Switching Gears

Online Teaching in Higher Education
in the First Wave of the COVID-19 Pandemic

Claudia Moessenlechner[✉], Regina Obexer, Maria Pammer, Julia Waldegger
Management Center Innsbruck, Innsbruck, Austria
`claudia.moessenlechner@mci.edu`

Abstract—In March 2020, the COVID-19 pandemic turned into an urgent priority for higher education institutions in that they had to move to remote teaching within a matter of weeks. This paper presents the results of a quantitative survey looking at the challenges university faculty were facing when moving their course(s) online during the first semester of the COVID-19 crisis. The survey looks specifically at course design and formats used in online teaching during the crisis and compares differences occurring between disciplines (STEM and management education). The outcomes overall mirror a sense of achievement due to the successful delivery of online courses with little preparation. Difficulties that lecturers identified were related to promoting student interaction and engagement, technical issues, the effort required to plan and prepare online learning materials, and challenges with regard to online assessment. Having access to training and support in various forms was highlighted as an important success factor.

1 Introduction and background

In spring 2020, the sudden and unexpected pandemic under COVID-19 impacted all parts of society and almost all sectors of the economy. In higher education (HE), the crisis has affected some 220 million students and resulted in institutional lockdowns, leaving HE institutions (HEI) with unprecedented challenges and significant impacts across all organizational levels [1, 2].

The adoption of technology for teaching to keep students and faculty safe and to comply with safety regulations under this first wave of COVID-19 was an immediate response of almost all HEIs worldwide. This, however, has also led to an educational crisis [1] for some, as the emergency transition to online teaching represented a major disruption of traditional class-based teaching and learning.

The shift to remote teaching during lockdown has not been smooth for most HEIs [3], although the overall transition was rated as "successful" by most university

leaders, and most institutions also provided training and technical support of some sort for faculty [2].

The emerging literature and studies conducted under the first wave of COVID-19 dealing with the effects of the pandemic on HE specifically point at the overall challenges and difficulties faced by both governments and institutions, as well as technical constraints such as internet access and speed, availability of hardware, and the sourcing of online materials and suitable learning platforms [2, 4]. Only a few of these studies are specifically addressing the challenges HE faculty have been facing in their teaching during the pandemic in terms of *online pedagogy*. However, some studies, like the IAU Global Survey Report, specifically break down "teaching and learning activities" by also including some comments and items on "distance learning competencies and pedagogies" and "fields of studies" when looking at distance teaching in their survey report [5].

In October 2020, Mseleku [3] identified some 85 peer-reviewed articles out of 910 that are directly connected to e-learning and e-teaching under COVID-19. These articles do not exclusively look at HE settings, but include colleges and schools alike. Some studies also note that the transition to online teaching was specifically [6] challenging in disciplines that have a practical component [5]. However, pedagogical challenges in online teaching during COVID-19 are, if at all, only touched upon in the literature. Here, it is especially a lack of knowledge concerning the use of technology and learning platforms and, respectively, the lack of time to gain such knowledge, that is considered in more detail [2].

It should be emphasized that the body of literature and the number of reports and studies dealing with the impacts of the ongoing pandemic on HE is growing rapidly, and most likely, there will be more evidence available by the time this paper is published. Currently, for an overall overview drawing on some 75 reports, surveys and studies the NESET report [2] is highly recommended.

