Enhancing research practices: digital technologies in the social sciences and practical tools for doctoral students

Miłosz W. Romaniuk, Patrycja Mika, Jagoda Apanasewicz, Ewa Duda-Maciejewska

Abstract—**The paper is a result of a complementary advanced publication workshop accompanying the curriculum course exercises for PhD students, on the role of ICT in the research work of a scientist. This article discusses the impact of digital technologies on research practices in the social sciences, focusing on tools supporting qualitative data analysis, interview transcription, and knowledge management. It presents a detailed analysis of CAQDAS programs such as NVivo, MAXQDA, and ATLAS.ti, and transcription tools such as Trankriptor and Word. It also discusses the use of the digital Zettelkasten system in knowledge management and academic writing. The article highlights the benefits and challenges of integrating these technologies, offering practical advice for doctoral students.**

Keywords—**ICT; CAQDAS; transcription tools; Digital Zettelkasten; digital competencies**

INTRODUCTION

THE development of digital technologies has significantly influenced research practices in social sciences and humanities, providing new tools that support both research and analytical processes. These technologies have revolutionized the way researchers collect, analyze, and manage data, offering unprecedented opportunities for enhancing the quality and efficiency of research. This article explores three main areas of digital technology application: CAQDAS (Computer-Assisted Qualitative Data Analysis Software), transcription tools, and the digital Zettelkasten system. Each of these areas is examined in detail in the subsequent chapters, highlighting their functionalities, benefits, and challenges associated with their use. By integrating these technologies into their research practices, doctoral students and researchers can improve their methodological rigor, streamline their workflows, and foster innovative approaches to data analysis and knowledge management.

The first chapter focuses on CAQDAS (Computer-Assisted Qualitative Data Analysis Software) programs that support qualitative and ethnographic data analysis. A detailed comparison of tools such as NVivo, MAXQDA, and ATLAS.ti is presented, highlighting their functionalities, accessibility, and value in scientific research.

The second chapter addresses transcription software, which plays a key role in processing qualitative data, particularly in-depth interviews. Various tools, such as Transkriptor and Word, are analyzed with regard to their performance under different conditions.

Authors are with The Maria Grzegorzewska University (APS), Warsaw, Poland (e-mail of corresponding author: mromaniuk@aps.edu.pl). Abstract, introduction, and conclusions are written by M. W. R., as is the overall edition of the paper. Chapter I is written by P.M.; II by J. A.; III by E.D-M..

The third chapter explores the application of the digital Zettelkasten system in knowledge management and academic writing. The benefits of integrating analog and digital methods are discussed, along with the challenges of adapting new technologies, particularly those involving artificial intelligence.

I. DIGITAL TOOLS IN ETHNOGRAPHIC RESEARCH: AN ANALYSIS OF SELECTED CAQDAS SOFTWARE

Qualitative research is a well-established approach in the social sciences that allows for understanding, describing, interpreting, and explaining social phenomena [1]. One of the main methods in this approach is ethnography [2].

In ethnographic research, it is recommended to use several data collection techniques, combining both qualitative and quantitative methods. Triangulation makes the conclusions drawn more comprehensive [3, 1]. The extensive material collected by the researcher, particularly in descriptive form, must be recorded, organized, analyzed, and interpreted to gain scientific value.

The digital environment enables the use of numerous tools at every stage of the research process, which are increasingly supported by AI [4], and their application can significantly enhance the effectiveness and quality of ethnographic research. However, it is important to remember that the use of digital tools is not without its risks and drawbacks, such as excessive formalization, over-focus on analytical techniques, the loss of the "human" aspect of document analysis (researcher reflexivity), and the need for advanced technical skills [5, 6]

CAQDAS (Computer-Assisted Qualitative Data Analysis Software) refers to software designed to support the analysis of qualitative data. They facilitate the collection, coding, processing, and analysis of textual data (articles, interviews, field notes) as well as audio, video, and image materials. These programs enable, among other things, the creation of codes, categorization of information, data searching, and visualization of analysis results, which aids in the interpretation of complex qualitative data.

This section of the article addresses selected CAQDAS (Computer Assisted/Aided Qualitative Data Analysis) programs.

In the course of the review of available sources (recent scientific articles, user recommendations on ResearchGate regarding CAQDAS), it was determined that the most commonly used and recommended programs by researchers are: NVivo, MAXQDA, ATLAS.ti, and Dedoose [7, 6]. Other programs considered useful include HyperResearch, Provalis Research Text Analytics Software, Quirkos, Raven's Eye, Qigga, webQda, TRANSANA, F4analysis, Annotation, Datagrav, MQA MiNER LITE [8, 9].

Before starting work, it is essential to carefully consider which program will be most suitable [10]. The research approach should be determined, as well as whether the project will be a one-on-one or a team project and how long it should last (will a one-year license be sufficient?). MAXQDA favors a phenomenological approach, while ATLAS.ti and Nvivo favor grounded theory. At the stage of selecting a program, it is necessary to determine the type of data to be analyzed and make sure that the program we are considering supports it (text files, audio, video, social media data, photographs, posters, drawings, etc.) and supports the nature of the data collected (qualitative, quantitative or mixed). The program's interface, language version, and compatibility with various operating systems (e.g., Windows, iOS, Android) are also important considerations. A key factor for doctoral students when choosing the right CAQDAS software is availability. Licenses tend to be expensive, but some universities offer free access to selected programs for doctoral students, which can be a persuasive argument in the final choice of a tool. According to Niedbalski [10], it is worthwhile to take the time to test trial versions of the software to make an informed decision.

