Doctoral Education in Ukraine: the Application of Digital Tools and Services by Doctoral Students under COVID-19 Pandemic

Lyudmyla Khoruzha[a] , Olena Lokshyna[b*] , Nataliia Mazur[a] , Volodymyr Proshkin[a]

[a] Borys Grinchenko Kyiv University, 18/2 Bulvarno-Kudriavska St., Kyiv 04053, Ukraine
[b] Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine, 52 D Sichovych Striltsiv St., Kyiv, 04053, Ukraine
* Correspondence: olena.lokshyna@gmail.com

Abstract

The paper aims to explore the peculiarities of doctoral education under COVID-19 in Ukraine. The application of digital instruments and services by doctoral students has become a priority during distance training. However, this approach is mainly a new experience and, accordingly, undergoes theoretical substantiation and piloting. The focus of the study is two-fold. It theoretically discusses the digital support of dissertation research at various stages. Secondly, based on the findings of the survey on the doctoral students' application of digital tools and services the challenges have been identified. We conclude that the priority of digital education in the EU countries, especially under COVID-19 pandemic highlights the task of restructuring the doctoral education in Ukraine towards its dynamic digitalization. The digitization should be comprehensive and systematic. Systematization should include technical, organizational, motivational and developmental components aimed at synergy of institutions, doctoral students and supervisors. The complexity should include both the digitization of the training component and independent work of the doctoral students while writing a dissertation. The groups of DT&S for application by doctoral students are recommended for the inclusion into the doctoral students' training curriculum both in the format of a separate course and by integration into the syllabi of other disciplines. Based on the research findings the targeted scientific/methodical events (seminars, master classes, doctoral schools, etc.) providing knowledge and skills on DT&S application are recommended.

Keywords: doctoral education, doctoral students; digital instruments and services; university; Ukraine.

1. Introduction

The perspective of Europe's digital sovereignty by building and deploying technological capabilities in a way that empowers people and businesses to seize the potential of the digital transformation is proclaimed in 2030 Digital Compass. Digitally skilled population and highly skilled digital professionals are named as a target for achieving solidarity, prosperity, and sustainability (European Commission, 2021). The EU vision of digital skills and competences is outlined in the European Digital Competence Framework, also known as DigComp (Vuorikari et al., 2016) and updated in DigComp 2.1: The Digital Competence Framework for Citizens (European Commission, 2017). The DigComp 2.1 identifies the components of digital competence in the areas of information and data literacy, communication and collaboration, digital content creation, safety, problem solving. Skills to locate and retrieve digital data, information and content; interact, communicate and collaborate through digital technologies; create and edit digital content; identify needs and problems, and to resolve conceptual problems and problem situations in digital environments, etc. are defined as basic for the EU citizens.

Making better use of digital technology for teaching and learning, improving education through better data analysis and foresight and enhancing digital skills and competences for the digital transformation are proclaimed a priority in the EU Digital Education Action Plan (2021-2027) (European Commission, 2020). The digital literacy has been declared a necessary condition for the development of the European Educational Area by 2025 (European Commission, 2020a). This actualizes the mission of education, respectively universities are viewed from the standpoint of leaders in generating innovations. 2017 Communication on a renewed EU agenda for higher education (European Commission, 2017a) has confirmed the importance of strengthening links between education, research and innovation. Given this high quality doctoral education is viewed critical for the promotion and adoption of new ideas.

The Salzburg Principles developed at the Bologna Seminar on "Doctoral Programmes for the European Knowledge Society" (Bologna Seminar, 2005) and enriched in the Salzburg II Recommendations in Berlin (European University Association, 2010) provide universities with clear ideas to cultivate the research mindset, nurture flexibility of thought, creativity and intellectual autonomy through an original, concrete research project. However, the dynamic

development of the world, which involves the digitalization of all spheres of human life, is making changes in the organization of doctoral education. In the digital world a modern researcher is to perform many research tasks, namely to:

• Carry out the expanded search and use data from various databases within the research, including scientometric;

• Collect statistical data and use digital tools (software applications, online calculators, etc.) for scientific statistical data analysis;

• Adapt scientific knowledge digital spaces for the exchange of experience (conferences, seminars, scientific associations, etc.);

• Use digital tools to disseminate research results (web publications, blogs, etc.).

The COVID-19 pandemic has intensified changes of the doctoral education format. They are complex and multi-layered taking the application of digital tools and services (DT&S) by doctoral students to a new level. The study aims to explore the peculiarities of the application of DT&S by doctoral students during research in universities under COVID-19 in Ukraine. This paper is, therefore, intended to respond to the following research questions:

- What types of DT&S correspond to the specifics of doctoral research?

- What DT&S do doctoral students use at different stages of their research?

- What factors inhibit doctoral student to apply DT&S while doing dissertation research?

2. Literature Review

In order to conduct literature review, the authors carried out literature search collecting relevant papers/documents focusing on digitalisation/digital transformation, doctoral education, the

use of DT&S by doctoral students. Priority was given to the papers/documents published after the COVID-19 pandemic had begun.

The Eurodoc documents provided a holistic view of the doctoral education in Europe under COVID-19 pandemic. The sources analysed include also the academic journals papers, which the authors classified into three categories, namely digitalisation/digital transformation as a phenomenon of today; digitalisation of higher education; digitalisation of doctoral education.

