

Analysis of experience of digital transformation in education in Germany

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Abstract

The article analyzes the experience of digitalization of higher education institutions in Germany. Based on the analysis of scientific papers for the last 10 years, it has been found that the issue of digital transformation in education is important in the German educational discourse. This is indicated by the analysis of search results in Google Trends, Google Scholar, ERIC, Scopus and Web of Science. The detailed analysis of papers for the last 5 years has been made. For this, the criteria have been determined (5-year period of publication, compliance with the field of higher education in Germany, clear indication of ways to implement digital transformation, significant practical contribution and effectiveness). The selected papers have been classified into 5 thematic groups. Significant examples of scientific papers from each thematic group have been analyzed in detail. Based on the analysis, certain ways to improve the digital transformation of Ukrainian higher education institutions have been proposed.

Keywords

digitalization of education, higher education, education in Germany, digital transformation

1. Introduction

The current century is characterized by digital changes, comprising the emergence of new technologies such as computers, digital television instead of analogue one, digital photo and video cameras, digital data transmission, use of the Internet of Things, etc. Digital technologies become a part of everyday life and merge with everyday objects, making them less visible than the heavy computers of the recent past. Concepts of digital society [1], digital dictatorship [2], digital image [3], digital citizenship [?], digital competence [4], digital design [5, 6], digital culture [7] etc. are emerging. Educational institutions also face some challenges of digital

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transformation. After all, today a person is surrounded by many digital tools that make their lives comfortable, for example, digital online services. Therefore, higher education is also affected by digital technologies, and digital transformation in education is carried out at higher education institutions.

Nowadays, there are more and more questions, which ways of digital transformation in education are appropriate and effective, which technologies are worth using at higher education institutions, which resources exist to implement the tasks of digital transformation in education.

In order to find answers to these questions, it becomes important to analyze the experience of digital transformation in education in the leading countries of the European Union, the educational space of which Ukraine strives to enter. One of the influential countries of the European Union is Germany, where the educational system was earlier a model for Ukraine and it is a sample for Ukraine now. Therefore, the study of the experience of digital transformation of higher education in Germany to find out ways to improve digital transformation of Ukrainian higher education institutions was set by us as the purpose of the current research.

2. Methods of the study

The following research methods have been used during the study:

- the quantitative analysis of papers on the research topic to select criteria for selecting papers for the analysis;
- in order to determine the priority directions of the research, the methods of analysis, systematization, classification, generalization of psychological-pedagogical, specialized and technical sources regarding digital transformation in education in Germany for the last 10 years have been used;
- methods of concretization and systematization of theoretical knowledge and practical achievements of German scientists have been used to develop research tasks.

3. Theoretical basis

Digital transformation is the beginning of the transition to completely new dimensions due to technological updates [8]. It is primarily seen in the digital production and distribution of media and refers to the important fact that digital transformation often occurs within and not just outside the course, for example through the widespread use of mobile devices, which is a sign that the separation of the analogue presence and the digital phase of self-learning becomes less distinct [9]. When we talk about digital transformation, we primarily mean the development of a technological society [10], digitalization of business, economy and enterprises [11], the use of certain hardware and software [12], a system of platforms and Internet services [13].

In the context of our research, we understand digital transformation as a process where digital technologies create disruptions triggering strategic responses from organizations that seek to alter their value creation paths while managing the structural changes and organizational barriers that affect the positive and negative outcomes of this process [14]. Digitization of education is considered as the saturation of the information and educational environment with

electronic and digital devices, means, systems and the setup of electronic and communication exchange between them, which actually enables the integral interaction of virtual and physical things, that is, creates a cyber-physical educational space [15].

4. Results

4.1. Strategy for searching for scientific papers

In the course of the research, we have set the purpose to find out how important the issue of digital transformation in education is in the German educational discourse.

For this purpose, a search has been carried out in the Google Trends service to find out the appearance frequency of the term “digital transformation in education” in relation to the total volume of search queries in Germany in the German and English languages for the last 10 years. The search has yielded no results. For such a search query, the reply “Not enough data has been collected for your search query to display here” has been received. Therefore, a search has been made for the term “digital transformation” in the German and English languages for the last 10 years (figure 1).