This chapter presents an analysis of three tested and frequently used programs in the context of data analysis: NVivo, MAXQDA, and ATLAS.ti. The tester had no prior experience with any of these programs, meaning no bias was present. Each of these programs was installed at the same time in their free trial versions and tested on the same data, which included sample articles and audio files.

The criteria used by the researcher to compare selected CAQDAS were primarily: application response time (file upload time, opening, and saving files), software functionality (intuitiveness and ease of use, support for various data formats, ability to transcribe audio files). Additionally, the availability of educational materials (online instructions, free textbooks, tutorials) was considered. The comparison table also included information regarding the costs associated with purchasing licenses for each software and their additional features.

NVivo is a software useful for organizing, analyzing, and interpreting both qualitative and quantitative data. It supports text, audio, video, images, surveys, social media data, etc. [11]. The program allows the assignment of codes to specific sections of text, which facilitates later identification, categorization, searching, and analysis of information. NVivo offers the ability to create data visualizations such as graphs, mind maps, diagrams, and models. It also allows data exchange with applications such as Microsoft Excel and IBM SPSS Statistics and supports teamwork [12], and users can use the NVivo Collaboration Cloud. The program allows synchronization of projects on both Mac and Windows computers and is compatible with Citavi [13].

The main improvement in NVivo version 15 (September 2024) is the introduction of the AI-based assistant (Lumivero AI Assistant), which offers automatic summarization of written text or entire documents and facilitates coding using AI. This feature is available for datasets in selected languages (English, Spanish, Portuguese, Chinese, Russian, French, German, Japanese, Italian, and Korean) [14].

The program's interface is in English, and its design and layout resemble Microsoft Word. A significant advantage is the ability to work on multiple documents simultaneously (tabs). Coding is intuitive, and there are English-language tutorials available,

although many of these were recorded before recent updates, meaning that the interface in the tutorial videos differs, which may complicate learning how to use the program. Uploading a test audio file lasting one minute took several dozen seconds, which is relatively slow. To transcribe the file, the program redirects users to the NVivo website, where they must purchase an additional package. Another disadvantage is the relatively high cost of the license (at least 105 €/year plus additional paid features), which may be problematic, especially for doctoral students early in their academic careers [11, 15].

MAXQDA is a program similar to NVivo with very similar functions and support for the same data formats. It is used for both qualitative and quantitative research and can analyze tweets and YouTube comments. The program supports teamwork via Team Cloud and works on both Windows and iOS, offering an identical interface in both systems.

TABLE I
COMPARISON OF THE MOST POPULAR CAQDAS PROGRAMS

CAQDAS Software	NVivo	MAXQDA	ATLAS.ti
Price for students (scan of ID required for purchase)	From €105/ 1 year	From 95.20 €/ 1 year Often offered for free at the university	From 84 €/ 1 year
Last update	NVivo 15, September 2024	MAXQDA 24.6, October 2024	ATLAS.ti 24, June 2024
Compatibility	Windows, Mac	Windows, Mac	Windows, Mac
Polish language version	No	Yes	No
Support of document formats	TXT, RTF, DOC/X, PDF, BMP, GIF, JPG, TIF, PNG, HTML, MP3, MP4, WMA, WAV, M4A, WMV, MPG, XLS/X, AVI, MOV, 3GP, MPE, GT, MTS, M2TS, ODBC, XML	TXT, RTF/D, DOC/X, ODT, PDF, GIF, JPG, TIF, PNG, HTML, MP3, MP4, WMA, WAV, M4A, WMV, MPG, AAC, XLS/X, AVI, MOV, 3GP, MV4, 3GGP	TXT, RTF/D, DOC/X, ODT, PDF, BMP, GIF, JPG, TIF, PNG, HTML, MP3, MP4, WAV, M4A, WMV, AAC, XLS/X, AVI, MOV, 3GP, OOXML, JPEG, TIFF, 3G2, 3GP2, ASF, M4V
Supported social networks	Twitter, Facebook YouTube	After installing the Web Collector plugin: Twitter, YouTube	Facebook, Twitter, Instagram, YouTube, TikTok
Audio and video transcription	Manual and automatic (15 min. free, then 28.50 €/ 60 min. of recording	Manual and automatic (60 min. free, then 23.80 €/ 120 min. of recording	Manual
AI support	Lumivero AI Assistant - extra charge 227.27 €/ 1 year	AI Assist - extra charge 143 €/ 1 year	GPT chat integration
Tutorials	Instructional videos on YT (English)	Instructional videos on YT (Polish), tutorials on the official website (English)	Instructional videos on YT (English and Spanish), tutorials on the official website (English)

The latest version, MAXQDA 24.6, released in October 2024, includes AI Assist, which automatically analyzes and summarizes elements of a research project, creates comments on coded data, and suggests new codes.

The program's interface includes a Polish language option. Articles, also in Polish, are available to help users understand how to work with the software [16, 17]. It is possible to work with multiple files simultaneously, although the visual aspect is not as clear as in NVivo. Coding is straightforward, and an additional advantage is the ability to assign specific colors to codes in a very intuitive way. To transcribe an audio file, users must log in and purchase a package (the first 60 minutes are free, then 23.80 €/120 minutes of recording). The speed of uploading an audio file is faster than in NVivo. The 14-day trial period, numerous tutorials, user manuals, and instructional videos available in Polish on YouTube can be helpful when learning how to use the program. MAXQDA is often offered to students and researchers through their universities (e.g., APS, SGH, Gdańsk University of Technology), making it accessible for doctoral students without the need to invest in a license.

