E-learning in the practice of teaching doctoral students

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Abstract: This article presents the teaching methods implemented in the course ‘Modern methods and techniques of teaching in higher education institutions’ for doctoral students of exact sciences in the Doctoral School of Maria Curie Skłodowska University who were not taught classes before and who originally were not very interested in another course. The e-learning mode entails many challenges. In this particular case, the greatest challenge was to convince doctoral students to participate actively in classes and to become genuinely interested in the course. The article describes the topics of the classes and the methods used to teach PhD students of science (the author is a representative of social sciences). After the classes, a questionnaire was conducted online, which was aimed to identify students’ satisfaction. The survey was aimed at examining the interest of doctoral students in e-learning, their assessment of the usefulness of distance learning and preparation for the implementation of teaching applications during the coronavirus pandemic. The use of a number of didactic applications; setting new challenges, research problems to be solved and changing roles; and conducting classes for students of media sciences gave positive results. The classes show that a teacher from the social scientific discipline can introduce a completely different view of teaching in exact sciences, especially in a remote form. During the exercises, didactic applications and methods were introduced during joint classes with teachers from the University of Mons (Belgium), which were conducted initially remotely and then stationary. The article is based on the results of research conducted under the Polish National Agency for Academic Exchange (NAWA)—project ‘E-learning and ICT in education in Poland and Belgium. Comparative study’ (Poland-Wallonia Bilateral Exchange Program).

Keywords: PhD students; Challenges with online teaching; Social and exact sciences; e-learning in practice; Modern methods and techniques of teaching in higher education institutions

Introduction

Student’s use of the course material is the key factor in e-learning. The course content should be designed in such a way as to achieve results through the sustainable use of e-learning media, online support opportunities and other teaching tools in the case of courses based on blended learning. Blended learning is considered the basis of the information society. In this type of study, teaching has a flexible formula, students’ IT skills are additionally upgraded, the lifelong learning idea is implemented in practice and the education system is organised accordingly. In the relevant literature, it is emphasised that remote education should include practical teaching, which encompasses the social media. They considerably enrich education, where students can share knowledge, solve tasks, find solutions and achieve goals through educational activities and development of competences, including teamwork skills. Furthermore, it allows students to find partners for international cooperation, comprehensive support and knowledge sharing, which lead to the achievement of better results and correction of actions that had been undertaken. The role of a university teacher is to identify a better route of teaching, correct any mistakes, boost productivity of actions, motivate students to gain knowledge, gradually switch from theory to practice and help students acquire professional social competence (Amzalag & Shapira, 2021).

In particular, the course content should be meaningful, relevant and presented clearly. Syllabuses of e-learning courses should be based on a logical structure and sequence of modules and should take into account the following interactions: student–content (of tasks) and student–student. Development of skills, effective group work and analysis of authentic case studies are essential to distance learning. We should also remember that with modern technical opportunities,
online laboratories can function successfully, and education can make use of games, simulations and current feedback from teachers. The focus should be on practical actions including preparation to apply specific skills in real situations, learning how to adapt knowledge to given circumstances and improving IT and social skills. Other essential issues are trust in online study and in one’s own capabilities (in mass-scale distance learning of teachers and students alike) and verification of learning progress on an ongoing basis (Hasani et al., 2022).

Furthermore, there are many tools available to support the process of designing teaching and sharing project outcomes. Course designers should regularly update not only the factual content of particular modules but also additional applications used in the teaching practice. The knowledge of ICT gives additional qualifications in the labour market. Moreover, it is valuable to gain experience in teamwork and project management via videoconferences and forums, to have a chance to disseminate the outcomes of students’ work through wiki and social media and to improve soft skills, including support for particular members of the group during the learning process (Park & Choi, 2009).

