education sciences

MDPI

Article

Teachers' Appreciation of Benefits and Shortcomings of Online and Blended Higher STEM Education

Iouliia Skliarova [1,*], Inês Meireles [2,*], Tatiana Tchemisova [3], Isabel Cação [3] and Natália Martins [3]

[1] Institute of Electronics and Informatics Engineering of Aveiro (IEETA), Intelligent Systems Associate Laboratory (LASI), Department of Electronics, Telecommunications and Informatics, University of Aveiro, 3810-193 Aveiro, Portugal
[2] Research Centre of Risks and Sustainability in Construction (RISCO), Department of Civil Engineering, University of Aveiro, 3810-193 Aveiro, Portugal
[3] Center for Research and Development in Mathematics and Applications (CIDMA), Department of Mathematics, University of Aveiro, 3810-193 Aveiro, Portugal
* Correspondence: iouliia@ua.pt (I.S.); imeireles@ua.pt (I.M.)

Abstract: This paper is devoted to identifying online teaching strategies appropriate for blended and face-to-face higher STEM (Science, Technology, Engineering, and Mathematics) education. The study is inspired by the experience gained during the COVID-19 pandemic lockdown, which forced many higher education institutions worldwide to shift abruptly to distance education and try many new tools, teaching methods, and strategies. Some of these tools and strategies were abandoned as soon as the lockdown had been lifted and the institutions returned to their regular functioning, but some of them are bound to stay. Certainly, it would be beneficial to include the most valuable of the gained skills and competences in traditional on-campus and blended courses. The study is based on an online questionnaire, addressed to the STEM faculty of the University of Aveiro, Portugal (which is an example of an institution that used to provide face-to-face instruction), whose analysis permits to derive a number of important recommendations. The results are compared with our previous work, where the students' perspectives were analyzed, and similarities and discrepancies in appreciation of the involved parties are highlighted. This work extends the body of knowledge about the impact of the COVID-19 pandemic on STEM education by examining the challenges and opportunities faced by teachers. The recommendations derived contribute to improving the learning outcomes of online STEM education in many similar institutions.

Keywords: higher education; science, technology, engineering, and mathematics (STEM); online/blended education; teaching and learning strategies; teachers' perspective

Citation: Skliarova, I.; Meireles, I.; Tchemisova, T.; Cação, I.; Martins, N. Teachers' Appreciation of Benefits and Shortcomings of Online and Blended Higher STEM Education. *Educ. Sci.* **2023**, *13*, 338. https://doi.org/10.3390/educsci13040338

Academic Editors: Chung Kwan Lo and Khe Foon Hew

Received: 22 February 2023
Revised: 18 March 2023
Accepted: 23 March 2023
Published: 25 March 2023

1. Introduction

For many years, education was one of the least digitized and most human-intensive sectors of the economy. The COVID-19 pandemic has greatly affected the way the majority of Higher Education Institutions (HEIs) are functioning worldwide. While, before the announcement of several lockdowns, the online educational model was not so widespread, in 2020–2021, many universities had to adopt it as the default model, often in a not well-planned and chaotic way. Certainly, the fast development of videoconferencing and online communication tools in the recent (pre-pandemic) years has accelerated the transition to either full or partial online education. For instance, according to U.S. Department of Education data [1], the percentage of undergraduate students enrolled in any type of distance education has increased from 15.6% in 2003–2004 to 43.1% in 2015–2016, although the growth of enrollment in fully online degree programs was not as sharp (4.9% in 2003–2004 to 10.8% in 2015–2016). The enrollment of graduate students in online programs is traditionally higher than that of undergraduate students [1]. In the European Union (EU), only 8% of people reported taking an online course in 2019 (4% in 2010), according to

Eurostat [2]. The extensive switch to distance education was triggered by the pandemic with the accelerated enrollment in online courses. According to [3], the percentage of U.S. undergraduate students enrolled exclusively in distance education courses reached ~46% at public institutions in the autumn of 2020. In the EU, 27% of people reported using online learning materials in 2021, a 19% increase compared with 8% in 2019 [2,4].

In this study, we follow Kentnor [5] in defining distance education as education that is performed with teachers and students physically apart. Online education can be a component or a form of distance education when computers and the Internet are used as the delivery mechanism.

The sudden shift to remote forms of education delivery has exposed the shortcomings of education systems regarding the availability and adequacy of digital infrastructure and has led to an increasing focus on the digitization of education [6]. Many high-tech companies offered free (or discounted) access to their products to teachers and students, gaining millions of new users and contributing to the much greater use of technology in education [6]. HEI's teachers have acquired numerous new competences in both online content delivery and active instructional strategies aimed at increasing the student retention rate [7].

Nowadays, as the lockdowns have been lifted, many HEIs switched back to the traditional forms of teaching and learning (despite the fact that certain parts continue being delivered online). Some of the acquired skills and competences could contribute to the effective teaching process even in traditional on-campus or blended education. We consider a teaching strategy to be effective [8,9] if it:

- raises student motivation;
- increases student engagement;
- helps students to achieve their learning goals;
- favors positive relationships with students;
- contributes to the satisfaction of both teachers and students.

In STEM (Science, Technology, Engineering, and Mathematics) programs, i.e., programs that are focused on technical disciplines of science, technology, engineering, and mathematics, verbal and nonverbal communication is particularly important, as the success of the students relies on their capacity to answer questions and solve problems with intelligence and creativity [10]. In addition, a substantial part of STEM education relies on simulations, experiments, and models, many times conducted with specific instruments and in laboratory environments [10,11]. These characteristics present an additional challenge to STEM online education.

This study addresses online education at the University of Aveiro, Portugal, within STEM programs, as a case study, and focuses on targeting the following research questions:

(1) What are the main problems faced by STEM teachers with little or no experience in online education?
(2) What teaching strategies promote student and teacher engagement and motivation in STEM programs?
(3) What are the most appropriate teaching strategies in STEM courses?
(4) How do the most effective educational strategies identified by the teachers correlate with the students' appreciation of the learning process in STEM programs?
(5) What educational strategies could be recommended for future face-to-face, online, or blended STEM courses in order to make them more efficient?

The major novelty of this study compared to previous works is the cross-comparison of the teachers' appreciation of distance education with the students' point of view (data for analysis were collected in one university from students and faculty of three departments involved in STEM curricula). The secondary novelty is that the research is based on a long and detailed questionnaire, specifically directed toward STEM-subject instructors, which aims to analyze many different aspects of distance teaching, learning, and assessment in

higher education. To the best of our knowledge, there is no other analysis available which combines the aforementioned two aspects in a single study.

The rest of this paper is structured as follows. Section 2 provides a summary of the relevant research. Section 3 characterizes the study method in detail. The results are presented in Section 4. A comparison of these results to the students' perspective is completed in Section 5. A discussion of the findings (in light of the literature reviewed in Section 2) is done in Section 6. Conclusions and recommendations are given in Section 7.

2. Relevant Research

Several authors conducted research and analyzed various aspects of the abrupt mass transition to distance education during the COVID-19 period and lockdowns. The majority of the works focus on students' perceptions while there is less research centered on the teachers' point of view. The selected works, involving teachers' perspectives, are briefly characterized below, being grouped according to the main contributions and conclusions.

2.1. Perception of Online Teaching and Learning

A widespread way to understand and evaluate the teachers' perception of online education is to conduct a survey of teachers' opinions on the subject. We have performed a thorough analysis of various surveys directed to teachers in order to identify the most typical opinions, problems, and solutions, in the context of COVID-19.

The study [12], conducted in autumn of 2020, examines the impact of the COVID-19 pandemic on the higher education faculty in STEM fields in the U.S. and presents an analysis of 896 responses from STEM faculty teaching at both graduate and undergraduate levels. The most serious barrier detected for the successful implementation of distance STEM education is the lack of student motivation to take part in online courses. Respondents believe that the shift to online learning has widened the gap between wealthier and poorer people because of disparities in access to technology and required related services.

Lucas and Vicente [13] collected and analyzed answers from 636 teachers, distributed across 54 countries, to two open-ended questions aimed at identifying the main benefits and challenges of emergency distance education. The results show that many challenges recognized by the teachers can be considered as benefits and vice versa; for example, time management. The authors concluded that both teachers and the involved HEIs are not prepared to use assessment methods that are inherently designed for digital environments. More diverse forms of learning approaches, centered in the student, and different ways of assessment are required, which, in turn, demand broader pedagogical digital skills.

In Asgari et al. [11], engineering students and teachers from the California State University, U.S., were asked to participate in a survey including qualitative and quantitative questions about the experienced challenges. From the teachers' perspective, the lack of access to hardware and software, necessary online tools, and insufficient hands-on training for students (essential for engineering courses) are the biggest challenges.

Hadzieva et al. [10] performed a qualitative analysis of teachers' appreciation of the abrupt transition to distance education (specifically for STEM courses). Nine teachers from five European countries, India, and Brazil were interviewed and their opinions were analyzed in order to identify the main barriers (both technological and psychological) in implementing e-learning. The main research objective was to detect problems in the transition to distance teaching. The authors enumerated and discussed many of such problems, e.g., technological challenges, the increased time investment required to prepare lectures, the exhaustion of teachers, difficulties in students' assessment, and issues with cheating.

Matuuk et al. [14] conducted a study among 20 teachers of ICT (Information and Communications Technology) at a university in Libya, reporting that online learning is beneficial to develop students' technological skills, but there are barriers related to the internet services, self-isolation, and high implementation costs.