1.1 Higher education and online teaching

Long before the pandemic struck, online teaching and learning in HE was experiencing considerable growth worldwide [6–8]. The main reasons for this strategic change are to be found in the challenges HE organizations are facing (and the opportunities they imply), like the digitalization of the economy, significant demographic changes and increasing student diversity affecting the very nature of HE programs. As a consequence, many HEIs worldwide are re-designing and partly digitalizing their teaching and business models in an increasingly disrupted and diverse market [8]. Additionally, in an attempt to improve and harmonize HE across Europe, the Bologna Process has triggered an increasing use of outcomes-based teaching [9] and a move to more agility in curriculum development and teaching [10], also urging HEIs to measure and demonstrate both teaching quality and the quality of student learning outcomes. As a direct result, HEIs have become much more concerned about the quality of teaching to help students learn, and the teaching modalities to support this ambition. A change in the delivery mode (i.e., a move to online) can lead to more flexibility in terms of time and place for learning; however, given the low completion rates and higher dropout rates in some

online learning programs [11], learner engagement and learning outcomes are key points when designing online programs [12]. When comparing traditional classroom settings with online settings, literature especially mentions instructor and student roles, communication, interaction, and teaching flexibility that undergo a major shift when teaching online [13, 14].

Given that traditional settings and patterns must be re-designed for online teaching, unsurprisingly, the COVID-19 crisis has brought to light many of these issues.

1.2   Online teaching modalities

Online teaching can be defined as teaching remotely in a virtual environment and through the following modalities: synchronous activities, asynchronous activities or a combination of both by blending synchronous and asynchronous activities [7]. These modalities can be applied individually or combined in multiple teaching patterns, all of which result in course concepts for online teaching using synchronous and asynchronous modes (see Figure 1).
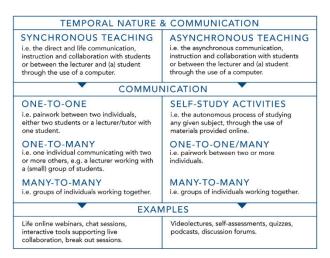
TEMPORAL NATURE & COMMUNICATION	
SYNCHRONOUS TEACHING i.e. the direct and life communication, instruction and collaboration with students or between the lecturer and (a) student through the use of a computer.	**ASYNCHRONOUS TEACHING** i.e. the asynchronous communication, instruction and collaboration with students or between the lecturer and (a) student through the use of a computer.
COMMUNICATION	
ONE-TO-ONE i.e. pairwork between two individuals, either two students or a lecturer/tutor with one student.	**SELF-STUDY ACTIVITIES** i.e. the autonomous process of studying any given subject, through the use of materials provided online.
ONE-TO-MANY i.e. one individual communicating with two or more others, e.g. a lecturer working with a (small) group of students.	**ONE-TO-ONE/MANY** i.e. pairwork between two or more individuals.
MANY-TO-MANY i.e. groups of individuals working together.	**MANY-TO-MANY** i.e. groups of individuals working together.
EXAMPLES	
Life online webinars, chat sessions, interactive tools supporting live collaboration, break out sessions.	Videolectures, self-assessments, quizzes, podcasts, discussion forums.

Fig. 1. Online teaching modalities

When designing their online classes, lecturers have a distinctively wider set of responsibilities. Online teaching activities not only relate to direct, live teaching contexts, but also to asynchronous settings, where students learn independently and/or in peer groups. The literature has reflected this in describing "flipped classroom" teaching models (also known as inverted classroom models), in which traditional, lecture-based teaching is combined with asynchronous online learning activities [15–17]. Online faculty has to carefully design materials and activities that promote active learning and give timely feedback to make asynchronous learning successful. These requirements go well past the traditional reading lists faculty in traditional HE might have made available for students as course materials.

In purely online learning settings, building relationships is often considered difficult. Despite vast technological possibilities for student-teacher and student-student interactions, the teachers cannot expect the interaction to automatically occur. Therefore, they must purposefully include interactive elements in their course design. For example, assignments should not only address cognitive, but also socio-emotional and affective, processes to make room for social interactions [18]. Furthermore, Davis *et al.* [19] highlight the importance of teachers making proactive efforts to humanize themselves and become trusted allies in the process of education. This can be referred to as "social presence" that describes behavior that fosters the student-teacher interaction and requires a set of competencies, such as oral and written communication skills and the ability to create a cordial learning environment, as Ní Shé *et al.* [20] describe in their list of competencies for effective online teaching.

