

Dariusz Mikułowski¹

ORCID: 0000-0002-4567-7846

Stefan Svetsky²

ORCID: 0000-0002-2186-5957

Branislav Misota³

ORCID: 0000-0002-4346-4003

¹ University of Siedlce
Faculty of Exact and Natural Sciences
Institute of Computer Science
ul. 3 Maja 54, 08-110 Siedlce, Poland

dariusz.mikulowski@uws.edu.pl

^{2,3} Slovak University of Technology in Bratislava
Institute of Management
Vazovova 5, SK-812 43 Bratislava, Slovak Republic

{²stefan.svetsky,³branislav.misota@stuba.sk}

WPad BVI - a multilingual universal knowledge exchange tool with support for visually impaired users

DOI: 10.34739/si.2023.29.08

Abstract. Nowadays, users need to work simultaneously with many files and folders on their computer and various resources on the Internet, including several software pieces. It means that they have many windows open simultaneously, and they must continuously

switch between different opened applications such as web browsers, text editors, or audio-visual programs. These problems are also crucial to blind or visually impaired users, for whom this issue is even more difficult. Due to the nature of their work, i.e., they do not use the mouse and cannot see the video and graphic content, they have to remember, at each moment, which programs they have open and which they no longer use. In this paper, we propose an approach that consists of universal software, where, on the one hand, the user can collect and view data; on the other hand, he can produce ready-made output packages in simple web pages. This solution consists of two main parts: an offline software WPad and the online - Personal Knowledge Information System (PIKS). We propose a simplified and more automated version of an earlier developed WPad software system called WPad for BVI, which visually impaired persons and other beginners can use. The solution was tested by two BVI users (one BVI student and one BVI teacher) and several non-disabled teachers and students from Poland and Slovakia. Feedback from users was collected that will be used to improve the system further.

Keywords: Knowledge exchange, visually impaired users, Universal software, Education

1 Introduction

Nowadays, users need to work simultaneously with at least five to ten files and folders on their computer and various resources on the Internet, including several software pieces. It means that they have many windows open simultaneously, and they must continuously switch between opened applications such as web browsers (Edge, Google Chrome, opera, firefox) or the environment of some applications (text editors and audio-visual programs. These problems are also crucial to blind or visually impaired users (in short, BVI), for whom this issue is even more difficult. Due to the nature of their work, i.e., they do not use the mouse and cannot see the video and graphic content, they have to remember, at each moment, which programs they have open and which they no longer use. It often happens that, for example, in two windows in the notebook, the BVI user edits the text and, by mistake, saves the wrong version or loses his job.

Experience in knowledge management shows that BVI users and sighted people like to work on files and folders while switching to the Internet and looking for the necessary information. In other words, users need a functional hybrid IT tool, software that functions as their personal information system or a personal social network. It navigates them and switches between the Internet and the offline environment (file content transfers and communication). However, a simple survey of the scientific literature focused on software support for BVI users shows that the research focuses mainly on hardware solutions and IT tools in the Human-Computer Interaction field. We emphasize that software design must be tested and tailored for the BVI community.

To fill this gap and try to solve these problems, in this paper, we propose an approach that consists of universal software, where, on the one hand, the user can collect data and view them, and on the other hand, he can produce ready-made output packages in the form of simple web pages. This solution is a personal universal knowledge processing system that consists of two main parts: An offline working software called WPad and the online software - Personal Knowledge Information System (PIKS). The WPad software, which was developed

several years ago without taking into account the needs of BVI users, has a lot of menus and options. Therefore, a user with minimum IT skills or other individuals with special needs, i.e., BVI, can get lost. That is why we propose a simplified and more automated version of the WPad software, which we call WPad for BVI. It has only two dedicated menus with the most frequently used options, which causes BVI and every other beginner can use it. The solution was tested by two BVI users (one BVI student and one BVI teacher) and several non-disabled teachers and students from Poland and Slovakia. During these tests, feedback was collected that will be used to improve the system further.

The rest of the paper is structured as follows. In the following sections, we will describe problems encountered by BVI users while working with computers, using social media, and remote education. We will also explain some solutions to these problems described in the literature. Next, we will present the WPad BVI plus PIKS knowledge-sharing system concept and describe how WPad for BVI was used by students and teachers in Slovakia and by BVI teachers and students in Poland. We will summarise with conclusions in which we present further plans and problems that remain to be solved in our solution.

