Article

Influence of COVID-19 Pandemic on Dissemination of Innovative E-Learning Tools in Higher Education in Poland

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Abstract: The paper presents the results of the research on the influence of the COVID-19 pandemic on the dissemination of innovative e-learning tools in higher education. Research was carried out in Poland in December 2021 on a sample of 621 students. The main issue that was the subject of the author's analysis was the influence of the COVID-19 pandemic on the change in the use of innovative e-learning tools in university education. After conducting the research and discussing this and related research about e-learning during the pandemic, it was concluded that the percentage of students familiar with the analyzed e-learning tools has increased significantly during the pandemic. There has been a visible rise, especially in the usage of the following tools: MS Teams, Zoom, and Google Classroom. The most frequently used e-learning tools during the COVID-19 pandemic have been mainly videoconferencing tools such as MS Teams and Zoom. However, students also have used e-learning platforms and e-mails. The author's research identified three hidden factors (categories) of the used e-learning tools. They include the following categories: popular services and applications adapted to e-learning; popular applications for synchronous meetings adapted to e-learning; and other synchronous and asynchronous e-learning methods. The familiarity with information technology, as well as an interest in innovative e-learning tools, have positive influence on the ease of acquiring content in e-learning. Having the proper resources also positively influences the absorption of e-learning content. On the basis of the achieved results, the authors prepared a model of relations between students' interest in innovative e-learning technology and the resources they possess to participate in e-learning classes. This model enables us to assess which method—e-learning, traditional or hybrid—should be used in the given situation. The developed model can be useful for universities. They can assess the students' interest in innovative e-learning technologies and their level of technical resources using questionnaires and on this basis divide students into groups to prepare the optimal learning way—e-learning, traditional or hybrid.

Keywords: innovation; COVID-19 pandemic; e-learning; traditional education; synchronic education; innovative education

1. Introduction

The COVID-19 pandemic outbreak has resulted in different changes for mankind in many spheres. In the latest literature from 2020 to 2022, the authors discuss and analyze the world economic [1–3], social [4,5], psychological [6,7], demographic [8], market [9] and many more consequences of the pandemic. There is also an opinion that the effects of lockdowns caused by the pandemic will be more severe than those of the times of the Great Depression [10]. The pandemic has also had an enormous influence on education. Out-of-the-blue educational institutions around the world have had to face teaching according to the provided restrictions that were assumed to prevent the spread of the COVID-19 disease. Most of these institutions were not prepared for huge changes in the way and method of teaching. Despite the fact that e-learning tools were available long before the pandemic [11], learning institutions have mostly used traditional ways to provide knowledge to students.

E-learning tools were not used on a large scale before the COVID-19 pandemic [12,13]. The outbreak of the pandemic forced education to undergo major changes in teaching.

It should be highlighted that the youngest generation of students often has problems with focusing for a longer time during lectures which are given in a traditional way (oral presentations or blackboards). For this reason, education should also strive to use modern technologies and apply them to teaching and thus involve students in lectures [14]. Currently, many articles describe the usage of innovative technology for teaching purposes. Mobile education and fragmentation of education become new trends. Popular new research domains include, for example, artificial intelligence [15], virtual reality [14,16], augmented reality [17,18], and many more. Naturally, the use of remote work methods [19–21] and digital tools [22–25] is observed not only in education, but also in different work areas.

Based on analysis of the literature [19–21,26–40], the authors have found the research gap in the case of the influence of the COVID-19 pandemic on the use of innovative e-learning tools in high education. The main problem that was analyzed in the paper was the influence of the COVID-19 pandemic on the change in the usage of innovative e-learning tools in university education.

In our research, we have stated the following goals:

- G1: to assess the increase in familiarity with innovative e-learning tools due to forced remote education (due to the COVID-19 pandemic);
- G2: to assess the level of use of remote working tools in higher education;
- G3: to compare the ease with which students learn content in traditional and remote education;
- G4: to investigate the relationship between the level of familiarity with innovative technologies and the use of remote working tools;
- G5: to build the model of using innovative technologies among students.
- To realize these goals, we formulated the scientific hypotheses. On the basis of goal 1, we prepared hypothesis H1. Hypotheses H2 to H4 were prepared on the basis of goal 4. The process of formulating the hypotheses was also supported by the literature review. The hypotheses are as follows:
- H1: Due to forced remote education (due to the COVID-19 pandemic), there has been an increase in knowledge of innovative educational tools;
- H2: Familiarity with information technology has a positive impact on learning through e-learning;
- H3: Interest in innovative e-learning technologies positively influences the learning experience through e-learning;
- H4: The resources required for participation in e-learning positively influence e-learning.

The value of the study is connected with the analysis of the factor influencing the effectiveness of the usage of innovative e-learning tools. On the basis of the analysis, we prepared a model which can be useful for universities to analyze what educational approach will be best suited for them—e-learning, traditional or hybrid. The model of using innovative e-learning tools for a group of students was prepared on the basis of correlational analysis, which is the main contribution of the paper. The analysis on the student's preferences regarding e-learning and traditional learning can be used to assess the usage of e-learning tools and as a basis for improving the effectiveness of innovative e-learning tools use.

2. Literature Review

As far as nine years ago, scientists were looking for new methods to transfer knowledge and teach practical skills [41]. Universities were searching for solutions that were believed to revolutionize higher education. Thanks to smartphones, immersive gaming software, and other rapidly evolving technologies, the learning process could become more effective, available, and progressive than the traditional one. In the article published 14 years ago [42], it was claimed then that virtual schools were increasing in popularity and presence. However, the authors noted that at that time there was a relative lack of research related

to teaching and learning in virtual schools. They analyzed the Michigan Virtual School (MVS). Currently, it can still be confirmed that there is not enough research, and thus practice, on online, virtual, and remote teaching methods. The pandemic has shown that many universities were not prepared to successfully transition from traditional learning to e-learning [34,43,44]. On the other hand, the authors of [45] indicated that although the online teaching experience was unplanned and had a high potential for anxiety and resistance, positive emotions were higher than negative ones. It is also worth noting that the sense of emergency of the COVID-19 outbreak forced lecturers to take on the task of continuing to teach and maintaining routine, for their own benefit and in the service of their students [46]. According to the author of [47], such a change in education would probably have raised more resistance in regular times and evoked more negative emotions.

The COVID-19 pandemic has changed the rules of modern education. Many universities, for example [35,36,48,49], due to pandemic conditions, have started to use and spread a new, innovative e-learning approach to the education process. It has completely changed the conditions of modern education and may have long-lasting effects on the possibility and use of innovative solutions in modern high education [50].

The first economist to draw attention to the importance of innovation was Joseph Schumpter [51]. He distinguished five types of innovation, which include the following [52]:

- Introduction of a new product or a qualitative change in an existing product;
- Process innovation new to an industry;
- The opening of a new market;
- Development of new sources of apply for raw materials or other inputs;
- Changes in industrial organization;
- Innovation is any new or substantially improved [53]:
- Good or service which has been commercialized;
- Process used for the commercial production of goods and services.

Innovation in product is the introduction of a new or significantly improved good or service on the market, while innovation in process is the implementation of a new or significantly improved production process, distribution method, or support activity for goods or services [53].

The innovative solutions are used in many areas of business activities today. Especially important among them is open innovation. This solution can be used for example to analyze the cryptocurrency market [54–56]. The increase in organizations where technological activity is dominant should lead to the development of a new technological solution and its use [57]. Currently, innovation is the basis for business development. There is research on new models of open innovation for businesses [58–62], especially for digital companies [63], which are an achievable direction in Industry 4.0 [64]. Business models have also recently been a subject for research related to the pandemic; for example, they refer to the COVID-19 crisis [65], mobile market during COVID-19 [13], COVID-19 transformation of an urban public transport system [66], management after COVID-19 [67], and identification of digital transformation paths in the business model of SMEs during the COVID-19 pandemic [68,69]. When it comes to Industry 4.0 and innovations, many scientists are carrying out studies on the competitiveness and effectiveness of an open business model in Industry 4.0 [70–74], enhancing creative intensity and profit on the open-source digital platforms [75,76], evolution of technology [77,78], expanding technology acceptance [79], and many more topics—also referring to responsible research and innovation [80]. Open innovation in education has also been the preferred field of research in recent years [81–83]. In addition, open innovations are widespread nowadays [84–88]. Many of the innovative e-learning tools described in the paper can be seen as open innovations which can be used for free in education activities [89,90].

