Analysis of the state of the art of modern e-learning in higher education in Germany

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Abstract. E-learning as a part of blended learning and a means for implementing distance learning, as well as an independent phenomenon of the modern information society, has been introduced and studied by researchers for several decades. In various countries, the relevance of e-learning and the use of e-learning tools in higher education have increased during the coronavirus pandemic. Different countries have their own approach and experience in using e-learning tools. Therefore, it is advisable to study it both for each country separately and in comparison. In the course of the research, the analysis of scientific publications on the topic of e-learning in higher education in Germany over the last 10 years has been made, which has shown certain changes in the interest in this issue of German scientists. The survey of students and teachers of the University of Konstanz (Germany) has been conducted regarding the use of e-learning tools and their attitude to e-learning. Despite the fact that the results of the analysis of the scientific works of German scientists show a drop in interest in e-learning problems in Germany and a slight rise during the coronavirus pandemic, the results of the survey indicate an unequivocal interest in e-learning tools of teachers. In general, it is possible to state the positive attitude on the part of teachers and uncertainty on the part of students.

1. Introduction

Digital technologies have revolutionized all spheres of human activities, including higher education. Large volumes of knowledge today are difficult to convey at clearly allocated lecture time, so e-learning tools are often used to deepen learning and provide more information to those students who need it. The advent of e-learning tools has allowed universities to attract more students who cannot attend face-to-face classes for religious, political or financial reasons to learning.

Studies conducted by scientists show the growing demand for e-learning services in the USA [1], China [2], Ukraine [3–6], etc. and the use of e-learning tools in traditional education, that is, blended learning [7–9]. In general, interest in e-learning has been growing in the EU countries for the last few years. In 2021, 27% of people aged 16 to 74 in the EU reported that they did an online course or used online learning material in the last three months prior to the

survey, there was a 4 percentage points (pp) increase compared with 23% in 2020. Compared with 2019 before the pandemic, the share of people doing online courses or using online learning material increased in all Member States, except for Romania where it decreased (-4pp) to 10%. Among the sharpest increases were the Netherlands (+21pp), followed by Luxembourg and Slovenia (both +19pp), and Greece (+18pp) [10] (figure 1).

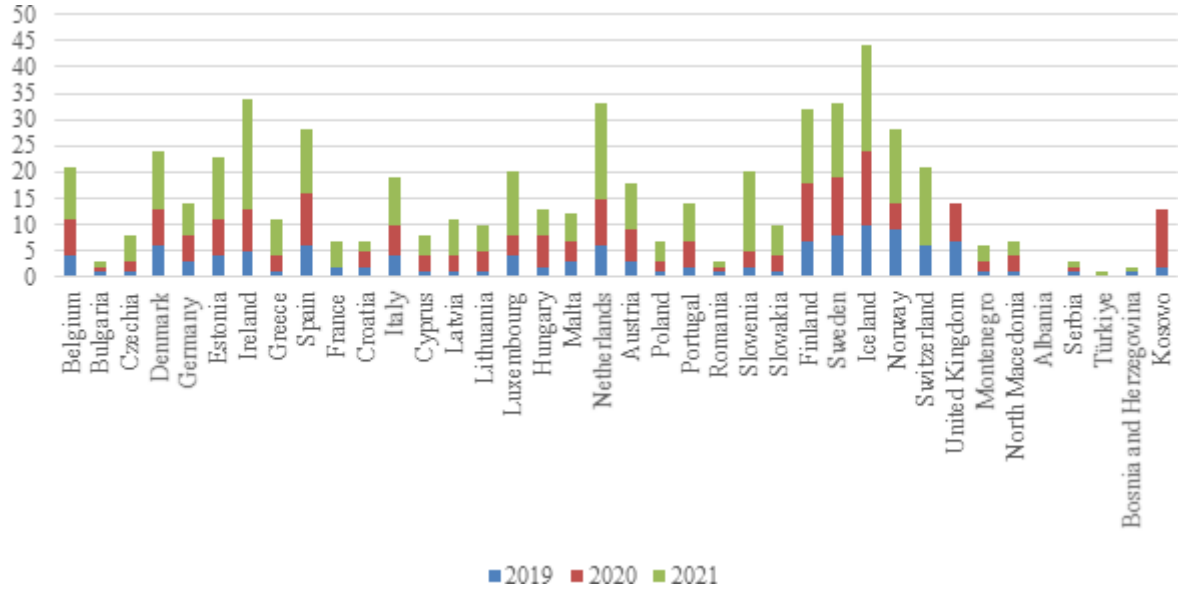

Figure 1. People doing an online course or using online learning material in the EU in the 3 months prior to the survey (percentage of people 16 to 74 years old) [10].

At the same time, the study of e-learning and its tools in EU countries, namely Germany, requires additional research, in relation with the changes caused by the coronavirus pandemic. Also, according to the research data illustrated in figure 1, in Germany the percentage of those interested in online courses is increasing, but not much (2019 – 3%, 2020 – 5%, 2021 – 6%). Therefore, the question arises: what is the reason for such a small increase in interest in e-learning in Germany?

Therefore, we have set the purpose to analyze the state of the art of e-learning and the tools used for e-learning in higher education in Germany. For this, we consider it expedient to perform the following research tasks:

- to analyze scientific publications on the topic of e-learning in higher education in Germany for the last 10 years;
- to conduct a survey of students and teachers of the University of Konstanz regarding the use of e-learning tools and their attitude to e-learning;
- to analyze the results of the survey of students and teachers of the University of Konstanz and compare with the theoretical analysis of scientific publications.