The use of technology and ICT integration in the curriculum has been widely considered in teacher education programs [21, 22], as well as in European policy frameworks, such as the European Digital Competence Framework for Educators [23, 24]. The motivation to use technology for teaching, however, depends on the correlation between perceived usefulness, perceived enjoyment in the use of technology and personal attitude toward technology. In other words, the intention to use technology for teaching directly stems from the behavioral attitudes toward technology by the user [25].

Therefore, it is both positive behavioral attitude as well as knowledge and experience in pedagogical design that are required to create successful online courses, and this can represent a major challenge when teaching online for the first time.

1.3   Faculty readiness and teaching proficiency in higher education

Although there is strong agreement on the need for pedagogical training for faculty in HE in general, opinions differ when it comes to the design and type and the quantity of training for online delivery of courses. Literature agrees that postsecondary faculty tend to teach following the methodology through which they themselves were taught and form their professional identity through personal and contextual factors like social experience, educational context, demographic characteristics, professional image and experience, personal development, and self-engagement [26, 27].

In many universities, teaching qualifications are neglected toward the subject expertise of a researcher/lecturer, assuming that a strong track record in research is the main criterion to get tenure. However, professional development and support for teaching in HE become critical with a changing teaching environment, which is a phenomenon we can observe during the current crisis.

Given the clear and increased responsibility HE teachers have during COVID-19, the following questions are addressed in this study:

How have HE teachers dealt with the overall challenges when teaching online? Which teaching modalities have they used? What did they have to adapt in terms of teaching materials, assessment and workload for students? How did they cope with new technology? What kind of support did they need and seek?

2 Empirical study

This survey assesses the key challenges university faculty were facing when moving their course(s) online during the first wave of the COVID-19 crisis 2020 at MCI Innsbruck. The survey specifically explores the key challenges, didactic approaches, training and support, and individual experiences of faculty during the first "COVID-19 term" from March 2020 through July 2020.

2.1 The case of MCI

MCI, the Entrepreneurial School®, was founded as a HEI in 1995. Located in Innsbruck, Austria, MCI currently welcomes around 3,400 students in 27 study programs at undergraduate and graduate level, as well as post-graduate and non-degree programs in its executive education department. Most programs offered at MCI are on-campus programs, with students normally attending mandatory, full-day courses on MCI premises. In March 2020, MCI offered eight online programs, including residential periods in different weightings and forms. Faculty training courses for online teaching in blended-learning programs have been in place as part of faculty-training programs since 2014, and faculty is entitled to take part in all courses offered by the central support unit, MCI Learning Solutions, for free.

MCI currently employs tenured professors, lecturers or full-time teaching assistants. External (adjunct) faculty are industry experts from the respective fields, faculty from other universities or freelance HE faculty, dividing their time teaching between various HEIs.

2.2 First wave of COVID-19 and the emergency shift to online teaching at MCI

In Austria, all HEIs had to at least partially close their premises within a one-week period in March 2020. This was also the case at MCI, where courses had to be moved online as of March 9, 2020, and the campus was shut down for both students and faculty. Accordingly, all other institutional events such as graduation ceremonies, talks and conferences were postponed, canceled or moved online. In line with government regulations, MCI staff, including faculty, were asked to work remotely from home wherever possible. The immediate move to online teaching occurred on MCI's established learning systems, the learning management system Sakai for asynchronous and Adobe Connect for synchronous online learning. Sakai had been in use for a decade and had served as a main hub for teaching in all study programs.

A core program to support the faculty in online teaching was made available online immediately. Courses in small bite-sized formats were offered, specifically focusing on relevant topics, and on a rolling daily basis. This gave faculty the opportunity to participate in their own time and adapt their courses simultaneously. The faculty program incorporated the use of technology, as well as pedagogical elements in online teaching—i.e., online collaboration, discussion facilitation and the design of asynchronous online lessons. Additionally, Q&A sessions were offered where faculty could ask for support

regarding individual technical or pedagogical challenges they were facing. Toward the end of term, the faculty program was adapted and a specific focus was put on online assessment. All in all, 140 lecturers took part in these courses.