The innovation in the education system should be a vital part of improving university efficiency in the current century. The implementation of innovative tools in universities can bring many benefits to students and can help the university to produce knowledgeable and skilled students to fulfil existing and future needs on the job market [91]. Accord-

ing to researchers [92,93], the innovation should make a desirable and valuable change. This educational innovation should be able to improve the current situation. Mykhailyshyn [94] defined the term innovation in education as educational, scientific, social, technological, administrative and other innovation. In this paper, the authors concentrated on the technological innovations in education. According to Mykhailyshin, technological innovation in education is the result of intellectual property transfer into implementation and applications [94].

Nowadays in education, technology is the main driver for innovation [95–97]. According to Serdyukov [98], innovation in education is not merely connected with adopting the latest technology. The usage of new technology in education should concentrate on the facilitation of the learning process to save time and resources compared to the traditional way of learning [99,100].

Innovative teaching should incorporate technology into learning activities to create a new and rich learning experience for students [30,31]. This, according to Khairnar, can lead to increased effectiveness of teaching processes [29]. Nowadays, the changing education condition and the globalization of education lead to the implementation of many innovative solutions because educators are required to have the ability to adapt to technological changes and solve complex problems [32].

One of the innovative teaching methods described in the literature is the usage of multimedia tools in education. The usage of various digital media, such as audio, images and video, can be an effective approach to knowledge transfer [33]. Innovative e-learning tool can be defined as an innovative technological solution—mainly a computer application that can be used in e-learning and can add new value to the learning process. In this division, the tool is a part of the method. An innovative learning method is e-learning, and the tool is a part of it.

E-learning, as an innovative method in education, was implemented largely because of the increased access to the Internet [101]. As schools explore online learning, new and more effective e-learning models are being proposed. Online learning tools are being developed and practiced in an innovative way. According to [102] the most effective e-learning models have a well-balanced combination of synchronous and asynchronous sessions. They provide more desirable ways to learn. Instead of teaching online all the time, it is recommended to conduct inquiry-based learning. This means that students receive instructions from online resources or synchronous meetings. Then they conduct an inquiry, create products (individually or in small groups), and make presentations in class synchronous meetings. Instead of just lecturing, teachers can create videos of lectures or find videos made by others and share them. The fundamental point is that there is minimal benefit and student engagement with teachers giving long lectures all the time—more interesting and challenging instructional models can be developed.

In the literature, many benefits of e-learning can be found. They include the following [27,28,103]:

- The use of the multimedia material;
- No need for visiting the university every day;
- The possibility of joint communication with other course takers;
- Elimination of anxiety which can be created by the prospect of oral expression in public situations;
- More convenient deadlines for task completion using e-learning platforms;
- Reduction in anxiety which can be created by face-to-face contact between students and lecturers.

3. Methodology

Research on the use of innovative e-learning tools was carried out in Poland in December 2021 on a sample of 621 students at Polish universities. An internet questionnaire was used for the study. The survey was conducted using a Google questionnaire web form. The questionnaire was sent using social media pages of Polish technical universities students

on social networks, such as Facebook, where a link to the survey was posted. Google Forms offers survey administration, which means that despite the possibility of creating a form with questions, it allows to automatically collect data and save them to an MS Excel file. Therefore, the research used a quantitative data collection method. Subsequently, the collected data were subjected to statistical analysis. The study is descriptive; it describes the results of the conducted survey and of the statistical analysis, and also discusses them in the context of the results of other studies.

According to the calculator of the minimum research sample, for an unknown population size and the assumed statistical significance $\alpha = 0.05$, the sample is 386 students. The number of questionnaires obtained meets the conditions of the minimum research sample. In the questionnaire, a five-point Likert scale was used for all questions.

The authors prepared the list of the management faculties of technical universities in Poland. Subsequently, they found the students' forums of those faculties in Facebook. They uploaded links to the questionnaires in all those forums. Moreover, the authors uploaded links in each forum three times over a one-week interval. The sample (621 questionaries) was bigger than the calculated minimum sample that was calculated using the special calculator of the minimum sample. The first sample was 629 questionnaires; however, incompletely filled questionnaires were rejected.

To achieve the validity and reliability of results, Cronbach's alpha test was used for the questionnaire. The results of Cronbach's alpha test were higher than 0.9.

The questionnaire was based on the literature about tools used in e-learning. To prepare the questionnaire, papers from Scopus and Web of Science database were used [19,20,34–39,104]. On the basis of the analyzed papers, a list of the mainly used tools was prepared, and next, the pilot studies to check out the correctness and clarity of the questionnaire for students were conducted.

The first part of the survey was devoted to the knowledge and frequency of use of e-learning tools. The research included, among others, the following tools: e-learning platforms, MS Teams, Zoom, Facebook, Discord, Click Meeting, Google Classroom, Skype, YouTube, and e-mail. The next part concerned the usefulness of devices, such as laptops, desktop computers, tablets, and smartphones in e-learning. The respondents were then asked to determine the ease of acquiring the material for traditional classes and for e-learning activities.

The analysis of the papers connected with the e-learning widespread in university [26–29,39,40,101,103,104] give an insight that the knowledge of the student about information technology and the access to resources can have an impact on e-learning usage. However, those were only suppositions, and what is more, there was no paper with the proper correlation analysis about the relation between these factors and the effectiveness of e-learning usage. Additionally, because e-learning is an innovative solution, it was supposed that the interest of students in the usage of innovative e-learning technology could also affect the effectiveness of e-learning. Another group of questions referred to the knowledge of and access to appropriate technology. They consisted of the following aspects:

- Knowledge of information technology;
- Interest in innovative e-learning technologies;
- Access to the resources necessary to participate in e-learning.

The last two questions of the questionnaire were related to the innovation of e-learning and the possibility of the future use of it in higher education.

The STATISCICA-13.3 software was used to analyze the collected data.

The construction of the questionnaire is the limitation of the study. Other scholars could use different e-learning tools to conduct an analysis. Additionally, the tools that turned out to be the most used in Poland may turn out to be different for another country. This can then affect the results. Despite these notices, the analyzed e-learning tools are internationally applied and widespread in almost all developed countries.