2. Methods of the research

The following research methods have been used during the research:

- 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 e-learning 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, as well as the anonymous survey, the analysis of its results and presentation using graphical methods of statistical data representation.

3. Results

3.1. Analysis of scientific publications for the last 10 years

In the course of the research, we have set the objective to find out how important the issue of e-learning in higher education is in the German scientific discourse. For this purpose, the search has been carried out in the Google Trends service to identify the appearance frequency of the term "e-learning" and "electronic learning" in relation to the total volume of search queries in Germany in the German and English languages for the last 10 years (figure 2).

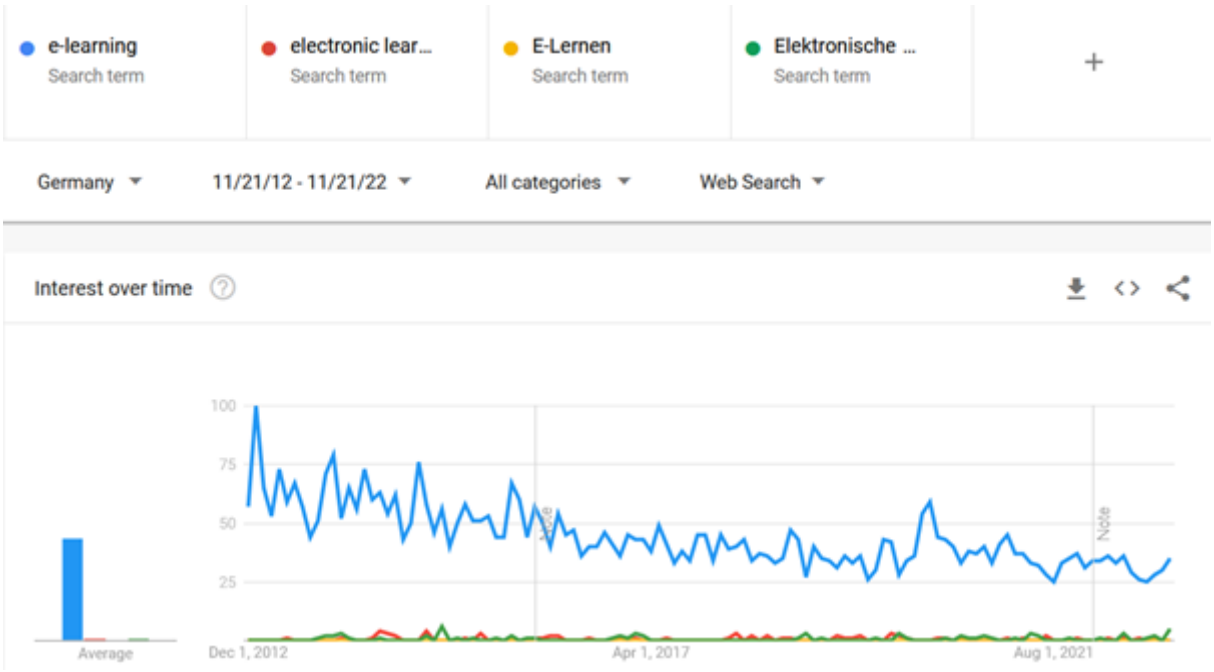

Figure 2. Search results in the Google Trends service for the term "e-learning" and "electronic learning" in the German and English languages for the last 10 years.

Analyzing the search results in Google Trends, it can be stated that e-learning became the most popular in 2012. The interest in e-learning subsequently declined until 2020, which can be explained by the demand for e-learning tools during the coronavirus pandemic. As we can see, the decrease in the intensity of the pandemic ultimately leads to a decrease in interest in the problem of e-learning.

As a result of the analysis of the data displayed in figure 3, the interesting fact is observed: in all 16 German states, the most popular term is "e-learning" (100 percent).

The search for the key phrases "e-learning" and "electronic learning" (German: "E-Lernen" and "Elektronisches Lernen") has been carried out using the search engine according to Google Scholar scientific publications. The search results have been divided into 2 periods for 5 years (table 1).

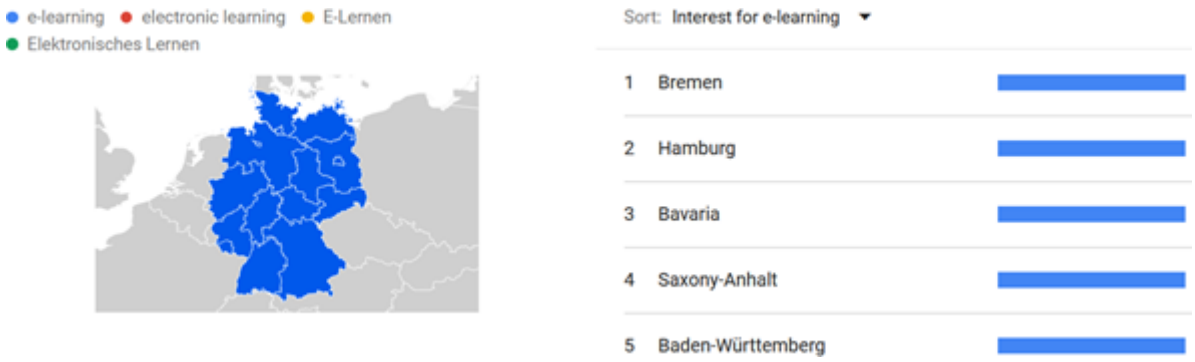

Figure 3. Comparison of the terms "e-learning" and "electronic learning" according to the frequency of their use in certain regions of Germany.