2.1. The digitalisation/digital transformation as a phenomenon of today

Google Scholar finds approximately 757,000 "digitization" hits, 599,000 "digitalization" hits, 115,000 "digitalisation" hits and 4 190 000 "digital transformation" hits. It confirms the importance of the scientific understanding of the holistic integration of digital technology into all areas of human life. The researchers focus on the interrelationships and interactions between digitization (as a process of conversion of analog data into digital format) and digitalization, which in Randall's et al. (2018) vision means the transformation of all sectors of our economy, government and society based on the large-scale adoption of existing and emerging digital technologies. As a result of the terminology study Van Veldhoven & Vanthienen (2019) collected seventeen definitions of the digital transformation that emphasize various aspects of this process, i.e. use of digital technologies, society transformation, organizational transformation, digital innovation, digital economy, new business models, etc. Based on the developed Digital Transformation Framework Van Veldhoven & Vanthienen (2019) define the digital transformation as the continuously increasing interaction between digital technologies, business, and society, which has transformational effects and increases the change process's velocity, scope, and impact.

2.2. The digitalisation of higher education

The studies on the digitalization of higher education are particularly relevant as this sector is considered to be crucial in providing the highly skilled human capital for economic growth. The studies address the relationship between digital transformations and the developments in higher education, the impact of digital transformations on academic teaching, ways to overcome barriers/gaps in digital teaching and lack of digital teaching/ learning resources to increase the potential of higher education.

The problem of digital skills and competencies is no less relevant. The scholars state that digital transformation covering the development of new infrastructure and increasing use of digital technologies and resources for instruction necessitate mastering digital skills by students and teachers. García & Ferrando (2014) underline that digital literacy requires the high level use of technological resources. Araújo, Cardoso, Toubes & Fraiz (2020) write about the importance of mastering digital competence by students in Spanish university education. Basing on the findings of the research the scholars recommend including curricular programme methodologies that provide skills to younger generations to make the use of new technologies expedient. Sales, Cuevas-Cerveró & Gómez-Hernández (2020) hold a similar opinion advocating incorporation of the information and digital competence into the work methodology of all subjects in a university. On the example of Borys Grinchenko Kyiv University Khoruzha, Proshkin & Hlushak (2020) prove the effectiveness of digital technologies (distance learning systems, electronic libraries, scientific and metric databases, resources for communication and cooperation with mobile devices, services for real-time surveys time, online video services, resources for creating multimedia presentations and interactive testing of existing knowledge, skills, etc.) to implement the training programme. Based on a systemic literature review of the extant literature on adopting e-learning systems at higher education institutions Awan, Afshan & Memon (2021) argue the importance of such systems adoption. The paper identifies and puts forward the level of compatibility and readiness of students and teachers in adopting e-learning, factors that motivate and hinder the adoption of e-learning respectively, benefits of adopting an e-learning system, and the strategies for implementing e-learning at higher education institutions. The research of Erdmann, Presedo & Valdes (2021) on the digital transformation of universities caused by COVID-19 pandemic is especially relevant. The authors describe the process of digitalization of educational institutions and analyse students' insights regarding the implementation of hybrid methodologies of learning and identify potential differences in perception across university degrees.

2.3. The digitalisation of doctoral education

Google Scholar finds approximately 10,900 "digitalisation of doctoral education" hits, 30,300 "digitalization of doctoral education" hits and 640,000 "doctoral education under COVID-19" hits that indicate the relevance of this problem for the research. The scholars stress the importance of

ICT for raising both the efficiency of the research and the quality of the research product. At the same time, the research of Sanchez-Macias & Veytia-Bucheli (2020) shows that doctoral students often do not have a higher level of digital competence solely because they belong to this level of education. This conclusion correlates with opinion of Sim (2016) who is convinced that doctoral students require greater support to enhance the ICT usage during their study because of low "e-literacy". The author advocates for a shift to a new understanding of doctoral study schema by evolving a mutual understanding of ICT application among institutions, PhD supervisors, and PhD students in the doctoral research. Batool et al. (2021) have concluded that use of ICT has a significant impact on the performance of the research students.

The COVID-19 pandemic has accelerated the digitization of doctoral education, intensifying challenges. To the common to Europe, the Eurodoc referrers obstacles for geographical or intersectoral mobility under lockdowns; a lack of interaction of doctoral candidates with supervisors/mentors, with obvious effects on their work; problematic access to research resources (non-digital libraries, lab physical resources, etc.) or at precise physical locations (archaeological, geological sites, etc.); lack of an adequate working environment at home; lower productivity and increased precarity; increased sense of isolation and anxiety (Eurodoc, 2020). Besides, the scholars underline the problem of the so called "digital divide" (Persky et al., 2020), negative impact on the overall psychological health of doctoral students and lack of interaction with peers and in-person discussions (Varadarajan, Brown & Chalkley, 2021). Important for our study are the findings of Lambrechts & Smith (2020) relating the problem of data collection (interviews and focus groups survey) by doctoral students during COVID-19 pandemic. The responders of their survey have reported about the necessity to move data collection online, which requires updating the research strategy and actualizes the availability of technical conditions. The use of multitude of online tools for the research is becoming the norm today and is assessed as enhancing student academic learning (Börgeson et al., 2021).

At the same time, the literature analysis shows that most research on this topic concerns the use of DS&T during doctoral training. Innovativeness is that the paper offers recommendations on raising the effectiveness of the use of DT&S by doctoral students in the process of their individual work on writing a dissertation.