Challenges

E-learning is based on educational resources, which can take various forms (Fiorell & Mayer, 2012). Interactive materials are an important part of a course. These materials, accessed online, can cover the whole or part of the course. E-learning may comprise various sources, but the style of learning is the most important for the student who is sometimes expected to demonstrate completely new competences, including independence in learning, use of numerous sources available, critical analysis of texts and frequent cooperation with other learners. In e-learning, it is important to add a variety to students’ work so that they not only complete individual tasks but also work in project groups. Both group work and individual study are used in the traditional teaching formula. These methods of work perform well also in e-learning, but in the case of group work, the best results are achieved when members of a group knew each other beforehand (hence, blended learning is recommended). However, this is not always possible, and thanks to e-learning, people from different cities or countries (also of various cultural backgrounds) can learn together. This enables experience sharing with the use of electronic devices, which highly enriches work (Schellens et al., 2009).

It can be claimed that e-learning is more formalised and creates few opportunities for informal contact, so it is important to use applications that facilitate integration within the group and provide a chance to discuss some issues loosely connected with the subject of the course. E-learning has many advantages. It enables studying at as flexible time, place and rate but, at the same time, demands great degree of self-discipline from the learner. The lecturer is a tutor and an adviser, but he or she should not be the supervisor. E-learning gives an opportunity for better adjustment of the way of teaching to students’ preferences, interaction with the course content and cooperation in any student group. Furthermore, e-learning demands interactivity. The student should not get bored and play back training materials passively. It is crucial to create interactive materials, which will provide an opportunity for active studying. Another characteristic feature of e-learning is diversification of teaching methods. The student should be motivated for work, and various teaching methods make a course more suited to the learner’s needs. In this form of studying, formal and informal help of the lecturer is very important. Needless to say, e-learning is based on independent work of the student, and the lecturer’s role is to offer help. However, the student’s self-discipline and determination are the most important.

In e-learning, the teacher can influence the educational process by means of activation and boosting learners’ self-confidence, should provide help on an ongoing basis, answer questions and moderate discussion (if a need arises, especially at initial stages of work with e-learning methods) (Fiorella & Mayer, 2013; Marciniak, 2022).

Effectiveness of online teaching increases when specific goals of learning are identified, diverse teaching methods are applied and knowledge is verified from time to time (also in the learning through play formula). In some cases, it is necessary to introduce elements of tutoring and mentoring (depending on the number of students in particular groups) and mutual teaching (the teacher does not know everything, he or she also learns from students, and students may have extensive professional experience and teach others on the basis of their own case studies). As regards E-lectures, important issues are selection of information, management of knowledge, its integration with effects of learning and transfer of practical knowledge (Marciniak & Cáliz Rivera, 2021).

An effective e-learning course is based on an appropriate arrangement of multimedia tools. They facilitate the achievement of the teaching outcomes planned, but they should also enable self-study and regular verification of results by students themselves. When we design e-learning courses, we need to pay attention to the diversity rule (monotonous applications...
should be avoided), visualisation rule (attractiveness and accessibility of a course, achieved, e.g., with photos or graphic software), evaluation rule (materials should be useful, so we ought to avoid too much content, perhaps not important and obscuring the whole presentation of the course) and spaciousness rule (students should be given space for their own interpretation and creative thinking). E-learning requires regularity and self-denial. It is easy to get discouraged by difficult issues, so the course should initially consist of simple tasks. It is a good idea to divide the training into chapters (after each chapter, make a test in the form of a test), so as not to frighten students with the enormity of the material to be mastered. However, you cannot rely on one version of the training for years. Current updates are necessary, so that students do not have to learn outdated issues. An important aspect of remote teaching is also the emotions that inevitably accompany new situations, fears of lecturers and students, whether they will cope with new tasks and use of equipment and applications. Sources of negative emotions can also be imprecise wording of instructions; misunderstanding of the topic, or parts of it, by learners; or excess of facts transmitted during synchronous connections. Learners take various actions that stem precisely from emotions. For example, they avoid problems with operating equipment by involving bystanders, ask for help from the group or the lecturer or try interventions to remove tasks they think are too difficult to perform. Emotions are evident throughout online teaching, which can be expressed, for example, by students’ inactivity. The distance caused by distance learning, therefore, does not exempt from following the reactions of the audience to the tasks set before them, encouraging systematic work and motivating them to undertake projects that can challenge learners. In this case, the creation of virtual communities is highly beneficial, which can become a support throughout the learning process. Through online learning communities, the identity of individual group members is built through interaction with others. Such communication has a specific action as its goal, the implementation of sentences, but quite often it is based on a phatic function. Communities focus on maintaining contact and creating closer ties between its members. Typically, such communities are formed in a formalised way, on the online platforms of the educational institutions that provide the course. The main goal of these groups is to perform a specific task or project. Their subject matter is defined, as well as the rules of operation, a system of punishments and rewards, a scheme of group management and a hierarchy of participants, while the form of control of participants in such communities is often hidden. Such a formula is quite effective and efficient, for example, in the implementation of group projects, where each participant should perform individual tasks, which are then assembled into a unified whole and subject to evaluation as a collective work. In the case of covert recording of the activities of individual group members, it is very easy to determine who contributed to the project and to what extent, which helps in fair evaluation of individual team members (Mikulski, 2015).