Table 1. Google Scholar search results for the term "e-learning" and "electronic learning" in Germany for the last 10 years.

Period	"e-learning" ("E-Lernen")	"electronic learning" ("Elektronisches Lernen")
2013-2017	131	16700
2018-2022	136	16200
Total	267	32900

Analysis of the search results by key phrases in Google Scholar confirms:

(i) the most used term in Germany is "electronic learning" ("Elektronisches Lernen");
(ii) the number of publications in which the term "e-learning" ("E-Lernen") is used has slightly increased;
(iii) the number of publications in which the term "electronic learning" ("Elektronisches Lernen") is used has not decreased significantly.

So, we can conclude that for 10 years there has been no significant surge of scientific articles on the topic of e-learning in Germany indexed in Google Scholar, if compared, for example, with the USA [11].

The search on the Web of Science platform for article titles using keywords in the German language ("E-Lernen", "Elektronisches Lernen") has yielded no results. Therefore, the search has been conducted using keywords in the English language ("e-learning", "electronic learning") with clarification by years (2012-2022) and the country (Germany) [12, 13] (figure 4).

As a result, 263 items have been obtained for the search term "e-learning" for the specified period (2013-2022), and 3 articles for the search term "electronic learning". Therefore, it can be concluded that the term "e-learning" is widely used among German scientists. This conclusion has been also confirmed by the results of a search in the Scopus database (table 2), which was carried out according to the following search queries:

1) "E-Lernen" – `TITLE-ABS-KEY ( e-lernen ) AND ( LIMIT-TO ( PUBYEAR , 2019 ) );`
2) "Elektronisches Lernen" – `TITLE-ABS-KEY ( elektronisches AND lernen ) ;`

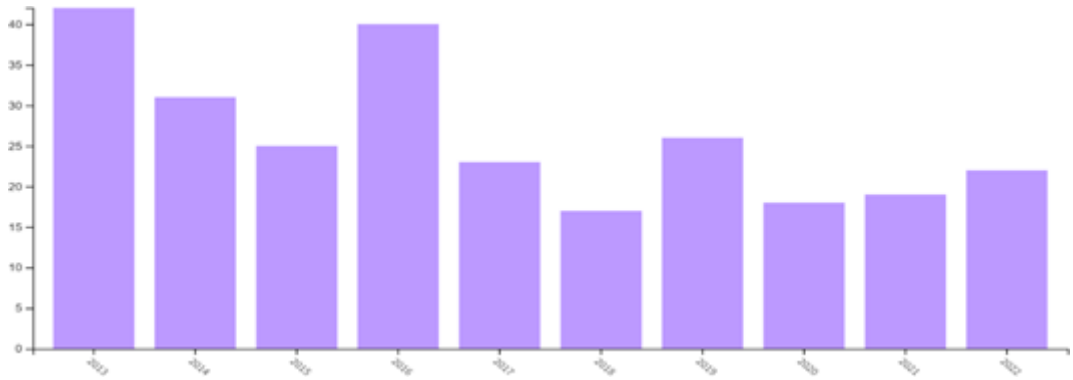

Figure 4. Search results for the term "e-learning" for the last 10 years in the WoS platform.

Table 2. Search results for the term "Digital transformation in education" for the last 10 years in the Scopus.

Year	"E-Lernen"	"Elektronisches Lernen"	"e-learning"	"electronic learning"
2013			490	
2014			542	
2015			445	
2016			394	
2017			342	2
2018			255	
2019	1		311	
2020			309	
2021		1	248	2
2022			212	
Total	1	1	3548	4

3) "e-learning" – `TITLE-ABS-KEY (e-learning) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013)) AND (LIMIT-TO (AFFILCOUNTRY , "Germany")) ;`
4) "electronic learning" – `TITLE ("electronic learning") AND (LIMIT-TO (AFFILCOUNTRY , "Germany")) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013)).`

From the analysis of the search results in the Scopus database, it can also be concluded that the interest of scientists in the problems of e-learning has decreased from 2013 to 2019, that is, before the start of the coronavirus pandemic. Next, we can observe the small increase in interest in 2019-2020 and a fading again in 2021-2022.

The next step in our research was a content analysis of the scientific articles found through search queries. It has been aimed at finding out what e-learning tools are used in higher education institutions in Germany and how teachers and students feel about e-learning. Therefore, for this purpose we have selected those articles in which these issues have been covered. In total, the number of analyzed articles has been 294. In this analysis, the following results regarding the use of e-learning tools in German universities have been obtained (table 3).

Table 3. E-learning tools in Germany.

E-learning tools	Web of Science	Scopus	Total reference number
Virtual reality		75	75
Massive Open Online Course (MOOC)		51	51
Mobile applications		33	33
Multimedia	2	27	29
Learning management system, e-learning-platform	1	28	29
Online course		18	18
Online laboratory, simulations		11	11
Automatic assessment management system, testing		8	8
Social media		6	6
Augmented reality		6	6
Cloud E-learning	1	5	5
Advising systems		3	3
Learning Analytics		3	3
Platform for video communications		3	3
Wiki systems		3	3
Conversational agents		2	2
3D-modeling		2	2
E-assessments		1	1
Hybrid campuses		1	1
Electronic Learning Diary	1		1
Podcasts		1	1
Educational chatbot		1	1
Learning glasses app		1	1
Total	5	289	294

As a result of the content analysis of scientific publications for the last 10 years, the following conclusions have been made:

(i) the vast majority of scientific works on the topic of e-learning relate to the study and implementation of virtual technologies, massive open online course (MOOC), mobile applications, multimedia technologies, learning management systems and platforms, online courses, online (virtual) laboratories and simulations;

(ii) among the analyzed scientific works, the vast majority of papers deal with medical education and the use of virtual technologies in it;

(iii) the vast majority of scientific publications are indexed in the Scopus database.