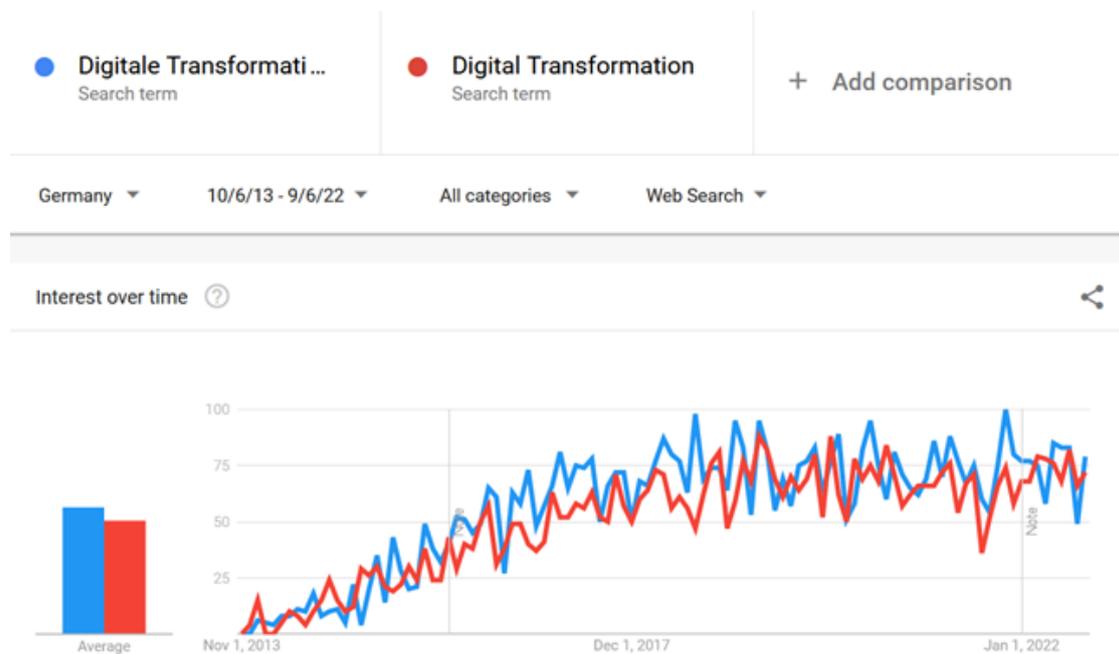


Figure 1: Search results in the Google Trends service for the term “digital transformation” in the German and English languages for the last 10 years

The analysis of the results shows the increase in interest in the phenomenon of digital transformation in Germany for the last 10 years, but does not indicate its relation to the problem activation of digital transformation in education.

Table 1

Google Scholar search results for the term “digital transformation” in the German language for the last 10 years

Period	Number of documents	Percentage of the total
2013-2017	15 700	48 %
2018-2022	16 800	52 %
Total	32 500	100 %

The search for the key phrase “digital transformation in education” (German: Digitale Transformation in der Bildung) has been carried out using the search engine within Google Scholar scientific publications. The search results have been divided into 2 periods for 5 years (table 1).

The analysis of search results in Google Scholar confirms the growth of the publication activity of German-speaking scientists on the topic of digital transformation in education.

The search in the ERIC online digital library of research and information in the field of education using the same key phrase in the German language has shown the small increase in the number of publications on digital transformation in education in the German language: there have been 2 more papers compared to the first five-year period (since 2018 (the last 5 years) the number of publications has been 13, since 2013 (the last 10 years) the number of publications has been 28).

The search in the multi-field abstract and citation database Scopus using the search term “Digital transformation in education” with a restriction by country has given the following results: since 2013 33 articles have been published on this topic, one paper was published in 2014, 2015, 2016, 2017, and 6 papers were published in 2018, 4 papers in 2019, 3 papers in 2020, 12 papers in 2021, and 5 papers in 2022. So, the sharp increase in interest in the topic of digital transformation in education in Germany in 2021 can be observed. This reiterates the fact that in 2021, at the 81st General Assembly, the German UNESCO Commission adopted the resolution “For an equitable design of the digital transformation in education” (German: “Für eine chancengerechte Gestaltung der digitalen Transformation in der Bildung”) [16]. In the resolution the commission calls to include digitalization measures in the overall strategy for equal and inclusive development of the education system in Germany.

The same result can be observed when analyzing the search results on the Web of Science platform (table 2): the gradual increase in papers on the specified topic and the sharp increase in papers in 2021 can be traced.