Saide and Sheng [15] examined 290 research papers and the 51 most relevant were selected for further analysis. The results of this work mainly contribute to exploring the most successful paths for transfer knowledge in the teaching–learning process in the framework of the COVID-19 pandemic through maximizing the use of ICT tools and improving the way knowledge is managed.

Thacker et al. [16] interviewed 25 undergraduate STEM instructors revealing a broad range of adaptations made to both their courses and to the way they communicated with students. The authors suggest several strategies to best sustain students' feelings of belonging and community, highlighting the importance of synchronous student–teacher interactions, and stressing the necessity of supporting faculty in using technology. Faculty's anxiety due to low student attendance and participation rates is also indicated.

Oliveira et al. [17] carried out a study aimed at understanding how the learning and teaching process was supported by ICT tools and how students and teachers experienced this extraordinary learning context during the first COVID-19 lockdown. The authors concluded that the use of ICT platforms was predominantly a positive experience for students and teachers, while personal adaptation to emergency distance education was largely a negative experience. Regarding teacher–student interaction, the authors identified both positive and negative aspects. From a positive point of view, during online classes, teachers demonstrated greater availability to communicate and assist students. From a negative point of view, teachers and students missed on-campus interaction and human contact.

Sieber et al. [18] assessed the life satisfaction and general well-being of students and teachers during the pandemic. The authors registered that teachers felt higher pressure (compared to normal values) to accomplish their goals, especially regarding the responsibility to teach remotely.

A systematic review of faculty perceptions in higher education can be found in Alangari [19]. The authors evaluated only web-based STEM programs and emphasized that further research should be conducted in this area to determine how the various distance education programs differ from the traditional programs. In this study, the challenges, constraints, and opportunities faced by faculty in delivering online STEM courses and their impact on student creativity are identified. In terms of the effectiveness, the authors note that faculty viewed the transition from face-to-face instruction to distance teaching as effective, although they reported facing some challenges. Many faculty registered positive performance of pre-service teachers on online exams and noted that the student creativity improved. Other findings of [19] are that the design of online STEM programs must take into account student learning outcomes and that teachers should be well trained. These findings support the conclusions of the review of the pre-pandemic critical literature on STEM courses conducted by Winberg et al. [20], which concluded that most of the studies reviewed did not address what makes STEM challenging to teach. The authors of this latest study stress how qualified STEM teacher training is significant. In particular, they underline the importance of interdisciplinary collaboration and show that in STEM, content, and pedagogy are closely linked. Acquiring scientific knowledge is an arduous process that requires both expertise and training in how to structure and communicate this knowledge.

It is worth mentioning that, at the University of Aveiro, Portugal Mathematics students' perception on distance learning in the context of the first wave of the COVID-19 pandemic was studied in December of 2020 and the results are published in Freitas et al. [21]. A quantitative descriptive analysis of the responses shows that, in spite of a number of negative aspects, distance education has some positive aspects, such as student interaction encouraged by group activities and the development of some personal competences, such as auto effectiveness.

2.2. Online Teaching Competences

As noticed in Alangari [19], the sustainable growth of the economy depends to a large extent on the qualification of the labor force in the various sectors of the economy. This

development is highly dependent on the demonstration of competencies in key knowledge areas, and therefore, there is a critical need for effective teaching and learning in higher education. The author affirms that education must focus not only on the cumulative skills of learners, but also on their assessment.

Digital proficiency has gained a lot of importance in the educational setting and is now one of the essential abilities that all citizens, and teachers, in particular, need to possess in the modern society. Though the majority of models and frameworks are geared to pre-university students, a lot of attention is now being dedicated to understanding the level of the university staff's digital competences, including their skills, expertise, and abilities that are required to use technology efficiently. The goal of the study [7] by Basilotta-Gómez-Pablos et al. was to provide a systematic overview of research papers from the Web of Science and Scopus databases published between 2000 and 2021 and dedicated to studying digital competences. Having recognized, categorized, and evaluated this selection of papers, the authors of [7] intended to enrich and improve the research being done on this topic in the university context. The findings of this study reveal a predominance of works that focus on the analysis of the self-assessment of the university teachers and comments on their digital competences. The teachers are aware that they lack a number of abilities, particularly those that are necessary for the evaluation of teaching methodology, and that their digital competences are low or medium. The authors come to the conclusion that, despite multiple studies existing, it is important to keep working to improve research in this field, deepen the assessment of digital competences of the university staff, and use the results of this assessment to create more useful and individually tailored training programs that address teacher's needs in the digital world.

According to Balgopal and Weinberg [22], for STEM educators to thrive, it is not enough to have digital competences. Teachers do not only need resources, but also a feeling that they belong to a community, as STEM professionals, in order to be able to encourage their students to learn. According to these authors, this community feeling of STEM teachers should start during their graduation and should be further strengthened in the beginning of their careers.

Mishra et al. [23] describe the online teaching and learning strategies used by Mizoram University, India, during the COVID-19 lockdown in 2020. The study shows that university faculty and students made greater use of educational technologies during the lockdown. The tools employed for online instruction ranged from Learning Management Systems (LMS) to Google Classroom/Zoom/Skype, and YouTube for disseminating instructional videos. In addition, the authors found that a very high portion of teachers used traditional phone calls (87%) and WhatsApp/Telegram/e-mail (100%) to connect with students. These findings are consistent with those of Sieber et al. [18], who studied the use of educational technologies before and during the lockdown at the University of Zurich. According to these authors, teachers used asynchronous online resources, such as audio and video recordings and text forums, more frequently than synchronous resources. Similarly, Sarfaraz et al. [24] found that about two-thirds of the faculty surveyed taught taking advantage of asynchronous resources (61%), while about one-third taught synchronously during the lockdown (39%), despite the fact that ~76% of the instructors had prior experience delivering lectures online.

Martin and Bolliger in [25] highlight that planning effective online teaching and learning pedagogies is a paramount in teachers' competences and propose a number of recommendations for teachers, including a role swap (participating as a student in an online course), peer mentoring, interaction promotion, and the importance of students' feedback.

In their case study [26], Iglesias-Pradas et al. analyzed the switch to emergency remote teaching at the School of Telecommunications Engineering in Madrid, Spain. The study uses quantitative data from academic records of all 43 subjects of the bachelor's degree program in Telecommunication Engineering, and qualitative data from a survey conducted among all course coordinators during the first days of the COVID-19 lockdown. The results

show that students' academic achievements improved compared with the previous three years. The authors of this study consider that the fact that most teachers are highly skilled in technology, and they frequently apply various synchronous/asynchronous communication techniques and virtual learning environments, might have been a factor that stimulated a rapid and efficient deployment of emergency remote teaching. Regarding academic performance, the authors also mention that there is a possibility of fraud during online tests, despite the efforts of teachers in taking measures to prevent cheating. It should be noted that some other studies support the idea that, in general, the transition to online teaching of STEM disciplines was not so difficult thanks to the already existing competences of teachers in this area. For example, study [12] reports that when teaching mathematics through screen sharing, using video, and recording lectures, not much is lost compared to face-to-face teaching. Engineering teachers report that given the unique aspects of STEM, what has been done is amazing and there is a lot of potential for more. However, both Computer and Information Science faculty members and students agree that STEM courses function better in face-to-face mode. There is an urgent need for a quality inclusive STEM instruction. Some educators are very optimistic that change will happen, but pessimistic about the readiness of the top leadership of higher education to see it through to the end.

2.3. Future of Digital Learning in Higher Education

The COVID-19 pandemic led to a significant shift in how faculty view distance and online STEM education. In the coming years, an understanding of how to better develop, deploy, and assess the tools and strategies educators can use to achieve successful outcomes in online learning may be critical.

Guppy et al. [27] discussed the future of post-pandemic digital learning from the perspectives of students, faculty, instructional design specialists, and administrators, and concluded that the vast majority of respondents expected the greatest growth in blended/hybrid forms of digital learning after COVID-19 with some envisioning more fully online courses (the students being more skeptical among the other groups). The majority of teachers from science disciplines admit that they became more positive about the advantages of online instruction, in contrast to non-science faculty, who share this opinion to a much lesser extent (~22% less). Interestingly, this difference noted by faculty of different disciplines regarding fully online courses was not detected among students.

Iglesias-Pradas et al. [26] noticed that the technical infrastructure and support provided by the institutions, flexible structures that facilitate decision-making, the availability of informal channels of communication, and the development of faculty members' digital skills are some of the significant factors that favorably influence the transition from face-to-face to online teaching in the context of a crisis or paradigm shift.

The reflection paper from the European Commission's Directorate-General for Education, Youth, Sport, and Culture [28] provides an extensive overview of the current discussion on how the impact of the COVID-19 pandemic has been assessed for distance learning practices. The work reviews the challenges of distance learning in higher education during the pandemic period and reveals four proposals that are considered essential: guaranteeing access to comprehensible digital technology; developing digital skills; establishing a digital learning culture; and providing financial support. Therefore, students, teachers, and administrators must join forces to meet the new challenges.

3. Methods

3.1. Research Context

This study aims to assess STEM teachers' perceptions regarding the extensive shift to distance teaching and learning and is based on the analysis of responses to an online questionnaire filled in by faculty of the University of Aveiro, Portugal. The questionnaire covers two academic periods: the second semester of 2019/2020 (when the first lockdown occurred) and the academic year 2020/2021 (in the first semester, the new lockdown was

enforced). The vast majority of faculty had no experience with distance teaching prior to 2020.