We have also paid attention to the research of German scientists regarding the positive and negative results of the implementation of e-learning tools. However, we should immediately note that there are more positive results of research on the impact on the quality or improvement of the level of education than negative ones. In particular, Peine et al. [14] have conducted their research in order to compare extant traditional teaching methods with new instruction forms (such as e-learning and curriculum-guided self-study) in terms of learning effect and student satisfaction. The study shows that students in modern study curricula learn better through modern self-instructed methods than through conventional methods. These methods should be used more intensively, as they also show good levels of student acceptance and higher scores in personal self-assessment of knowledge.

Skulmowski and Rey [15] describe the positive experience of implementing the strategy of hybrid campuses. They highlight the need for multimodal learning, that is, learning settings that use multiple sensory modalities. This approach describes how the social distancing measures currently in effect can be used to re-think higher education based on a reasonable use of technology. This research shows, that students in modern study curricula learn better through modern self-instructed methods than through conventional methods. So, researchers state that these methods should be used more, as they also show good levels of student acceptance and higher scores in personal self-assessment of knowledge.

In the research [16] the results indicate that learning approach goals of faculty are positively associated with perceiving the shift to online teaching as a positive challenge and as useful for their own competence development.

Considering the benefits of ILIAS in e-learning van Bonn et al. [17] make the following conclusions:

- e-learning cannot completely replace the conventional training in medicine, but it offers a good alternative in case of restrictions due to diseases or pandemics;
- e-learning is highly valued by students as an additional offer for practice;
- the results indicate a high degree of acceptance of e-learning among students, as well as its use regardless of place and time;
- e-learning is not a competitor, but a complement to face-to-face learning.

The last conclusion of the previous study has been confirmed in the article [18] which, based on the results of the survey, shows that medical students demonstrate broad acceptance of the online course during COVID-19 pandemic and indicates that digital learning options can partially replace conventional face-to-face teaching. For the content taught by lecture, online teaching might be an alternative or a complement to traditional education.

Händel et al. [19] has investigated how higher education students were ready for emergency remote teaching due to the COVID-19 pandemic and how this influenced their socio-emotional perceptions. Results indicate that higher education students seem to be ready for digital learning. A k-means cluster analysis revealed two groups of students that significantly differed with respect to their readiness for digital learning (in terms of technology equipment availability, prior experiences with e-learning, and skills for digital learning). Students' socio-emotional perceptions, that is, stress-related emotions (worries, tension, joy, and overload) as well as social and emotional loneliness significantly differed due to cluster membership. Hence, the study points the need for support of higher education students in successfully coping with the challenges of emergency remote studying.

So, in general, German scientists indicate a positive attitude towards the implementation of various e-learning tools, while noting that their implementation should not be an end in itself. It should be appropriate and justified, as well as be based on the experience of using information and communication technologies by teachers and students.

3.2. Research on the use of e-learning tools

In addition to the theoretical analysis of the experience of using e-learning tools in higher education in Germany, the aim of the research is to conduct a survey of students and teachers regarding the use of e-learning tools and their attitude to e-learning. The survey has been conducted at the University of Konstanz. It has been anonymous and consisted of two parts. In the first part, questions about the use of distance learning systems and e-learning tools have been asked in order to find out which e-learning tools were used by teachers and students in the educational process. In the second part, with the help of questions, we have been aimed to study how teachers and students perceive e-learning.

For the survey, a university mailing has been made with an offer to take the survey. 26 students and 8 teachers of the University of Konstanz have taken part in the survey. In total, 10 966 students studied at the university during the winter semester when the survey was conducted [20]. By 2022, 219 professors and 7 teachers and assistants had worked at the university [21]. The results of the survey are given below.

Almost all teachers (90.9%) and students (96.2%) have admitted that their educational institution (University of Konstanz) has opportunities for introducing e-learning (figure 5).