2 Literature review

Despite the development of modern technologies, BVI users still need more access to electronic education and knowledge. Because visual information reaches them to a limited extent, they must use different assistive technologies. Blind people use special software called screen readers [2] while the visually impaired use magnification programs [12]. Generally speaking, these programs work as follows. They run in the background, read all the information on the screen using speech synthesis, and send them to a braille display connected to the computer. In the case of a partially sighted user, information is also shown in magnification, an adequately adjusted contrast, and a color scheme. Due to this functionality, BVI users can use any standard software, such as office programs, web browsers, or social media channels. Nevertheless, there is a problem because they get a flood of information, i.e., browsing Internet pages or using social media portals or online shops. There are a lot of misleading elements on the pages, such as advertisements and content, that have slight importance from the point of view of the user's needs. A BVI user listens only to voice information and does not use the mouse, which sometimes frustrates him. For this reason, he must filter out unnecessary information that reaches him in this way. This inconvenience can be reduced by setting the amount of information that the screen reader provides to him. For example, he can set that the descriptions of keyboard shortcuts for menu options or descriptions for elements of the website that the user visits again are not read. In this context, properly designing an application or website is crucial for BVI users. It should comply with the Web Content Accessibility guidelines recommended by the W3C as the WCAG standard [15].

Like all users, BVI people also use various social media. It is essential because it allows them to catch up with communication difficulties and fulfill different social roles. However, their primary barrier is the need for more access to graphics and video content, which plays a crucial role in portals such as Facebook or Instagram. As described in the literature, [6] in general, social media portals thought about accessibility very late, i.e., Facebook started to introduce solutions to facilitate its use by BVI after ten years of its existence. During this time,

they introduced facilities such as the automatic creation of graphic descriptions. A similarly unfavorable situation for BVI users is in the case of Instagram service. Twitter was also not available to screenreaders for a long time.

Similar problems are worsened even more in the context of remote education, which was especially evident during the COVID-19 pandemic [8]. C. Alves and coauthors surveyed a large group of teachers and stated that since technologies for people who are blind differ from technologies for the partially sighted, teachers should have a very individual approach to each student [1]. Dunn and Darlington [5], after making investigations with students, share tips and experiences regarding making geographic resources accessible to BVI users. They provide recommendations showing how such materials for visually impaired students should be adequately presented. They advised that the educational content must be separately adapted for people with Low vision, color blindness, and dyslexia. The paper entitled "Accessibility Assistance for Visually Impaired People in Digital Texts." [11] describes how to adjust color contrast and legible text in a way that visually impaired students should require. They present a new tool, not intended merely to provide another form of computer access for the partially sighted but to offer a means of education in the regular classroom. BVI users encounter considerable problems working with other sighted colleagues on the same document. [4]. In this situation, the screen reader reads too much information because it tries to keep up with other collaborators' changes in the document. It is frustrating for blind users and often very distracting for them. Therefore, tools are needed to facilitate the work on online documents that would be appropriately adapted to them. One such tool proposes Buzzi and Leporiniand [4]. Using this tool, several students can work on one document online, and all changes made by one user are visible to the others.

Video games can also support remote and online education. Unfortunately, most standard video games are entirely not usable by Blind users. Neto and Fontoura propose such an accessible educational game [10]. Their paper describes the design, implementation, and evaluation processes of an accessible version of the educational game Em Busca do Santo Grau, based on EduGameAccess. It also provides recommendations that integrate educational, playability, and accessibility aspects for people with visual impairments.

As mentioned below, an immense problem for BVI users is showing them different information typically presented as graphics. See and Advincula propose The TacPic system [14], a cloud-based solution for creating raised graphics for blind users. It allows them to upload images to a website and uses AI cloud computing on the Amazon Web Services platform to label graphics with braille labels. The user can create 3D graphics and print them for the blind student as an educational aid. Currently, the types of TEMs that can be created are tactile flashcards, tactile maps, and tactile peg puzzles, which can be developed within a few hours. It is in contrast to a development period of weeks using traditional methods such as swell paper or hot stamping [3], which are both expensive and time-consuming. Furthermore, two BVI teachers and six BVI students tested the tactile educational materials described in the mentioned paper.

Another solution was presented in the article, "An approach of explaining math function graphs through the sound representation for blind students" [9]. It presents a method of sharing mathematical graphs using sound signals emitted when a blind user moves his finger on the touch screen. The solution is up-and-coming; however, it requires changing the habits of blind

students who are used to seeing tactile graphics with their whole hands and not with one or two fingers.