3. Methodology

In the study, we follow Marakovits's (2021) understanding of the DT&S as Internet-based programmes and resources which can be used to support, enhance, and facilitate the doctoral research and instruction. Both qualitative and quantitate research methods have been used. The international organisations', governmental and institutional websites; research papers at Google Scholar (https://scholar.google.com/); reference resources at Wikipedia (https://en.wikipedia.org/wiki/Main_Page) have been addressed to search for various documents on education digitalisation. To map the findings, a content analysis method has been applied, with which the documents/papers were read to select keywords linked to digitalisation of a) education; b) higher education; c) doctoral students' education. Analysis, synthesis, generalization, systematization, comparison of the research findings have made it possible to develop the authors' vision of the DT&S that meet the specifics of doctoral education.

The survey on the doctoral students' usage of digital tools and services during their research was conducted during May-June 2021. The target group comprised 35 doctoral students of the 1st – 2nd years and 19 doctoral students of the 3rd – 4th years of the Borys Grinchenko Kyiv University (Kyiv, Ukraine), Alfred Nobel University (Dnipro, Ukraine), Donbass Pedagogical University (Slavyansk, Ukraine) and Pavlo Tychyna Uman Pedagogical University (Uman, Ukraine). The Google form questionnaire was used for data collection. Conducting the survey at several universities made it possible to identify common characteristics of the DT&S use of by doctoral students under COVID-19 in Ukraine.

The data derived from the survey have been analysed to explore the peculiarities of DT&S application by doctoral students. The survey instrument delved into the following domains: doctoral students' attitude towards the use of DT&S at different stages of the dissertation research; experience of doctoral students to apply DT&S for implementing the dissertation research; factors that inhibit the use of DT&S for the research; DT&S proficiency level of doctoral students during dissertation research; prospects to improve the efficiency of DT&S use while doing dissertation research.

4. Findings

4.1. The authors' vision on the DT&S application by doctoral students during dissertation research

Under COVID-19 pandemic, the use of DT&S s becomes a necessity for the doctoral research. At the same time, such research has its own specifics, to the key features to which we referrer the phasing character of doctoral research (that traditionally covers elaboration of the theoretical basis; generalization of the theoretical research results; designing and doing an experiment; statistical processing of experimental results; preparation and publication of research articles on the research findings; etc.); the sufficient level of digital skills of most doctoral students; prevalence of the independent format of doctoral students' work during writing dissertation. Therefore, it is important to select DT&S corresponding to such specifics, the number and variety of which is very large. In the study the following criteria were developed to select such resources: the compliance with the specifics of the dissertation research; providing a researcher with an opportunity to conduct research at all stages (search for publications, compiling bibliography, doing experiment, statistical processing of quantitative data, etc.), matching with the level of digital skills of doctoral students, the possibility of application on most digital devices. According to the criteria, DT&S were grouped into clusters.

Electronic search and usage of information. During the writing of the theoretical part of the dissertation it is necessary to search for and analyse the scientific works of scholars who conduct research in the area relating of the doctoral student's dissertation. Electronic search and use of available information from the specialized electronic libraries, institutional repositories and online databases can significantly reduce time. As a result, a large amount of data is accumulated that need to be stored and processed correctly. The bibliographic managers, i.e. programs or online services for bibliography management are the most valid to facilitate such activities. Examples of such resources are BibMe (www.bibme.org), ClassTools.net (www.classtools.net), Writinghous (www.writinghouse.org), Makecitation (www.makecitation.com/index.php), EndNote (https://endnote.com), Zotero (www.zotero.org), Diigo (www.diigo.com), etc. Diigo is one of the simplest and the most effective one for these purposes. For correct and convenient work with this online service it is necessary to make the eponymous application to the browser in which the

researcher works, and to register on a resource. Next, viewing the materials of articles, books, images from various sources, you need to click on the appropriate icon of the application in the upper right corner of the browser, fill in the appropriate fields (title; search keywords; section of the study to which this material belongs; if necessary, specify a group for collective processing of the specified material) and click Save. As a result, a link to the Diigo will be added to the specified section or group (Fig. 1).
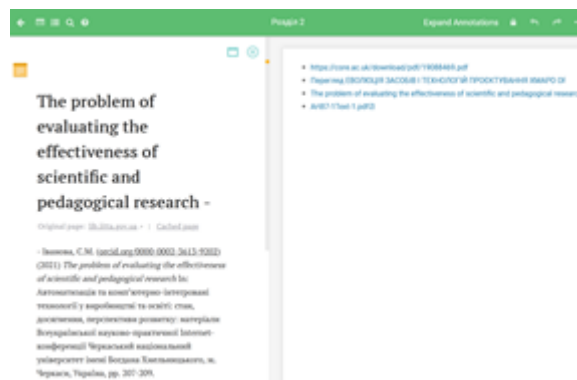

Figure 1 Page viewing materials to a specific section on the Diigo resource
Source: Own work

The advantages of the bibliographic manager Diigo include:

• Ability to save links to various sources: web pages, images, pdf-files;

• Ability to group sources by a certain criterion;

• Possibility of creating groups and further study of the sources of the group as a researcher and his supervisor (scientific consultant);

• There is an option to add handwritten annotations and notes to each added source;

• Simple and user-friendly interface;

• Lack of unnecessary advertising that distracts from work.