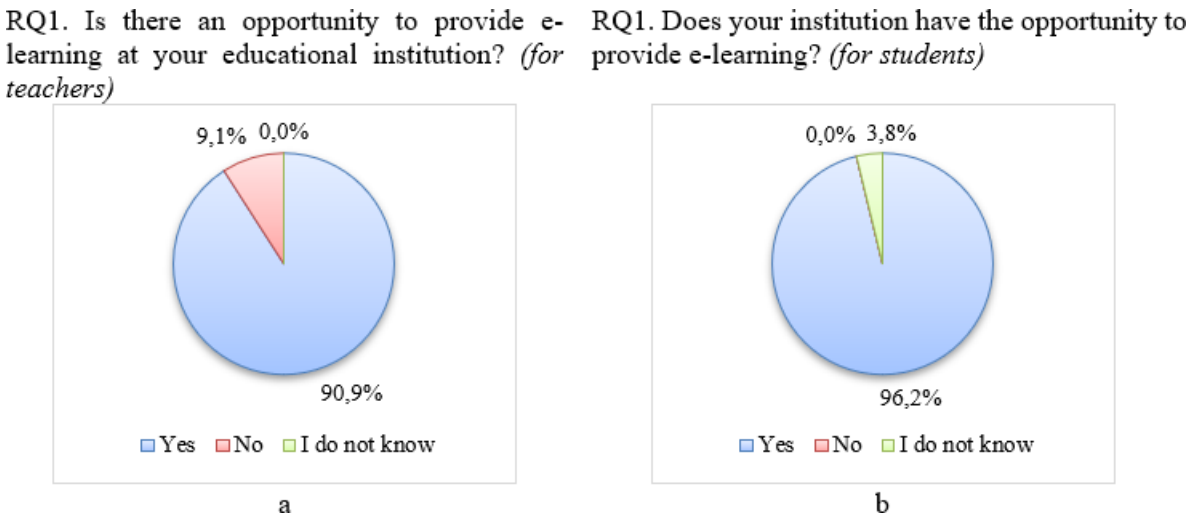

Figure 5. Teacher (a) and student (b) opinions on accessibility of e-learning at their educational institution.

The majority of teachers (72.7%) have noted that they used e-learning tools in the educational process, and 18.2% partially used them. Instead, 48 percent of students have indicated that teachers partially used e-learning tools, and 44% of students indicated that teachers mostly used e-learning tools (figure 6).

Both the vast majority of teachers (90% respondents) and students (88.5% respondents) prefer blended learning to traditional or electronic learning (figure 7).

Based on the answers to the question RQ4 (figure 8), 81.8% of teachers and 61.5% of students used more than 50% of their time for e-learning. So, we can conclude that many teachers need a lot of time to work with electronic learning tools.

The vast majority of teachers (72.7%) and all students (100%) note that ILIAS is most often used as a distance learning platform (table 4).

ILIAS is the main educational platform of the University of Konstanz. Electronic educational documents from all departments and other institutions of the university are available here. The access to certain courses is free, and it is possible to have the access for members of the University of Konstanz after logging in. The hosting and support of ILIAS are provided

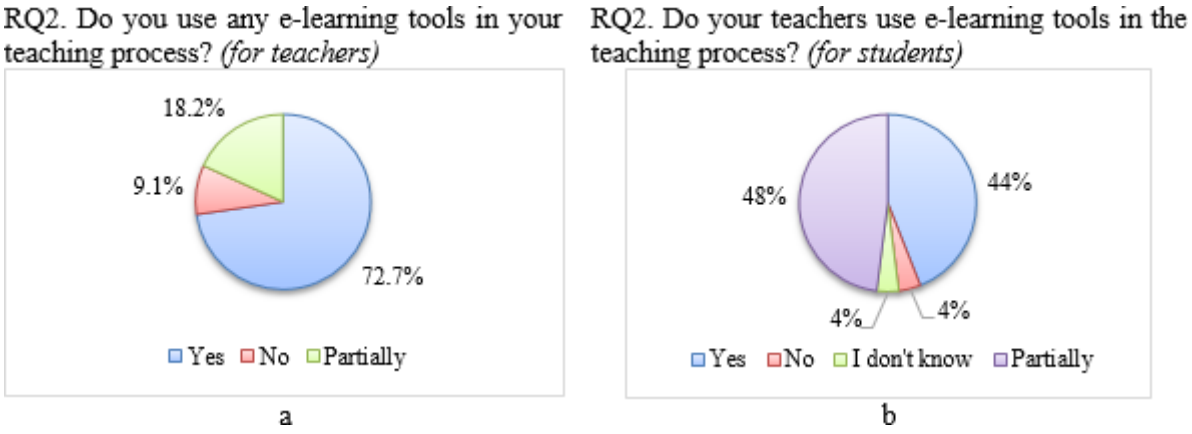

Figure 6. Application of e-learning tools by teachers in the teaching process: teacher (a) and student (b) opinions.

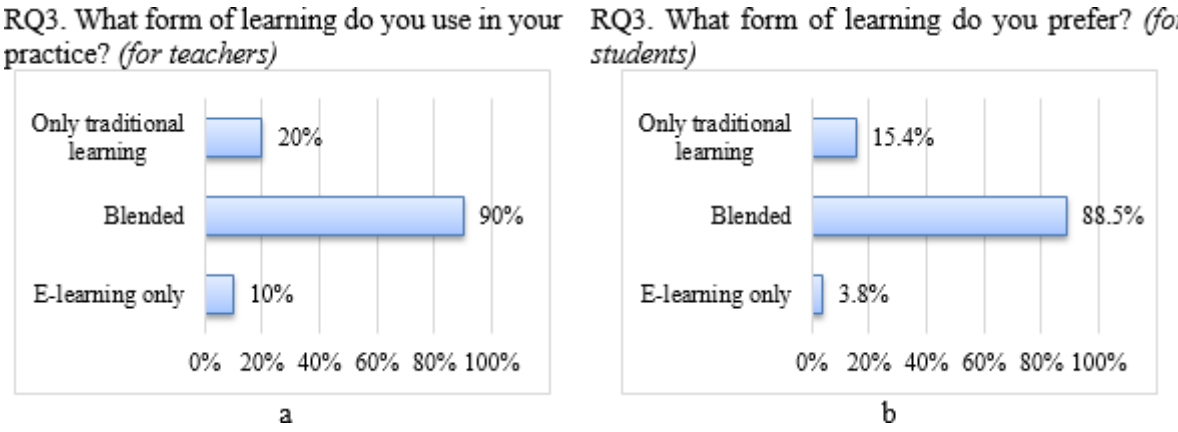

Figure 7. Information about the most used (a) / preferable (b) form of training.