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4. Results

4.1. E-Learning Tools

In the first stage of the analysis, it was decided to check what e-learning tools were known to the students surveyed before the COVID-19 pandemic and which are known today. The tools known before the pandemic are summarized in Figure 1, while the tools currently known are in Figure 2. The results are presented in the percentage value of the total number of respondents. Figure 3 summarizes the differences between the knowledge of a given tool before and at the present time of the COVID-19 pandemic.
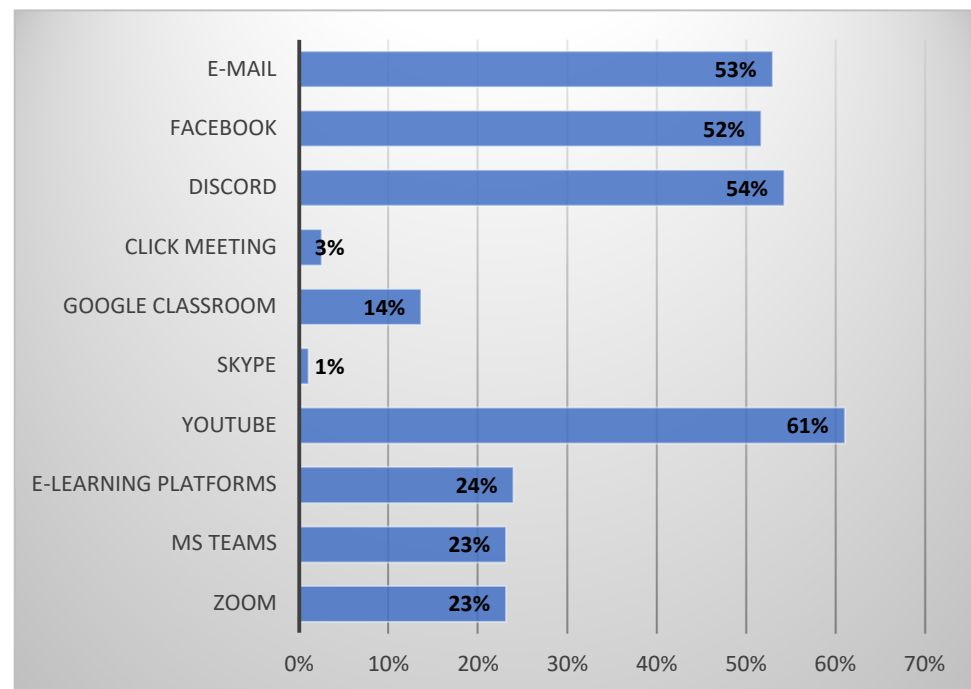

Figure 1. Percentage of students familiar with a given e-learning tool before the COVID-19 pandemic.
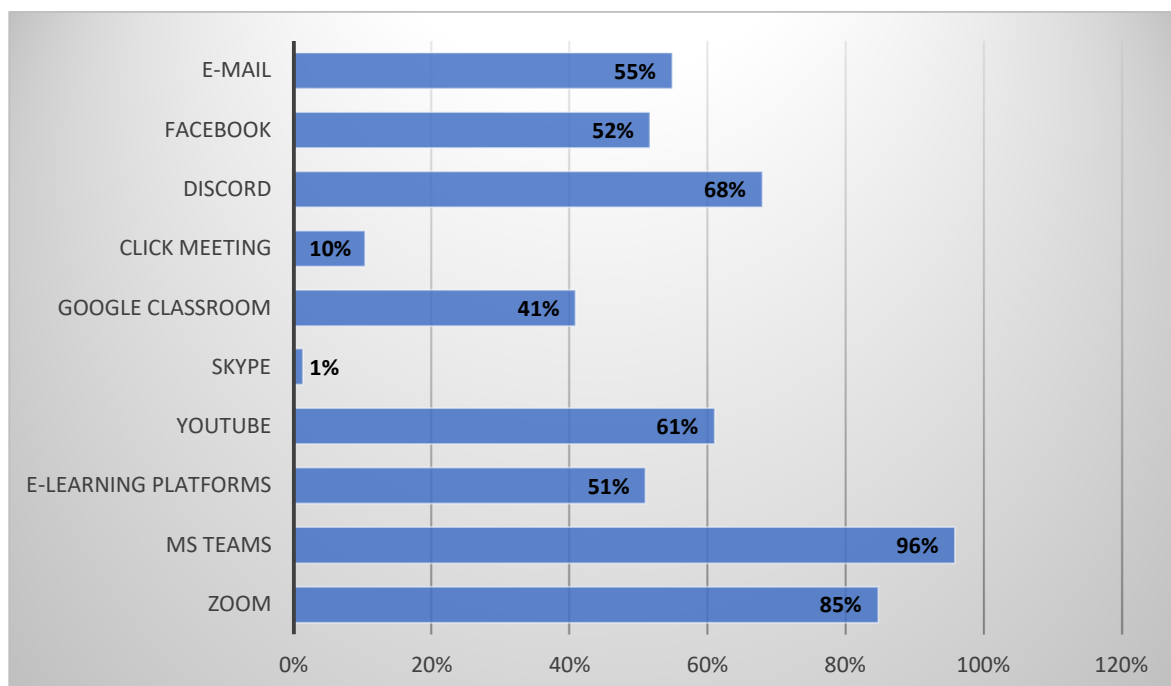

Figure 2. Percentage of students familiar with a given e-learning tool—currently.
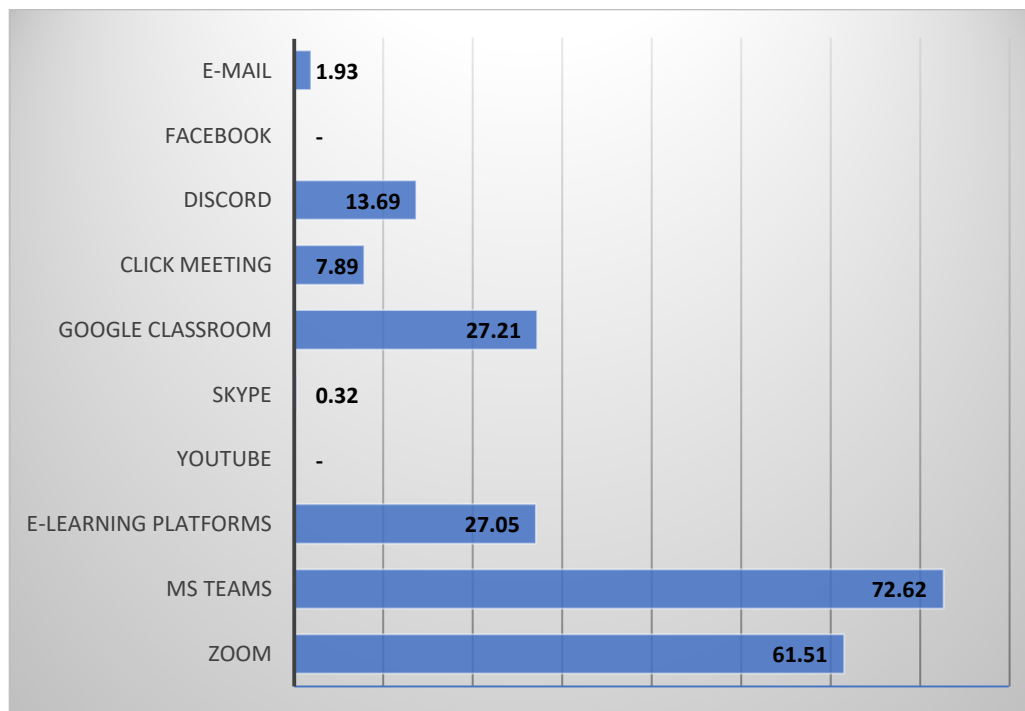
Figure 3. Increase in knowledge (in percentage points) about a given e-learning tool from the pre-pandemic period of COVID-19 to current days.

Based on the results, it was concluded that before the pandemic, students mainly had knowledge of services for transmitting/sharing content in the form of videos, photos, and other materials, as well as for communication. More than half of the respondents showed knowledge of using YouTube (61%), Discord (54%), e-mail (53%) and Facebook (52%) in e-learning. Innovative e-learning tools allowing for synchronous or asynchronous communication with students and conducting classes via the Internet were known to slightly more than 20% of students—this applies to tools such as Zoom, MS Teams and e-learning platforms used by universities.

The situation has changed due to the COVID-19 pandemic, which has forced universities to switch to distance learning. As a result, the knowledge of e-learning tools has increased significantly. Moreover, nowadays it is the innovative e-learning tools, especially those allowing for synchronous communication and conducting classical classes via the Internet, that are most known. Knowledge of MS Teams was indicated by 96% and Zoom by 85% of the respondents.

It is worth noting (Figure 3) that in the case of most of the tools examined, a significant increase in knowledge about them was observed due to the COVID-19 pandemic outbreak. The largest increases can be observed for the two most popular tools for synchronous communication: MS Teams increased by 73 percentage points and Zoom increased by 62 percentage points.