The disadvantages include the following: lack of support for languages other than English; in the free package there are restrictions on working in only three groups and adding links of certain types, etc.

Research design and preparation. During the design and preparation of a dissertation research or scientific article, it is often necessary to present the material in a concise schematic form or in the form of an image. To do this, text editors have the appropriate graphics tools (for example, SmartArt in a Microsoft Word word processor), but they have limited functionality and do not always allow the researcher to present the material in the appropriate form. Therefore, it is advisable to use elements of infographics and tools for the development of mental/knowledge maps for the design of schemes, certain algorithms or generalizing images.

Information graphics or infographics are graphical visual representations of information, data, or knowledge designed to display complex information quickly and clearly (Infographics). Infographics creation services have a number of advantages: clarity of the interface and simplicity of work; a large number of ready-made templates to fill in your own data; the ability to use both static and animated elements; presentation of various types of data (analytical; description of a certain event or algorithm of actions; presentation of data chronologically, etc.); the result of the work is stored in the form of an image that is easy to place in a dissertation or scientific article. The algorithm for developing infographics is quite simple: choose a resource and register for it; among the proposed templates to choose the most appropriate for the purpose of creating such an image; highlighting any blocks in the template, they can be edited or formatted to your liking; save the received image with data on the resource (it will be possible to always return and edit something if necessary); add the finished image to the dissertation. The resources for creating infographics we propose are Piktochart (https://piktochart.com), Creately (https://creately.com), Visual.ly (https://visual.ly), Google Charts (https://developers.google.com/chart), Easel.ly (https://www.easel.ly), Cacoo (https://cacoo.com), etc.

A mind map or knowledge map is a diagram that displays words, ideas, tasks, or other elements radially around the main word or idea (Mind map). An example of a knowledge map is given in Fig. 2.
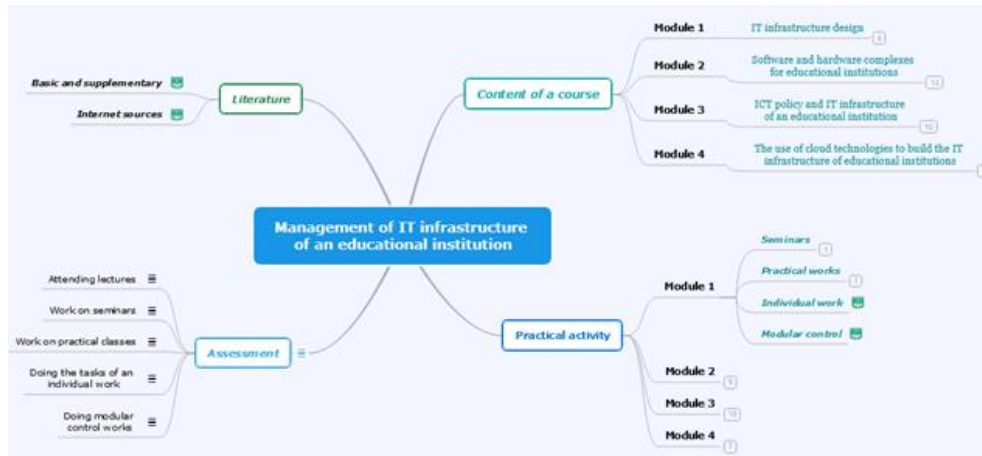
Figure 2 Example of a knowledge map of the structure of the discipline, developed on the resource Mindomo
Source: Own work

The most popular services for developing mental maps are Coogle (https://coggle.it), MindMeister (https://www.mindmeister.com), Mindomo (www.mindomo.com), BubblUs (https://bubbl.us) and others. Some researchers attribute mental maps to infographics, but this, in our opinion, is not entirely correct. A mental map allows a researcher to focus on certain keywords or theses, while infographics allow visualizing the idea in general. The advantages of using knowledge maps when writing a dissertation or scientific article include:

• Simple and user-friendly interface;

• Quick and complete overview of a large topic (areas, problems, topics);

• Ability to use multimedia objects and links to other online resources;

• Collect and present a large amount of different data on one sheet, showing the links and distances;

• Save time;

• Stimulate imagination and problem solving by developing new ways, etc.

Doing a pedagogical experiment. A pedagogical experiment to confirm the effectiveness of the proposed ideas with quantitative and qualitative data is an important part of a dissertation. To do this, the doctoral student is to develop appropriate tools for obtaining statistical data and conduct an appropriate analysis of the results obtained according to relevant statistical criteria. It is advisable to use various online services to develop a questionnaire/test. Such services available on the Internet include Google Form (www.google.com/intl/ru_ua/forms), Kahoot! (https://create.kahoot.it), MyTest (http://mytest.klyaksa.net), Quizlet (https://quizlet.com) and others. The online service Google Form is especially popular among scholars in Ukraine due to the possibility to develop a single questionnaire for different categories of survey participants. To do this, a researcher needs to develop separate sections for different groups of respondents, and then in the first question to set the triggers-transitions to the appropriate section (Fig. 3).
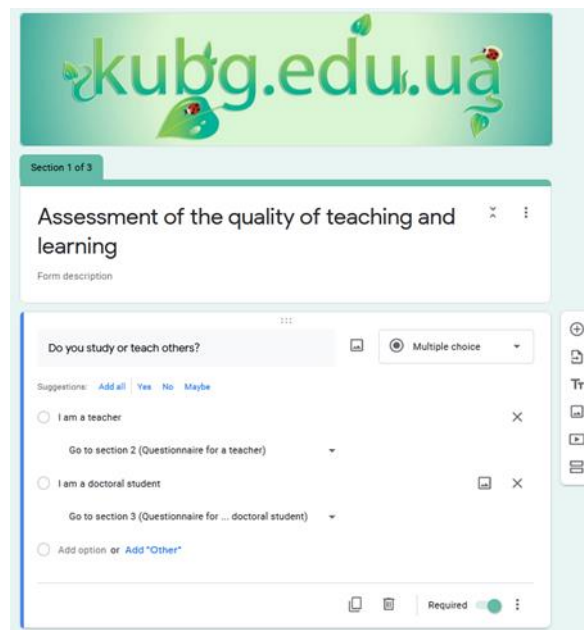