3.2. Study Design, Participants, and Data Collection

The questionnaire was developed as a part of an international research project in the area of education and was applied in four European universities. In this paper, only the results obtained at the University of Aveiro, Portugal, are analyzed. The research team opted for a long questionnaire to be able to answer several research questions in one study. The questionnaire was implemented using LimeSurvey software, reviewed and tested by a few STEM teachers, and validated by the University's Communication, Image, and Public Relations Services. An invitation was then sent to ~150 teachers of three involved STEM departments (Electronics, Telecommunications, and Informatics; Civil Engineering; and Mathematics) by e-mail. The teachers were asked to anonymously answer a total of 40 questions during the period from October 19 to November 7, 2021. Finally, 32 valid answers have been collected and used for further analysis.

The questionnaire included 40 questions of the following types:

- Closed-ended questions that have predetermined answers to choose from.
- Three/five-point Likert scale questions aimed at measuring teachers' satisfaction with a statement.
- Open-ended questions designed to encourage a full answer with details.

The questions fall into five categories:

- **General**—general questions allowing for categorizing the participants' profiles according to gender and experience as a teacher.
- **Preparation**—questions related to preparation for teaching and support given by the university.
- **Delivery**—questions connected with the delivery of online classes, related to the infrastructure, ICT tools, and innovative strategies.
- **Assessment**—questions about the employed assessment models and the resulting problems.
- **Evaluation**—questions evaluating the quality of the distance learning techniques and strategies used.

3.3. Data Analysis

The work presents a case study of a single exploratory type (see Yin [29]), according to a quantitative research methodology, using an analysis of frequencies of responses given to a questionnaire constructed for the survey. The collected responses to the closed-ended and Likert scale questions were analyzed in an Excel spreadsheet by calculating the frequencies of the pre-defined responses.

Since it is intended to identify where the highest frequencies are observed, the analysis carried out has, mostly, a descriptive component, in order to collect information on a little-known topic, which is why the type of research carried out is of an exploratory nature. Therefore, for open-ended questions, the answers were collected, categorized, and analyzed qualitatively. To determine if the teachers' and students' perspectives were statistically different, a statistical analysis of the responses to comparable questions was conducted using the software tool IBM SPSS [30]. Similarly to [31], this study counted categorical data from respondents' answers to determine how many cases fell into a certain category of a variable. These calculations were then organized in a frequency distribution table. To relate the categories of one variable with those of another variable, a cross-tabulation was used accomplished by the Chi-square test to determine whether or not a particular relationship was statistically significant (i.e., if the p-value is less than 0.05, the relationship is statistically significant). For the performed tests, the statistical approximations were previously verified and validated.

4. Survey Results

This section summarizes all the questionnaire responses grouping them according to five categories presented in Section 3.2.

4.1. General Category

The introductory part of the questionnaire consisted of questions aimed at identifying the profile of the respondents while keeping their anonymity. The sample is balanced in terms of gender (56% males versus 44% females), and almost all are very experienced teachers (91% have more than 10 years of experience and 60% have more than 21 years of experience).

4.2. Preparation Category

The preparation category questions evaluate the previous experience and support provided by the university to teachers to help them with switching to distance education. All the participants used portable computers for teaching and communicating with students, augmented with other devices such as mobile phones (13%), desktop computers (19%), tablets (16%), multiple monitors (25%), and digital tables (9%). The teachers have been acquainted with the university learning management system (Moodle) and some of them (22%) already used videoconferencing tools (such as Zoom and MSTeams) before the pandemic. The results of some of the answers are summarized in Figure 1.

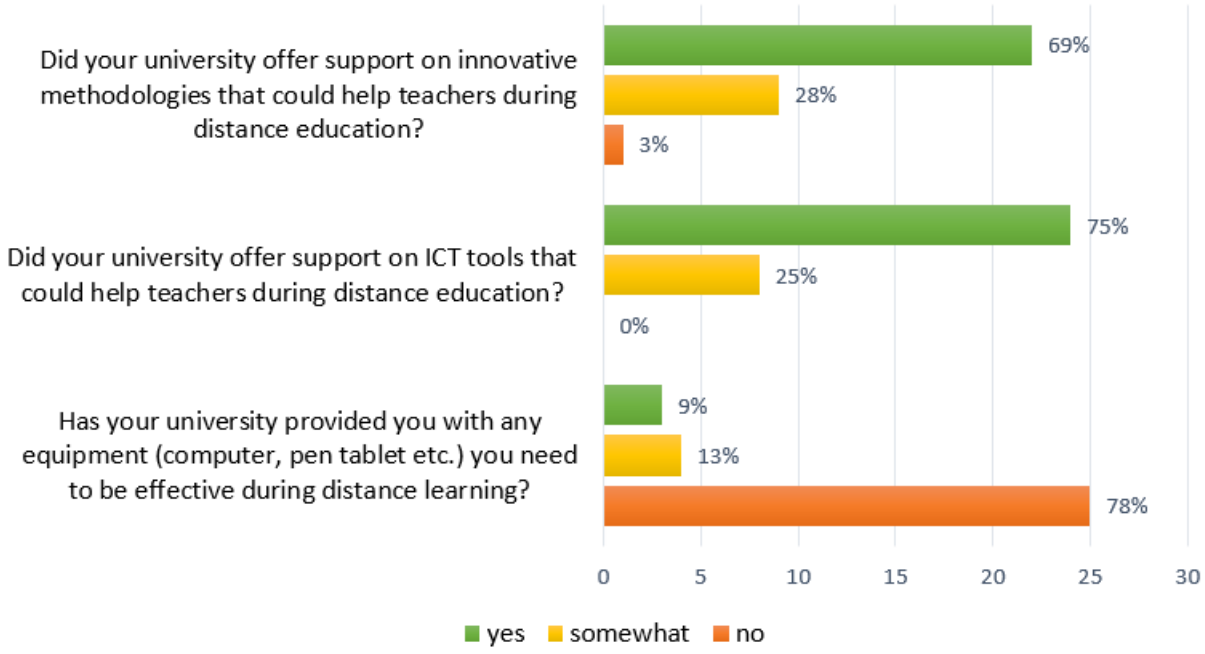

Figure 1. Support provided by the university.

4.3. Delivery Category

The delivery category includes questions on the teaching strategies and software tools employed during the online and blended classes. The great majority of teachers (84%) recurred to traditional expositive synchronous classes. At the same time, 53% in their classes used some elements of collaborative and team-based learning, 31% resorted to flipped classrooms, and 6% included gamification elements in their classes (see Figure 2).

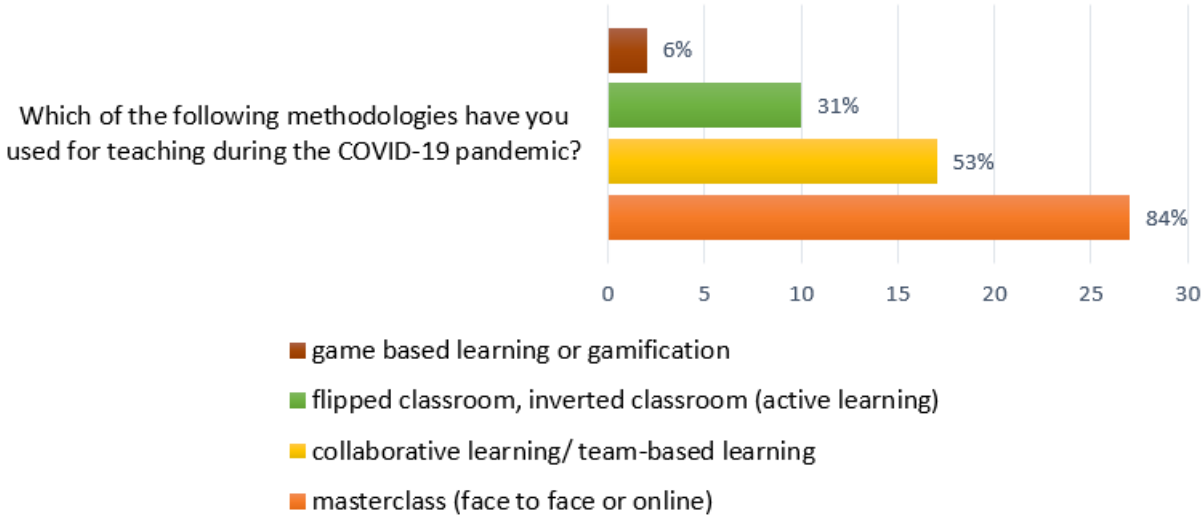

Figure 2. Teaching strategies used during the COVID-19 pandemic.

The most popular videoconferencing/communications tools used for class delivery were Zoom and MSTeams. That is explained by the fact that the Scientific Computing Unit of the National Foundation for Science and Technology of Portugal provided the entire community of national HEIs with respective access to encourage the use of video and audio technologies for meetings and classes.