Another matter is an issue of the availability of Information Resources for Visually Impaired Students in University Libraries [7]. Horsfall and Opara researched over 20 university libraries in Nigeria under this account. Their study reveals that most of the University libraries lacked information resources for visually impaired students, The reason for this is usually too little funds and too little knowledge of library staff, who must learn how to prepare and make available materials for students with special needs.

Most BVI students in European countries do not attend special centers but learn in mainstream schools. Therefore, their education should be as inclusive as possible. It means that they should use, as far as possible, similar teaching aids, books, and other materials as their sighted peers. Reynaga-Pena and López-Suero [13] propose scientific aids that will be attractive not only to people who are blind but also to sighted students. For example, educational materials that use Braille could have color illustrations and regular printed text or three-dimensional models should have the characteristics of tactile resolution favorable for blind people but also hold contrasting colors while containing attractive visual information for persons with low vision or without visual impairment. In the same venue, more sophisticated materials could provide auditory and visual information and other sensorial data, such as smell, when appropriate.

As we have seen, BVI users use different tools and face different problems when learning and accessing social media. There is a lack of universal tools to manage educational materials, knowledge, and entertainment information.

3 Design and use of intelligent knowledge exchange structure

In order to provide a universal, personalized tool for knowledge management and exchange, taking into consideration the needs of BVI users, we propose an approach that consists of two main parts: The WPad is a desktop software, and the Personal Knowledge and Information System (PIKS) is an online system (PHP/MySQL application). Using them, on the one hand, the user can collect and view data; on the other hand, he can produce ready-made output packages in the form of simple web pages that can be later distributed and shared.

Unfortunately, the WPad software, developed several years ago without considering the needs of BVI and other non-advanced users, has a lot of menus and options. Therefore, a user with minimum IT skills or a BVI individual can get lost, For this reason, we proposed a simplified and more automated version of the WPad software, which we called WPad for BVI. It has only two dedicated menus with the most frequently used options, which can be used by BVI and every non-advanced user. We will provide more specific examples of its use in one of the following sections.

The second part of the proposed system is an online knowledge exchange channel that we shortly called PIKS. In a sense, it is a web representation of WPad but with a very simplified structure. It allows users to add knowledge to the database and exchange it. It can be used on mobile devices, i.e., when one student writes some information in the Table, others can use it and add their own. Deleting unnecessary records is also possible based on the two-stage mechanism of saving records to the Table. More specifically, a new record written to the Table

has an asterisk next to its key, meaning it is a temporary record that can be deleted later. When the user duplicates this record without the asterisk next to its key, this final version will be permanently saved in the database. The record with the asterisk will be deleted. Thanks to this mechanism, users can chat in which the messages are not simple text but also entire records containing structured knowledge. An example procedure of adding a new record to the PIKS channel is shown in Figure 1.

The screenshot shows the PIKS interface with the following fields filled out:

- Nr.:** 0
- Topic:** * Cloud Computing
- Topic-more...:** Some information about cloud computing
- Category:** IT knowledgeg
- Sub-Category:** PIKS
- Link:** https://pl.svti.sk/upload
- Table:** PL

A 'Submit-Go :: Kliknite' button is located at the bottom right of the form area.

Figure 1. Adding a record with information to the PIKS channel. (Source: own study.)

Let us mention that both communication channels presented above use the same concept of data structuring. The data storage itself is designed to store many different data types in one table format. This approach can be treated as a simple ontology, a system linking free tables where different kinds of data are stored. It is solved so that individual fields (columns) are used by default for various activities. Unlike typical database tables, where fields have prescribed keys, and their attributes, fields in a virtual table are an abstraction. That is, to combine any and unrelated information. In other words, the Table represents an empty abstract object or an empty knowledge base, the implementation of which depends exclusively on the user who "learns" it according to the needs of processing tacit and explicit knowledge. The designer's vision is to program a self-regulating primitive intelligence that does not use machine learning or natural language according to information technology but the natural language of a person. We will add that the above structure is the basis of the utility models UV 7340 and UV 8787 registered at the Slovak Patent Office,

The principle of working with WPad, WPad BVI, or PIKS software is to find a suitable way for a sighted or BVI user to insert unstructured, semi-structured, or structured information into the Table. For this purpose, he can use the following default fields of the Table:

- **TEXTUNI** – where information can be inserted manually or using the menu options. This field refers to the topic, an object of the inserted information. It allows filtering, searching data in the Table, or creating selection tables
- **KODF** – where universal keywords are inserted, thus ensuring the basis of the ontology.
- **KOD** - allows switching between tables
- **KOD1** - can contain offline paths, links to WEB, and keywords for internet search.