Figure 3. Example of a trigger question in the Google Form service
Source: Own work

In addition, the advantages of this resource include:

• Free of charge;

• Ease of operation and clarity of the interface;

• Availability of various questions and support for multimedia content;

• Viewing the answers received both on the site in the form of tables and diagrams, and the ability to export data to a spreadsheet for further processing;

• Joint work in the development of questionnaires and questionnaires, etc.

According to the requirements to dissertation research the obtained findings of the ascertaining and formative stages of the pedagogical experiment should be analysed, applying certain statistical criteria in accordance with the chosen scale of data presentation. The Pearson or Kolmogorov-Smirnov criteria are recommended if the results of the study are presented in an interval school, and the Student's or Mann-Whitney criteria when using a relative scale. To do this, we consider the specialized data processing software, such as SPSS Statistics, Statistica, StatPlus or MS Excel spreadsheet to be the most efficient for this. Statistica, developed by StatSoft implements procedures for data analysis, data management, data acquisition and visualization (Fig. 4).
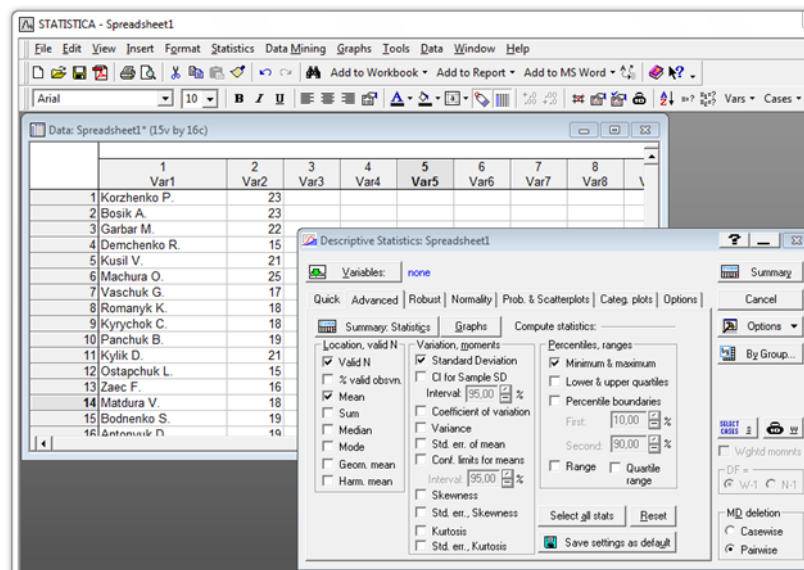

Figure 4 Example of a trigger question in the Google Form service
Source: Own work

The main features of the program are:

- contains a complete set of classical methods of data analysis: from basic methods of statistics to progressive methods, which allows flexible organization of analysis;

- is a means of building applications in specific areas;

- the set of software includes specially selected examples that allow you to systematically master the methods of analysis;

- meets all Windows standards, which allows you to make the analysis highly interactive;

- the system can be integrated into the Internet;

- supports web-formats: HTML, JPEG, PNG;

- easy to learn, and as practice shows, users from all applications quickly learn the system;

- Statistica system data is easily converted into various databases and spreadsheets;

- supports high-quality graphics, which allows you to effectively visualize data and perform graphical analysis;

- is an open system: contains programming languages that allow you to extend the system, run it from other Windows applications, such as Excel.

In addition, free online resources are available to perform statistical evaluation of data. For example, on the website PSYCHOL-OK (www.psychol-ok.ru/lib/statistics.html) a researcher can perform calculations according to any of the above criteria. However, it should be noted that the available online resources for the analysis of the obtained research data reflect only the final results and conclusions of their analysis, but do not demonstrate intermediate calculations and do not guarantee the correctness of the calculation. Therefore, these tools should be used as an auxiliary tool to verify the correctness of the calculation by the researcher. Examples of other online services for statistical analysis are Social Science Statistics (https://www.socscistatistics.com/tests),

Statistics Kingdom (https://www.statskingdom.com), DATAtab (https://datatab.net/statistics-calculator/descriptive-statistics) and others.

Thus, under digitalization and COVID-19 pandemic, the use of DT&S becomes a prerequisite for the preparation of the dissertation. Today, digital resources are widely available meeting the objectives of each stage of the dissertation research. Using them in complex saves time and increases the validity of the research findings. At the same time, the motivation of the doctoral students, the level of their digital skills is the key condition for this. The availability of technical conditions (computer or mobile devices, speed of Internet connection) is equally important. In order to study these aspects, a survey on doctoral students' attitude towards the use of DT&S has been conducted.