As a result of the pandemic, familiarity with Google classroom synchronous communication software also increased by 27 percentage points and e-learning platforms by 27 percentage points. An increase in familiarity with YouTube, Facebook, and Skype was not noted. In the case of email, the increase was only 2 percentage points.

The research results show that the COVID-19 pandemic has led to a greater knowledge of innovative e-learning programs, especially those used for synchronous and asynchronous communication. The results support hypothesis H1: thanks to forced remote education (due to the COVID-19 pandemic), there has been an increase in knowledge of innovative education tools.

The COVID-19 pandemic has marked a turning point in the development of the use of innovative e-learning technology. The tools that could have been used for this purpose

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already existed in the pre-pandemic times, but their prevalence, due to the conservatism of most universities and student habits, was low. The pandemic has greatly accelerated the spread of this type of innovative technology, which may have a positive impact on the possibilities and quality of using e-learning in higher education in the future.

In the next stage of research, it was decided to investigate which of the above-mentioned e-learning tools were used during the classes attended by the surveyed students. The results of the investigation are summarized in Figure 4. The answers were rated on a scale of 1–5, where 1 means that a given tool is used very rarely in e-learning, while 5 means it is used very often.
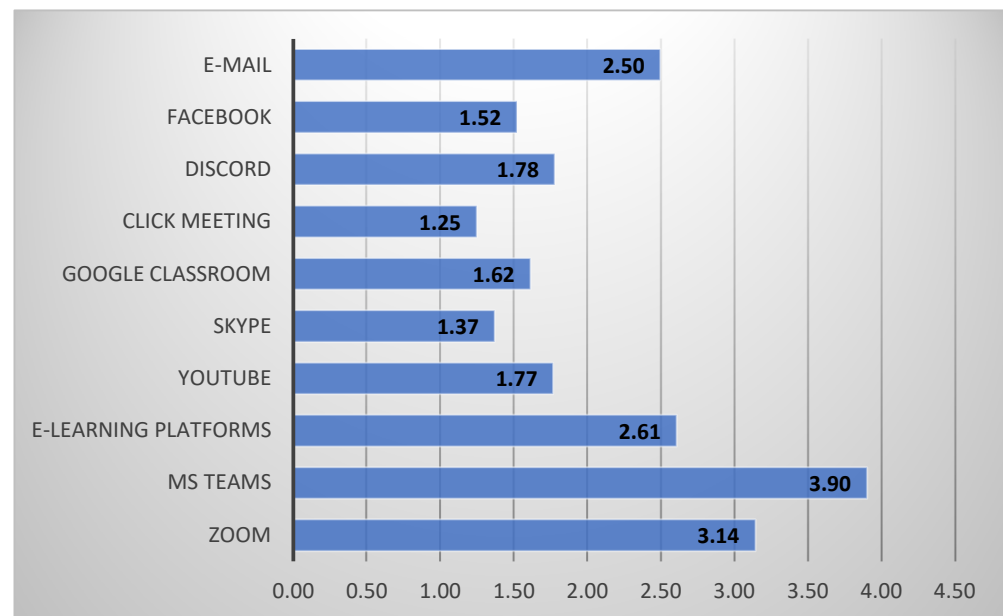

Figure 4. Assessment of the frequency of using e-learning tools during classes.

Research shows that the most frequently used e-learning tools during the COVID-19 pandemic have been communication platforms, mainly for videoconferencing. Such innovative e-learning tools enable full, synchronous conducting of classes (lectures, exercises, projects) via the Internet on similar principles as in the case of traditional classes. The highest number of respondents indicated the use of MS Teams (3.9 on a 5-point scale) during classes, while Zoom was in second place (3.14). Tools for the use of asynchronous learning methods, such as modern and innovative e-learning platforms (2.61) and the classic tool such as email (2.5), were also often used.

The other examined tools were used much less frequently—the score was below 2 on a five-point scale. They include communication applications, Discord (1.78) and Google Classroom (1.62); webinar platform, Click Meeting (1.62); the most popular social network, Facebook (1.52); and the Internet service, YouTube (1.77).

Confirmatory factor analysis was carried out for the studied e-learning tools in order to determine the factors that are related to the studied variables. Based on Cattell's scree plot, the number of factors was determined to be 3. Factor loadings were calculated for each factor and are summarized in Table 1. The factor analysis is a technique which can be used for the reduction of a large number of variables into fewer factors. The factors loading in the table were calculated using Statistica 13.3 software. We used the varimax standardized method with a single rotation of factor analysis. According to factor analysis methods, the particular variable belongs to the factor for which the factor loading has the highest value. The factors loadings should be higher to confirm that particular independent variables identified a priori are represented by a particular factor. The explained value provides information about the variation explained by the factor [105]. In the table, we bold the highest values for a particular variable to highlight to which factor the variable

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belongs. We used the name "category" for each factor because it is better adjusted to the meaning of the results.

Table 1. Factor loadings.

	Factor 1	Factor 2	Factor 3
Zoom	0.05	0.22	0.62
MS Teams	0.13	0.61	0.52
E-learning platforms	0.21	0.50	0.65
YouTube	0.73	0.14	0.00
Skype	0.58	0.14	0.04
Google Classroom	0.42	0.61	0.03
Click Meeting	0.28	0.31	0.18
Discord	0.52	0.22	0.26
Facebook	0.77	0.08	0.16
E-mail	−0.05	0.22	0.62
Explained value	2.37	1.35	1.21

Based on the confirmatory factor analysis, the following three factors (categories) were identified:

- Category 1—The factor explains 23% of the variance. The factor was called popular services and applications adapted to e-learning. It includes variables such as YouTube, Skype, Discord, and Facebook.
- Category 2—The factor explains 13.5% of the variance. The factor was called popular applications for synchronous meetings adapted to e-learning. It includes three variables: MS Teams, Click Meeting, and Google Classroom.
- Category 3—The factor explains 12.1% of the variance. The factor was called other synchronous and asynchronous e-learning tools. It includes three variables: Zoom, e-learning platforms, and email.

4.2. E-Learning General Assessment

In the next stage, it was planned to study the usefulness of the given devices used by the respondents for e-learning. A summary of the usefulness of the devices is presented in Figure 5. The evaluation was carried out on a five-point scale, where 1 means that the device is not useful in e-learning and 5 means that it is very useful.

Research shows that the most commonly used e-learning device is a laptop. Most of the respondents found it very useful in e-learning—the usefulness score was 4.75. A desktop computer turned out to also be a very useful device in this regard. Its usefulness in the field of e-learning was assessed slightly above the high level—4.29. The usefulness of other devices, such as tablets (3.18) and smartphones (3.35), was assessed at an average level.