Furthermore, a website was developed including recordings of courses that were part of the "teaching online" program, online materials and links for teaching various subjects, as well as samples of how to design asynchronous online lessons. The faculty was informed and reminded about the website and courses regularly via email. Additionally, in some departments, informal online discussion rounds were organized by faculty who were experienced in online teaching. These measures enabled MCI to successfully transfer some 600 courses/lectures to the online teaching space within one week.

2.3   Methodology and research design

This paper presents the results of a quantitative survey among tenured and adjunct faculty teaching during the first wave of COVID-19 at MCI Innsbruck (N = 674) using an online questionnaire with the LimeSurvey Software. The questionnaire is based on frameworks and research findings relating to online teaching [28–32] and contains questions relevant for MCI as a HEI.

The survey consists of five content parts, namely, adaptation of teaching, key challenges, didactics, training and support, and individual experiences, as well as a set of demographic questions at the end. Each content part consists of several closed questions with a four- or five-point Likert-scale. To gain better insight and offer faculty the opportunity to address and/or mention additional, critical issues the questionnaire might not fully integrate, some open questions were added to the survey.

2.4   General findings

Following ethical clearance, all lecturers teaching at MCI in the addressed period were contacted via email on August 20, 2020. A reminder email was sent on September 25, 2020. The study resulted in the return of 250 questionnaires of which 157 were completed. This results in a response rate of 26.0% (n = 157).

As far as sex is concerned, the pool of lecturers consisted of 31.1% female and 68.9% male lecturers with an average age of 45 years. In total, 28.7% of the respondents are female, 61.8% male.

The age distribution of survey respondents is shown in the figure below:

Half of those surveyed—51.8%—were teaching in economics and social sciences, 33.6% in STEM subjects, and the rest were teaching in humanities (5.7%), law (5.2%), and medicine (3.6%).

Asked for the organizational form of the study program they operated in, 39.1% reported teaching in a full-time and 18.0% in a part-time bachelor program. For the master programs, 21.1% reported teaching in a full-time program and 13.5% in a part-time program. Only a few participants taught in online programs—2.3% in an online bachelor program and 1.5% in an online master program. The rest of the participants were in executive education programs (1.9%) or extra-curricular career center classes (2.6%).

In terms of teaching experience of respondents, results show that, on average, the respondents have 9.4 (SD 8.1) years of teaching experience at MCI, and 14.8 (SD 11.7) years at other institutions. The average online teaching experience before the period of March to July 2020 was 1.8 (SD 3.7) years at MCI and 1.5 (SD 2.7) years at other institutions.

In addition to the years of online experience, the respondents were asked to rate their prior online experience on a descriptive scale that was adapted from the proficiency levels described in the DigCompEdu framework [23]. Referring to their teaching experience prior to the summer term 2020, 30.8% claimed they had little or no contact with digital technologies in teaching. In total, 23.1% said they had started to integrate digital aspects, 17.2% reported they had experimented with digital technologies, 11.2% had already used digital technologies creatively and confidently, 9.5% had comprehensively and consistently used a broad repertoire of digital technologies, and 1.2% of the respondents reported that they had been working with innovative and complex digital technologies.

Quantitative data analysis was conducted using SPSS Data Analysis System statistics and Microsoft Excel. The comments from open questions were analyzed deductively with codes corresponding to the preceding question and were interpreted based on the content items and in relation to the quantitative results.