- **KOD2** - it can contain a more detailed description of the topic stored in the TXTUNI column (e.g. if in TXTUNI, there is information about a published article at the FTC2023 conference, the title of the article is entered in the KOD2) column.
- **TP** - the heart of the software is a text memo field for both plain text and more extensive (e.g. conference proceedings as plain text) or even HTML content with links and formatting. Directing hyperlinks to the Internet or a personal offline computer is also possible, including launching files instead of running SHELL commands.

WPad tables constructed as described below can be routinely copied and transferred, so they can be used for communication between users to exchange structural information, thus supplementing email communication, which currently suffers from overload. For example, while writing this article, its authors exchanged WPad tables with the manuscript's text. Both programs, WPad and WPad BVI software, allow the user to create mirrored HTML tables (using the CTRL-F1 keyboard shortcut) or an HTML file from a single line of the Table (F9) from the knowledge of WPad tables with one click. This software also works as a simple HTML creator that can be used by a teacher or a student with weaker IT skills (used for e-learning design).

However, while developing and testing our solution, we encountered a big problem because the BVI screen reader needed help reading this text field. Hence, the BVI user lost the advantage of using hypertext. We partially eliminated this problem by linking the Windows text editor Notepad with WPad and converting this memo field to an HTML file, which the screen reader software used by BVI can already read. Recently, thanks to the advent of Windows 11 features, the user can dictate text directly into tables or BVI into a simple text editor. Since Windows 11 enables Speech recognition (Windows function key plus the letter H), writing an article manuscript is also automated. Another significant advantage is that the EDGE browser, which works in Windows, enables Text-To-Speech, that is, HTML tables and files the user creates in his native or other languages, and the computer reads them to him. From the point of view of self-study and education, this way creates opportunities to tailor educational and training materials.

4 Examples of the use of WPad BVI applications

Our pedagogical experiment aimed to verify some possibilities of creating multilingual educational materials by university students, which they could later use for their studies in their native or preferred language. Since our project involved universities from four countries: Slovakia, the Czech Republic, Poland, and Hungary, educational packages that would be useful for all students should be created in several languages.

4.1 Using WPad BVI at a Slovak partner's university

In our experiment provided in Slovakia, we used a version of PIKS that was more suitable for use on mobile devices, which most students prefer. This modified version also contained links that allowed quick access to the tools used, such as a machine translator and a link for uploading working versions of study materials translated through collaboration within student teams. This approach allows students to use their language resources and increase their motivation

and autonomy in learning. Within their student teams, students created multilingual material as PDF or PPT files. Then, they uploaded their translated study materials, which represented ten files, to the PIKS communication channel (Internet). This situation is shown in Figure 2.

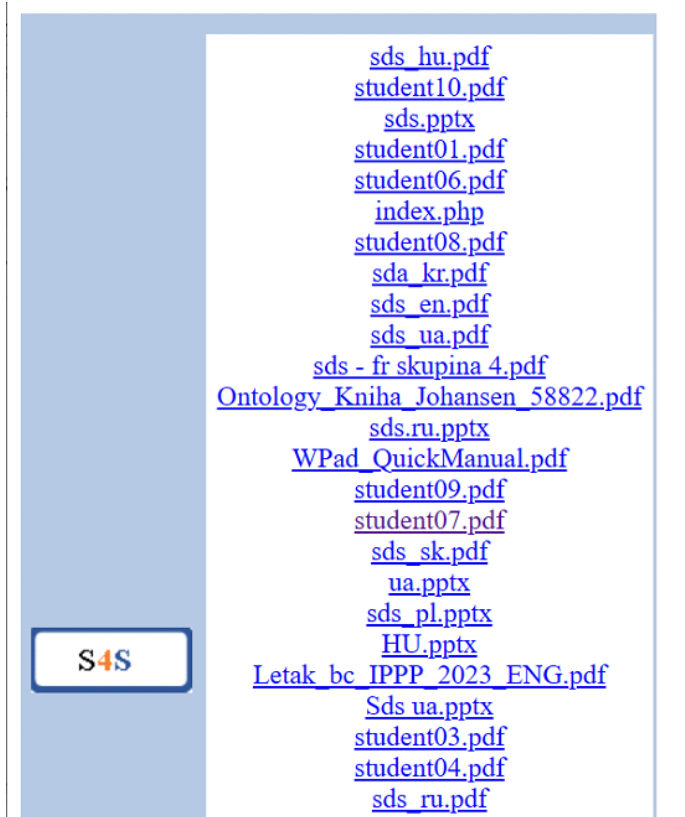


Figure 2. Content uploaded by students to the PIKS communication channel. (Source: own study.)