ATLAS.ti is another program like NVivo and MAXQDA, allowing for the import, analysis, and processing of various file formats. It supports text documents, PDF files, images, audio, and video formats. It can sort comments and annotations from Word and PDF files. ATLAS.ti is compatible with both Windows and Mac and allows saving results to the cloud. ATLAS.ti integrates with Citavi, Mendeley, Zotero, Endnotes, and Evernotes. It also enables importing data from social media and allows sentiment analysis (positive, neutral, or negative tone) expressed in text, which can be useful when studying subjective assessments or feelings [18].

The latest version, ATLAS.ti 24 (June 2024), is supported by AI through collaboration with OpenAI (integration with GPT chat) [19]. The English interface is similar to Microsoft Word. Coding is analogous to that of the other programs. However, there is no built-in functionality for transcribing audio files. The official website of ATLAS.ti offers video tutorials and a range of free training materials in English and Spanish. ATLAS.ti was acquired by Lumivero, the creator of NVivo, in September 2024, making its future uncertain.

Use of CAQDAS (Computer Assisted Qualitative Data Analysis Software) in ethnographic research can offer significant benefits, such as better data organization, systematic coding, and enhanced analysis. These programs help in collecting and organizing large volumes of qualitative and, in some cases, quantitative data, which is essential in ethnographic studies. They also facilitate coding, which allows for a deeper analysis of the material. CAQDAS tools enable the comparison of data from various sources (e.g., interviews, observations, documents), a feature particularly important in ethnographic research. Visualizations of results assist in presenting analyses, while collaboration features ease teamwork. The latest versions of CAQDAS incorporate AI-based tools, providing further support in data analysis.

However, CAQDAS also has its drawbacks. The software requires time to learn, and the abundance of unnecessary features can be overwhelming for novice researchers. Moreover, the high cost of licenses can pose a barrier, especially for doctoral students. One possible solution to support the use of CAQDAS could be for universities to organize courses or workshops for doctoral students planning to use these tools in their dissertations.

To effectively use the chosen program, doctoral students should have a basic understanding of how to operate the software. However, it is crucial to remember that CAQDAS is just a tool—while it supports their work, the quality of the research ultimately depends on the researcher's overall knowledge, the application of appropriate methodology, the analysis of results, and the ability to draw sound conclusions.

II. SOFTWARE FOR TRANSCRIBING IN-DEPTH INTERVIEWS IN QUALITATIVE RESEARCH

A researcher conducting qualitative research must preserve and, if necessary, present the collected research material. This confirms the reliability of the research conducted by him/her (i.e. insight into the research material, data standardization) [20, 21].

In qualitative research using the in-depth interview technique, transcription of interview content is essential. Referring to the reliability of transcription, Widodo points out that: "Transcription is a powerful act of data representation, analysis, and interpretation in such a way that it exerts considerable influence on how data are conceptualized. Transcripts as a result of transcription should be well organized, analyzed, and interpreted to represent and construe a set of social actions" [21, p. 107].

Interview transcription can be done manually, where the researcher personally converts the audio content into written text. Kvale says of this method: "The time it takes to transcribe will depend on the quality of the recording, the skill of the transcriber, and the requirements for accuracy and detail of the transcription. Transcription of large numbers of interviews is usually a time-consuming, stressful task." [20, pp. 156, 157].

A more effective and increasingly used transcription method [22, 23] is the use of automatic transcription software, which varies in efficiency and availability.

The weakness of both manual and automatic transcription is that the researcher cuts out some of the data from the interview in favour of a concise and easy-to-analyse text. Fragments that are irrelevant to the subject of the study are removed, as well as the reactions of the person being interviewed, such as laughter, exclamations, repetitions, etc. In connection with this, the interview is deprived of emotions that can serve to better interpret the collected data.

It is worth mentioning that each interviewee has their language abilities and way of speaking (especially an accent), which can be hard to differentiate by transcription software. There are times when manual transcription is a better solution, although it is more time costly.

There are many interview transcription programs available today, such as: oTranscribe [24]; HappyScribe [25]; Transkriptor [26]; Rev [27]; Otter [28]; GoTranscript [29]; Scribie [30]; TranscribeMe [31].

Many office applications and other platforms introduce audio-to-text transcription as one of their features (e.g. MS Word, MS Teams). YouTube also allows the generation of automatic captions from shared videos. Automatic transcription is becoming an increasingly accessible and widely used tool.

Most transcription software comes with a fee. Some of them offer a free trial version (which usually has limitations in terms of available features/options). A comparison of the availability of selected transcription programs is presented in Table II.

TABLE II
AUTOMATIC TRANSCRIPTION SOFTWARE COMPARISON

Transcription software	Availability
oTranscribe	Allows you to play audio and transcribe mechanically (no automatic transcription). Free access.
HappyScribe	Free version for files up to 10 minutes in length, paid $10 for 24 hours per year, $17 for 60 hours per year, and $29 for 1200 hours per year.
Otter	Free trial version, paid $8.33/month for 1200 transcripts of max 90 minutes and $20/month for 6000 transcripts of max 4 hours length.
	Doesn't provide transcription in Polish (only English, French and Spanish).
Rev	Free trial version, paid $9.99/month for 1200 transcripts of max 90 minutes and $20.99/month for 6000 transcripts. Provides transcription in English only.
Transkriptor	Free trial paid $4.99/month for 300 minutes of transcription and $12.49/month for 2400 minutes of transcription.
GoTranscript	Paid (per minute of recording). Transcription in 28 languages - €0.78/min.
Scribie	Paid (per minute of recording) - $0.80/min.
TranscribeMe	Paid (per minute of recording) - $0.79/min.
Word	This is not a transcription program, it has transcription options, paid as part of the Office suite.
Teams	

music from a café and a group of friends having a loud conversation at a nearby table.