Table 4. The most used e-learning platforms.

Questions	Answers
RQ5. Which e-learning platforms do you prefer? (for teachers)	ILIAS (72.7%), Moodle (9.1%), Mahara (9.1%), Twitch and Discord (9.1%), None (9.1%)
RQ5. Which e-learning platforms are used at your educational institution? (for students)	ILIAS (100%), Moodle (7.7%), D2L (3.8%), Articulate 360° (3.8%), Kahoot (3.8%), I do not know (3.8%)

by the Communication, Information, Media Centre. In addition, this centre offers a separate environment for ILIAS exams. This means that two different types of online written exams or a combination of both (home exam and online exam) are available.

In the ILIAS exercise module, students can take exams at home using the Download-Work-Upload model, where they download the exam task file, then they work offline and finally re-upload the answer sheet. This type of exam is particularly suitable if students have to write

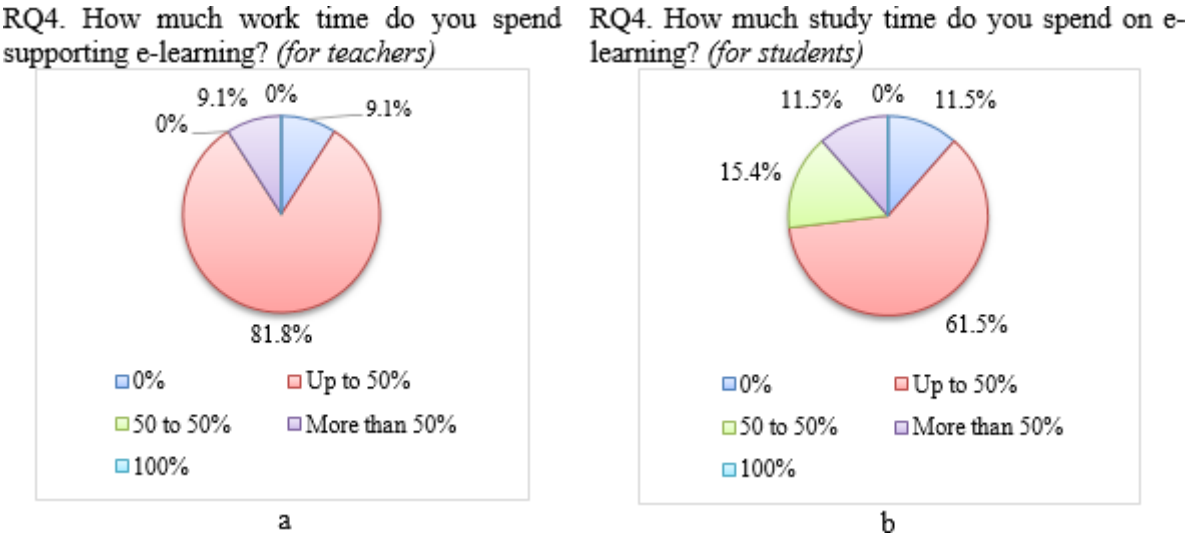

Figure 8. Time spent on e-learning by teachers (a) and students (b).

longer texts. Its advantage is that this type of exam places lower demands on students' technical equipment (such as the Internet connection), since they do not need to be online during the entire exam. The disadvantage is that autocorrection of single or multiple choice questions is not possible.

Online exams can be taken in the ILIAS test module, in which students must be online in ILIAS during the exam and enter their answers directly into ILIAS (e.g. single-choice, multiple-choice, assignment questions, open-ended questions). This type of test is particularly suitable for automatic testing. It is not suitable for longer texts (essays, numerous open-ended questions, etc.). It is not possible to comment on texts or upload corrections for further examination reviews with this type of exam. The disadvantage of this type of exam is that this form of the exam places high demands on the technical equipment of the students (for example, the Internet connection), since they must be online during the entire exam. The advantage is the possible automatic correction of questions with one or more answer options.

Answering the question "Which e-learning tools do teachers prefer?", 36% of respondents answered None, 27% of respondents have difficulties with the answer, 27% of respondents use Articulate 360, 9% of respondents use Mentimeter, Learningapps, Oncoo (figure 9).

The vast majority of teachers (83.3%) note that they use other e-learning tools in their professional activities. Almost the same percentage of students indicate that teachers do not use (46.2%) or use (42.3%) other e-learning tools (figure 10), except for those indicated above in table 4.

The results of the answers of teachers and students regarding which e-learning tools are used in the educational process in addition to the mentioned above are presented in table **??**. From their analysis, it becomes clear that teachers and students agree that they most often use electronic correspondence and teamwork services.

Figure 11 presents the results of the survey of teachers about what has helped them master e-learning tools. All the teachers (100%) claim that they independently have mastered e-learning tools, 82% have mastered e-learning tools with the advice of colleagues, 46% have mastered e-learning on special courses at the educational institution where they work, 19% have learned it during participation in conferences and seminars, 9% – during university studies, 9% – during courses and trainings of the pedagogical society.