The possibilities of using our WPad educational software, including the PIKS communication channel, represent an example of a practical application or automation of the teacher's activity. Furthermore, we can mention it as an example of good practice and recommendations for teacher work automation, as the PIKS communication channel has downloaded student files to the `c:\websupport` folder to create an educational package automatically from the menu. The presentations were downloaded to a folder `c:\websupport\sds` and converted to PDF files. This situation is shown in Figure 3.

Creating multilingual educational materials by university students for their studies also contributes to developing digital skills, as students have to search for, process, and summarize information from different sources and work with them simultaneously in different languages.

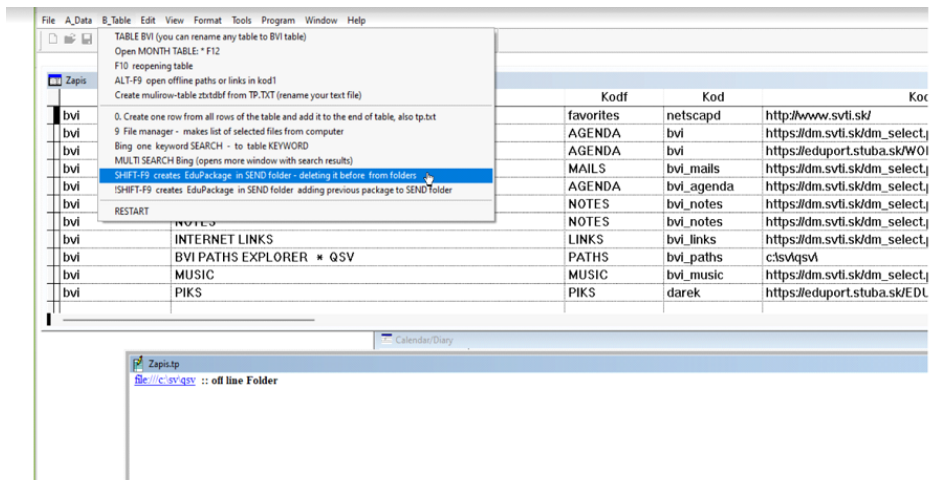


Figure 3. Presentations uploaded by students to the PIKS communication channel (Source: own study.)

4.2 Using WPad BVI at the Polish partner's university

The WPad plus PIKS solution was used by the Polish partner as a tool to create educational packages for students. An unusual case was that the WPad-BVI was used by a BVI teacher with screen reader software and by sighted students, one of whom was also a deaf person. The primary view of the WPad user interface is a table, so the BVI user can navigate across it using the keyboard, i.e., by pressing arrow keys, home, end page up, or page down.

The first educational package was prepared from existing tutor materials collected in PDF, HTML, or TXT files. Finally, WPad software generated an educational package in the form of a navigational web page, which was available on a server to view in the student's web browser. So, to create an educational package, the teacher performed the following steps:

1. Prepared educational materials in PDF, PPT, or other files.
2. Copied his files to the source folder, for example, c:\sv\pdf.
3. In the WPad-BVI program selected a "Create EduPackage" (SHIFT-F9) item from the "B_Table" menu.
4. After performing these steps, a window with the option of entering the path to the source files folder was opened.
5. After entering the path and closing this window with the escape key, all files from the source folder were copied to the c:\sv\send folder, and then the Table SEND was generated.
6. After a few seconds, the HTML navigation page representing this Table was generated and opened in the browser. This situation is shown in Figure 4.
7. In the next step, a teacher arranges the Table to correct the lesson order and completes the data in other columns, such as lesson topics, course author, and description.
8. Finally, the teacher again generated the HTML package from the Table by pressing CTRL-F1. Then, the finished educational package was opened in the web browser.

9. In the last stage, a Collection of HTML files and all PDF and text files with educational materials were placed on a web server and shared with students.