With the current possibilities of social media, it is also not a problem to establish informal learning communities centred around a given research problem or project. It can include learners from a particular course, as well as students from other courses who want to share their experiences with a wider group of interested people. However, the participant in the online learning process is alone. E-learning is characterised in large part by an individualised approach to learning. However, social support and inclusive processes in remote learning cannot be underestimated. Online learning communities have little emotional cohesion, while they exemplify a task-based community. The lack of emotional cohesion is primarily related to the inability to manage conflicts that inevitably arise during group work. It is difficult to resolve conflict situations online, and it generates additional misunderstandings, so it is useful to avoid topics that generate group conflicts, or the arbitrary resolution of a crisis in the work of the group by its leader. The nature of distance communication requires additional skills from the lecturer or group leaders to ensure team cohesion (Rak et al., 2008).

Remote education does not mean only courses taught, for example, during higher education. It is a type of activity that is manifested throughout life. Taking into account the competence in the choice of content and the way of learning, it is necessary to distinguish between independent learning and learning under the guidance (e.g., lecturer). Learning consists of relatively permanent changes in response that occur as a result of exercise. In a narrower sense, learning is limited to the conscious, intentional acquisition of knowledge and skills (Launillard, 2012).

The effectiveness of remote teaching depends on many factors. The basis is people and their systematic further training in modern educational methods. It is necessary to invest in human resources, increase the competence of academics and learn that in e-learning, the student has a completely different role than in traditional teaching. Additionally, the role and function of the academic lecturer in e-learning is changing, so it is necessary to constantly upgrade skills, including technical skills. Students need to take responsibility in the learning process, be able to use the knowledge
they have acquired in practice and communicate appropriately with lecturers and other group members (online interaction skills). It is also necessary to change the thinking of lecturers and students themselves about the poor effectiveness of remote teaching. The teacher should be ready to methodically improve the forms of online learning and take into account the rather specific pedagogical interactions and the psychological interactions of remote learners. Cultural factors are also important, that is, the lack of a tradition of distance learning in Poland, the lack of reference, for example, to the processes of globalisation and that the need for e-learning will translate into the development of e-business, e-services or e-government. It is necessary to recognise that e-learning responds to the needs of lifelong learning, regardless of current life situation or age. Financial factors are also important, including the cost of course development, or the outlay associated with implementing software necessary for the efficient administration of e-learning and e-learning support platforms. Other important factors relate to content issues (Kuźmicz, 2015; Mokwa-Tarnowska, 2020).

The emergence of new technologies, as well as new ways of communicating, has caused the perception of online and offline communication to change as nowadays people are most of the time online. Initially, cyberspace accompanied communicators quite sporadically and only among well-known people, but over time, it became apparent that people barely known or even unknown are often accepted as friends on social networks, it is possible to create identities online, and boundaries exist only on paper. In addition, online presence improves well-being and promotes the maintenance of many interpersonal contacts, and participants in online communication processes are more open and more willing to admit their weaknesses. Classic styles of linguistic, textual and non-verbal communication, under the influence of the network, have become audiovisual, graphic and interaction styles in Internet-based communication. The progressive process of new media development brings with it issues of digital exclusion, especially of older generations. This is evident not only among the poorer segments of society but also, for example, older generations of lecturers who are afraid of new technologies. In these times, we should constantly educate ourselves, expand our competencies and collectively create network resources, keeping in mind those less proficient in the use of new media. An additional problem becomes the immediacy of posting information online, the lack of critical thinking and news selection. The ability to evaluate information posted online is one of the basic social and cultural competencies in modern times.