The following factors are considered indicators of transcription quality: the type of errors made (e.g. missing punctuation), the percentage of mistaken words, and background sounds visible in the transcription. These indicators are presented in Table III.

Word has options for transcribing from live recording or a downloaded file, and a choice of transcription language. After transcription, the program downloads the text to a document. The time it takes to generate a transcript is longer in Word than in Transkriptor. In an interview with background noise, the program interspersed background conversations within the transcript content.

The free version of Transkriptor allows you to transcribe by recording a conversation or by sending a file. The free version has a limited number of minutes of recording (130 min). This program allows one to download a selected file format with the option of adding the names of speakers and time stamps. Transkriptor also offers the option of making summaries and notes from recordings. It also has access to AI chat. This version of Transkriptor picked up individual conversations from the background but confused fewer words than Word.

The paid version of Transkriptor has all the features available

TABLE III
COMPARISON OF TRANSCRIPTION SOFTWARE QUALITY

	Transcription quality indicators	Word	Transkriptor (free version)	Transkriptor (paid version)	HappyScribe
Interview with background noise	Type of errors made	Single word errors. Omits single words. Confuses interviewers. Missing commas in sentences. Splits sentences.	Confuses speakers in an interview. Separates the statements of one speaker. Missing commas in sentences.	Single word errors. Omits single words. Confuses interviewers.	Single word errors. Omits single words. It very rarely confuses interviewers. Missing commas and dots in sentences.
	Background noise	Often picks on background conversations.	Occasionally picks up background conversations.	No background noise or conversations picked up.	Occasionally picks up background conversations.
	Percentage of mistaken words	61/840*100= (7,3%) **7%**	37/840*100= (4,4%) 4%	41/840*100= (4,9%) **5%**	29/840*100= (3,5%) **4%**
Interview without background noise	Type of errors made	There are errors in words. Separates the statements of one speaker. Splits sentences.	Single errors in words. Omits single words.	Single errors in words. Omits single words.	Second transcription not possible due to the end of a free trial
	Percentage of mistaken words	33/731*100= 4,5% (**5%**)	28/731*100= 3,8% (**4%**)	29/731*100= 3,9% (**4%**)	-

Otter and Rev cannot be considered by Polish researchers conducting interviews in their native language as they do not provide transcription in the Polish language.

Doctoral students of The Maria Grzegorzewska University receive free access to programs from the Microsoft Office suite, so it is worth taking a look at the possibility of transcription using one of these programs. Therefore, this text contains the results of a comparison of the performance and accuracy of a transcription made in Word, transcription between the free and paid versions of the Transkriptor program, and transcription available in the free version of the HappyScribe program.

The transcription in each case consists of two 5-minute interview fragments. The first interview had no background noise, the second interview had background noise in the form of

in the free version. It has from 300 to 2400 minutes of transcription per month, depending on the price option. This version of the program coped well with background noise. Interestingly, it had a similar number of errors to the free version (and even a few more). The program recognizes pauses in the speech of one interlocutor and combines them into a whole.

HappyScribe had the most satisfying results in terms of errors in words. Unfortunately, second translation was not possible due to the end of a free trial, therefore this program will not be considered as a valuable option.

Transkriptor achieved better results than Word. The conclusion is that dedicated programs can be used, among which the paid ones are at a better level than the free ones. However, assuming that Word is free for PhD students of The

Maria Grzegorzewska University, one may wonder whether using a slightly worse transcription program is not more beneficial.

Unfortunately, there is a need to review and check the automatic transcription. The programs get lost especially when detecting single words from the interviewer (e.g. signs of active listening). To make the process of checking automatic transcription correctness more efficient, one can listen to the recording of an interview and simultaneously scan the text correcting errors that emerge on the spot. It is best to transcribe the interview directly after conducting it. The memory from the interview would be fresh and it can be easier to find errors in text, remembering what interviewee's intention was.

Nowadays, automatic transcription programs are not perfect, but they still take relatively less time than manual transcription, so their use is worth considering.

III. DIGITAL ZETTELKASTEN – ENHANCING CREATIVITY AND PRODUCTIVITY IN DOCTORAL RESEARCH

A. Challenges in Doctoral Studies

Doctoral studies are a demanding path in scientific development. One in every three doctoral students in Europe does not complete their studies within six years [32]. Hight workload is negatively related to the level of satisfaction and sense of progress, while positively related to the intention to drop out of further education [33]. Doctoral students face challenges in four primary areas: financial, academic, social, and technological [34]. In the academic field, the process of writing research papers is often connected with stress and frustration [35]. At the same time, there is an exponential increase in the number of scientific articles that doctoral students shall stay up to date with – the number of publications indexed in Scopus and Web of Science in 2022 was 47% higher than in 2016 [36]. The Zettelkasten method, which enhances knowledge management and creation, offers a potential solution to the challenges faced by doctoral students.