The teachers have mentioned several digital tools they employed to foster active and collaborative learning: Padlet (31%), Kahoot!(13%), Miro (9%), Poll Everywhere (9%), Mentimeter (16%), and Trello (6%). At the same time, about 10% of teachers mentioned no government or university support has been offered to acquire the respective licenses, albeit a few training courses have been organized by the university. All the teachers continued to use the university learning management system (Moodle) and about 44% recorded videos and posted them on YouTube and Educast (the national repository of educational videos) platforms. STEM courses frequently require specific equipment for labs, which is not easily available at teachers' and students' homes. Because of this, 22% of teachers employed virtual laboratories to organize the experimental part of their classes and 34% resorted to simulators, which are anyhow frequently used even in on-campus education. Shared whiteboards have been practiced by about 53% of respondents. To communicate with the students, mainly Moodle was used, with some exceptions of WhatsApp and Facebook.

During synchronous activities (i.e., when both teachers and students were connected online to each other in real-time), the majority of teachers valued maintaining eye contact with their students to obtain some immediate feedback that is readily available during on-campus classes (see Figure 3).

All the teachers felt the need to diversify the learning activities offered to students (see Figure 4). Some of them are "inherited" from the traditional on-campus knowledge delivery, such as expository real-time writing/drawing/demonstration or utilizing websites. At the same time, new types of activities were tried such as watching videos (previously recorded by the respective teachers) and taking online quizzes (that were not so widespread before the pandemic).

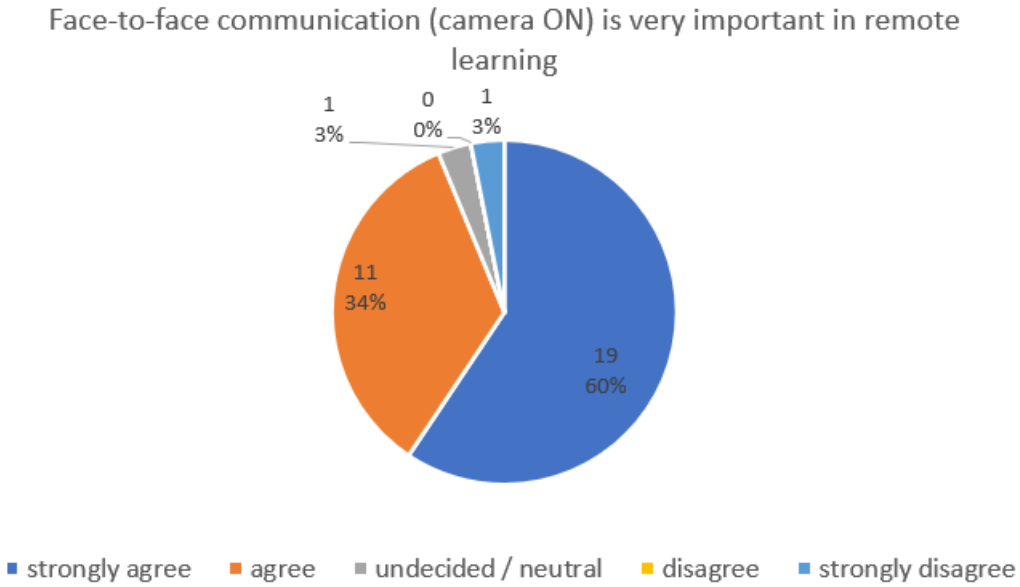

Figure 3. How do teachers appreciate the importance of using cameras during synchronous online classes.

4.4. Assessment Category

Questions of this category were intended to rate the assessment procedures adopted and to reply to the following queries:

- Were the assessment procedures implemented in the university during the distance education fair?
- What types of assessment have you used?

In the second semester of the 2019/2020 academic year and in the first semester of 2020/2021, the decision of the Rector was that distance assessment should be the default option, and that traditional assessment procedures should only be allowed in exceptional cases. To prevent fraud in student assessments, each department made a number of recommendations, which included restricting the number of students per virtual room, making it mandatory to turn on the camera, and requiring all students to be identified by an ID card. In addition, many teachers requested a second camera to monitor student's workspace and resorted to tools that limit navigational freedom and prevent switching to other applications (such as Safe Exam Browser).

Faculty respondents felt that the assessment procedures implemented during the pandemic were fair (31%) or fair enough (59%). Only 9% sensed that these procedures were not fair. Depending on the subject, 47% of teachers applied exclusively online assessment, 1% used entirely on-site assessment, and 44% resorted to both forms of assessment.

The analysis of the answers to the questionnaire shows that the most favored types of assessment were written exams (63%), open-ended questions (59%), multiple choice/true-false questions (59%), and completion of group projects and assignments (59%)—these are illustrated in Figure 5. Only 6% of teachers noticed an improvement in the students' learning outcomes compared to the pre-pandemic period and 50% consider that the outcomes became worse.

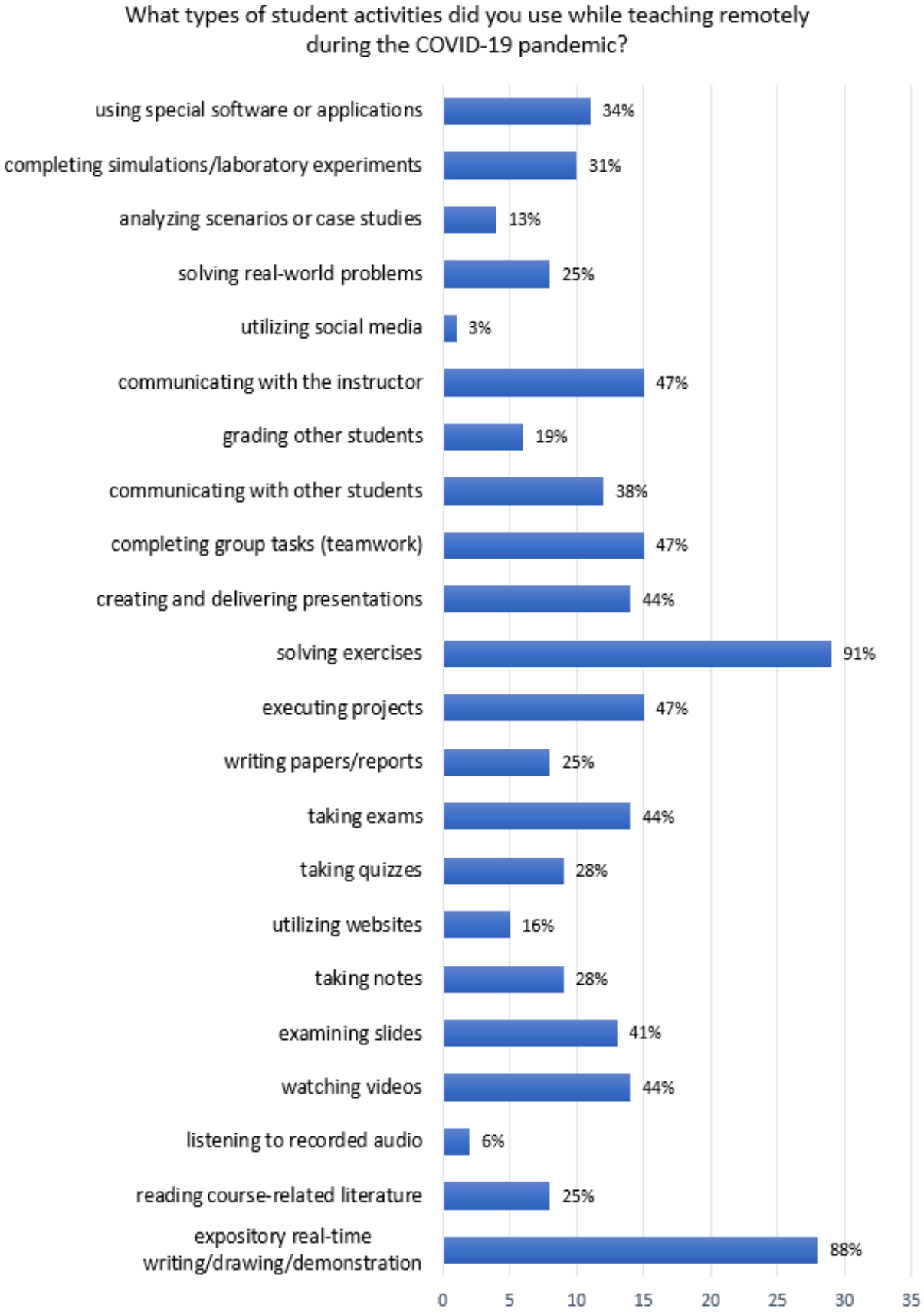

Figure 4. Students' activities that the teachers promoted when educating remotely.

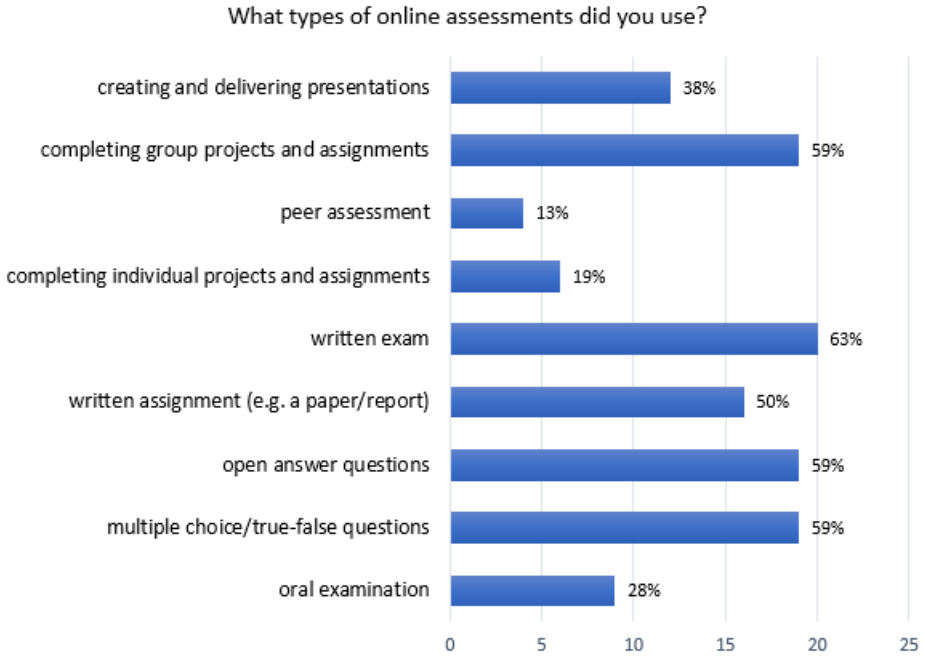

Figure 5. The used types of online assessment.