In the course of the research, the search has been made using the same key phrase in the German language in the literature search system for both printed and electronic resources of the University of Konstanz (Germany) KonSearch. It contains all the elements of the local directory, as well as journal papers, book chapters, books and much more. The full-text access is available for resources that the University of Konstanz has licensed or purchased. 3,510 records have been found for the last 10 years, 2,759 items have been found for the last 5 years. After applying filters limiting the field of knowledge to fields such as computer science, library and information science, educational science, science (general) 613 scientific works on the researched topic for the last 10 years have been selected: 125 papers were published in 2013-2017 and 488 papers

Table 2

The search results for the term “Digital transformation in education” for the last 10 years in the Web of Science platform

Years of publication	Number of publications	Percentage of the total number
2022	19	15,4 %
2021	30	24,3 %
2020	18	14,6 %
2019	23	18,7 %
2018	19	15,4 %
2017	9	7,3 %
2016	3	2,4 %
2013	2	1,6 %
Total	123	100%

were published in 2018-2022. This also indicates the increase in the number of scientific works on the issue of digital transformation in education.

Therefore, taking into account the conducted quantitative analysis, we consider it appropriate to analyze the scientific works of German scientists regarding the digital transformation of higher education, starting from 2017, that is, for the last 5 years.

4.2. Criteria for the selection of papers, their classification and analysis

When selecting research papers, both relevance to research questions and the research quality have been taken into account. The following criteria have been used to select papers for the analysis:

- 1) the scientific paper had to be published within the last 5 years;
- 2) the relevance of the research to the practice of digital transformation in higher education in Germany;
- 3) the presence of clear instructions on ways to implement digital transformation at higher education institutions in Germany in the research results;
- 4) the significant practical contribution and evidence of results regarding digital transformation at a higher education institution in Germany.

Taking into account these criteria, we have selected 47 scientific works (including books, monographs and papers) for the analysis in order to generalize the experience of digital transformation in education in Germany.

They can be classified by their subject into 5 groups:

- 1) papers dealing with the work of libraries of higher education institutions and their contribution to the digital transformation of educational processes;
- 2) papers on the practices of training companies highlighting successful strategies for the digital transformation of learning;
- 3) papers that highlight the role of teaching staff in the process of using digital media and spreading knowledge about digital technologies;

- 4) papers in which the authors reveal the system of digital transformation of the department, faculty or the entire university;
- 5) papers in which the experience of individual teachers or research groups in the implementation of digital transformation of a separate speciality or academic discipline is highlighted.

In particular, the demonstrative research belonging to the 1st group of papers dealing with the work of libraries of higher education institutions and their contribution to the digital transformation in educational processes is the paper by K. Gantert, G. Neher and F. Schade [17], where the experience of digital transformation in education in the work of German university libraries has been analysed. It is emphasized that universities have different priorities and different decisions, depending on which their courses are offered, what place certain subject areas have in the curricula, what areas of activity are deliberately strengthened, etc.). In particular, universities conduct their research in the fields of digital libraries and digital long-term archiving, information behaviour, information infrastructure, information literacy, research data management, information processing, information retrieval, development of electronic dictionaries, human-machine interaction, e-learning and social networks, machine learning, semantic web technologies, data science, information visualization, and open access and research data management. The Learning Research Center of Stuttgart Media University conducts the research on future appearance of physical learning spaces in the future.

All the universities analyzed in this scientific work support their teaching with the help of web-based learning platforms and, in addition to providing learning materials regardless of place and time, such standard functions as discussion forums, wikis or the possibility of self-testing are integrated into the relevant learning format.

In the second group of papers on the practices of training companies, highlighting successful strategies for the digital transformation of learning, the paper of S. Dietl and M. Hennecke [18], dealing with the digitalization practices of training companies, is the important research. Transformation in education, according to the authors, can be carried out in several contexts, namely: demand planning, educational marketing, the selection process, the process of operational training/promotion of trainees, evaluation of trainees, graduate support, recruitment and professional development of trainers, training of full-time instructors, finance and budgetary planning, audit-related processes, and space planning.

1. The context of demand planning involves taking into account the problems of personnel turnover, which is based on digital accounting (using big data, existing and stored data, the use of mathematical methods such as regression, correlation, etc.) allows educators to calculate the demand that will have to be covered by trained employees in the future.
2. The context of educational marketing is revealed through the use of virtual tours of buildings or educational workshops, smartphone applications, social networks, bionic exhibitions, industry 4.0 exhibits in order to demonstrate the innovative power, attractiveness and modernity of educational companies to interested parties.
3. The context of the selection process involves the use of online applicant management systems, online tests, intelligent video programs, etc., in the process of employee selection and trainee admission, in order to effectively select people with the necessary qualities that a future employee should possess.

