the above-mentioned online and offline resources, perform a simple search or multi-search, and save items to the tables. Naturally, for each paper for a conference or journal, the teacher can create separate tables, which can also hold various associated information and data from communication with organizers and instructions for authors.

2.2.2 Paper Writing

After selecting a conference or journal, the teacher must study the instructions for authors and perform the above-mentioned steps, from choosing the conference to creating the final presentation (be aware that each piece of information can be contained in one line of the WPad table). Here, it is important to download the required formatting template. If the research team members publish in the pedagogical, IT and technical areas, they will immediately find that conferences use their own templates and require various reference styles (IEEE, APA, Harvard, ISO 690). This is seemingly not a problem, but for authors who have at least 15–30 references, rewriting them in another style is very time consuming.

In terms of synchronisation, the publishing activities represent a system of algorithms for which it is possible to write source codes. In this context, during the development of WPad, the teacher also began to logically create WPad tables to support the writing of scientific papers. In practice, it was useful to use a separate table for each article; this table served as a manuscript with plain text. Its content was finally transferred to a Word text editor, where it was edited and formatted as necessary. In the same table,

there were also outputs from the literature search, annotations and associated information, and links to the above-mentioned resources. This could be considered one example of a synchronisation solution. The teacher performs some partial steps related to publishing, and at the same time, the needed source codes are being written.

The principle of synchronisation is based on the authors' basic focus on the automation of knowledge-based processes (where teaching and learning come together). This means that the slowest stage of the process is addressed. The use of the function key F6 was programmed for this reason. If an author has 30–50 rows (records) in the WPad table, he must click between them and needs to filter them thematically. However, this will slow down the writing of the paper, even though there are several items in the user menu for this. Therefore, for this activity (similarly, it can be a learning activity), source code for using the F6 key was written. The author can look at a specific record that includes the word he is searching for, and after the author presses F6, only the rows in the table containing that word are shown. For example, if the word CECIIS is in a given row, and it is in four rows of a table, then pressing F6 will show only those four rows of the table (so that the user does not have to go to the user menu).

Using the F6 key is especially useful if the table's content was created automatically and contains thousands to hundreds of thousands of rows. For example, the university's publication system makes it possible to generate a list of teachers' publications in the form of an RTF file. After copying and pasting the content of the RTF file into WPad, a table is automatically created; it contains each item in the list in a separate row. Now, the table can be searched quickly by pressing F6.

To illustrate this, the author included in a table a list of all the papers published by the faculty at his university from 2005–2021 and searched this table in order to evaluate the quality of the publications of the faculty. As the table had tens of thousands of rows, he selected a row that included his name. After pressing the F6 key, only his publications for the period were shown, as Fig. 3 illustrates.

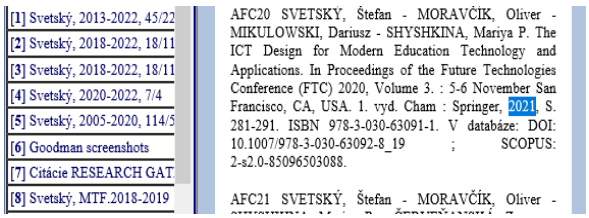

Figure 3. Search results in a WPad table

It should be emphasised that each WPad table can be converted into an HTML table by simply pressing the keys CTRL-F1. The screenshot shown in Fig. 3 illustrates the HTML output of the database of the university publishing system. This is a huge advantage for the teacher or even the students, as they can produce personal or working HTML tables for various educational purposes (e-learning, e-scripts, any content for distance learning, support face-to-face teaching with computers in the classroom, internet search). Users work with WPad tables and/or HTML tables as needed, which are simply copied to the online environment of servers and the web. Moreover, unlike other software, ordinary computer skills are sufficient to work with the tables. Thus, in this case, the technology is adapted directly to the educational needs of the teacher and students and enhances learning.

3 Conclusion

It is clear from the description of writing scientific papers that there are several activities involved. The principle of synchronisation is precisely that the source code is written while the activity is being performed. The most important step is to always address the activities that are part of the slowest stage of the process. This is mainly the writing of the introductory part of the paper, which requires a literature online/offline search. To speed up this process, it is possible to program a simple internet search or multi-search and to create tables with the author's own dictionaries (or containing sentences with frequently used phrases). There is again a large number of other possible procedures. For example, one can choose to use more search engines, such as Bing, Google, IxQuick, DuckDuckGo, or Brave, or perform searches of German, French, and domestic sources.

In principle, one could design a separate software application for each group of activities, but WPad is programmed to be a multifunctional, all-in-one, personal TEL software for teachers. Thus, programming multiple menu items in this way allows the teacher to perform a wide range of IT support tasks. In this context, the programming of a personal information system that can support the publishing activities of individuals will be designed in future research.

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