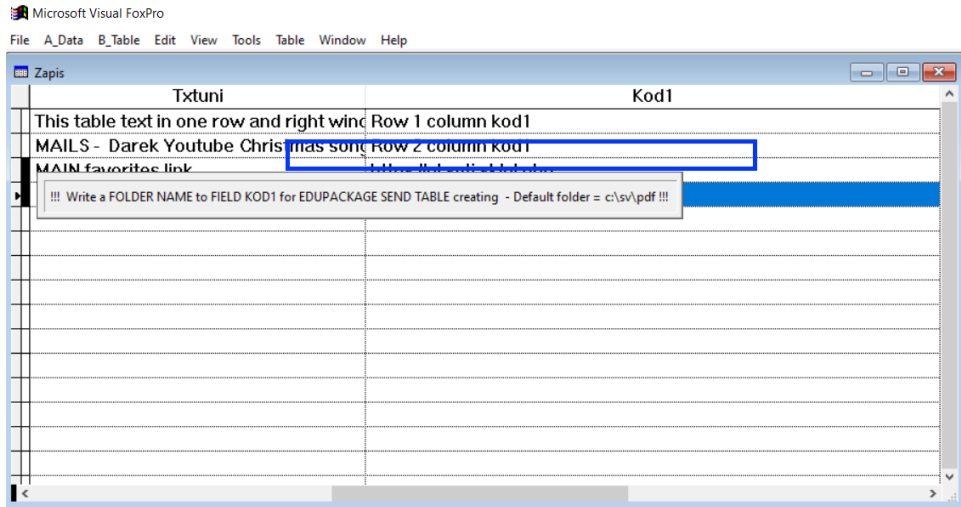


Figure 4. First version of Educational package in WPad-BVI. (Source: own study.)

Another way to use WPad for BVI was to prepare educational packages based on materials found on the web or developed independently in the form of slides. To prepare such a package, the teacher followed these steps:

1. Created a new table by selecting "New Table" option from the "A_Data" menu. BVI user typed the table name, pressed enter, and then pressed an escape key. A table with two rows was created.
2. Added data to the second record in the Table.
3. Moved the focus to the last Memo field using the CTRL-END short key and then switched to the text paste window by pressing the CTRL-HOME shortcut key.
4. Pasted or type the text of the first slide into the text TP field.
5. Return to the table window by pressing the CTRL-W shortcut key.
6. Created a new record by selecting "empty row adding" from the "A_Data" menu or pressing the CTRL-Y shortcut key.
7. Repeated steps 2, 3, 4, and 5 for the second record by entering the content of the second slide in the text box.
8. Repeated steps 2, 3, 4, and 5 for all his needed lessons.
9. Saved the final Table with a name under which the course should be available for students by pressing the F4 key.

As we can see, preparing such an educational package is a relatively easy task, even for a BVI user who uses only a keyboard and a screen reader. As described above, the teacher prepared a sample educational package about mobile agents for his students. After completing the entire Table with training materials, the situation is shown in Figure 5.

Kod	Kod1	Kod2	Notes - Larger Texts	Datum
Author	file:///c:/sv/katalog.htm	Institution	Memo	22.07.2023
	file:///c:/sv/katalog.htm	<h2>Lecture Agenda</h2>	Memo	22.07.2023
	file:///c:/sv/katalog.htm	<h2>What are mobile agents?</h2>	Memo	21.07.2023
	file:///c:/sv/katalog.htm	<h2>The beginnings of multi-agent systems</h2>	Memo	21.07.2023
	file:///c:/sv/katalog.htm	<h2>BD1 Agents</h2>	Memo	22.07.2023
	file:///c:/sv/katalog.htm	<h2>BD1 agent architecture.</h2>	Memo	22.07.2023
	file:///c:/sv/katalog.htm	<h2>M-Agents</h2>	Memo	22.07.2023
	file:///c:/sv/katalog.htm	<h2>M-Agents</h2>	Memo	22.07.2023
	file:///c:/sv/katalog.htm	<h2>Mobile agent life cycle</h2>	Memo	22.07.2023

Figure 5. Table filled with training materials for the educational package. (Source: own study.)

After validating the Table’s contents, the teacher generated an HTML page with the course content by pressing the CTRL-F1 keys. An example of the content of this generated package is shown in Figure 7. Note that since the HTML content has been entered into the KOD2 and TP fields in the Table, the educational material on the generated page is formatted with elements such as lists or headers, which improves its visual attractiveness.