4. The context of the process of operational training/advancement of trainees is as follows. Given the massive impact of digital transformation, it is expected that the learning process will become more operational. After all, it will be supported by such technologies as virtual reality, augmented reality, radio frequency identification (RFID), robotics, collaborative learning, data security and encryption, data storage systems, computer-aided manufacturing (CAM), computer-aided design (CAD), etc. In addition, the method of imparting knowledge has also changed: virtual flashcards, digital educational programs, online quizzes and game-based learning are used. Didacticization and mediatization are changing. If a few years ago computer-based learning and worksheets were used, now it can be an application or an online sheet that can be filled out by dragging and dropping, the integration of short videos, a live connection to an online tutor or a virtual study group, chats and forums for communication. The use of a professional web-based learning management system is common nowadays.
5. The context of student assessment involves the use of various proposed media for successful learning. Training should result in a reflection of the student achievements, which are evaluated due to various modern technologies (automated testing, feedback systems). In the future, well-developed artificial intelligence will also be able to determine in which environment a trainee feels comfortable: then the evaluation result will be related to the social environment (for example, the number of employees in this department, work experience, gender structure, average age, etc.).
6. The context of alumni support. Recommendations of alumni are a reliable help in increasing the number of entrants to an educational institution. High trust can be built, for example, through chats or short video blogs that are offered to applicants for downloading or can also be sent via messengers. In this way, applicants can be truthfully and reliably shown what is possible after training.
7. The context of recruitment and professional development of trainers is based on the fact that the main actors of digital transformation and quasi-creators of bridges between technologies and people are trainers. Trainers are the initiators of many innovations. However, this presupposes that they are able to cope with the subject and also work on themselves and develop further to keep up. Today, they should navigate the following topics: smart devices and media literacy, leadership and communication, online didactics and setting up online courses for students, copyright in the era of digitalization, big data, new forms of learning and online applications, and the development of digital thinking.
8. The context of staff instructor training. Training instructors can also be included in the holistic concept of digitization, since they are the ones who must support the transfer of, for example, provided equipment (such as tablets, etc.) to the trainees.
9. The context of finance and budget planning is based on the idea that speech recognition and artificial intelligence can help simplify financial and budget planning in education by inputting and processing basic data such as tuition fees, duration of education, etc. using voice.
10. The context of audit-related processes can also be supported and increasingly automated by intelligent IT systems. Speech recognition could also be used in the future for auditing.
11. The context of space planning. The digitalization of spaces and the creation of modern learning centres that can be visited virtually thanks to AR and VR technologies already

exist and allow the creation of “virtual architecture”, and therefore virtual tours, supplemented with relevant camera images (for example, applications for a 360-degree camera or 360-degree images).

Such developments in the field of training will be appropriate at higher education institutions. In particular, the infrastructure of the University of Konstanz, which includes the Communication, Information and Media Centre [19], can be mentioned as an example. This Centre is the university’s central service provider for IT and library services. CIM was created by combining the library, IT Service Centre and administrative IT. It supports teaching, research and study at the University of Konstanz. In order to use various digital services at the university, students and instructors need to get a single login and password in their corporate e-mail. This will allow them to use university library services (Search, Borrow and access media, Document delivery, Reference management, Acquisition request, New acquisitions, Special collections and archives), e-mail and Internet services on campus and beyond (Wi-Fi/WLAN, University email, LAN cable connection, CampusLAN, Remote access to the campus network (VPN), Mailing lists, IT security and privacy), digital services of the centre (Accounts and passwords, Learning and working, Research and teaching, Lecture Recording & Media Production, Software and hardware, Data servers and cloud computing, Administration and maintenance, Collaborative Team Work), etc.