4.2. The doctoral students' attitude towards the DT&S application to do dissertation research

A total of 35 doctoral students of the 1st – 2nd years and 19 doctoral students of the 3rd – 4th years were interviewed on their attitude towards the use of DT&S at different stages of the dissertation research:

• Elaboration of the theoretical basis of the dissertation research (Stage 1 in the Table 1);

• Substantiation and development of author's know-how (pedagogical conditions, technologies, systems, forms and methods, etc.) (Stage 2 in the Table 1);

• Designing and doing an experiment (Stage 3 in the Table 1);

• Statistical processing of experimental results (Stage 4 in the Table 1);

• Generalisation of the theoretical research results (Stage 5 in the Table 1);

• Writing and publication of research articles on the research findings (Stage 6 in the Table 1);

• Approbation of research results through participation in conferences, seminars (Stage 7 in the Table 1);

- Dissertation testing for compliance with scientific ethics (Stage 8 in the Table 1);

- Pre-defence and defence of the dissertation (Stage 9 in the Table 1).

Among the possible answers: "important", "rather important", "rather unimportant", "unimportant", the vast majority of graduate students chose the first two (Table 1).

Table 1 The attitude of doctoral students to the usage of DT&S at different stages of the dissertation research

Stage of dissertation research	PhD students of the 1st – 2nd years Answer options				PhD students of the 3rd – 4th years Answer options			
	Important	Rather important	Rather unimportant	Unimportant	Important	Rather important	Rather unimportant	Unimportant
1.	30	4		1	15	4		
2.	24	10		1				
3.	21	10	2	1	16	3		
4.	29	3	2	1	17	1	1	
5.	22	11	1	1	15	2	2	
6.	24	9	1	1	16	3		
7.	24	9	1	1	14	5		
8.	24	8	2	1	18	1		
9.	21	11	2	1	15	3	1	

Table 1 shows that doctoral students of the 3rd – 4th years are more supportive of the DT&S application while among 1st – 2nd years students there are many who are hesitant and have chosen the answers "rather important" and "rather unimportant". We attribute this to the fact that the 3rd – 4th years doctoral students have completed the educational component of the doctoral education that contains the "ICT in modern research" discipline. This shaped their vision on the importance of DT&S for the research, developing necessary digital skills.

Noteworthy is the fact that the 1st – 2nd year doctoral students differently assess the importance of the DT&S application at different stages of their dissertation research. The respondents believe that DT&S should be primarily applied at the stages of elaboration of the theoretical basis of the dissertation research (86% of respondents) and statistical processing of experimental results (83%). The use of such resources at the stages of generalisation of theoretical research findings (63%),

designing and doing an experiment, pre-defense and defense of the dissertation (60%) is viewed as the least important.

The next question concerned the students' experience of using DT&S for doing dissertation research (table 2). The following resource groups were proposed for the evaluation:

• Resources for visualization (Visme, Power BI, Easel.ly, Google Charts, Piktochart, Venngage, Canva, Mentimeter, etc.) (1 in the Table 2);

• Resources for doing an experiment/conducting survey, etc (Google Forms, Classtime, Mentimeter, Kahoot !, Poll Everywhere, EDpuzzle, ClassMaker, Online test pad, Triventy, QUIZIZZ, etc.) (2 in the Table 2);

• Resources for searching publications (repositories, libraries, Google Academy, etc.) (3 in the Table 2);

• Resources for bibliography design (bibliographic managers) (BibMe, ClassTools.net, BibTeX, EndNote, Zotero, etc.) (4 in the Table 2);

• Resources for statistical processing of quantitative data (Microsoft Excel, SPSS, MathCAD, Statistica, etc.) (5 in the Table 2.).

Table 2 Doctoral students experience of using DT&S for doing dissertation research

Resources	1st – 2nd years PhD students Answer options			3rd – 4th years PhD students Answer options		
	Yes	Partial	No	Yes	Partial	No
1	14	12	9	9	8	2
2	20	14	1	10	9	
3	27	8		16	3	
4	14	18	3	12	5	2
5	17	17	1	13	5	1

Table 2 shows that the resources for searching publications (repositories, libraries, Google Academy, etc.) have been named as the most used. This is affirmatively indicated by 77% and 84%

of doctoral students of the $1^{st} – 2^{nd}$ and $3^{rd} – 4^{th}$ years, respectively. The resources for doing an experiment/conducting survey and for the statistical processing of quantitative data have been also named by doctoral students as being actively used.

In order to develop recommendations for improving the quality of the DT&S application for doing the dissertation research, it was important to identify the factors that inhibit this process (Table 3).

Table 3 Factors that inhibit the process of DT&S application while doing dissertation research

Factors	1-2 years PhD students Number of answers	Ranks	3-4 years PhD students Number of answers	Ranks
Reluctance, passivity of doctoral students	12	3	11	1
Reluctance, passivity of scientific advisors	2	6	4	4-6
Unsatisfactory technical capabilities (low speed Internet connection, limited computer or mobile devices)	21	1	8	3
Insufficient knowledge of doctoral students about the usage of computer programs and online services	19	2	9	2
Lack of time to use DT&S	9	4-5	4	4-6
The workload of the doctoral training programme	9	4-5	4	4-6

Table 3 shows that doctoral students of the $1^{st} – 2^{nd}$ and $3^{rd} – 4^{th}$ years identify the factors inhibiting the use of DT&S differently. The $1^{st} – 2^{nd}$ years doctoral students rank unsatisfactory technical capabilities and insufficient level of digital skills to use DT&S as the most significant factors. The reluctance/passivity of the doctoral students is the most significant factor for the $3^{rd} – 4^{th}$ years doctoral students. Insufficient level of digital skills to use DT&S ranks the second place in their answers. The reluctance, passivity of scientific advisors; lack of time to use DT&S and the workload of the doctoral training program are ranked as insignificant.