4.5. Evaluation Category

This category is the most interesting and informative as it permits the evaluation of teachers' appreciation of distance education and allows the derivation of important recommendations. This category contained the following questions:

1. How did you feel about the shift to distance education?
2. Has the lack of personal contact with students and other teachers on campus affected your motivation?
3. How would you rate students' in-class activity (in online and blended mode)?
4. How does distance teaching affect your relationship with students?
5. Do you agree that you have gained new skills in using online educational resources and strategies that you will continue to use in on-campus/blended classes?
6. Do you prefer distance, on-campus, or blended education?
7. What do you think would help students to reach a higher level of motivation?
8. What are the most effective activities for online teaching?
9. What has been the biggest challenge in distance learning and teaching?
10. What would you recommend to improve the quality of distance learning and teaching?

The answers to questions 1, 5, 7, and 8 are presented in Figures 6–9. Figure 6 illustrates that teachers' feelings regarding the switch to distance education are very mixed but at the same time predominantly positive (53% of respondents classified their feelings as either very happy, confident, motivated, easy, or natural).

Replying to question 2, only 25% of respondents thought that the lack of personal contact with students and other teachers on campus did not affect their motivation, with the remaining 75% being either heavily (31%) or somehow (44%) influenced. From the answers to question 3, we conclude that about 19% of the teachers considered that the students were active enough during synchronous online sessions. The relationship with the students became more distant according to 72% of respondents and only 9% observed a closer connection with the students (question 4).

Figure 7 corresponds to the analysis of the answers to question 5 and illustrates the extent to which teachers agree with the statement that they have acquired new skills in using online educational resources and strategies that they would continue to use. This is a very positive signal, as 75% of the respondents confirm that they gained novel skills,

which definitely contribute to both diversifying the teaching activities and raising the digitalization level of education.

According to the answers to question 6, none of the teachers opted for preferring distance education, with 44% favoring blended classes and 56% exclusively on-campus classes. However, when asked if they would select campus over distance teaching, 84% confirmed, 13% were neutral, and 3% disagreed.

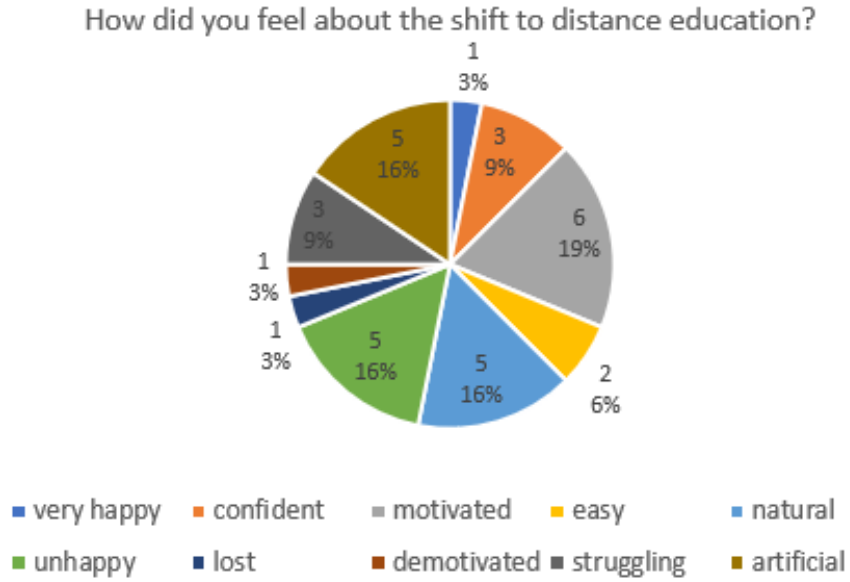

Figure 6. Teachers' feelings about the sudden switch to distance education.

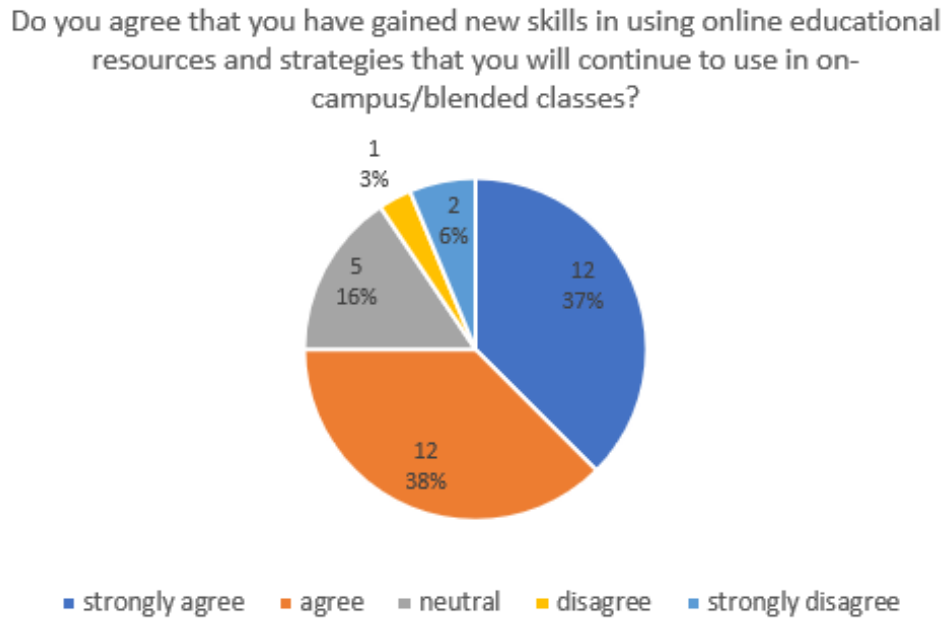

Figure 7. Teachers' acquisition of new competences on using online education resources.

The types of activities that the teachers consider helpful for students to reach a higher degree of motivation are presented in Figure 8 (question 7). Question 8 suggested to choose the most effective activities that contribute to knowledge acquisition in online learning. The answers to this question are summarized in Figure 9.

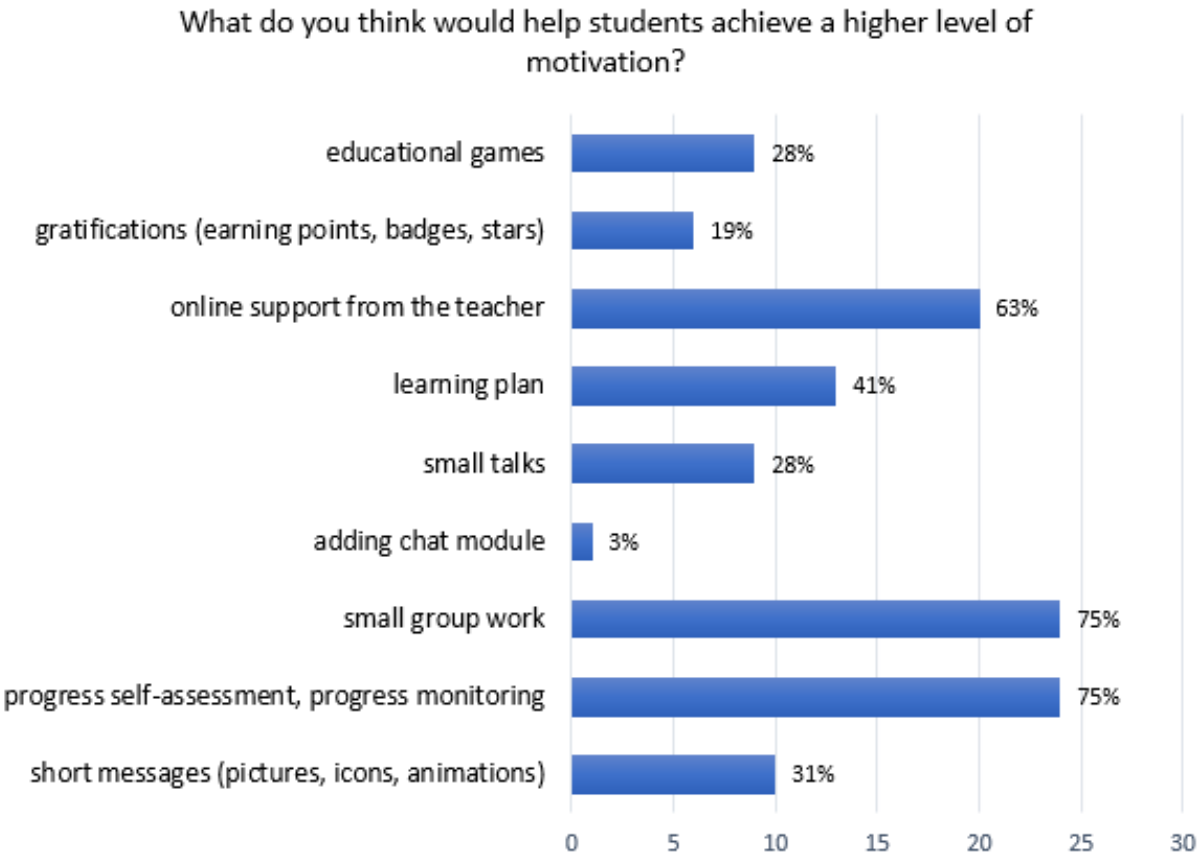

Figure 8. Types of activities that the teachers consider helpful for students to reach a higher degree of motivation.