Figure 6 presents a comparison of traditional and e-learning activities in teaching. Respondents were asked to rate the ease of content acquisition in the case of traditional and e-learning classes. Ratings were made on a scale of 1–5, where 1 means that the content is very difficult to digest, and 5 is very easy.
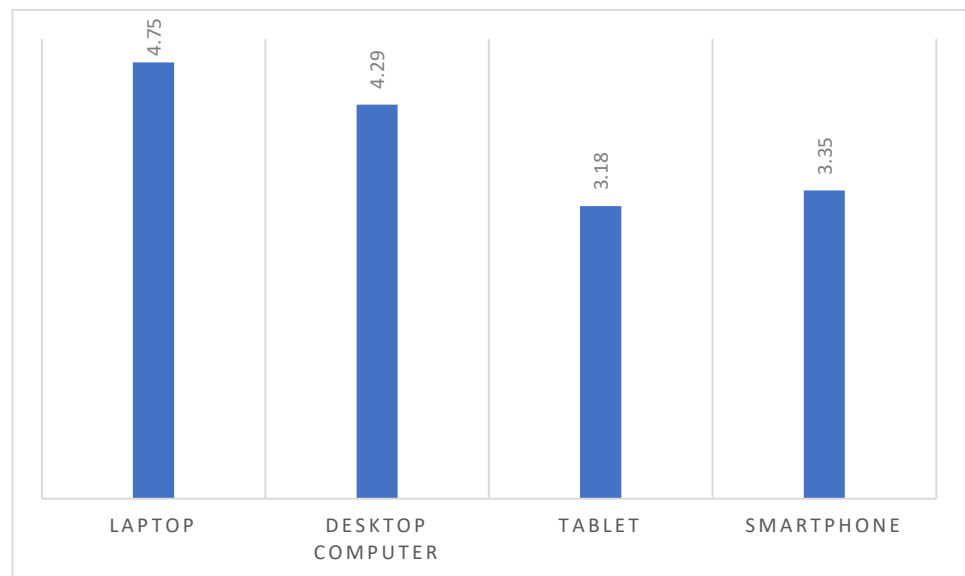
Figure 5. Assessment of the usefulness of the given devices used in e-learning.
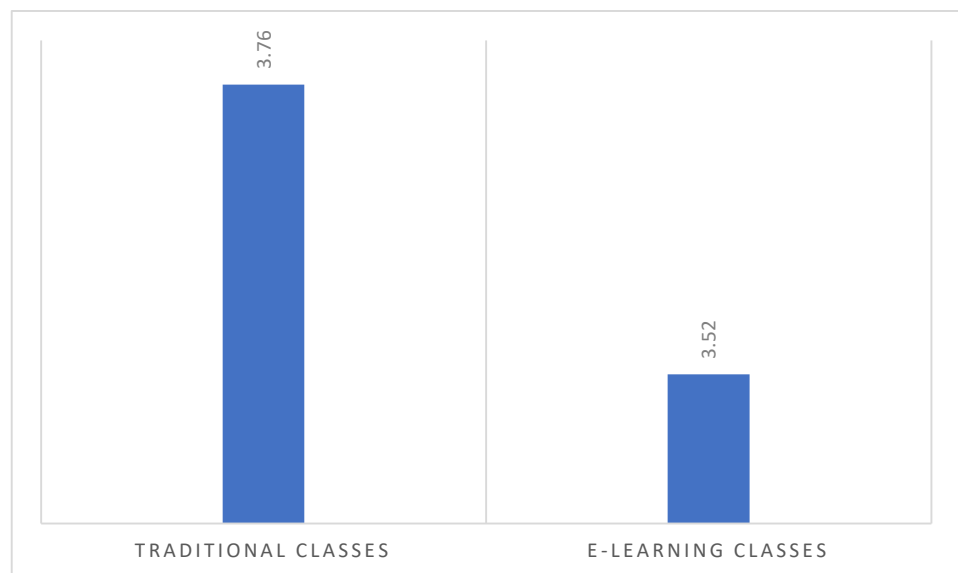

Figure 6. The ease of content acquisition in the case of traditional and e-learning classes.

The research shows that the respondents found that it was easier for them to acquire the content of classes conducted in a traditional way (score 3.76) compared to e-learning classes (3.52). It is worth noting that in the case of e-learning classes, a higher standard deviation (at the level of 1.23) compared to traditional classes (1.04) was observed. Histograms for the examined variables are presented in Figures 7 and 8.

The analysis of the histograms allows for interesting observations. In the case of traditional learning, the greatest number of respondents assessed the level of ease of learning content as "good", about 250 people, with slightly less as "very good" or "average", about 150 people. On the other hand, very few people rated the level of ease of content acquisition as "very bad", about 20 people, and "bad", about 50 people.

The situation is different when using innovative e-learning tools. In this case, a very large number of people (around 180) found e-learning "very easy" to learn. It is worth noting that this is a greater number of people than in the case of the evaluation of traditional education. In addition, many more people rated e-learning as "very difficult" to learn (about 40 people) or "difficult" to learn (about 100 people).

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The obtained results suggest that a higher rating of innovative e-learning tools may result from the personal ability of students to use them. The low rating of e-learning tools may be due to lower skills in using tools or lack of access to appropriate devices enabling trouble-free use of e-learning tools. For this reason, the authors decided to check whether the above-mentioned factors affect the assessment of the ease of use of e-learning. The results are presented in the further part of the publication.
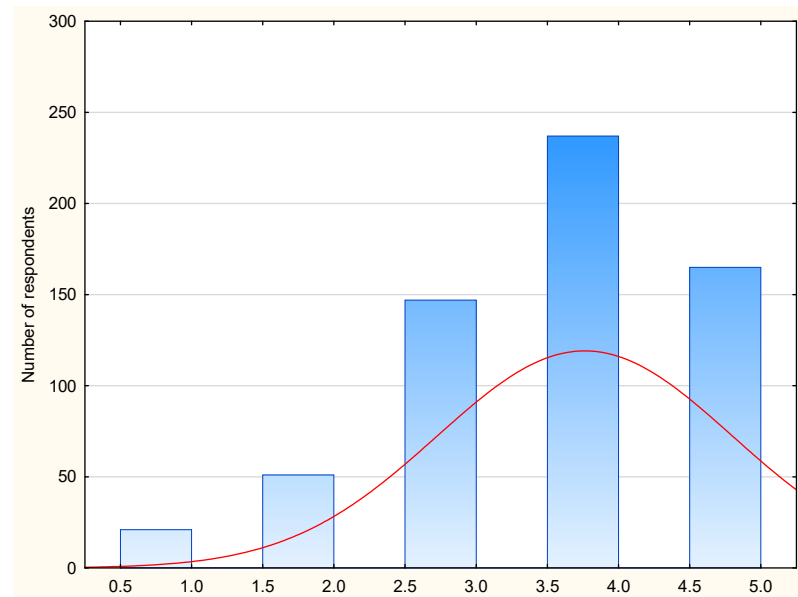

Figure 7. Histogram of the ease of class content acquisition from traditional learning.
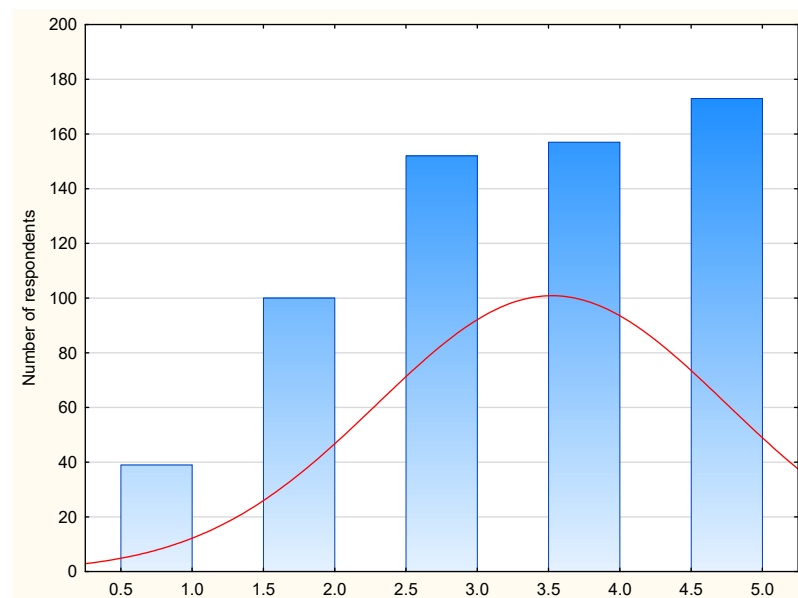

Figure 8. Histogram of the ease of class content acquisition from e-learning.

4.3. E-Learning in the Context of Technology Innovations

In the next part of the investigation, the responses to the assessment of familiarity, interest, and the possibility of using e-learning technologies are analyzed. In this case, the following variables were studied:

- Students' self-assessment of familiarity with information technologies;
- Students' interest in e-learning technologies;
- Assessment of the resources necessary to participate in e-learning activities.