2.5 Adapting teaching modalities

As stated in the literature review, online teaching requires a significant adaptation of teaching strategies and methods. Despite the challenges, more than two-thirds of the respondents perceived the transition to online teaching as easy and successful. Only 8.9% of respondents did not, and 20.7% did rather not agree. This is all the more surprising as, compared to their classroom teaching, 90.6% of respondents (rather) agreed that they had to significantly adjust their teaching methods in terms of delivery and learner engagement (e.g., lecture, group work, experimental work in laboratory). Almost two-thirds (59.2%) stated that they also had to adapt assessment elements, and almost half of the respondents (46.8%) (rather) agreed on the need for adapting written documents serving as study materials (e.g., worksheets, readers, slide sets).

Unsurprisingly, faculty who already had extensive online teaching experience before the summer term 2020 agreed that the transition to online teaching was easy. Interestingly enough, however, 22.4% of lecturers without or with little prior experience in online teaching also agreed or rather agreed (40.8%) that moving from on-campus to online teaching was easy for them.

2.6 Course design, workload distribution and materials

The question of student workload becomes especially relevant in online teaching. Unlike in on-campus courses, online courses should depict, illustrate and outline course content in the form of carefully designed materials, which increases the course preparation time for faculty, especially when they are new to online teaching [33]. Bearing this in mind, it is not surprising that course design and developing materials for online teaching was perceived as challenging.

The most common method used for teaching was lecturing (applied at least once by 93.8% of respondents). This was followed by asynchronous individual tasks (76%) and synchronous individual tasks (72.2%) assigned to students.

Many lecturers also facilitated group work either asynchronously (70.2%) or synchronously (58.3%) at least once, for example, by moderating online discussion forums or live group discussions. Additionally, one-on-one interaction between the lecturer and an individual student or student groups was used by 76.2% of lecturers. Simulations were used by 30.3% at least once. Naturally, experiments in laboratories were a rather rare occurrence (12.7%) due to constraints of the pandemic and the closing of the campus. However, some lecturers used live videos to demonstrate lab exercises.

The use of videos for teaching was highlighted by several respondents as an important strategy. Half of those mentioning video use described producing their own teaching videos (e.g., for teaching math) the other half talked about using existing videos (e.g., from YouTube).

Several respondents added that they offered virtual office hours and coaching sessions (for groups and individuals), as well as agile forms of collegial (peer) advice. Others specifically mentioned that they developed written and digital instructions for learning activities, including worksheets, PowerPoint slides, and digital instructions for an excursion.

Student presentations and discussions were named numerous times as additional methods, without further comment, as was working with case studies, which were referred to both as input (discussion of cases) and output (developing case studies).

2.7 Discipline-specific differences

Developing an online course design is particularly challenging in STEM subjects with active learning components (e.g., lab work), where the required equipment and safety concerns, as well as the common live demonstrations in these subjects [34], make an online offering difficult. Nevertheless, for the current survey, no significant difference between the challenges for STEM teachers and teachers of other subjects can be seen, as the following tests show.

Even though the distribution of challenges (fostering interaction between and with students, course design) is similar between the disciplines Management and STEM, we found differences between disciplines excluded in the distinction between management and STEM with a more granular analysis. A Kruskal-Wallis test provides evidence of difference ($p = 0.031$) between the mean ranks of at least one pair of groups. The raw p values indicate statistically significant differences in the pair wise comparison between law and other disciplines (engineering $p = 0.024$; natural sciences $p = 0.048$; social sciences $p = 0.01$), as well as in the pair wise comparison of management and engineering ($p = 0.15$) and business and social sciences ($p = 0.004$). However, there was no evidence of differences between the pairs when using the adjusted Bonferroni correction to avoid error I type mistakes.

Thus, no significant differences between lecturers teaching courses in different disciplines and the challenges they faced could be observed.

For further analysis of the distribution of the teaching methods in the different disciplines, a comparison was made between management and STEM online courses.