The analysis of the (open) answers to question 9 shows that the difficulties and challenges experienced by teachers during distance education are three-fold. On one side, the teachers faced emotional problems such as an absence of personal on-campus contact and interaction with the students and nostalgia for using traditional classroom utilities, such as a whiteboard and pens. On the other side, some technical difficulties were reported: lack of digital whiteboards, dedicated and adequate working space, ergonomic camera, virtual laboratory, and weak internet connection. Moreover, the teachers stated the shortage of sufficient knowledge in using modern digital teaching tools: how to create a video, how to design a quiz, how to create a mind map, etc. These limitations notwithstanding, 63% of respondents noticed an improvement in the quality of online teaching in 2020/2021 when compared to 2019/2020, 75% verified that they learned how to support students in their learning through digital tools, and 78% developed their own skills in using digital tools and online education strategies.

As the most difficult aspects of distance learning and teaching, the following were pointed out:

- controlling the students' behavior;
- keeping students motivated;
- fair assessment;
- producing quality online study materials;
- lack of in-person interaction between the students and their psychological well-being;
- lack of contact with students and colleagues;
- lack of immediate feedback from students;
- difficulty in understanding the students' progress;
- adaptation to new teaching approaches;
- balance between work and family.

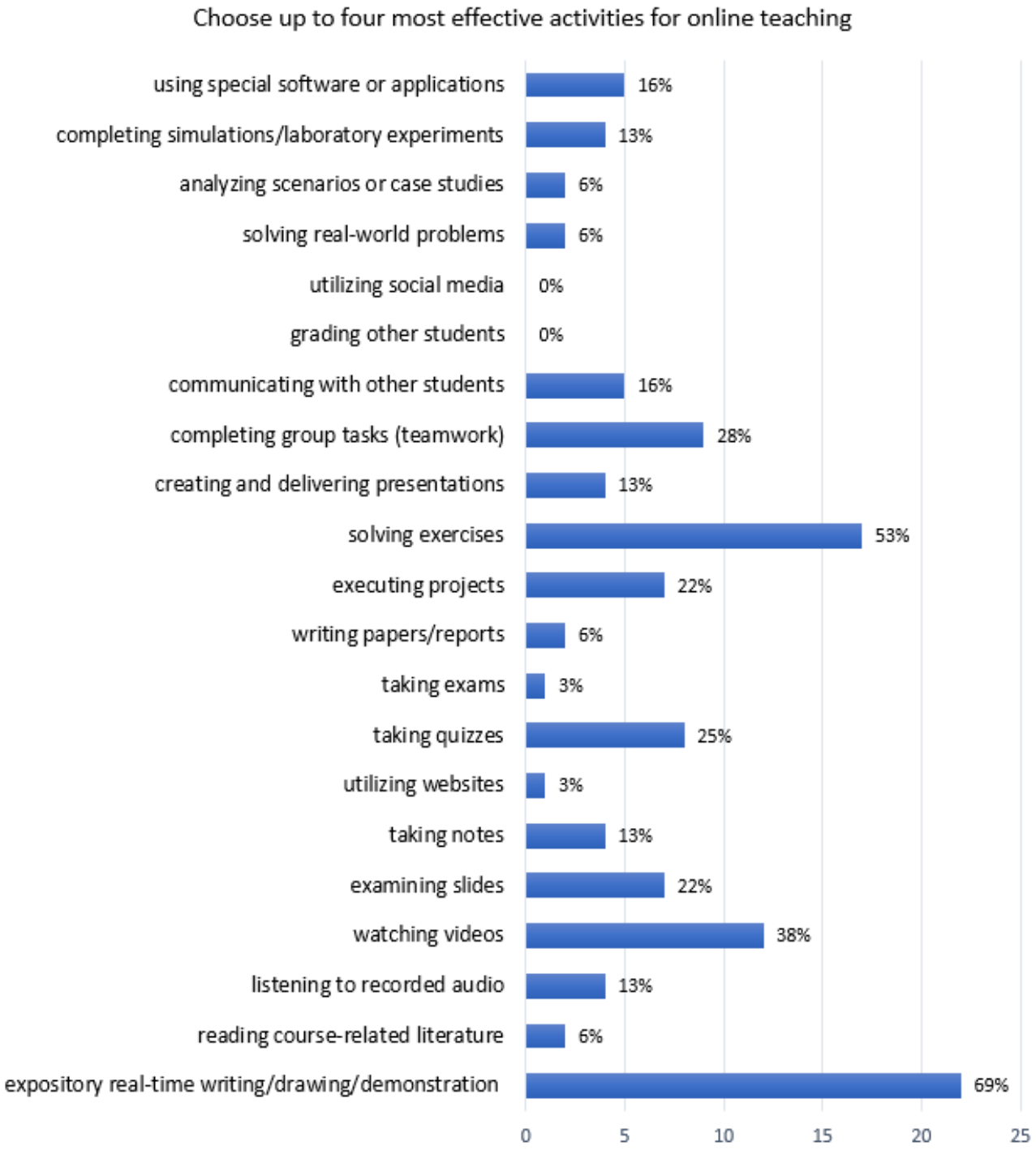

Figure 9. The most effective activities for online teaching.

The answers to the last question in this category, question 10, contain recommendations on how to improve the distance teaching/learning quality. In what follows, we present the most typical recommendations grouped into four classes:

- Technical basis: provide good technical conditions (computers, digital whiteboards, and sufficient internet bandwidth).
- Support from the university: more training on the efficient use of innovative learning-teaching methodologies is required.
- Methodological issues: diversify activities to increase the students' interest and engagement (such as interactive quizzes/polls); give time to learn new tools and strategies;

promote self-learning (e.g., flipped classroom); produce better online study materials; reduce expository lecture times; and promote social interaction events.
- Control: implement some kind of supervision of teachers, because several teachers have stopped teaching and referred students to reading and watching third party videos.

5. Analysis and Comparison to the Students' Perspective

In this section, the teachers' appreciation of distance learning is compared to the students' perspective. The data for the comparison are taken from the previous work of the authors ([31]) and are based on a questionnaire targeted towards the STEM students of the same departments. Students' responses were collected and analyzed, both quantitatively and qualitatively (including a more profound statistical analysis).

5.1. Preparation

Both the students [31] and faculty of our university have had virtually no experience with distance education. The university made a great effort to identify ICT tools that could be used and organized online workshops on the application of those ICT tools along with sessions on innovative teaching and learning strategies, identified all students with internet or equipment problems, and created groups and services guaranteeing emotional and psychological support and counseling for students. All these measures contributed positively to a very fast and relatively smooth shift to distance education. There were no restrictions imposed on the tools to be used, but the selections were ultimately done by the teachers and the students had to adapt. It is interesting to note that only a small portion of students (5%) reported technical issues (such as poor internet connectivity or equipment failures), contrary to teachers complaining of both lack of equipment (34%) and insufficient infrastructure (41%). This indicates that the level of expectation of teachers is much higher than that of students.

5.2. Delivery

Similar to the students [31], the surveyed teachers also indicated that their preparation workload has amplified compared to traditional teaching. The vast majority of faculty believe that face-to-face communication with cameras on is important in distance learning (94%)—a bigger proportion compared to students (62%) [31]. In fact, the difference between the responses of teachers and students about the importance of having cameras on was observed to be statistically significant (p-value = 0.002).

Teachers and students were also unanimous in preferring on-campus to distance learning (73% of students and 84% of teachers). Both parties identified the lack of student motivation as the major problem and proposed incorporating activities such as progress self-assessment (students—50%, teachers—75%), small group work (students—44%, teachers—75%), more online support from the teachers (students—60%, teachers—63%), a learning plan (students—46%, teachers—41%), and educational games (students—36%, teachers—28%).

5.3. Assessment

Very few students (14%) and teachers (9%) considered the assessment procedures implemented during distance education as not fair. The majority considered them to be fair enough (students—56%, teachers—59%), and less than one third of all the respondents thought that these procedures were fair (31% of both students and teachers). No statistically significant differences were observed between the opinions of students and teachers regarding the fairness of the implemented assessment procedures (p-value = 0.798). However, nearly half of the students (47%) thought that their efforts to achieve the same grades as before the pandemic had increased, which may partly explain the high percentage of students and teachers considering the assessment procedures as fair enough, instead of fair.