B. The Zettelkasten Method for Knowledge Management and Creation

Niklas Luhmann (1927-1998), a scientist of extraordinary productivity and creativity, developed the Zettelkasten method. Luhmann, a professor of sociology at the University of Bielefeld and the creator of the social systems theory, has produced over 500 articles and books and left more than 150 unpublished manuscripts in his paper archive. His collection of notes contains over 90,000 cards documenting his ideas and research [37].

Luhmann developed a unique method of scientific work, which was based on creating individual notes (Zettels), which were numbered, linked to each other and stored in file boxes (Zettelkastens). The index of key words and the bibliography served as "maps" for accessing specific thematic areas within his knowledge network [38].

The Zettelkasten method is based on two fundamental principles: "one idea – one note" and "bidirectional linking" [39]. Such a system offers countless possibilities for combining notes, which are free from their original context and previously imposed structure [40]. This open, non-hierarchical system of connections allows for the smooth development and adaptation of the knowledge structure in tune with evolution of thinking [37].

For Luhmann, Zettelkasten was a lifelong companion in his productive academic life – he described it as a partner in dialogue and research, claiming that sophisticated, scientific thinking is impossible without writing [38].

There are numerous testimonials highlighting both the benefits and challenges of the Zettelkasten method. Academic users on the Obsidian Forum share how the tool and method have supported reference management, article structuring, and the creative transformation of knowledge within the Zettelkasten framework.

"I imagine that it may take a little time to actually put together this document, but equally I think it would be useful for a variety of reasons (helping with structuring your article, making explicit exactly what you need to reference and from where, ensures familiarity with the key points, certain entries can be later recycled if needed for future articles etc." [41]

The PhD student in humanistic psychology is sharing early experience with the Zettelkasten method, presenting the routines of 'Feeding My Zettelkasten' and 'Being Fed by My Zettelkasten.' on the Zettelkasten Forum:

"Seriously, it's like Ahrens said in How to Take Smart Notes: with a Zettelkasten, your paper is basically written as you read. All you have to do is pull it forth when it's time. If you're a student wondering whether it's worth starting a Zettelkasten— it is!" [42]

Testimonials from academic users highlight the benefits and challenges of the Zettelkasten method, particularly its impact on reference management, article structuring, and fostering creative knowledge transformation.

C. Digitization and Artificial Intelligence

Luhmann's analog method of bidirectional note-linking today corresponds to the concept of hyperlinks [43]. Modern digital versions of Zettelkasten, such as ZKN3, Zettlr, The Archive, RoamResearch, and Obsidian, resemble Luhmann's work organization, enabling easy creation of bidirectional links, keyword tagging, and bibliographic referencing [39]. Pitura [44], in a review of 24 digital tools useful for academic notetaking, also lists those mentioned by Ahrens [39]. The table below presents a comparison of the key features of the five popular digital Zettelkasten tools.

Table IV compares the key features of digital Zettelkasten tools based on data from their original websites. Each tool offers a distinct combination of features, usability, and cost-effectiveness. Obsidian and Roam Research excel in innovation, with advanced features such as network visualization and AI plugins but differ significantly in cost and data storage models. Simpler tools like The Archive and ZKN3 appeal to traditionalists, while Zetlr effectively bridges academic workflows with Zettelkasten methods. Ultimately, user preferences—such as data privacy, platform compatibility, and budget—play a significant role in tool selection.

Key digital enhancements to the original Zettelkasten method include local text file storage (Markdown) and flexible linking systems (e.g., wikilinks or freelinks), which support fast application performance and data resilience against software changes [43].

TABLE IV
DIGITAL ZETTELKASTENS' KEY FEATURES

Tool	Obsidian	Roam Research	The Archive	Zetlr	ZKN3
Free Access	YES (paid sync)	NO	NO	YES	YES
System	Android, iOS, Linux, macOS, Windows	Linux, macOS, Windows	macOS	Linux, macOS, Windows	Linux, Windows, macOS
Bidirectional Linking	YES	YES	YES	YES	YES
Network Visualization	YES	YES	NO	YES	NO
Data Storage	Markdown files locally	Cloud	Text files locally	Markdown files locally	XML database
AI Plugin	AI Assistant	users' plug-ins	NO	NO	NO
URLs	obsidian.md	roamresearch.com	zettelkasten.de/the-archive/	zettlr.com	zettelkasten.danielluedecke.de

The ability to visualize the network of connections also adds value, as it documents the dynamic process of reading and note-taking, serving as a motivating factor [45]. Additionally, there are emerging attempts to integrate artificial intelligence into the workflow. Among the listed tools, Obsidian stands out for its combination of technical and price accessibility, with the added flexibility offered by plugins such as the "AI Assistant.".

D. Challenges of Digital Integration and Artificial Intelligence

Digital Zettelkasten comes with new challenges associated with automating the writing process. Luhmann emphasized that a note is useless if not written in a way that allows for its future use. This active process takes time but enables long-term knowledge retention and usage [46].

Kadavy [43], comparing analog and digital Zettelkasten systems, highlights several advantages of the analog system:
1) physical notes users can rearrange by moving and reordering,
2) handwritings improving focus and memory retention,
3) limited accessibility to the notes by unauthorized person.
He acknowledges that digital tools make Zettelkasten more efficient in managing and creating knowledge, offering:
1) fast searching of notes by keywords,
2) quick creation and linking of notes and efficient sorting and processing of changes,
3) accessibility from any location and device,
4) reliable backups creation.