Even though lecturing is the most common teaching style in management and STEM courses overall, 62.5% and 22.9% of lecturers in STEM courses use lecturing often or sometimes compared to 46.7% and 41.3% in management courses. Working in groups outside the synchronous live webinars is often facilitated by 26.6% or sometimes by 40.5% of lecturers in management courses. In contrast, only 22% (often) and 20% (sometimes) of STEM lecturers used this strategy. Moreover, 40% of STEM lecturers never used group work for teaching outside their live webinars, compared to 17.7% of management lecturers. Similarly, working in groups during webinars is more common in management (27.5% often, 27.5% sometimes, 33.8% never) than in STEM courses (18% often, 22% sometimes, 52% never).

Besides working in groups and lecturing, designing and facilitating individual tasks is a common teaching method. Individual work outside webinars was often facilitated by 20% and sometimes by 47.4% in management courses, whereas in STEM courses, it was often used by 24% and sometimes by 20%.

The distribution of individual work during webinars between management and STEM is more similar. In total, 16.7% of lecturers employed individual tasks during webinars often and 43.6% sometimes in management courses. In STEM courses, 10% of lecturers facilitated individual tasks during webinars often and 44.5% sometimes.

2.8 The biggest challenges in online teaching

The challenges faculty were confronted with during the first wave of online teaching under COVID-19 are manifold and individually different.

To get a clearer picture of perceived obstacles, participants were asked to indicate what aspects posed the biggest challenges for them in the sudden change to online teaching with respect to didactic and organizational issues.

To analyze the responses in this area, a Principal Component Analysis (PCA) was performed to extract the most important independent factors. The following three factors, which are also frequently discussed in the literature (e.g., [19, 20, 35–37]) could be confirmed.

Interaction with students. Factor one is defined as "interaction with students" and includes the items "building social connections with students," "prompt response to student inquiries," "support of interaction between students," "encouraging active participation of students," and "prompt feedback to students." With a mean of 2.89 (SD 0.75), the interaction with students was perceived as the biggest challenge when switching to online teaching.

There is a negative correlation between the self-assessment of lecturers' online teaching competence and the challenge in creating interaction with and between the students ($r = -3.57$, $p < 0.001$). Lecturers self-assessing their online teaching competence as more advanced faced fewer challenges in fostering interaction between students and interaction with students. Interestingly enough, the analysis of the teaching experience in an online and/or face-to-face setting yielded no significant results in relation to the challenges.

This finding is also mirrored in the analysis of the qualitative comments faculty made. The second largest reason for negative experiences can be subsumed under the

heading "missing personal contact and interaction." Lecturers found that there was little interaction and personal contact with students, which was mentioned as being essential to a positive learning environment. Several respondents specifically mentioned the students' inability or reluctance to switch on their web cameras, others referred to the loss of visual contact or to talking to a monitor rather than to students, and the resulting lack of direct feedback from the class. Student participation and engagement were also seen as difficult. Lecturers mentioned the challenges monitoring participation remotely, and there were several comments regarding (some) students' reluctance to actively engage in a variety of activities (completion of tasks, group work, online discussions, being logged on but not "there").

Lecture design. Factor two, lecture design, comprises the items "developing new materials for online classes," "developing new assignments for online classes," "adapting existing materials for online classes," "assessment of the workload for students," and "exam preparation."

With a mean of 2.77 (SD 0.78), designing online lectures was also perceived as challenging. Since "online teaching does not allow for casual course preparation" [19, p. 258], the sudden move online presents a clear challenge for first-time online teachers. Even though the teachers are experts in their fields, they must deal with new aspects of their teaching, as well as with a wide variety of technological tools at hand [37].

In the qualitative comments, many respondents commented on the general workload for course design, including organization and communication during this phase. Several reported increased workload, with some estimating a doubling or tripling of the time required to prepare and teach online and noted that there was no compensation for this extra work.

Several mentions came up in the area of lecture design related to negative experiences with examinations. These included difficulties with re-designing assessments, open book exams as a factor that might have been confusing or making exams easier, disappointing results compared to other years, and technical glitches during the exam.