It should also be emphasised that we are seeing a process in which, in the labour market, knowledge and intelligence are only valuable if they form the basis of creativity. Modern technologies have more and more applications, which promotes the access to knowledge, efficient organisation of business activities based on information systems or computerisation of government activities. Remote learning means savings in economic terms, but also in terms of teaching time, appropriate adjustment to the learners’ available time to enable them to perform, for example, professional duties, more precise than classical monitoring of the progress of learning effects. Online courses can be attended by an unlimited number of applicants (all the more so if they are open training courses), easily modified didactic programs (depending on the needs of learners and the expansion of the knowledge of the lecturer) and unlimited access to learning resources (both in terms of territory and time—as long as there are no special access blocks introduced for individual course modules) (Koohang et al., 2015).

It is also important to properly operate visualisations, graphic programs and appropriate graphic design of courses that will encourage learners to work. Experimenting with online innovations is inspiring and enhances creativity. In addition, students gain self-efficacy awareness. It is necessary to provide systematic feedback from the lecturer so that the student's motivation does not change. It is necessary to show learners that their innovations in practice are easy to use, and it is also worth trying out confident processes in the real market. Online teaching is difficult due to less opportunity to control the learner. On the other hand, students can be influenced in the learning process, but control will not produce effective, consistent learning outcomes. In e-learning, it is important to be automatic, to make it a habit, for example, to do some of the homework (projects) every day, or to look at the discussion board (Eitel et al., 2013).

The e-learning mode entails many challenges. In this particular case, the greatest challenge was to convince doctoral students to participate actively in classes and to become genuinely interested in the course (which can also be useful to doctoral students in the field of exact sciences). Another problem is a sense of anonymity, particularly when group work is not evaluated individually and is not an obligatory part of the course. It may also be difficult to understand the intentions of particular group members and the lecturer. Other problems include disagreement and arguments in a group in establishing the work schedule and dividing duties. It is worth noticing that students are just learning how to be independent of the top-down management of
the educational process and the lecturer’s supervision. They practise autonomous thinking, but they want the teacher’s supervision, and they find it difficult to switch to work management by the group members themselves. Therefore, lecturers have to teach students effective group work and problem management beforehand. Moreover, evaluation of tasks completed remotely should be based on motivation, clear criteria and mutual support, and not based on creating stress. Evaluation criteria should be transparent and established at the beginning of work with students. It is necessary to introduce mutual evaluation between group members who know best how much effort was actually put in by particular students. Lecturers should support students from a distance to give them freedom; on the other hand, learners have to master group work management in practice. It is also very important to maintain social interactions, not only the official interactions on e-learning platforms but also those on social media, for example, on Facebook. Both lecturers and students may encounter technical problems while using various types of teaching applications. This is also a valuable experience to cope with such problems and come up with creative solutions. However, a course should not be dominated by communication between students, which frequently happens, especially when a group is large or very active in information sharing. In e-learning, the basis is to properly motivate students to work. Thus, the lecturer should systematically stimulate interest in the content of the class, surprise, give space for creative thinking and build an attitude of curiosity about the class and a desire to find solutions to research problems. It is also important to stimulate a desire to understand what is going on around us, to trigger our own actions and to withhold explanations of problems until the task is completed. In doing so, it is necessary to stimulate and maintain attention, activate prior knowledge, introduce new knowledge to the learners’ memory and organise it, provide feedback (including not only an assessment of the end result but also the path to it), create a good working atmosphere conducive to memorisation and knowledge transfer and make the final goal of teaching clear. In Poland, the approach to e-learning is quite specific. Not enough people focus not only on the multimedia techniques of education but also on appropriate motivating contact between a student and a lecturer. It is crucial to teach effective online communication to motivate learners and to use a relevant system for grading students’ works or final effects of distance learning in general. Despite the fact that an increasing number of researchers are interested in writing monographs on e-learning and many methods and techniques of distance education are implemented, most university authorities still treat e-learning as an addition. There are no relevant procedures that would guarantee the coexistence of traditional and remote methods and forms of teaching. There are not enough professional methodologists, IT specialists, programmers and graphic designers who would coordinate publication of subsequent training modules on university e-learning platforms. Furthermore, the approach to the working hours in remote education is very stereotypical: the necessity to prepare materials and check students’ works for many hours is often ignored. It frequently happens that the time devoted to designing and checking asynchronous tasks, which are indispensable elements of e-learning, is not counted as online classes. All these weaknesses of the implementation of distance learning in academic practice became evident during the COVID-19 pandemic in 2020 and 2021. It turned out that lecturers typically focused on transferring lectures prepared in a traditional form to the Internet (Pokrzycka & de Lièvre, 2022).