Artificial intelligence can rapidly expand the network of connections between notes – AI automatically summarizes text, searches for keywords, and generates new links. However, if the created connections lack explanations of their relevance, they fail to enrich the author's knowledge system [38]. Cevolini [40] stressed that without documenting why the connections were created, the system loses effectiveness. Although AI helps with stylistic and grammatical correction, its impact on critical and creative thinking remains uncertain [47]. And ethical considerations should be carefully addressed when using Zettelkasten AI plug-ins. Doctoral students should prioritize

paraphrasing, focus on generating original insights while taking notes, and ensure precise links to original quotes and sources. Given the potential for AI-generated hallucinations, it is crucial to apply thoughtful human judgment when verifying and contextualizing the content of created notes [48].

Digital tools enable surpassing physical limitations in information storage but also pose the risk of ineffective information processing. Digitization can increase the likelihood of committing the "collector's error," mindlessly copying content that is neither processed nor analyzed [39]. For doctoral students, this can result in accumulating excessive information that does not contribute to authentic research development, potentially leading to feelings of being overwhelmed by accumulated information.

E. Digital Zettelkasten – An Investment in a Scientific Partner

In an information-overloaded world, Zettelkasten becomes a valuable "black box" – an external memory that can support doctoral students in organizing knowledge and fostering creative thinking [40].

Zettelkasten facilitates the organic development of ideas, helping to avoid the "confirmation bias," a tendency to seek only information that supports the hypotheses posed [39]. The bottom-up process of collecting ideas can also reduce the stress associated with facing a "blank page" in the writing process.

Luhmann [38] pointed to randomness and the countless possible combinations as unique features of the Zettelkasten method [38]. Zettelkasten is a "surprise generator," revealing unexpected connections of a general, collective, and specific nature [40]. In academic work, the element of surprise can support the process of creating new and valuable ideas, which is how creativity is defined [49].

The Zettelkasten method encourages habit change, aiding in recall, knowledge consolidation, and unplanned information processing [39]. In practice, Zettelkasten can help doctoral students effectively organize literature reviews, integrate acquired knowledge, and generate unique research ideas.

Zettelkasten is not a universal solution that can easily fit every type of work [50]. Ahrens [39], in popularizing this method, highlights two main difficulties in applying it in an educational context. The first arises from the interdisciplinary nature of Zettelkasten, which connects knowledge across catalog and domain boundaries, conflicting with an educational system lacking subject integration. The second challenge is adapting a new system under time pressure, which does not foster habit change and experimentation with new methods [39].

Due to the method's high effectiveness, the Geneva Graduate Institute presents the Zettelkasten Method as part of a selection of tools designed to make academic life easier. They recommend starting with three simple steps:
1) Take smart notes by asking yourself what might be useful to you.
2) Connect your notes with the intention to support, oppose, or expand linked Zettel.
3) Iterate, allowing for serendipitous discoveries and the bottom-up evolution of themes.
The approach is about an attitude, not just the tool: stepping out of your comfort zone, breaking old habits, and experimenting to create a system that fits your needs. It's worth the effort to stick with a new routine for a couple of weeks. [51]

Zettelkasten needs several years to reach critical mass – a factor that discourages many [38]. However, a digital Zettelkasten can become a useful dialogue partner not only at the doctoral stage but also throughout one's lifelong academic development. Such a change, however, requires persistence and an environment conducive to change, which is why it is worth implementing early in one's research journey.

"Having a Zettelkasten makes nothing easier, but it makes anything possible" [52]

CONCLUSION

Digital technologies are transforming the scientific landscape by equipping researchers with innovative tools for participant recruitment, data analysis, knowledge organization, and academic publishing. This article underscores the diverse opportunities and challenges these advancements present, with a particular focus on their implications for social science research. The integration of CAQDAS programs, transcription tools, and digital Zettelkasten systems into research practices offers significant benefits, including enhanced data organization, systematic coding, and improved analysis capabilities. However, these technologies also present challenges, such as the need for adequate training, financial resources, and critical engagement with the tools to avoid potential pitfalls. Despite these challenges, digital technologies serve as invaluable tools for researchers in a rapidly evolving scientific environment. Their effective integration requires the development of technological competencies while maintaining scientific integrity and ethical standards. By embracing these technologies, researchers can enhance their productivity, creativity, and overall research quality, contributing to the advancement of knowledge in the social sciences.

The recommendations are as follows. CAQDAS programs significantly facilitate qualitative data analysis by providing tools for coding, categorizing, and visualizing data. However, their effectiveness depends on adequate user training and financial resources. Researchers should invest time in learning how to use these programs effectively and seek institutional support for access to necessary licenses. Transcription tools greatly accelerate the data processing phase, particularly for qualitative research involving interviews. While these tools can save time, their accuracy may be limited in challenging acoustic conditions. Researchers should be prepared to review and correct transcriptions manually to ensure data quality. Digital Zettelkasten systems support creativity and efficiency in knowledge management by enabling the organization and linking of notes. These systems require time for adaptation and a critical approach to data integration. Researchers should focus on generating original insights and maintaining precise links to sources to maximize the benefits of these tools.

Digital technologies, despite their challenges, represent essential tools for researchers navigating the complexities of modern scientific inquiry. Their successful integration into research practices necessitates a commitment to ongoing learning and adaptation [15, 53, 54, 55], ensuring that researchers can leverage these tools to their fullest potential while upholding the highest standards of scientific rigor and ethical conduct.