Table 4 shows how doctoral students assess the level of their own digital competence for the implementation of dissertation research (1 – very low, ..., 5 – very high).

Table 4 Self-assessment of the level of own digital competence for realization of dissertation research

Level	PhD students of 1st – 2nd years Number of answers	PhD students of 3rd – 4th years Number of answers
5	5	3
4	12	13
3	15	3
2	2	-
1	1	-

Besides, the respondents were asked to assess their level of digital competence in accordance with the levels of the Corporate Standard of Digital Competence of Educators of Borys Grinchenko Kyiv University (Borys Grinchenko Kyiv University, 2021) (Table 5).

Table 5 Corporate Standard of Digital Competence of Educators of Borys Grinchenko Kyiv University

Levels	Level description
A	Mandatory Perform a simple search in scientometric databases, repositories, etc; analyse and systematize information related to the research topic; critically evaluate online resources. Collect and analyse statistics using digital tools from the content of the study. Usage digital tools to test the uniqueness of research texts. Format, layout scientific publications according to the requirements of the publication. Update your own scientist profiles.
B1	Sufficient Carry out an advanced search and use data from scientometric databases in accordance with the problem of scientific research. Collect, analyse and interpret statistics using digital tools from the content of the study. Format, layout publications (including templates) using cross-references to sources and bibliographic managers. Disseminate scientific ideas and research results through profiles in scientific social networks.
B2	Create and use databases with research materials. Collect statistics and use digital tools (software applications, online calculators, etc.) for scientific statistical data analysis. Analyse trends in digital tools and predict their use for research. Carry out expert assessments using digital tools, provide opinions on research activities. Systematically use digital tools to disseminate research results (web publications, blogs, vlogs, posts in the international community,

	etc.).
	High
C1	Involve colleagues in collaboration in the database of research materials that the team is working on. Adapt digital science spaces to share experiences (conferences, science schools, etc.). Experiment with the introduction of new digital tools in research and involve colleagues. Use innovative formats for the organization and implementation of collective research and project activities.
C2	Manage research activities using digital tools. Develop digital scientific spaces for the exchange of experience (conferences, scientific schools, training programs, etc.). Adapt / develop and implement innovative digital research tools. Coordinate research in research projects using digital tools. Organize and manage research teams with coverage of their research through a variety of digital tools.

The Corporate Standard of Digital Competence of Educators of Borys Grinchenko Kyiv University developed and adopted within 2020 – 2022 Borys Grinchenko Kyiv University Concept of Digitalization (Borys Grinchenko Kyiv University. 2020) is aimed at increasing the level of digital competence of educators and thus enhancing the quality of education under COVID-19 pandemic. It defines mandatory (A), sufficient (B1, B2) and high (C1, C2) levels of digital competence. As a result of the survey, it was found that the majority of the 1st – 2nd year doctoral students assess themselves at the level of B2 and C1 (77% of the respondents), the 3rd – 4th year students – mostly at the C1 level (68%).

The last question of the survey concerned the suggestions for the improvement of the efficiency of the DT&S usage for doing dissertation research. The following suggestions were received:

- organization of scientific and methodical events (seminars, master classes, doctoral schools, etc.) for doctoral students on the usage of DT&S (36 respondents);
- development of teaching materials on the usage of DT&S (33 respondents);
- updating the content of the academic disciplines of PhD training to open opportunities for the DT&S usage to do dissertation research (25 respondents);
- organization of scientific and methodical events (seminars, master classes, etc.) for scientific supervisors on the usage of DT&S (11 respondents).

The findings of our research answer the research questions:

Research question 1. What types of DT&S correspond to the specifics of doctoral research? In the paper the specifics of doctoral education has been substantiated, the key features of which include: the phasing character of doctoral research; the sufficient level of digital skills of most doctoral students; prevalence of the independent format of doctoral students' work during writing dissertation. The following criteria have been developed for the DT&S selection: the compliance with the specifics of the dissertation research; providing a researcher with an opportunity to conduct research at all stages (search for publications, compiling bibliography, doing experiment, statistical processing of quantitative data, etc.), matching with the level of digital skills of doctoral students, the possibility of application on most digital devices. Based on the selected criteria the groups of DT&S for application at different stages of a dissertation research have been defined: resources for visualization (Visme, Power BI, Easel.ly, Google Charts, Piktochart, Venngage, Canva, Mentimeter, etc.), resources for doing experiment/conducting survey (Google Forms, Classtime, Mentimeter, Kahoot !, Poll Everywhere, EDpuzzle, ClassMaker, Online test pad, Triventy, QUIZIZZ, etc.), resources for searching publications (repositories, libraries, Google Academy, etc.), resources for bibliography design (bibliographic managers) (BibMe, ClassTools.net, BibTeX, EndNote, Zotero, etc.), resources for statistical processing of quantitative data (Microsoft Excel, SPSS, MathCAD, Statistica, etc.). The defined groups of the resources in complex form a digital package of methodological support for doctoral students' training.