In 2022 (two visits to Mons University—in June and September), as part of a NAWA research project ‘E-learning and ICT in Poland and in Belgium. A Comparative Study’—Poland—Wallonia Brussels, headed by me, research was carried out on the implementation of e-learning, as exemplified by the pedagogy major at Mons University. There is a special centre, established at the Faculty of Pedagogy and Psychology at Mons, that is responsible for design of e-learning courses and for implementation of innovations among students and lecturers. Furthermore, the centre deals with international cooperation, training courses and seminars conducted, for example, for participants of the CONECTE project (implemented in cooperation with the Lebanese universities). The extensive experience of the university, which participated in the grant, in the implementation of e-learning in social sciences prompted me to get more acquainted with the functioning of the centre, the innovations introduced and verification of effectiveness of remote teaching organised at the highest level currently attainable. I participated there, for example, in the classes conducted under Erasmus+ projects and in an international seminar for e-learning researchers. The project results are published in two e-books: L. Pokrzycka, B. de Lièvre, Innovative teaching methods. E-learning in practice, Lublin 2022 (link: https://wydawnictwo.umcs.eu/js/elfinder/files/Ebook/InnovativeTeachingMethods.E-learning.in.Practice.pdf) and L. Pokrzycka, B. de Lièvre, Innovative teaching methods. E-learning in Poland and Belgium, Lublin 2022 (link: Innovative.Teaching.Methods.E-learning.pdf (umcs.pl)).
Course for PhD Students of Exact Sciences

During author visits to Belgium, it was evident that in practice modern methods of education are applied with the use of multiple applications. In Mons, there is an emphasis on the rich course design and the use of diverse applications, including Padlet, Sway and Canva. As a result, the doctoral and master’s students the author was in contact with declared that they want to take additional studies exclusively online, and then they can study when they have the time and desire to do so. They also emphasised the very easy access to knowledge through e-learning, which gives the opportunity to learn innovative issues at a distance and with minimal educational costs. It was summarised that this way of education meets the modern requirements of lifelong learners. Blended learning is the future of teaching, and it is necessary to know the trends in the development of e-learning in order not to be excluded. It will be and is one of the most popular methods of teaching due to time savings, flexibility of teaching and lowering the cost of education (due, e.g., to the lack of commuting). All the PhD students from Belgium author met during two stays confirmed their familiarity with online applications, including the use of Mentimeter, Flipgrid, Wakelet, Keynote, Learning Apps, Trello, Timeline, Kotobee, Screenflow or Google Classroom, in addition to the very popular applications suggested. It should be noted that the Belgians believe that the best learning is learning through play, in a relaxed, stress-free form, focusing on the student’s interests, with an individual approach to each learner (this is especially possible for small year classes, such as doctoral studies).