Each of the variables was assessed on a scale of 1–5, where 1 meant a very low level and 5, very high. Figure 9 shows the results.
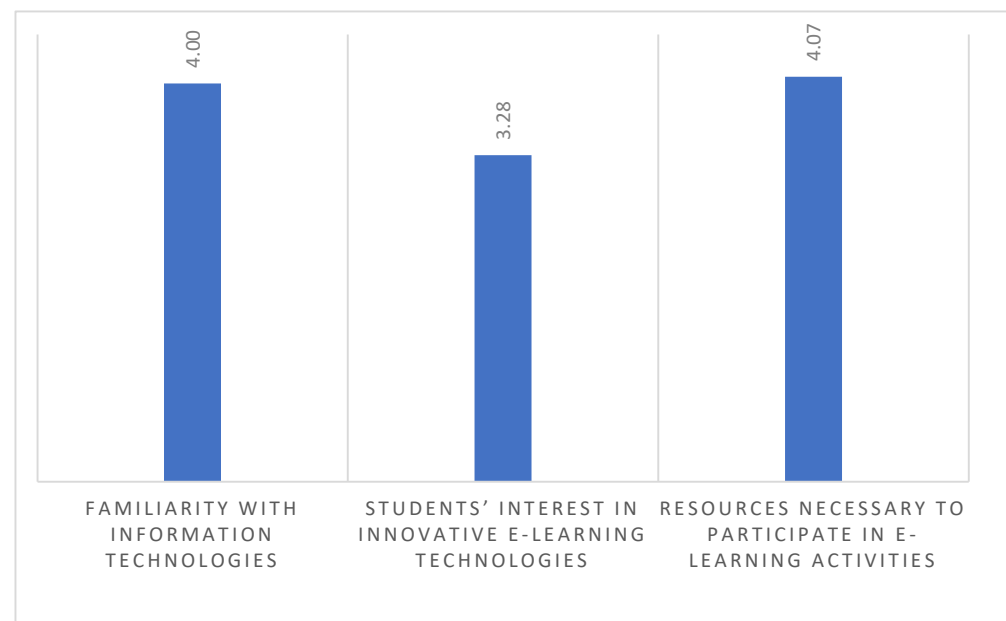

Figure 9. Assessment of familiarity, interest, and the possibility of using e-learning technologies.

Most of the respondents assessed their knowledge of information technology as "good" (4), also assessing the resources necessary to participate in e-learning as "good" (4.07). The interest in new e-learning technologies of the average respondent student is at the "average" level (3.28).

Spearman's rank correlation coefficient was used to analyze the relationship between technology variables and the ease of acquiring content using e-learning and traditional methods. The corresponding values of the coefficients are presented in Table 2. All correlations are statistically significant at the level of statistical significance $\alpha = 0.05$. The research shows that when assessing the ease of e-learning content acquisition, this ease is positively correlated with all the variables related to technology.

Table 2. Spearman's correlation between the ease of acquiring content and assessment of familiarity, interest, and the possibility of using e-learning technologies.

	E-Learning	Traditional Learning
Familiarity with information technologies	0.25	−0.14
Students' interest in innovative e-learning technologies	0.40	−0.24
Resources necessary to participate in e-learning activities	0.36	−0.12

The highest correlation coefficient (at the level of moderate correlation) occurs when interest in new technologies is indicated (correlation coefficient 0.4). People interested in new technologies more often positively assessed the effectiveness of e-learning because they have the appropriate skills and eagerly use innovative solutions. The results support hypothesis H3: interest in innovative e-learning technologies positively influences the learning experience through e-learning.

Having the resources necessary to participate in e-learning is also positively correlated with the assessment of the acquisition of e-learning content—a correlation coefficient of 0.36. It supports hypothesis H4: resources required for participation in e-learning positively influence e-learning. For the proper use of e-learning, one should have appropriate

resources (among others, equipment, programs, and access to high-speed Internet), without which the acquisition of the content may be difficult.

Additionally, familiarity with information technology is positively correlated with the ease of content acquisition using e-learning methods. This result supports hypothesis H2: familiarity with information technology has a positive impact on learning through e-learning.

It is also interesting to analyze the correlation between the assessment of the ease of acquiring material through traditional classes and individual variables related to technology. It turns out that in this case, all correlation coefficients are negative. This means the following:

- The greater the familiarity with information technology, the worse the assessment of traditional classes;
- The greater the interest in information technology, the worse the assessment of traditional classes;
- The better the students' access to the resources (necessary to participate in e-learning), the worse his/her assessment of traditional classes.

The data show that students interested in new technologies and who have the appropriate technical means positively assess e-learning and innovative teaching, while assessing traditional methods lowlier. It can be concluded that they "get bored" in traditional classes. They also believe that traditional classes do not allow them to fully use their skills and potential. They may also perceive that the classes are not fully adapted to the modern computerized world. In particular, based on variables related to the interest in new technologies and having the resources necessary to participate in e-learning, it is possible to present a model of the perception of e-learning and traditional learning by students. This model is shown in Figure 10.
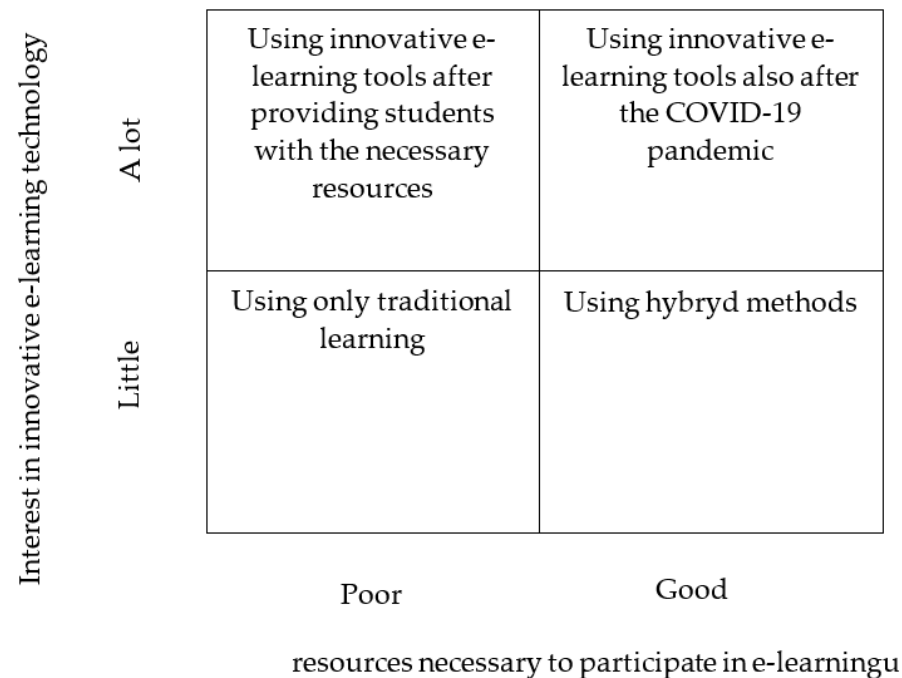
Figure 10. Model of using innovative e-learning tools for a group of students.

If a given group of students is interested in e-learning innovations and has adequate resources, it is recommended to continue to use e-learning tools after the COVID-19 pandemic is over. The transition to traditional methods is recommended to teach a group that does not show interest in new e-learning technologies and does not have the necessary resources. These traditional methods will be more effective and efficient. On the other hand, in the case of groups of students who are not interested in e-learning innovations, but have

the appropriate resources, e-learning can be used as part of a hybrid approach, combined with traditional teaching. On the other hand, when groups of students are interested in new Internet technologies but do not have adequate resources, universities should provide appropriate equipment that enables online learning.