The issue of the role of teaching staff in the process of using digital media and spreading knowledge about digital technologies concerns various aspects, from the attitude of teachers to their competencies to general developments in the fields of education and measures implemented for training and professional development of teachers. This issue is considered by M. Capparozza and I. Gabriele [20]. The researchers have identified three central topics focused on: 1) teacher competencies that are necessary for teaching with digital media and for preparing teachers-to-be for teaching with digital media, 2) individual factors that contribute to the use of digital media in the teaching process, 3) the role of institutional support for teachers in acquiring digital media skills. The main asset of this work is that certain recommendations have been made for the research and teacher training in German-speaking countries:

1. It is advisable to conduct repeated studies or in-depth studies on the professional training of teachers. This is particularly true for mentors, as they have a stronger connection to teaching than teacher trainers at universities and can therefore provide useful impulses for the development of teachers-to-be.
2. It is necessary to create and validate tools for measuring digital competence and the attitude of teachers towards digitalization, to investigate institutional factors influencing digitalization, as well as to develop measures for further training of teachers for working in a modern digital society.
3. Teacher trainers need not only technical skills, but also pedagogical skills in using digital media. They must be role models in the use of digital media and apply appropriate strategies to prepare teachers-to-be to teach with digital media.
4. Institutional support plays an important role in the use of digital media in education. For colleges and universities, this means providing educators with technology and infrastructure, as well as sufficient time to prepare and adequate opportunities for learning and sharing.

5. Given the heterogeneous training in the field of digital technologies, the strategic alignment of universities and educational seminars with one of the presented competency models (TPACK-Modell, SQD-Strategien, TETCs-Modell) can be useful. These measures could support teachers in using digital media in teaching and improve the quality of teacher training and preparatory services.

Among the analyzed publications, papers in which the authors reveal the system of digital transformation of the department, faculty or the entire university are widely represented. After all, in the context of the digital transformation of all aspects of the human activity, it is expected that universities, as research and educational institutions, will actively help shape these changes and contribute to the digital transformation in education. A broad discussion has been developed on this topic in following papers: “Participation in the digital educational world” (German: “Teilhabe in der digitalen Bildungswelt”) and “From e-learning to digitization. Myths, realities, perspectives” (German: “Vom E-Learning zur Digitalisierung. Mythen, Realitäten, Perspektiven”).

Many issues have been discussed by scientists in the book “Participation in the digital educational world” (German: “Teilhabe in der digitalen Bildungswelt”) [21], namely digitization strategies in German universities, management of digitization of research and teaching, participation of teachers in strategic thematic direction of digital learning at the university, solutions for successful transformation, prospects for future digital higher education, digital international mobility and cooperation, the use of digital technologies in teaching for active participation of students in acquiring knowledge, trends in the use of artificial intelligence in education, gamification in distance learning, use of immersive technologies to improve learning efficiency, teaching and learning scenarios using MOOCs in higher education, changing concepts of e-learning due to media didactics, the inclusive potential of digital media, methods of implementing digital technologies in the process of learning, control, and formation competencies.

In the empirical study of the methodological use of digital media at Saxon universities, the current state of their use has been investigated in detail by J. Riedel [22] for compatibility with the concept of a new learning culture, which is required by the standards. The basis for the analysis of the current state of the use of digital media in university teaching has been an online survey of all state universities in Saxony. The online questionnaire essentially includes questions about the frequency of use of digital media in university teaching, about their didactic implementation, their didactic purpose and relevant supporting factors. In total, 1171 people took part in the survey. The author has made many specific conclusions regarding the scenarios of the use of digital tools by teachers in the process of teaching courses, but has not made a generalized picture regarding the system of application of digital technologies at universities. It is also noted that the use of digital media is becoming more common at universities, but this does not automatically lead to a change in the culture of learning. Most teachers transfer traditional learning scenarios into the digital space by providing digital learning materials. To eliminate this shortcoming, it is proposed to create attractive offers for such teachers, and the content of current propositions for professional development must be checked for their connection with the new learning culture (digital culture).

Also using a survey tool, F. Cammann, E. Hansmeier, and K. Gottfried [23] have made an attempt to more clearly summarize the forms of digital media use that are common in university

teaching. Faculty members at the University of Cologne, the Technical University of Cologne and the University of Applied Sciences Hamm-Lippstadt have been invited by e-mail to participate in the online survey. A total of about 4,270 people have been invited for the survey. The results of the survey have shown that the most common scenario of using digital technologies is distributed e-learning (content is provided through digital media and is used by students by obtaining information and processing information independently without the support of teachers), in the second place there is e-learning through interaction (students receive content independently in interaction with an electronic environment), and in the third place there is electronic learning through cooperation (students who are physically separated from each other, communicate with each other and solve tasks and problems in the virtual space jointly).