The vast majority of interviewed teachers (72.7%) have a positive attitude towards e-learning,

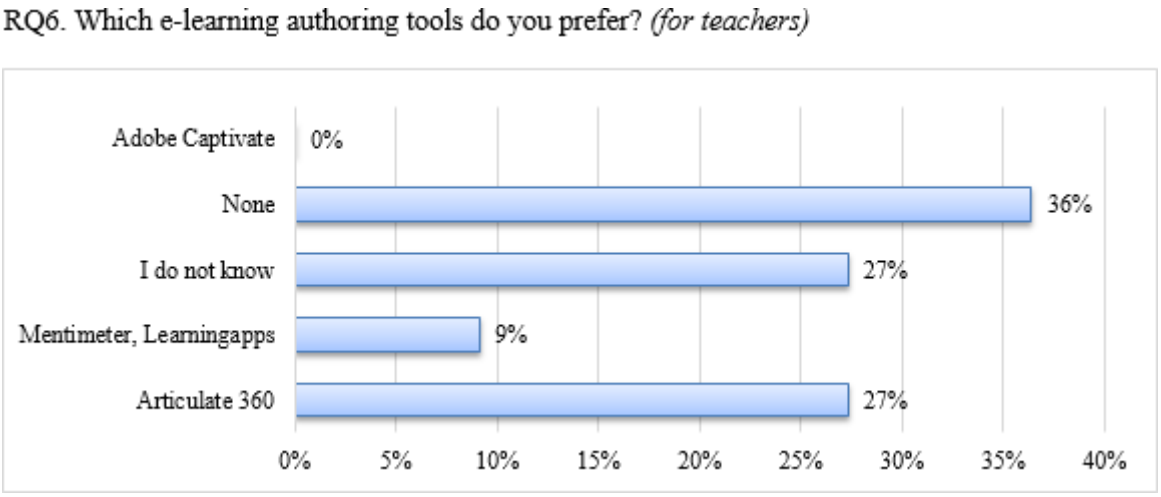

Figure 9. Additional e-learning tools which teachers prefer.

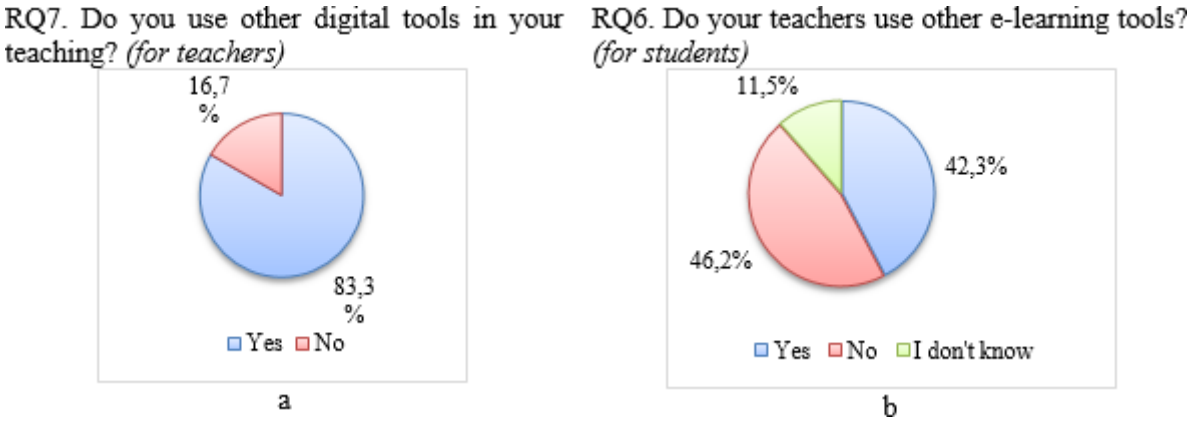

Figure 10. Details of other digital tools used by teachers (a) and students (b) in e-learning.

Table 5. The most used e-learning platforms.

Questions	Answers
RQ8. Which of the following do you use in e-learning? (for teachers)	Email (72.7%), Teamwork services (online boards, online documents) (54.5%), Video Hosting (YouTube) (45.5%), Learning websites (36.4%), Virtual reality (9.1%), Social networks (Facebook, Instagram, TikTok) (9.1%), Messengers (WhatsApp, Skype) (9.1%), Forum (9.1%), ILIAS Forum (9.1%), VEO (9.1%)
RQ7. Which of the following do your teachers most often use in e-learning? (for students)	Email (64%), Teamwork services (online boards, online documents) (44%), Video Hosting (YouTube) (40%), Learning websites (32%), Microblogging (Twitter, Tumblr, Tencent Weibo) (4%), Messengers (WhatsApp, Skype) (4%), Discord (4%), I do not know (4%), None (4%)

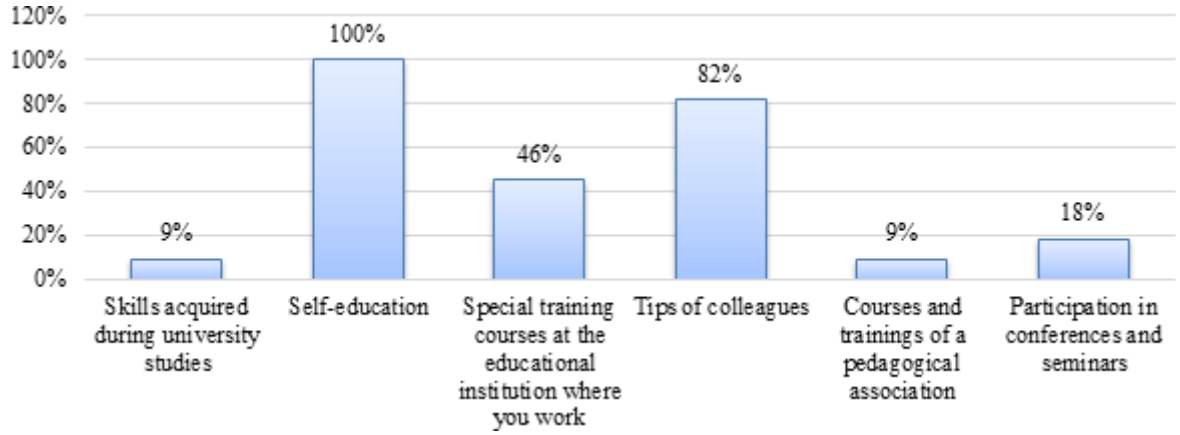

Figure 11. Ways of mastering e-learning tools by teachers Both teachers and students were asked a clear question about their attitude to e-learning.