Technological challenges. Factor three, with a mean of 2.50 (SD 0.88), describes the challenges of technological aspects and focuses on "using the learning management system," "using the conferencing software," as well as the "use of other software" and "assistance for students with technical problems."

Most qualitative comments regarding negative experiences when teaching online related to technical difficulties, particularly with conferencing software. These difficulties led to stress and anxiety about the stability of the system and a feeling that lecturers were left looking unprofessional in the eyes of the students. Other technical issues included the unavailability of the learning management system, loss of internet connection and electricity outages.

Other respondents noted that they were hampered by the lack of specific software (e.g., for producing videos or to enhance interaction) and hardware (e.g., no headsets and cameras on the lecturer's or the students' part). Some respondents felt that there was insufficient provision for online teaching on-campus (e.g., in the form of fully equipped online teaching rooms), as well as for teaching from home.

Further exploring the challenges lecturers faced when switching their teaching to a virtual classroom, we also investigated the influence of training and support.

2.9   Faculty training and organizational support

The faculty training offered to support the sudden move online was used by 53.5% of respondents at least once. Several respondents mentioned MCI's Learning Solutions Department as an important support option. It should be noted that, even before the campus closure, faculty previously teaching online had already engaged in formal workshops.

In total, 36.1% of respondents took advantage of support materials or training offered by external providers (mainly web-based resources such as YouTube, freely available webinars, or support available from other universities) during the first wave of COVID-19.

Many respondents reported that they had not received or needed any further support. Several of them stated that they had previous experience with online teaching, either in MCI programs, with specific teaching tools or at other institutions. Lack of time to engage in support offers was also mentioned.

When asked which further support is needed in the future, respondents made concrete suggestions for further training. The largest category of suggestions for additional training options referred to the use of technologies and tools—in particular, Adobe Connect and Sakai. Training in the use of additional teaching tools was mentioned and included particular suggestions of software packages (e.g., for video production).

The faculty also indicated that they need further training regarding didactic aspects and teaching modalities. The second highest number of comments related to training on how to enhance interactivity in online teaching and learning. In particular, respondents mentioned that they would like to learn how to design an interesting and interactive online lesson, how to motivate participants, and how to manage groups and use tools that would support the interaction among students.

Regarding the development of online teaching materials, respondents mentioned, in particular, the production of videos and online presentations and related aspects such as image databases, licensing issues and data protection. Assessment strategies using the learning management system were also suggested. There were also several mentions of the value of exchange with other lecturers and with the program head. This included discussions of best practice, getting tips from others, and co-design/co-teaching with a colleague.

A majority of respondents indicated that they had received support from their department, either from office staff and teaching assistants, or from the program head. There were several appreciative comments about the speed, quality and clarity of the information received, particularly concerning assessment, organizational processes and didactic options.

3   Summary, implications and conclusion

This study highlights several important aspects regarding online teaching. While these may be more pronounced due to the emergency situation, many of them confirm key tenets of online education and have relevance for the future.

First of all, it is interesting to note that, despite the challenges faculty were facing during the emergency transition, the shift to online teaching was perceived as both easy and successful by a majority of respondents. This could, on the one hand, hint at a relatively high readiness of faculty when it comes to working with technology.

On the other hand, however, the overwhelming majority of faculty relied on live webinars as the main teaching method when transitioning their courses online. These results are also in line with findings of similar studies across European universities, where it was found that the main teaching method during the crisis was via live webinars [2, p. 7]. It could be argued that a possible methodological shift to lecturing was easier to manage, as faculty is already familiar with this most traditional form of HE teaching. In addition, although lecturing is an important and valuable teaching method in itself, the advantages of which have been specifically described [38], *online education* calls for teaching formats and modalities that go beyond the standardized lecture-based instruction to support learning. Adding possibilities for collaborative learning through interaction and collaboration [39], as well as providing online learners with self-study exercises and assignments, can help students to actively learn and engage in a digital environment. Simultaneously, it offers faculty the possibility of applying differentiated instruction, giving students the opportunity to play out their personal strengths, skills and interests [10].