Research question 2. What DT&S do doctoral students use at different stages of their research? The resources for searching publications (repositories, libraries, Google Academy, etc.) have been named by the doctoral students as the most popular. Resources for doing an experiment/conducting survey (Google Forms, Classtime, Mentimeter, Kahoot !, Poll Everywhere, EDpuzzle, ClassMaker, Online test pad, Triventy, QUIZIZZ, etc.) are also received the highest number of points from the responders. Resources for statistical processing of quantitative data (Microsoft Excel, SPSS, MathCAD, Statistica, etc.) took the third place. At the same time, the resources for visualization (Visme, Power BI, Easel.ly, Google Charts, Piktochart, Venngage, Canva, Mentimeter, etc.) and resources for bibliography design (bibliographic managers) (BibMe, ClassTools.net, BibTeX, EndNote, Zotero, etc.) are the least used by doctoral students according to their responses. Summarizing the answers we can conclude that doctoral students do not take full advantage of the innovative potential of DT&S (resources for visualization, for bibliography

design, etc.) when writing a dissertation. Besides, there is almost no difference in the use of DT&S by doctoral students of the $1^{st} – 2^{nd}$ and $3^{rd} – 4^{th}$ years. This shows that doctoral students do not improve their digital competence during their doctoral studies.

Research Question 3. What factors inhibit doctoral student to apply DT&S while doing dissertation research? It is clear that unsatisfactory technical capabilities (low speed Internet connection, limited computer or mobile devices) factor has an organizational and technical nature. Given this, creating a modern digital environment for doctoral students is an important task for universities. At the same time, insufficient knowledge/skills of doctoral students to use DT&S factor that ranks the 2nd place among answers allows us to draw a conclusion about the need for the targeted digital courses /programmes for the doctoral students.

Limitation of the study and areas of further research. The sample of the target group (doctoral students) is not representative. The inhibiting factors and proposals to improve the efficiency of the usage of DT&S for doing dissertation research reflect the common position of the doctoral students of all universities (Borys Grinchenko Kyiv University (Kyiv, Ukraine). Alfred Nobel University (Dnipro, Ukraine), Donbass State Pedagogical University (Slavyansk, Ukraine) and Pavlo Tychyna Uman State Pedagogical University (Uman, Ukraine). The article does not highlight differences in the answers of the respondents between universities.

The above limitations can be considered as areas of the further research. A comparative analysis of the use of DT&S by doctoral students of both classical (Borys Grinchenko Kyiv University (Kyiv, Ukraine). Alfred Nobel University (Dnipro, Ukraine)) and pedagogical universities (Donbass State Pedagogical University (Slavyansk, Ukraine) and Pavlo Tychyna Uman State Pedagogical University (Uman, Ukraine)) is promising.

5. Conclusion and Recommendations

Under conditions of the European vector of Ukraine's development, the education in Ukraine is being integrated into the European educational and research areas. The doctoral education is one of such areas of integration. The priority of digital education in the EU countries, especially in the

context of the COVID-19 pandemic (European Commission, 2020) highlights the task of restructuring the doctoral education system in Ukraine towards its dynamic digitalization. The digitization should be comprehensive and systematic. Systematization should include technical, organizational, motivational and developmental components aimed at synergy of institutions, doctoral students and supervisors. The technical and organizational components include the creation of a digital environment by universities, as only 86.9% of the population in the cities and 69.8% in villages has access to the fixed broadband Internet at home in Ukraine (Ministry of Digital Transformation of Ukraine, 2019). This is the Internet that doctoral students need in the process of using the DT&S.

The personal digital development of the doctoral students is no less important. Such development should be constant, as digitalization is a dynamic process. Equally important is the formation of his / her motivation for such development.

The complexity should include both the digitization of the training component and independent work of the doctoral students while writing a dissertation.

Based on the findings of our study the following groups of DT&S for application at different stages of a dissertation research are recommended: resources for visualization (Visme, Power BI, Easel.ly, Google Charts, Piktochart, Venngage, Canva, Mentimeter, etc.), resources for doing experiment/conducting survey (Google Forms, Classtime, Mentimeter, Kahoot !, Poll Everywhere, EDpuzzle, ClassMaker, Online test pad, Triventy, QUIZIZZ, etc.), resources for searching publications (repositories, libraries, Google Academy, etc.), resources for bibliography design (bibliographic managers) (BibMe, ClassTools.net, BibTeX, EndNote, Zotero, etc.), resources for statistical processing of quantitative data (Microsoft Excel, SPSS, MathCAD, Statistica, etc.). The defined groups of the resources in complex form a digital package of the methodological support for the doctoral students' independent work in the process of writing a dissertation. Such a package is recommended for the inclusion into the doctoral students' training curriculum both in the format of a separate course and by integration into the syllabi of other disciplines.

At the same time, according to the findings of the survey, the doctoral students highly appreciate the effectiveness of the targeted scientific/methodical events (seminars, master classes,

doctoral schools, etc.) providing knowledge and skills on DT&S application. This has already been confirmed by the experience of Borys Grinchenko Kyiv University, which annually holds the Winter School for Doctoral Students as part of which the targeted classes on DT&S application are held.

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