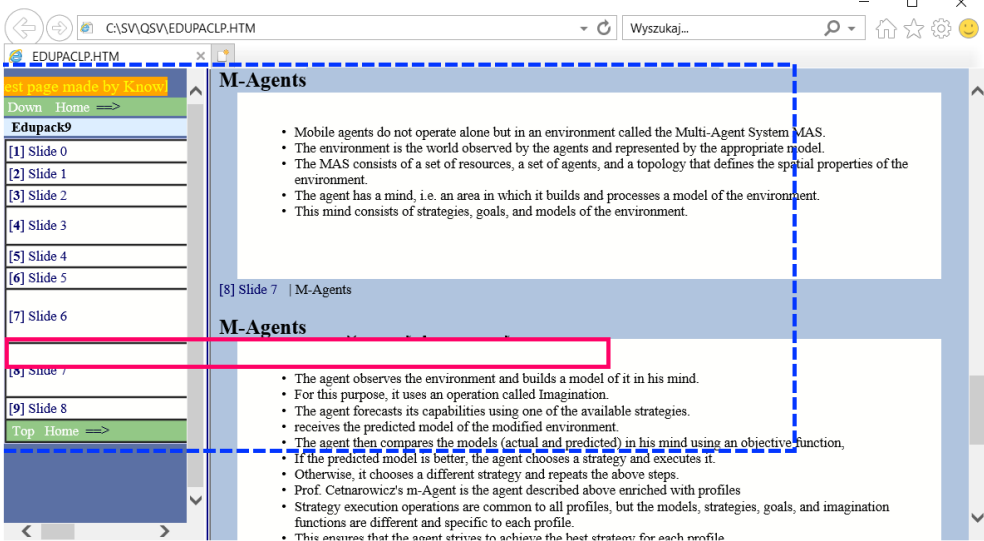


Figure 6. Educational package about Mobile Agents generated from WPad table. (Source: own study.)

5 Results

Project partners developed multilingual education and information packages using the PIKS online and WPad software described in the section above. They were placed on a virtual machine to which all partners had access. On the one hand, these were educational packages

intended for students and, on the other hand, more expensive packages containing information needed by project partners. In addition, each partner received its own separate PIKS channel, and a general channel was created in which partners exchanged information. It was information about similar solutions and journals and conferences with the possibility of publishing papers and content created by partners needed to create publication texts. The Slovakian partner worked with teams of students who created educational materials in 10 PDF and PPT files. Then, students transformed these files into educational packages for later use and uploaded them to the PIKS channel. The Slovak partner also created an educational package for teaching mathematics to primary school children using the WPad software. It has been developed in four languages: Slovak, Polish, Hungarian, and English, making it suitable for use by teachers in many countries. Educational packages for students on machine learning were also developed by a Slovakian partner.

The Polish partner has developed three educational packages for students on cloud programming and mobile agents, as well as technologies supporting the work and life of blind people. These packages were made available through the PIKS channel for students. A Polish partner also developed an educational package regarding English language teaching, which students at elementary school used.

6 Conclusions and discussions

From the point of view of the need to process hybrid information and knowledge, the problem is the need for a personal user layer between Internet services, the Windows operating system, browsers, USB devices, and application software. These problems are solved by an intelligent database structure acting as virtual knowledge. Using this structure, knowledge tables where the information is stored were created, creating a tailor-made environment for the user from which it is possible to switch between online and offline sources. The article describes how knowledge tables are created and managed by applications for BVI purposes through custom software WPad, WPad BVI (database application for Windows or virtual machine on Windows 2022 server), and PIKS (internet application). This in-house software and virtual knowledge tables create a personal middle layer between the global Internet environment, windows, and browsers, allowing further information processing from the web or offline computer files.

The basis of the success of the mass processing of knowledge is how the user can manually, semi-automatically, or automatically fill the knowledge tables with unstructured, semi-structured, or structured information and use them to automate the activities of users, whether they are sighted or BVI. The article presented some applications for automating the activities of university teachers, e.g., how hybrid IT infrastructure is used in the design of pilot activities in the V4 EDUPORT project.

From the point of view of software design for both the sighted and the blind, it should be emphasized that it is based on the fastest possible processing of information, which is not addressed in the usual scientific literature. This issue is because WPad has been developed for years in collaboration with undergraduates primarily to automate teacher activities. Furthermore, there is the limiting fact that the lesson is 40-50 minutes long, and when teaching undergraduates, the teacher has to build several thematic areas into his lesson. It can also only know what kind of quality material, video, or text its length is suitable for teaching in the

classroom. It can also be mentioned that this is one of the cheapest solutions for both sighted and BVI users because basic activities require Windows and the WPad or WPad BVI program, which can also be used from a cloud environment (tables can be directly opened, changed and saved from a virtual machine with a Windows server and the user's laptop).