For the faculty, online education requires switching gears in two main areas. On the one hand, online teaching changes roles as in collaborative contexts, instructors are becoming facilitators of the learning process and coaches for personal learning [13, 40]. However, developing course materials that fit different modes of online teaching (synchronous and asynchronous) requires intensive preparation and respective technological skills (e.g., for video and podcast production and using the tools within the respective learning management system). Here, it is both technological readiness and knowledge about course design that is required of faculty.

The results of this study indicate that both areas are challenging for faculty, as the biggest hurdle for faculty to overcome was the challenge to build a student-teacher relationship and an engaging, interactive learning community amongst students. These results conform to what literature says in claiming that managing teacher-student interaction and finding common ground are major teaching competences in online teaching [20].

Our study also suggests that course design and developing materials for online teaching were perceived as challenging in our sample. No specific difference between results and challenges for STEM teachers and teachers of other subjects could be observed.

Research suggests that targeted support is equally important as developing technological capabilities [41–43]. These findings agree with the findings of this study, where just-in-time support was highlighted by many respondents. Faculty training comprised not only technological support, but also best-practice examples on how to make online teaching more interactive and engaging. Faculty learned how to use the LMS and the conferencing software to foster student engagement. This also includes the use of online support materials specifically tailored to the frameworks used, such as technological requirements, but also conformity to policies such as examination regulations and others.

Literature identifies technological literacy as one of the main challenges for online teachers [36]. Due to the sudden shift to online teaching, the lack of practice can be identified as one of the major reasons underlying technological difficulties [44]. To be successful in online teaching, faculty need to feel comfortable with the technology. In the past, a teacher's comfort level was one of the major reasons that supported a decision for face-to-face and against online learning [31]. In this particular, the participants did not have a choice.

The survey results indicate a need and wish for further and continuous training and support regarding use of online tools, course design, student engagement, materials development and online-teaching methodology. Training that looks at online assessment processes to ensure academic integrity and quality standards was also seen as important.

On a system level, institutes of HE will have to provide more training to both faculty and students to enhance digital competences, allowing them to meaningfully teach and study in an online environment, which will also positively influence the quality of teaching [45–47]. For effective online teaching, the combination of content knowledge, technological knowledge and pedagogical knowledge is necessary [48]. Ideally, content, technology and pedagogy are fully integrated [48, 49] in institutional training.

This means that HEIs must further tie the faculty-university relationship and adapt quality assessment frameworks and regulations. This can in turn also increase satisfaction levels as Howe *et al.* [50] reported that mentoring, technical support and training for software and hardware also increases institutional satisfaction.

Although the results presented here are mainly focused on an emergency response to teaching online during the first wave of COVID-19 in 2020, the collected data also indicate a need to rethink online teaching modalities in HE. At the level of HE systems, a range of questions needs to be addressed that will also be relevant in the aftermath of the pandemic. This is all the more relevant against the background of digitalization, life-long learning, and the growing need for more agile and flexible offerings for HE to thrive in an increasingly diverse market with increasing responsibilities. Added to this, the potential dangers of medium- to long-term consequences the worldwide pandemic can have on the future of HE (financial cuts, tuition fee losses, increased drop-outs, decreasing internationalization) are yet to be analyzed [2].

4 References

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5   Authors

Claudia Moessenlechner is a professor and Head of Learning Solutions with MCI Management Center Innsbruck, Innsbruck, Austria.

Regina Obexer is a senior lecturer and PRME coordinator with MCI Management Center Innsbruck, Innsbruck, Austria.

Maria Pammer is a professor and department head with MCI Management Center Innsbruck, Innsbruck, Austria.

Julia Waldegger is an academic assistant and project coordinator with MCI Management Center Innsbruck, Innsbruck, Austria.