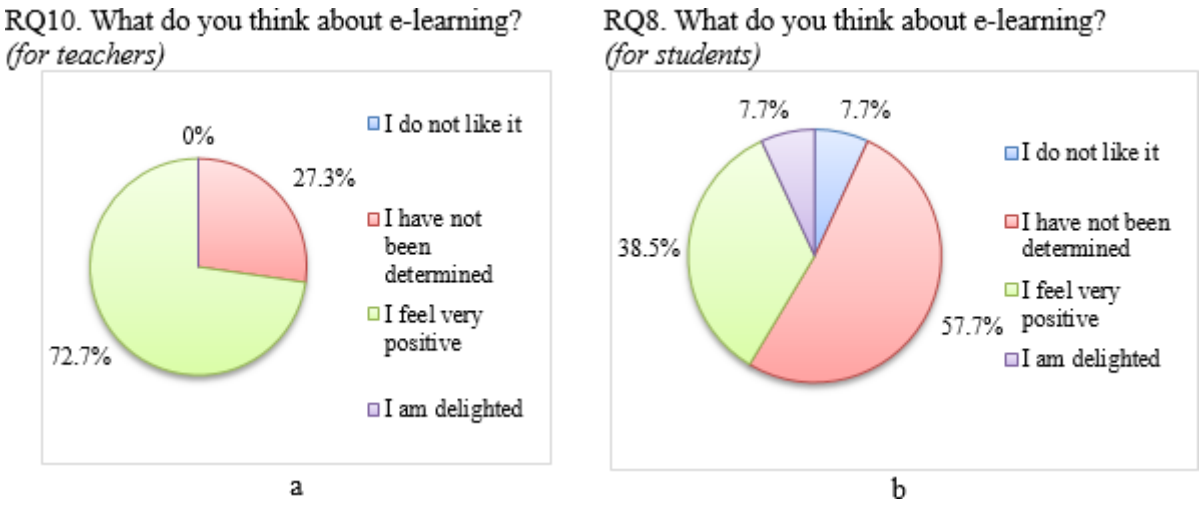

Figure 12. Teacher (a) and student (b) opinions on e-learning.

and a significant percentage of them (27.3%) have not yet decided on their attitude regarding e-learning. Among the surveyed students, slightly more than half (57.7%) have been undecided about their attitude to e-learning, while 38.5% of students have a very positive attitude towards it. Therefore, e-learning is not as successful for students as for teachers (figure 12).

Thus, with the help of the survey and the study of electronic resources at the University of Konstanz, we have studied the practical aspects of the use of various electronic learning tools used by teachers and offered to students during their studies. Based on the analysis of the scientific papers of German scientists, we understand the importance of the attitude and motivation of the subjects of the educational process (teachers and students) to e-learning for the implementation of a successful educational process. Therefore, with the help of the survey we have also analyzed how teachers and students of the German higher education institution perceive e-learning. In general, it is possible to state the positive attitude on the part of teachers and uncertainty on the part of students.

4. Conclusions

As the result of the analysis of scientific publications on the subject of e-learning in higher education in Germany for the last 10 years, it has been concluded that the relevance of the problem of the introduction of e-learning tools decreased from 2013 to 2019, but we observe the small increase in interest in 2019-2020 and fading again in 2021-2022. The content analysis of the scientific articles found by the search queries has been aimed at finding out which e-learning tools are used at higher institutions in Germany. Virtual technologies, massive open online courses (MOOCs), mobile applications, multimedia technologies, learning management systems and platforms, online courses, online (virtual) laboratories and simulations have turned out to be the most used e-learning tools. It has been also concluded that German scientists indicate the positive attitude towards the implementation of various e-learning tools, while noting that their implementation should be appropriate and justified, as well as based on the experience of using information and communication technologies by teachers and students, take into account students' motivation and access to information technologies.

In addition to the theoretical and content analysis of the experience of using e-learning tools in higher education in Germany, the survey of students and teachers of the University of Konstanz has been conducted regarding the use of e-learning tools in the educational process and their attitude to e-learning. Despite the fact that the results of the analysis of the scientific works of German scientists show a drop in interest in the problems of e-learning in Germany and a slight rise during the coronavirus pandemic, the results of the survey indicate an unequivocal interest in the means of e-learning of teachers and the uncertainty of students on this issue. Also, the analysis of resources and the information and technical support system of the University of Konstanz testifies the availability of modern technical equipment, information services and structures to support e-learning at the university.

The conducted research has some limitations: 1) as a result of the search in scientific databases by the selected keywords, some important scientific studies might have been missed; 2) the survey conducted at the University of Konstanz was voluntary and did not cover a sufficient number of respondents, being limited to teachers and students of one university. Therefore, in further studies, it is advisable to expand the geography of research.

Acknowledgments

Funded by the Federal Ministry of Education and Research (BMBF) and the Baden-Württemberg Ministry of Science as part of the Excellence Strategy of the German Federal and State Governments.

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