The author taught a course in Lublin—Maria Curie Skłodowska University—to 40 doctoral students of exact sciences and natural sciences on innovative teaching in a higher education institution. Lectures and classes were given in English language (as several students were foreigners). The author introduced students to the fundamentals of design thinking techniques, and the whole process was practised. To take full advantage of the opportunities offered by design thinking techniques, the author used Padlet application in group work. Subsequent classes were devoted to critical thinking in theory and practice. The task of the doctoral students was to critically evaluate the sources related to the subject matter of their research and doctoral dissertations. After that, the author discussed the issues connected with projects implemented online. Doctoral students read the most important fragments of theoretical guidelines of the project method on a shared interactive board. Their next task was to present a concept of a selected research problem (following a query on the Internet and offline) using a variety of free web applications. Further classes were focused on the use of new media in education. In that module, students learned about gamification in academic teaching and various game options and designed their own game, cooperating with each other, for example, in Padlet application. The effects of using games during classes were illustrated on an ongoing basis by Mentimeter software or Kahoot (where students checked each other’s knowledge in a stress-free way). Next modules were connected with visual communication: students created mind maps and planned exercises based on images designed on their own, which other participants were supposed to interpret. This module also encompassed the tasks related to m-learning (using mobile apps in education). Participants of classes worked in subgroups on creative tasks in Trello application and presented the final outcomes of their graphic design projects (with elements of m-learning) in SWAY application. Other issues discussed were connected with WebQuest in theory and practice (students were supposed to implement and promote one such project in groups, related to selected dissertation topics). Furthermore, the issue of motivating students to remote work was discussed. Special motivational badges were designed, and the best blogs devoted to education were analysed (the concept of such promotion of education was developed jointly). During the next stages of the course, students learned about the EPALE platform (a European community of experts in adult education), as well as Duolingo, Emaze, Flipgrid and Wakelet applications.

During the course, doctoral students were able to use the applications to present the results of their PhD-related research. The topics of the theses were quite narrowly related to physics, chemistry and biology. Thanks to mind maps, innovative methods of presenting research, they were able to better communicate their knowledge, systematise it and show the results of their work to younger colleagues (from other fields of study). They worked step by step, systematically implementing new applications, discussed their effectiveness and showed concrete results of their work (Figures 1–8).

The course did not end with a theoretical examination. Instead, doctoral students had a task to prepare, on their own or in groups of several people, classes connected with their interests (using a number of applications they learned about during the course). The role of students was played by media science doctoral students whose knowledge of exact sciences was quite poor. Therefore, doctoral students taking the examination in ‘Modern methods and techniques of
Figure 1. Graphic thinking map. Source: Materials of doctoral students developed and made available during classes.

Figure 2. Example of using SWAY. Source: Materials of doctoral students developed and made available during classes.

Figure 3. Kahoot voting page. Source: Materials of doctoral students developed and made available during classes.
Figure 4. Mind map with interactive images. Source: Materials of doctoral students developed and made available during classes.

Figure 5. Use of cartoons in presentations. Source: Materials of doctoral students developed and made available during classes.

Figure 6. Use of interactive elements in presentations. Source: Materials of doctoral students developed and made available during classes.
teaching in higher education institutions’ were supposed to present theoretical issues of physics, chemistry and biology in very accessible and attractive ways and then to involve their students in quizzes, competitions and games prepared in the applications. Most doctoral students taking the examination in such a way obtained excellent results and attracted the maximum attention of the participants to seemingly quite hermetic subjects.

**Introduction to the Survey Conducted among UMCS Doctoral Students**

After the doctoral students had passed the course: ‘Modern methods and techniques of teaching in higher education institutions’ (40 hr in total, including 20 hr taught in smaller groups), the author conducted an anonymous survey among the course participants (using an Survio online form). The survey results were summarised automatically by Survio.

The study was conducted after the last class, when the final grades had already been issued. The questionnaire was prepared by the author in the most accessible form for PhD students; it contained 10 questions (including 6 closed questions and 4 open questions).

The survey was aimed at examining the interest of doctoral students in e-learning, their assessment of the usefulness of distance learning and preparation for the implementation of teaching applications in the times of the coronavirus pandemic. Was remote teaching during doctoral studies effective? Did it broaden students’
knowledge of new technologies? What are the benefits of remote learning for students? For practitioners, PhD students in chemistry, physics and biology are such classes useful?

The participants of the survey were 22 doctoral students from the Doctoral School of Exact Sciences, aged between 27 years and 53 years (not all students took part in the survey).

**Results of the Survey**

A multiple choice question about the factors that could encourage a respondent to take part in online classes was answered in the following way: 65% of the respondents selected freely chosen time for study, 40% selected individual mode/pace of learning and financial considerations (travel costs) and 30% chose interactive personal contact with a lecturer (see Table 1).