REFERENCES

[1] U. Flick, Jakość w badaniach jakościowych, Warszawa: Wydawnictwo Naukowe PWN, 2011.

[2] H. L. Sharma and C. Sarkar, "Etnography research: an overview," *International Journal of Advance and Innovative Research,* vol. 6, no. 2, pp. 1-5, 2019.

[3] M. Angrosino, Badania etnograficzne i obserwacyjne, Warszawa: Wydawnictwo Naukowe PWN, 2010.

[4] M. Şen, Ş. N. Şen and T. G. Şahin, "A New Era for Data Analysis in QualitativeResearch: ChatGPT!," *International Journal of Education,* vol. 11, no. 1, pp. 1-15, 2023.

[5] G. Byrda, "CAQDAS a badania jakościowe w praktyce," *Przegląd Socjologii Jakościowej,* vol. 10, no. 2, pp. 12-38, 2014.

[6] G. Byrda and A. P. Costa, "Qualitative Research in Digital Era: Innovations, Methodologies and Collaborations," *Social Sciences,* vol. 12, no. 570, pp. 1-17, 2023.

[7] F. Freitas, J. Ribeiro, C. Brandão, L. P. Reis, F. Neri de Souza and A. P. Costa, "Learn by yourself: The Self-Learning Tools for Qualitative AnalysisSoftware Packages," *Digital Education Review,* no. 32, pp. 97-117, 2017.

[8] A. Rahman, "What is the most acceptable qualitative data analysis computer software package after NVivo?," 2021. [Online]. Available: https://www.researchgate.net/post/What_is_the_most_acceptable_qualit ative_data_analysis_computer_software_package_after_NVivo.

[9] K. Carrero, "Qualitative Analysis Software Recommendations?," 2021. [Online]. Available: https://www.researchgate.net/post/Qualitative_Analysis_Software_Reco mmendations/1.

[10] J. Niedbalski and I. Ślęzak, "Encounters with CAQDAS: Advice for Beginner Users of Computer," *The Qualitative Report,* vol. 27, no. 4, pp. 1114-1132, 2022.

[11] P. Limna, "The impact of NVivo in qualitative research: Perspectives from graduate students," *Journal of Applied Learning & Teaching,* vol. 6, no. 2, pp. 1-12, 2023.

[12] D. Allsop, J. Chelladurai, E. Kimball and L. H. J. Marks, "Qualitative Methods with Nvivo Software: A Practical Guide," *Psych,* vol. 2, no. 4, pp. 142-159, 2022.

[13] Lumivero, "Nowości w NVivo 14," 2012. [Online]. Available: https://www.nvivo.pl/?nvivo-14,127.

[14] Lumivero, "NVivo 15. Najbardziej zaufane oprogramowanie do analizy jakościowej staje się jeszcze lepsze," 2012. [Online]. Available: https://www.nvivo.pl/?-b-nvivo-15-nowa-wersja-b-,138.

[15] M. W. Romaniuk, A. Szarfenberg and I. C.-K. K. Pawłowska, "Doctoral Theses in the Digital Age – ICT use by Social Sciences PhD Students of The Maria Grzegorzewska University," *nternational Journal of Electronics and Telecommunications,* vol. 1, no. 70, pp. 199-204, 2024.

[16] K. Kołaczyńska, "Wykorzystanie programu MAXQDA w badaniach biograficznych dotyczących starzenia się członków rodziny," in *Warsztaty Badawcze Doktorantów. Między uwiedzeniem metodologicznym a krytyką,* Warszawa, Wydawnictwo Akademii Pedagogiki Specjalnej, 2017, pp. 35-51.

[17] J. Sajdera, "Zastosowanie narzędzi laboratorium tekstowego programu MAXQDA na przykładzie analizy porównawczej polskich i zagranicznych raportów badawczych," *e-mentor,* vol. 1, no. 98, pp. 42-51, 2023.

[18] ATLAS.ti, "Sentiment analysis in ATLAS.ti Web," 2024. [Online]. Available: https://atlasti.com/research-hub/sentiment-analysis-in-atlas-ti-web.

[19] ATLAS.ti, "Quick Tour ATLAS.ti Windows Analyze anything, faster.," 2024. [Online]. Available: https://manuals.atlasti.com/Win/en/quicktour/ATLAS.ti_QuickTourWin. pdf.

[20] S. Kvale, Prowadzenie wywiadów, Warszawa: Wydawnictwo Naukowe PWN, 2010.

[21] H. P. Widodo, "Methodological Considerations in Interview Data Transcription.," *International journal of innovation in English language teaching and research. 3(1).,* pp. 101-107, 2014.

[22] V. Wardell, C. L. Esposito, C. R. Madan and D. J. Palombo, "Semi-automated transcription and scoring of autobiographical memory narratives," *Behavior Research Methods,* no. Volume 53, pp. 507-517, 3 sierpień 2020.

[23] E. Meanwell, A. Walsh, P. Berg and E. Tuna, "Automated Transcription Service: Enabling Transcription at Scale for Social Science Research," *PEARC '24: Practice and Experience in Advanced Research Computing 2024: Human Powered Computing,* no. No.: 9, pp. 1-7, 17 Lipiec 2024.

[24] oTranscribe, "oTranscribe," [Online]. Available: https://otranscribe.com/.

[25] Happy Scribe Ltd., "Happy Scribe: Transkrypcja i napisy | Mowa na tekst," [Online]. Available: https://www.happyscribe.com/pl.