The practical experience of central and internal discussions at Ruhr University Bochum (German Ruhr-Universität Bochum) is described by S. Henze, S. Lippold, J. Ricken, and P. Salden [24]. It reflects how heterogeneous approaches to digital transformation at the university are, what caveats occur, and how viable solutions can be found for a common way. As the authors note, in 2017, all faculties and central scientific institutions of the university recorded the current state of digitization of learning and teaching in their respective fields. Based on this, each of them created a concept of digitization for a specific subject. They formed the basis of the general university strategy. This was preceded by a discussion at the central level with the participation of teachers and students regardless of their faculty affiliation.

Let us consider examples of papers in which the experience of individual teachers or research teams in the implementation of digital transformation of a separate speciality or educational discipline has been highlighted.

The experience of teachers in the implementation of digital transformation of a separate speciality has been presented by A. Rolf [25] as a didactic approach implemented in bachelor's programs in informatics and business informatics. The micropolis model proposed by the author comes from the interests of exploitation, involves the process of designing innovations and "recultivates" the expected consequences and interactions. In our opinion, the model of a joint project approach to digital transformation developed by the author seems to be more practical. It offers the creation of small projects of three or four participants, who independently develop a key question or analyze the opportunities and risks of digitalization on a topic of their choice, or develop a digital design idea. Both forms must be implemented in video, audio slides or other creative form. The project may, for example, relate to the way of using digitization technology in the book trade or the music industry to understand the essence of digitization with concrete examples. Project participants jointly analyze existing strategies and approaches, investigate how the book trade or music industry has historically developed up to digitization, identify deep power relations, explore socially acceptable innovative business models and implement them with their opportunities and risks, for example in a short video. Especially successful works are placed in the digital archive. A database for digital transformation is gradually being created, which is also available to all project participants as an instruction for project work. An example of such an archive was created by students of the Faculty of Informatics (see mikropolis.org).

So, we have analyzed the most qualitative studies in each of the 5 categories of papers that we defined, highlighting the problems of digital transformation in Germany.

5. Conclusions

The modern dynamics of innovation, which in the context of digital transformation especially affects the field of education, naturally raises the question of the extent to which new or modified didactic concepts appear, which are necessary in order to properly prepare young people for these new challenges, for activities in the digital society.

In Germany, position papers have been adopted from ministries, the Conference of Ministers of Education (KMK), the German Association of Cities (DST), the German Rectors' Conference (HRK), the German Research Foundation (DFG), the Research Council (WR) or European Union (EU) bodies, that formulate goals, guidelines and recommendations for mastering digital transformation and social and economic challenges.

At the same time, the theory and practice of digital transformation in education have also developed. They have taken place at several levels related to higher education: at the level of libraries, at the level of educational institutions, at the level of individual educational courses. Extensive discussions on the issues of digital transformation are presented in important and book publications and book series (for example, "Media in science" (German: "Medien in der Wissenschaft")). The great variety of scientific works on the theory and practice of digital transformation in education, in particular in higher education, prompted us to single out articles according to the relevant criteria (5-year period of publication, relevance to the field of higher education in Germany, clear indication of ways to implement digital transformation, significant practical contribution and effectiveness) and their consolidation into 5 groups (papers about the work of libraries on the digital transformation in education, the practice of training companies, the role of teaching staff, the experience of universities and individual teachers in digital transformation).

Based on the analysis of the experience of the digital transformation of higher education, the following ways of improving the digital transformation of Ukrainian higher education institutions have been identified:

1. Digitalization of libraries. Despite the fact that digitalization of library archives has been carried out in Ukraine, its level is still insufficient, in particular at some higher education institutions. Therefore, equipping university libraries with appropriate equipment for digitizing printed works, creating digital catalogues and effectively searching in these catalogues is an important direction of the digital transformation in education.
2. Digital transformation of all processes of a higher education institution (demand, educational marketing, document flow, informing all participants in the educational process, personnel selection, student support during studies, student evaluation, alumni support, teacher training, financial management and budget planning, audit, etc.).
3. Understanding the important role of university teachers and mentors as participants in digitalization has to lead to the development of a clear policy for improving their digital competence both in the country in general and directly at universities. We need not only help with technical and methodical issues, but also emotional support, for example, due to heavy workload and fear of change.
4. Development of a single digital environment in the structure of a higher education institution, supported by a single concept of understanding the digital transformation

of the university and a single means of authentication (one login and password for the access to all digital services, resources and services).

5. Provision of digitalization tools for teachers of a higher education institution, that includes the availability of modern digital laboratories for the creation of high-quality digital educational content.

Each of these ways is revealed in a set of tasks that can be analyzed by the authors in subsequent studies in order to specify the actions of digital transformation in education in general and a separate higher education institution in particular.

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