<table>
<thead>
<tr>
<th>Freely chosen learning time</th>
<th>65%</th>
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</thead>
<tbody>
<tr>
<td>Individual mode/pace of learning</td>
<td>40%</td>
</tr>
<tr>
<td>Interactive, personal contact with the lecturer</td>
<td>30%</td>
</tr>
<tr>
<td>Financial reasons (travel costs)</td>
<td>40%</td>
</tr>
<tr>
<td>Other</td>
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*Table 1.* What factors could most encourage you to participate in didactic classes conducted via the Internet? (select any number of answers)/in percents

An open-ended question concerned the factors that can hamper participation in online courses at doctoral studies in exact sciences. The students agreed that lack of direct communication (60%) and problems with Internet and computer hardware (40%) were the most troublesome to them. According to the respondents, lectures are the best suited to remote teaching (90% of replies to a multiple choice question), followed by seminars (45%) and exercises (25%) (Table 2).

<table>
<thead>
<tr>
<th>Lectures</th>
<th>90</th>
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<tbody>
<tr>
<td>Seminars</td>
<td>45</td>
</tr>
<tr>
<td>Exercises</td>
<td>25</td>
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<tr>
<td>Laboratories</td>
<td>-</td>
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</table>

*Table 2.* What form of didactic classes, in your opinion, is suitable for teaching via the Internet? (select any number of answers)/in percents

The question whether the respondents have ever participated in any courses organised in the form of e-learning/blended learning (a hybrid form) was answered (see Table 3) in the affirmative by 75% of the respondents and in the negative by \( \frac{1}{4} \) 25% (which may be surprising as the majority of courses in the academic year 2020/2021 were run solely in the e-learning formula due to the coronavirus pandemic).

<table>
<thead>
<tr>
<th>Yes</th>
<th>75</th>
</tr>
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<tbody>
<tr>
<td>No</td>
<td>25</td>
</tr>
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*Table 3.* Did you participate in classes organised in the form of e-learning/blended learning (mixed form)? (in percents)

Another open-ended question concerned advantages, disadvantages and effectiveness of courses taught remotely. The respondents replied in the following way: Such courses are effective (15% of replies); Currently, they ‘have to’ work; however, on-site courses are much more effective (15% of replies); A disadvantage is tiredness in front of the screen (45% of replies); I do not have to spend my time commuting, but I miss contact with other people and too long e-learning can contribute to a feeling of loneliness and development of depression (45%); Easier contact with the lecturer (45%); Theoretical classes in this form lose nothing or very little and they are much more convenient. However, in the case of laboratory classes, an on-site course is rather irreplaceable (90%); and If access is OK, such courses are beneficial but sometimes we have problems with gates and corporate restrictions, so it is difficult to use them fully, despite an opportunity to take part (15%).

Next, the respondents were asked which activities on the e-learning platform turned out to be the most useful (Table 4). This multiple choice question was answered in the following way: 45% of the respondents indicated request, 45% selected discussion forum, 55% chose files with documents and presentations and 20% selected links to websites. There was also a note added: ‘I prefer a standard lecture with an option of recording it and playing back remotely’.

<table>
<thead>
<tr>
<th>Request</th>
<th>45</th>
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<tbody>
<tr>
<td>Discussion forum</td>
<td>45</td>
</tr>
<tr>
<td>Files with documents</td>
<td>55</td>
</tr>
<tr>
<td>Website (links)</td>
<td>20</td>
</tr>
</tbody>
</table>

*Table 4.* Which forms of activity on the e-learning platform are the most useful? (select any number of answers)/in percents

The following answers were given to an open question what the respondents liked about the e-learning platform (that is the Virtual Campus of MCSU): availability; all materials gathered in one place;
flexibility; easy handling; transparency; an opportunity to store data, to share materials, to use the platform anywhere and anytime and to record and play back lectures; and an opportunity for the lecturer to upload obligatory and extra materials. On the other hand, the following drawbacks of the e-learning platform were enumerated: lack of intuitiveness, logging problems, technical problems, failure rate and server overload, which breaks the connections.

Another question was whether the student plans education in the remote system of e-learning/blended learning in the future: 90% of the respondents answered 'yes', while 10% answered 'no' or 'don't know' (Table 5).