[26] Transkriptor, "Konwertuj audio lub video na tekst [Transcripotion] - Transkriptor," 2024. [Online]. Available: https://transkriptor.com/pl/.

[27] Rev, "#1 Speech to Text Service in the World - Rev," [Online]. Available: https://www.rev.com/.

[28] Otter.ai, "AI Meeting Note Taker & Real-time AI Transcription - Otter.ai," 2024. [Online]. Available: https://otter.ai/.

[29] GoTranscript Inc., "100% Human-Made Transcription Services - GoTranscript," [Online]. Available: https://gotranscript.com/.

[30] Scribie. 2008-2024 CGBiz Corporation, "Scribie," [Online]. Available: https://scribie.com/.

[31] TranscribeMe, "Fast & Accurate Human Transcription Services - TranscribeMe," 2024. [Online]. Available: https://www.transcribeme.com/.

[32] A. S. B. B.-D. L. Hasgall, "Doctoral education in Europe today: approaches and institutional structures.," European University Association, Brussels, 2019.

[33] E. F.-B. M. & J. E. van Rooij, " Factors that influence PhD candidates' success: the importance of PhD project characteristics.," *Studies in Continuing Education,* p. 48–67, 2019.

[34] S. M. M. M. G. &. T. M. M. Muchaku, "No doctoral studies without hurdles: A review on pathways to prevent dropouts.," *Interdisciplinary Journal of Education Research,* pp. 1-12, 2024.

[35] A. C. H. N. M. L. &. H. K. Sverdlik, "The PhD Experience: A Review of the Factors Influencing Doctoral Students' Completion, Achievement, and Well-Being.," *International Journal of Doctoral Studies,* p. 361–388, 2018.

[36] P. C. P. &. B. D. H. M. Gomez Barreiro, "The strain on scientific publishing.," *Quantitative Science Studies,* 14 07 2024.

[37] J. F. K. Schmidt, "Niklas Luhmann's Card Index: The Fabrication of Serendipity.," *Sociologica,* no. 1, 2018.

[38] N. Luhmann, "Communicating with Slip Boxes. An Empirical Account," 1981.

[39] S. Ahrens, How to Take Smart Notes: One Simple Technique to Boost Writing, Learning and Thinking, 2nd ed. edition ed., Sönke Ahrens, 2022.

[40] A. Cevolini, "Where Does Niklas Luhmann's Card Index Come From?," *Erudition and the Republic of Letters,* p. 390–420, 2018.

[41] robotsheepboy, "Forum Obsidian. Research/PhD/Academics," June 2020. [Online]. Available: https://forum.obsidian.md/u/robotsheepboy. [Accessed 24 11 2024].

[42] jeannelking, "Zettelkasten Forum," September 2020. [Online]. Available: https://forum.zettelkasten.de/discussion/1348/phd-student-reporting-what-its-like-to-use-a-zettelkasten-for-the-first-time-with-my-classes. [Accessed 24 11 2024].

[43] D. Kadavy, Digital Zettelkasten: Principles, Methods, & Examples, Kadavy, INC., 2021.

[44] J. Pitura, "Digital Note-Taking for Writing.," *Digital Writing Technologies in Higher Education: Theory, Research, and Practice.,* p. 101–119, 2023.

[45] O. R. C. B. K. Kruse, "Creativity Software and Idea Mapping Technology," in *Digital Writing Technologies in Higher Education*, A. Shibani, Ed., Springer International Publishing, 2023, p. 63–79.

[46] N. Luhmann, "Learning How to Read," 1987.

[47] H. Aljuaid, "The Impact of Artificial Intelligence Tools on Academic Writing Instruction in Higher Education: A Systematic Review.," *Arab World English Journal (AWEJ),* pp. 26-55, 04 2024.

[48] N. &. I. T. &. O. O. &. A. O. &. A. A. &. O. P. &. O. J. Opele, "Clarifying ethical dilemmas of using artificial intelligence in research writing: A rapid review.," *Higher Learning Research Communications,* no. 14, pp. 29-47, 2024.

[49] E. Nęcka, Psychologia twórczości, Gdańsk: Gdańskie Wydawnictwo Psychologiczne, 2005.

[50] N. F. J. &. D. P. Inie, "How Researchers Manage Ideas," in *Creativity and Cognition*, Venice, 2022.

[51] "Geneva Graduate Institute. Library. Academic Toolbos. Zettekasten Method.," [Online]. Available: https://libguides.graduateinstitute.ch/toolbox/zettelkasten. [Accessed 24 11 2024].

[52] Sascha, "Zettelkasten. Indroduction to the Zettelkasten Method.," 27 10 2020. [Online]. Available: https://zettelkasten.de/introduction/. [Accessed 24 11 2024].

[53] M. W. Romaniuk and J. Łukasiewicz-Wieleba, "Information technologies in higher education teaching in the opinions of academic teachers," *International Journal of Electronics and Telecommunications,* vol. 70, no. 3, pp. 772-779, 2024.

[54] M. W. Romaniuk and J. Łukasiewicz-Wieleba, "Information technology in teaching and learning process at higher education institutions in students' opinions," *International Journal of Electronics and Telecommunications,* vol. 70, no. 3, pp. 767-772, 2024.

[55] M. W. Romaniuk and J. Łukasiewicz-Wieleba, "Generative Artificial Intelligence in the Teaching Activities of Academic Teachers and Students," *International Journal of Electronics and Telecommunications,* vol. 70, no. 4, pp. 1043-1048, 2024.