7 Future research

Our research has shown that a BVI user with higher IT skills can use the WPad software similarly to sighted users (even in our case with the V4 EDUPORT project solutions with greater intensity). Informaticists from the Union of the Blind of Slovakia also tested the previous WPad standard version. Unfortunately, this investigation evaluated that it is unsuitable for ordinary BVI users (e.g., it contains hundreds of menu items that an advanced person needs help finding his way around). Therefore, the program's first, much more basic pilot version, WPad BVI, was developed. It contains a modification of the most helpful menu items of WPad standard software, which was a solution to adapt the program for BVI and other non advanced users. However, it requires an entirely different approach to using state-of-the-art software. Therefore, the goal of the following design is not to explain the function of the menu items but to create an autonomous personal information system for the BVI user or a personal social network (combining the PIKS Internet application and the offline version of WPad BVI). In the future, it is also planned to further test and improve the proposed solution and develop educational materials on its use by a wider group of users.

References

1. Alves, C., Monteiro, G., Rabello, S., Gasparetto, M., Monteiro de Carvalho, K.: Assistive technology applied to education of students with visual impairment. *Revista panamericana de salud pública = Pan American journal of public health* **26**, 148–52 (Aug 2009). <https://doi.org/10.1590/S1020-49892009000800007>
2. Asakawa, C., Leporini, B.: Screen readers. In: *The Universal Access Handbook*, pp. 28–1. Taylor & Francis (Jan 2009)
3. Brayda, L., Leo, F., Baccelliere, C., Vigni, C., Cocchi, E.: A refreshable tactile display effectively supports cognitive mapping followed by orientation and mobility tasks: A comparative multi-modal study involving blind and low-vision participants. pp. 9–15 (10 2019). <https://doi.org/10.1145/3347319.3356840>
4. Buzzi, M.C., Buzzi, M., Leporiniand, B., Mori, G.: Designing E-Learning Collaborative Tools for Blind People (Mar 2012). <https://doi.org/10.5772/31377>
5. Dunn, K., Darlington, E.: Making resources accessible to visually impaired students. *Teaching Geography* **41**, 34–36 (Jan 2016)
6. Gill, W., Kolar, I.: Am I missing something?: Experiences of using social media by blind and partially sighted users. *Universal Access in the Information Society* **19** (Mar 2019). <https://doi.org/10.1007/s10209-019-00648-z>
7. Horsfall, M., Opara, V.C.: Availability of information resources for visually impaired students in university libraries in nigeria: A tool for inclusive university education (04 2023)
8. Kapur, R.: Challenges Experienced by Visually Impaired Students in Education (Mar 2018)
9. Mikulowski, D., Mankowski, J.: An approach of explaining math function graphs through the sound representation for blind students. *Studia Informatica. Systems and Information Technology. Systemy i Technologie Informacyjne* **1-2**, 21–29 (2018)

10. Neto, L., Fontoura Junior, P.H., Bordini, R., Otsuka, J., Beder, D.: Design and implementation of an educational game considering issues for visually impaired people inclusion. *Smart Learning Environments* **7** (Jan 2020). <https://doi.org/10.1186/s40561-019-0103-4>
11. Papadopoulos, K., Goudiras, D.: Accessibility Assistance for Visually Impaired People in Digital Texts. *British Journal of Visual Impairment* **23**, 75–83 (May 2005). <https://doi.org/10.1177/0264619605054779>
12. Putriani, Z., Kurniawan, R.: Assistive Technology in Education: Screen Magnifier. *Indonesian Journal of Integrated English Language Teaching* **2**, 65–69 (Jan 2016). <https://doi.org/10.24014/ijielt.v2i1.2368>
13. Reynaga-Peña, C., López-Suero, C.: Strategies and Technology Aids for Teaching Science to Blind and Visually Impaired Students. pp. 26–37 (Jan 2020). <https://doi.org/10.4018/978-1-5225-8539-8.ch002>
14. See, A.R., Advincula, W.D.: Creating Tactile Educational Materials for the Visually Impaired and Blind Students Using AI Cloud Computing. *Applied Sciences* **11**, 7552 (Aug 2021). <https://doi.org/10.3390/app11167552>
15. Web content accessibility guidelines (wcag) 2.1 - w3c (Last access: June 2020), <https://www.w3.org/TR/WCAG21/>