Table 5. In the future, do you plan to learn in a remote e-learning/blended learning system? Why yes/no? (in percents)

<table>
<thead>
<tr>
<th>Yes</th>
<th>90</th>
</tr>
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<tbody>
<tr>
<td>No</td>
<td>10</td>
</tr>
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Source: own research.

Finally, the respondents were asked whether the coronavirus pandemic increased their knowledge of modern technologies: 90% answered in the affirmative (some participants emphasised that even though it was a forced situation, they became familiarised with modern technologies and this was the only way those days to continue their studies), whereas only one person had known and used modern technologies/applications before.

Discussion

Answering the research questions, it can be stated that remote teaching during doctoral studies was effective. This can be evidenced by the wider familiarisation of learners with various remote learning options and the use of didactic applications (which were previously unknown to PhD students). According to the respondents, the lectures are most suitable for distance learning. PhD students appreciate in e-learning freely chosen learning time, individual mode/pace of learning and no travel costs.

To sum up, it can be claimed that the course content had been presented clearly before the classes began. The author could presume that doctoral students of exact sciences would not be very interested in this subject, which is rather perceived as a domain of humanities and social sciences. Initially, it was also difficult to integrate the group, and some arguments were inevitable at using, for example, design thinking or critical thinking techniques. However, they made the group even more integrated in the end. Furthermore, the transparent course scheme, accessible graphic design of the Maria Sklodowska University Virtual Campus and optional remote meetings, which were recorded to be played back later by absent people, created a platform for more effective study. This course was a considerable challenge because it was the first time when the doctoral students participated in a course during which they had a lot of freedom and were not strictly controlled but had to complete work, as a result of which they were later able to teach classes to doctoral students in the field of social sciences. The final effect was assessed by all examination participants, and there was no top-down evaluation by the lecturer. Each group work evaluation was preceded by questions from the participants and joint summary of classes. All in all, it can be claimed that the doctoral students in the field of exact sciences have mastered the foundations of innovative academic education at a high level, have learned how to employ creativity during classes with students, know design thinking and have no difficulty with critical thinking. Another motivation for effective work was the introduction of visual communication and a number of applications that can be used not only in teaching.

The multimedia provide an opportunity for regular contact between the lecturer and the learner and contribute to the individualisation of the educational process. However, e-learning requires the teacher to design courses in such a way as to develop students’ skills, stimulate their continued activity and motivate them to work. Students should be given space for growth, development of creative thinking and independent problem solving. They ought to be able to process information efficiently (there should be not too much of it), learn how to interact competently with the IT system (the e-learning platform used) and upgrade communication skills. When selecting tasks and challenges during the course, we need to take into account specific qualities of students, their ability to work on their own and their diligence.

An interesting aspect of the research was that some of the doctoral students surveyed were practitioners, people who had not used e-learning before, focusing on implementation doctorates, working in nitrogen plants, for example. They did not consider my subject important, were not familiar with didactic applications and did not want to actively participate in classes, as they explained it, for example, by the experiments they had to perform in the laboratory. They had no time to ‘play’ with didactics. At the beginning of the class, it was necessary to introduce a rather strict way of working (with deadlines for tasks, blocking on the e-learning platform). However, over time, more and more freedom could be left, convincing the doctoral students was
especially the use of Padlet for group work, as well as the introduction of gamification elements (for good task performance they received points in the form of badges, advancing to the next level of ‘initiation’). PhD students stop complaining about lack of time when they start working remotely in groups, where strict roles are assigned to be mastered (peer assessment is also introduced in groups). These are grown-up people, working and writing dissertations, where more creativity can be stimulated, thoughts can be taught to be presented clearly, thanks to, for example, mind maps, online discussions in applications like Padlet and use of innovative methods of presenting research, which are useful during conferences or dissertation defence. The doctoral students themselves admitted that they did not know most (or all) applications until now, and they will be useful in popularising their research online and during popularising public speeches.

The study is selective, and a small study group was surveyed, which should be increased in the future. The use of innovations in the teaching of doctoral students should be systematically studied, and innovations should be implemented on an ongoing basis. The article is only an introduction to the discussion, and further research in this area is needed.

References

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