Then, the respondents were asked to evaluate the innovation of their e-learning solutions and their use in the future. The results are shown in Figure 11. The students rated the innovation of the e-learning solutions used at a level between "average" and "good"—3.63 on a five-point scale. They assessed the possibility of future use of innovative e-learning as "good"—3.97. This means that the respondents assessed the solutions applied in Poland quite well. Furthermore, they were also interested in continuing the use of e-learning, even after the COVID-19 pandemic is over.
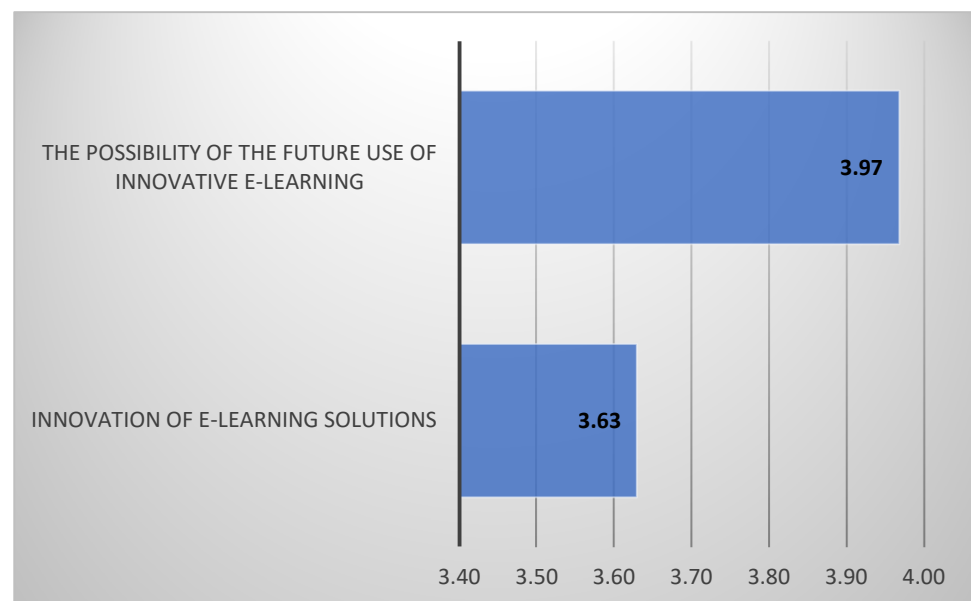

Figure 11. Innovation of e-learning solutions.

At this point, it is worth considering whether the variables discussed are correlated with the ease of acquiring content using e-learning and traditional methods. The relevant correlation coefficients are presented in Table 3—all coefficients are statistically significant at the level of statistical significance $\alpha = 0.05$.

Table 3. Spearman's correlation between the ease of acquiring content and the innovation of e-learning solutions.

	E-Learning	Traditional Learning
Innovation of e-learning solutions	0.32	−0.10
The possibility of the future use of innovative e-learning	0.58	−0.30

The research shows that students who claim that the e-learning content is easy to acquire assessed that the e-learning solutions used by their university are innovative—0.32. Students who easily acquired e-learning content declared their willingness to use innovative e-learning tools in their study practice in the future. In this case, the correlation coefficient was relatively high and amounted to 0.58. Students who easily learn and understand the content of e-learning were also more willing to use such methods in the future. However, the correlation coefficients are negative in the case of the study of students who easily acquire the content of traditional classes. This means the following:

- The worse a person perceives the innovation of e-learning, the more he/she prefers to use traditional classes;
- The easier a person acquires the material through traditional classes, the less often he/she wants to use e-learning in the future.

5. Discussion

This paper is mainly focused on the influence of the pandemic on the dissemination of innovative e-learning tools in higher education in Poland. However, in the literature, there are already discussed research works similar to the one in this article. The authors [35] discussed opportunities, quality factors and required changes during pandemics also in higher education but in Lithuania. The study aimed to map and test the factors that influence online learning success. They analyzed and presented factors that were the quality of institutions and services, the quality of infrastructure and system, the quality of courses and the information, and online learning environment. They used a similar method: survey, but also interviews. As a result, the authors provided the main criteria for successful education based on the administrative positions and design makers of educational organizations. It should be noted that the research presented the perspective of teachers and other knowledge providers, but not of students. This is the biggest difference between the research described in [35] and this article. It is worth adding that in conclusion, the authors refer to [37], which noted that new challenges associated with e-learning will create a space for innovative thinking and innovative solutions. In the study conducted by [38], a survey method was also used to assess online education. The research respondents were 96 students. This study examined the effectiveness of the online learning process. The results showed that the students were more interested in face-to-face learning than in online learning. The results are highly similar to ours because in our research, we also found that traditional classes are more effective and preferred by students. It is worth noting that the main obstacles faced by the students were Internet access and Internet quota. This was also confirmed in our research. On the other hand, the difference between their research and ours is the statistical part. Our research is based more on a deep analysis of correlation between the effectiveness of traditional and e-learning classes and other factors. Because of that, it can be pointed out that in some groups of students, for example, those familiar with information technology, the assessment of traditional classes can be lower. The ease of acquiring content using traditional approach decreases when students are keen on new technologies. We think that it is an interesting observation because with the prevalence of students that are more familiar with new mobile technology, for example, smartphones, from early stages of their lives, their level of acceptance for e-learning tools can increase.

Wijaya et al. [38] concluded that lecturers play an essential role in helping students learn online and that students need groups to share the impressions (e.g., happiness) of the learning process. Nevertheless, it was concluded that the readiness of lecturers and students for online learning needs to be improved with the support of learning technology devices. On the contrary, our research did not focus on aspects related to teachers, but more related to the learning tools and infrastructure themselves. However, it can be confirmed in both papers that technology devices have a great impact on the willingness to participate in e-learning.

This article is focused on education in general rather than teaching selected subjects. It can be considered as a limit in the research. In this case, it is worth conducting a more detailed and more specific survey in the context of the given subjects. However, such research can be found in the literature. The first example can be research on the e-learning of mathematics in higher education in Indonesia [36]. The authors conducted a qualitative case study, assisted by an online survey. The survey was aimed at lecturers who teach mathematics education study programs in Indonesia. The questions referred to the ability of platform mastery to support online learning. The study results revealed that all lecturers affected by the pandemic use a website based on a learning management system (LMS) as a means of online learning. The LMS was the most widely used (Google Class and

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Edmodo), while video conferencing was the second choice (Zoom and Skype). The results were slightly different from our results. In our results, Zoom was also very widespread, but Skype was rarely used by students. Another difference was connected with the rare usage of MS teams in the research of Irfan et al. [36]. In their research, it turned out that the LMS was less attractive to the lecturers. The study showed that there are obstacles in online teaching mathematics, which are limitations of writing mathematical symbols, limited basic capabilities of the learning management system, and multimedia software to support online learning. However, it should be stressed that this research was conducted from a teacher's point of view, not a student's point of view.

Similar research on one subject was conducted by [39]. The authors analyzed the effect of e-learning biology. The research was a quasi-experimental study with 76 biology education students. From the results, it was concluded that blended learning and project-based learning—two methods that were chosen for e-learning—were quite influential in increasing the creative thinking ability of pre-service biology teachers. Those methods appeared to be more effective than conventional methods in increasing creative thinking in biology learning. Those results were different from ours because our respondents claimed that traditional learning is more effective. However, the difference can be connected with the researched students. Their participants were from the field of biology, and ours were from the management faculty. It can be assumed that biology students have better knowledge about new technological solutions, and on the basis of our research, we know that this factor influences the results.

Another example of research on one subject teaching is a study conducted in higher education in Jordan [34]. One of the goals of the research was to explore how well online learning was carried out. Some teachers and students were asked to volunteer in this study. Participants were asked to provide written observations on their activities in the conduct of online language education. The results revealed that the e-learning was of poor quality. The reason for this was lack of experience, relevant policies, training, and planning. This study showed that teachers must first acquire the appropriate skills and knowledge to be able to offer learning for learning languages. It is different from our studies because in our study, the difference between traditional classes and e-learning effectiveness was only slight.