5.4. Evaluation

The study confirms the generally accepted opinion that the epidemic had a negative impact on the psychological state of the population. Thus, according to the results of our surveys, many of the teachers/students surveyed felt unhappy (16%/34%), lost (16%/29%), and struggling (9%/26%) with the switch to remote education. The teachers were significantly less motivated than the students (19% against 59%). Despite the difference in their assessment of motivation, about 70% of both faculty and students felt that the lack of face-to-face contact on campus affected their motivation, with no statistical differences between faculty and student responses (p-value = 0.334). Accordingly, as observed for teachers (84%), the majority of students also favor campus learning (74%); yet, in spite of a much higher detected percentage of students disagreeing with campus over distance learning, when compared with the teacher's answers (13% versus 3%), the responses of teachers and students have no statistical difference (p-value = 0.255). On the contrary, the majority of teachers (63%) reported an improvement in the quality of online teaching in 2020/2021 when compared to 2019/2020 (against 27% of students), while the majority of students (58%) have not noticed differences (against 31% of teachers), with the remaining teachers and students observing a deterioration in the quality of distance education. This difference was calculated to be statistically significant (p-value = 0.00045), which allows suggesting that notwithstanding the sudden switch to remote education, forcing teachers to quickly adapt to a new teaching environment, the efforts paid off, as students felt its quality was similar to the one of the subsequent year when teachers had more time to consolidate their way of online teaching. Teachers, on the contrary, felt an increase in the online education quality in the subsequent year, probably because in 2020/2021 they had time to consolidate the way to use online tools and online education strategies applied in the previous year.

The major challenges identified by both students and teachers are as follows:

- lack of students' engagement (48% of students felt that their peers are not engaged in synchronous online classes);
- lack of student concentration and focus of attention on lectures/classes (36% of students and 38% of teachers);
- lack of motivation (86% of students and 34% of teachers);
- overloaded with work.

When asked about the most effective activities for online learning, teachers and students presented rather similar preferences:

- having expository demonstrations from the instructor (46% of students and 69% of teachers);
- solving exercises (59% of students and 53% of teachers);
- watching videos (52% of students and 38% of teachers);
- completing group tasks (34% of students and 28% of teachers).

Despite the similarities between teachers' and students' preferences, it should be noticed that teachers rated "having expository demonstrations from the instructor" as the most effective activity (69%), although it was in third place for students (44%), after "solving exercises" (53% for teachers and 59% for students) and "watching videos" (36% and 53%, respectively).

Both teachers and students agree that peer assessment of other students and utilizing social media are not effective cooperative learning techniques. Teachers' and students' opinions about the usefulness of taking notes/browsing websites do not match: 47%/19% of students consider these as productive while only 13%/3% of teachers share this point of view.

6. Discussion

In this section, the main results and findings are compared to other similar research works, reviewed in Section 2, with the intention to identify similarities and to highlight discrepancies, if any.

6.1. Preparation

Experienced teachers participated in this study, but, albeit being motivated to switch to distance education and open to the possibilities of digital learning (consistent with [27]), some of them reported problems with equipment (34%) and infrastructure (41%) and confessed lacking important digital skills (25%), in spite of the significant training support provided by the university. This confirms the results of other similar research (e.g., [11,13,23]) where various logistical and technical issues were identified. For example, the study by Asgari et al. [11] discovered that 23% of the California State University faculty did not have good internet connection, 32% did not have access to a camera for online instruction, and almost half faced technical issues with online writing tools. In less developed countries, the high costs associated with a massive transition to distance education are referred to as an important barrier (see Matuuk et al. [14]).

6.2. Delivery

Contrary to the studies of Sieber et al. [18] and Mishra et al. [23], our work has revealed much more intensive use of synchronous online videoconferencing/communication tools, such as Zoom (97%) and MSTeams (72%). Sieber et al. [18], for instance, report that only ~32% of lectures in the University of Zurich have been given through bidirectional synchronous communication channels in 2020. We explain this by differences in HEIs' management policies, with our university actively promoting the widespread use of digital technologies. Our results are, however, in line with those obtained by Wu [32] in a study conducted in a university of Taiwan. Comparing synchronous and asynchronous online classes delivered in a university in Germany, Fabriz et al. [33] noticed that faculty perceived fewer differences between teaching and learning strategies in synchronous and asynchronous contexts compared to students, particularly with respect to feedback activities, which students said were more effective in synchronous contexts. However, the level of teacher's self-satisfaction was higher among those who predominantly used synchronous settings.

In [28], nearly 23% of the course coordinators expressed concerns regarding the low active engagement of students and a decrease in participation. The authors of this case study argue that since most of these courses were given asynchronously, one explanation could be that it is simpler for students to engage in a videoconference than it is for them to send a teacher an email with their doubts, questions, or ideas.

6.3. Assessment

Our study shows that teachers generally found the assessment procedures implemented during the pandemic to be fair (90%), although they reported technical difficulties in assessing students online. Lucas and Vicente [13] classify assessment as one of the major challenges in online learning. Cheating issues are also discussed in Hadzieva et al. [10], suggesting that students are usually ahead of their teachers in inventing ways to conduct a fraud. This is consistent with Oliveira et al. [17] who concluded that teachers had difficulties preventing unethical student behavior during online tests. In the latter study, teachers were found to have a lack of ICT solutions to avoid cheating. Therefore, they preferred to reduce the time available for solving exams/tests and elaborate more complex questions, believing that students have better access to information when they are outside the classroom and without proper supervision.

The issue of fraud was also analyzed in the case study [26]. In spite of teachers' efforts to take measures to prevent cheating on assessments, despite the existence of an organization's ethic code developed for online exams, and the utilization of plagiarism

detection software, supervision during online examinations was restricted due to privacy concerns. In this work, most of the teachers claimed that they made an effort to alter different assignments that learners needed to fulfill in order to successfully complete their course. In particular, a large number of the assignments for the continuous evaluation were either eliminated or simplified in terms of difficulty.

6.4. Evaluation

Producing quality online study materials was identified as one of the main challenges of online teaching. This confirms the works of Asgari et al. [11] and Martin and Bolliger [25], which state that technical support for online teaching is critical and that HEIs should offer professional development workshops for instructors who are new to online teaching strategies or who want to improve their expertise.

The vast majority of faculty surveyed felt that the lack of face-to-face contact with students and colleagues on campus affected their motivation (75%) and negatively impacted their relationship with students. It confirms the results of Lucas and Vicente [13] where very few instructors classified greater availability of choices for online communication and interaction as a benefit (4%) rather than a challenge (12%). Saide et al. [15] also emphasize that the lack of immediate feedback from students during teaching activities affects the learning and teaching process. Thacker et al. [16] likewise confirm that low levels of student attendance and participation rates contribute negatively to teachers' stress and anxiety.

In [26], the authors argued that the main problems experienced by the teachers were the limited time available for acclimating to new procedures and tools that enable online learning in the case of emergency, and technical difficulties with the different video conferencing platforms and learning management systems. Low student interest, motivation, and participation were also mentioned. This had a negative impact on courses with a heavy laboratory component and resulted in inferior instant feedback owing to the lack of social presence, eye contact, and face-to-face communication.

Oliveira et al. [17] also mention that, especially for engineering students, the educational process was affected, because the laboratory courses were particularly frustrating for students, since they did not have the opportunity to operate the equipment in the face-to-face environment.

Our results show that about 30% of teachers felt unhappy, lost, demotivated, and struggling with the shift to distance education and experienced difficulties in balancing work and family, which reinforces the results of Sieber at al. [18], indicating that participants in their study experienced lower satisfaction with life and work and more stress in their daily lives during the pandemic. Other works (e.g., [10]) endorse this conclusion.

Not just knowledge and content are important when it comes to online teaching. A big challenge is to provide interesting classes that could keep the students engaged and motivated by adopting some teaching strategies (for example, case studies, debates, discussions, experiential learning, brainstorming sessions, and games). The focus should be on using technology with minimal maintenance costs and maximum effectiveness to facilitate the educational process [34].

6.5. Study Limitations

The present study has limitations. First, the sample size is not very large (the survey response rate was 21.3%) and the research is limited to a single HEI. The length of the questionnaire may have impacted the participation rate. The relatively low response rate may have led to some participant bias in the results. Second, more in-depth and advanced statistical analysis methods could have been applied. Variables such as respondents' overall teaching experience and their experience with online learning were not used to classify conclusions. Third, this study was conducted with teachers from a single HEI, who have the same social and cultural background. It is expected that the results would be different if the same study were implemented with teachers with different profiles. These limitations may provide an impetus for future research.

7. Conclusions and Recommendations

The majority of faculty surveyed preferred campus to distance teaching. They indicated that it was challenging to keep students motivated, they denounced the lack of immediate student feedback, they could not track student progress from a distance, and they lacked contact with students and colleagues. The proposals for the improvement of distance education are mainly related to the development of a good technical base, extensive training support from the university, and restructuring the classes by making them shorter, targeting smaller groups of students, and incorporating more interactivity. Teachers believe that they need significantly more time to prepare distance classes. The problem of preventing unethical behavior in assessments is also notable.

Although the majority of respondents prefer on-campus instruction, it is clear that the experience gained can be used in future online and blended courses. For certain situations (such as natural catastrophes, human-caused disasters, and other emergencies), distance education is an indispensable solution and, to make it more efficient, the following recommendations are proposed:

- Guarantee that faculty and students have access to appropriate equipment and digital infrastructure.
- Organize customized training and provide suitable assessment tools for students and teaching staff.
- Supply teachers with innovative learning and teaching strategies and digital support.
- Distance assessment is the most challenging part of distance education, and explicit technical and organizational actions have to be applied.

Author Contributions: Conceptualization, I.S., I.M., T.T., I.C. and N.M.; methodology, I.S., I.M., T.T., I.C. and N.M.; validation, I.S., I.M. and T.T.; formal analysis, I.S., I.M. and T.T.; data curation, I.S. and T.T..; writing—original draft preparation, I.S., I.M., T.T., I.C. and N.M.; writing—review and editing, I.S., I.M., T.T., I.C. and N.M. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Erasmus+ project e-CLOSE–A model for Interactive (A)Synchronous Learning in Online STEM Education 2020-1-PL01-KA226-HE-096239 and by National Funds through the FCT—Foundation for Science and Technology, in the context of the projects UIDB/00127/2020, UIDB/ECI/04450/2020, UIDB/04106/2020.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data supporting reported results can be found in https://eclose.p.lodz.pl/ (accessed on 2 February 2023).

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

References

1. NCES (National Center for Education Statistics). Digest of Education Statistics 2019. U.S. Department of Education, Institute of Education Sciences. 2019. Available online: https://nces.ed.gov/pubs2021/2021009.pdf (accessed on 2 December 2022).
2. Eurostat. People expanding Their Knowledge by Learning Online. European Commission, Eurostat. 2020. Available online: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20200517-1 (accessed on 2 December 2022).
3. NCES (National Center for Education Statistics). Undergraduate Enrollment. U.S. Department of Education, Institute of Education Sciences. 2022. Available online: https://nces.ed.gov/programs/coe/indicator/cha (accessed on 2 December 2022).
4. Eurostat. Interest in Online Education Grows in the EU. European Commission, Eurostat. 2022. Available online: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20220124-1 (accessed on 2 December 2022).
5. Kentnor, H.E. *Curriculum and Teaching Dialogue*; Information Age Publishing: Charlotte, NC, USA, 2015.
6. Zancajo, A.; Verger, A.; Bolea, P. Digitalization and beyond: The effects of COVID-19 on post-pandemic educational policy and delivery in Europe. *Policy Soc.* **2022**, *41*, 111–128. [CrossRef]
7. Basilotta-Gómez-Pablos, V.; Matarranz, M.; Casado-Aranda, L.-A.; Otto, A. Teachers' digital competencies in higher education: A systematic literature review. *Int. J. Educ. Technol. High. Educ.* **2022**, *19*, 8. [CrossRef]
8. Borich, G.D. *Effective Teaching Methods. Research-Based Practice*, 9th ed.; Pearson: London, UK, 2017.

9. Chen, B.; Bastedo, K.; Howard, W. Exploring design elements for online STEM courses: Active learning, engagement & assessment design. *Online Learn.* **2018**, *22*, 59–75. [CrossRef]
10. Hadzieva, E.; Gunčaga, J.; Bose, S.C.; Sotiroska Ivanoska, K. Introductory Survey on Challenges Encountered by University Teachers in Online Teaching of STEM Subjects During COVID-19 Lockdown. *Central Eur. J. Educ. Res.* **2021**, *3*, 22–32. [CrossRef]
11. Asgari, S.; Trajkovic, J.; Rahmani, M.; Zhang, W.; Lo, R.C.; Sciortino, A. An observational study of engineering online education during the COVID-19 pandemic. *PLoS ONE* **2021**, *16*, e0250041. [CrossRef]
12. Seaman, J.; Allen, I.E.; Ralph, N. Teaching Online: STEM Education in the Time of COVID. Teaching Online: STEM Education in the Time of COVID. Bay View Analytics. 2021. Available online: https://www.bayviewanalytics.com/reports/stem_education_in_the_time_of_covid.pdf (accessed on 20 December 2022).
13. Lucas, M.; Vicente, P.N. A double-edged sword: Teachers' perceptions of the benefits and challenges of online teaching and learning in higher education. *Educ. Inf. Technol.* **2022**, *28*, 1–21. [CrossRef]
14. Matuuk, A.; Elberkawi, E.; Aljawarneh, S.; Rashaideh, H.; Alharbi, H. The COVID-19 pandemic and E-learning: Challenges and opportunities from the perspectives of students and instructors. *J. Comput. High. Educ.* **2021**, *34*, 21–38. [CrossRef]
15. Saide, S.; Sheng, M.L. Knowledge exploration–exploitation and information technology: Crisis management of teaching–learning scenario in the COVID-19 outbreak. *Technol. Anal. Strat. Manag.* **2020**, *33*, 927–942. [CrossRef]
16. Thacker, I.; Seyranian, V.; Madva, A.; Beardsley, P. STEM Faculty's Support of Togetherness during Mandated Separation: Accommodations, Caring, Crisis Management, and Powerlessness. *Educ. Sci.* **2022**, *12*, 632. [CrossRef]
17. Oliveira, G.; Grenha Teixeira, J.; Torres, A.; Morais, C. An exploratory study on the emergency remote education experience of higher education students and teachers during the COVID-19 pandemic. *Br. J. Educ. Technol.* **2021**, *52*, 1357–1376. [CrossRef]
18. Sieber, V.; Hüppi, R.; Praetorius, A.K. *Teaching, Motivation, and Well-Being during COVID-19 from the Perspective of University Students and Lecturers*; University of Zurich: Zürich, Switzerland, 2020. Available online: https://www.zora.uzh.ch/id/eprint/197791/1/InitialReport_190820.pdf (accessed on 2 December 2022).
19. Alangari, T.S. Online STEM education during COVID-19 Period: A systematic review of perceptions in higher education. *Eurasia J. Math. Sci. Technol. Educ.* **2022**, *18*, em2105. [CrossRef]
20. Winberg, C.; Adendorff, H.; Bozalek, V.; Conana, H.; Pallitt, N.; Wolff, K.; Olsson, T.; Roxå, T. Learning to teach STEM disciplines in higher education: A critical review of the literature. *Teach. High. Educ.* **2019**, *24*, 930–947. [CrossRef]
21. Freitas, A.; Neves, A.; Carvalho, P. Mathematics students' perception of distance learning—A case study in the context of the COVID-19 pandemic. *Indagatio Didact.* **2020**, *12*, 273–286. [CrossRef]
22. Balgopal, M.M.; Weinberg, A.E.; Sample McMeeking, L.B.; Lin Hunter, D.E.; Wright, D.S. A sense of belonging: The role of higher education in retaining quality STEM teachers. *PLoS ONE* **2022**, *17*, e0272552. [CrossRef]
23. Mishra, L.; Gupta, Y.; Shree, A. Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *Int. J. Educ. Res. Open* **2020**, *1*, 100012. [CrossRef]
24. Sarfaraz, S.; Ahmed, N.; Abbasi, M.S.; Sajjad, B.; Vohra, F.; Al-Hamdan, R.S.; Maawadh, A.A.; Al-Hamoudi, N.; Mokeem, S.A.; Aldahiyan, N.; et al. Self-perceived competency of the medical faculty for E-Teaching during the COVID-19 pandemic. *Work* **2020**, *67*, 791–798. [CrossRef]
25. Martin, F.; Bolliger, D.U. Designing Online Learning in Higher Education. In *Handbook of Open, Distance and Digital Education*; Springer: Singapore, 2022. [CrossRef]
26. Iglesias-Pradas, S.; Hernández-García, A.; Chaparro-Peláez, J.; Prieto, J.L. Emergency remote teaching and students' academic performance in higher education during the COVID-19 pandemic: A case study. *Comput. Hum. Behav.* **2021**, *119*, 106713. [CrossRef]
27. Guppy, N.; Verpoorten, D.; Boud, D.; Lin, L.; Tai, J.; Bartolic, S. The post-COVID-19 future of digital learning in higher education: Views from educators, students, and other professionals in six countries. *Br. J. Educ. Technol.* **2022**, *53*, 1750–1765. [CrossRef]
28. Humpl, S.; Andersen, T. European Commission, Directorate-General for Education, Youth, Sport and Culture. In *The Future of Digital and Online Learning in Higher Education*; Publications Office of the European Union: Luxembourg, 2022. [CrossRef]
29. Yin, R. *Applications of Case Study Research*; Sage Publishing: Beverly Hills, CA, USA, 1993.
30. IBM, Corp. IBM SPSS Advanced Statistics V27. International Business Machines Corporation. 2022. Available online: https://www.ibm.com/docs/en/SSLVMB_27.0.0/pdf/en/IBM_SPSS_Advanced_Statistics.pdf (accessed on 2 December 2022).
31. Skliarova, I.; Meireles, I.; Martins, N.; Tchemisova, T.; Cação, I. Enriching Traditional Higher STEM Education with Online Teaching and Learning Practices: Students' Perspective. *Educ. Sci.* **2022**, *12*, 806. [CrossRef]
32. Wu, S.Y. How Teachers Conduct Online Teaching During the COVID-19 Pandemic: A Case Study of Taiwan. *Front. Educ.* **2021**, *6*, 675434. [CrossRef]
33. Fabriz, S.; Mendzheritskaya, J.; Stehle, S. Impact of Synchronous and Asynchronous Settings of Online Teaching and Learning in Higher Education on Students' Learning Experience During COVID-19. *Front. Psychol.* **2021**, *12*, 733554. [CrossRef]
34. Dahawan, S. Online learning: A panacea in the times of COVID-19 crisis. *J. Educ. Technol. Syst.* **2020**, *49*, 5–22. [CrossRef]