Comparing the results with those of other studies, it can be claimed that the evaluation of e-learning can vary considerably. For example, completely different results of teaching evaluation were also obtained in Jordan by [40]. This study evaluated the online teaching of architecture design. Study participants were randomly selected students. The results showed that online teaching during the pandemic had been carried out regularly in the form of synchronous meetings. Students were satisfied with online teaching in theoretical courses; however, they were less satisfied with the design and basic design courses. For example, they reported technical difficulties.

The evaluation of six courses taught at the degrees in civil engineering of three universities—two from Spain and one from Peru—was carried out in [26]. The authors discussed the results based on the comparison of the students' performance with the previous (before pandemics) and current (during pandemics) course. It was concluded that, although the shift to online learning had to be made from day to day, e-learning can be favorable and advantageous in some respects. However, the authors highlighted that some aspects, such as student engagement and motivation, are more difficult to maintain during online classes than during face-to-face learning. In our research, the evaluation of e-learning was good, as well as in the mentioned paper. However, it should be noted that our research did not refer to the motivation to study. This issue is very interesting and worth studying. Therefore, motivation in online learning will be considered by us for our future research. In the literature, there are already many studies on online learning motivation [106–109]. According to [106], people from different countries perceive online learning motivation differently, and some learner characteristics and cultural orientation affect the online learners' learning motivation. More detailed research were conducted by [107], in which cross-sectional survey results (n = 186) revealed that students who were motivated

by asynchronous online collaborative writing were more likely to enjoy online learning in general when compared to students who reported motivation for video-synchronous online speaking practice.

On the other hand, social networks have begun to play an important role in education. The authors of [104], however, highlighted that the sources of education content are highly important—it means the credibility of social media. Based on the opinions of secondary school teachers and students of the study (n = 111), the authors distinguished four currently possible (possible during a pandemic) and attractive forms of online education with the use of social media. The categories are collaborative education, active self-education, education using social networks, and education with an emphasis on relationship behavior. Simultaneously, students rated online lectures and courses within the YouTube channel, education with an emphasis on practical learning, project teaching, gathering information from educational institutions within the social network Facebook, and indoor experiential learning as the most attractive. Those results are in accordance with our research. Our results show also the increasing frequency of the usage of YouTube and Facebook in e-learning.

Due to the results, it can be agreed with experts [110] that social media and their technological possibilities appear to be valuable resources in helping people deal with the current, and also longer-term, difficulties raised by the pandemic. A positive opinion on social media in learning has also been expressed by other authors [111]. We also concluded on the basis of the conducted research that social media can play a positive role in e-learning, and the usage of them during the pandemic has been increasing. The authors claimed [110] that because of the closure of many educational institutions, the use of social media is expected to bring benefits to both teachers and students. However, they noticed that a valid and reliable instrument to measure the integration of technology for e-learning should be developed.

6. Conclusions and Recommendation for Future Research

The literature analysis and discussion can be concluded with the following:

- There is yet not much research on evaluating broadly e-learning in higher education;
- More of the reviewed research present online teaching assessment from the teacher's point of view rather than the students' point of view;
- Universities were not prepared for shifting into online teaching from day to day;
- Many articles prove that a common problem is the preparation of teachers for e-learning;
- Despite the development of innovative e-learning tools, it is the teacher who plays the main role in the learning process;
- Students are eager to learn online, while teaching staff is not yet necessarily ready for it;
- There is a lack of general guidelines for successful e-learning.

The main problem that was the subject of the authors' analysis was the influence of the COVID-19 pandemic on the change in the usage of innovative e-learning tools in university education. After conducting the research described in this article and discussing the research on the subject of e-learning during the pandemic, the following can be concluded:

- The percentage of students familiar with the analyzed e-learning tools has increased significantly during the pandemic. There has been a visible rise, especially in the usage of the following tools: MS Teams, Zoom, and Google Classroom. The achieved results support hypothesis H1;
- The most frequently used e-learning tools during the COVID-19 pandemic have been mainly videoconferencing tools, such as MS Teams and Zoom. However, students also have used e-learning platforms and e-mail;
- The author's research gave a possibility to identify three hidden factors (categories) of the used e-learning tools. They include the following categories: popular services and applications adapted to e-learning; popular applications for synchronous meetings adapted to e-learning and other synchronous and asynchronous e-learning methods;

- Students' familiarity with information technology has a positive influence on the ease of acquiring e-learning content. The results support hypothesis H2;
- Students' interest in innovative e-learning technologies has a positive influence on the ease of acquiring e-learning content. The results support hypothesis H3;
- Having the proper resources also positively influences the absorption of e-learning content. The results support hypothesis H4.

On the basis of the achieved results, the authors prepared a model of relations between students' interest in innovative e-learning technology and the resources that they possess to participate in e-learning classes. This model gives a possibility to assess what method—e-learning, traditional or hybrid—should be used in the given situation. Based on the results, it can be concluded that innovative e-learning tools are recommended to be applied when the given group of students has interest in innovative e-learning tools and the proper technical resources. The use of traditional learning is recommended in the opposite situation. The hybrid solution is best when students have proper resources but are not particularly interested in innovative e-learning technological solutions. The developed model can be useful for universities. They can assess the students' interest in innovative e-learning technologies and their level of technical resources using questionnaires and, on this basis, divide students into groups to prepare the optimal learning method—e-learning, traditional or hybrid.

The study described in the article stands out with considerably large research trials: 621 students took part in the survey research. Compared to other articles on this subject mentioned in this article, this paper showed some correlations between the pandemic and the use of innovative e-learning tools. The surveyed students assessed the innovation of applied e-learning solutions at a level between "average" and "good" and the possibility of using innovative e-learning as "good". Respondents assessed the use of applied e-learning tools at the Silesian University of Technology quite well. In addition, they were interested in the continuation of the use of e-learning after the end of the pandemic.

The future research should concentrate on the analysis of the e-learning tool usage after the pandemic. It is interesting to know if, after the pandemic, the widespread use of innovative e-learning tools will increase, continue on the same level, or decrease. Additionally, it is possible to conduct the research in other types of universities, not only technical ones. What is more, it could be interesting to conduct the research in other countries, for example, Visegrad Group countries, and compare results between particular countries.

Institutional Review Board Statement: According to our University Ethical Statement, following, the following shall be regarded as research requiring a favorable opinion from the Ethic Commission in the case of human research (based on document in polish: https://prawo.polsl.pl/Lists/Monitor/Attachments/7291/M.2021.501.Z.107.pdf (accessed on 21 March 2022): research in which persons with limited capacity to give informed or research on persons whose capacity to give informed or free consent to participate in research and who have a limited ability to refuse research before or during their implementation, in particular: children and adolescents under 12 years of age, persons with intellectual disabilities persons whose consent to participate in the research may not be fully voluntary prisoners, soldiers, police officers, employees of companies (when the survey is conducted at their workplace), persons who agree to participate in the research on the basis of false information about the purpose and course of the research (masking instruction, i.e., deception) or do not know at all that they are subjects (in so-called natural experiments); research in which persons particularly susceptible to psychological trauma and mental health disorders are to participate mental health, in particular: mentally ill persons, victims of disasters, war trauma, etc., patients receiving treatment for psychotic disorders, family members of terminally or chronically ill patients; research involving active interference with human behavior aimed at changing it research involving active intervention

in human behavior aimed at changing that behavior without direct intervention in the functioning of the brain, e.g., cognitive training, psychotherapy psychocorrection, etc. (this also applies if the intended intervention is intended to benefit (this also applies when the intended intervention is to benefit the subject (e.g., to improve his/her memory); research concerning controversial issues (e.g., abortion, in vitro fertilization, death penalty) or requiring particular delicacy and caution (e.g., concerning religious beliefs or attitudes towards minority groups) minority groups); research that is prolonged, tiring, physically or mentally exhausting. Our research is not done on people meeting the mentioned condition. Any of the researched people: any of them had limited capacity to be informed, any of them had been susceptible to psychological trauma and mental health disorders, the research did not concern the mentioned-above controversial issues, the research was not prolonged, tiring, physically or mentally exhausting.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

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