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Barriers to Digital Higher Education Teaching and How to Overcome Them—Lessons Learned during the COVID-19 Pandemic

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Abstract: The COVID-19 pandemic forced a transition to digital teaching in higher education institutions (HEIs) as itwas the only safe method for higher education (HE) teaching during the pandemic. However, this crisis emphasized the barriers students face worldwide. For digital HE teaching to survive in the future, these barriers should be overcome. The present paper aimed to systematically identify these barriers and present recommendations to overcome them. For this purpose, a quantitative survey (n = 369) was conducted with students in three countries, and qualitative student statements were analyzed. Possible countermeasures for corresponding barriers are described, and related stakeholders are identified. Thus, the study provided an overview of recommendations for stakeholders to overcome the barriers. The recommendations to resolve most barriers entail offering hybrid formats, adjusting lecture design, and ensuring proper communication.

Keywords: digital teaching; barriers; higher education institutions; COVID-19 pandemic; recommendations

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1. Introduction

Even before the impact of the COVID-19 pandemic, higher education institutions (HEI) had to support, engage, and graduate stressed students [1]. The stresses students faced were further emphasized by the challenges induced by the COVID-19 pandemic, when face-to-face interactions had to be avoided, and digital teaching was adopted exclusively within a short time. Original teaching methods had to be discarded, leading to a significant transformation into emergency response teaching (ERT) for teachers without proper planning, implementation, or quality assurance [2]. As a result, ERT was assumed to be just a substitution according to the substitution augmentation modification redefinition (SAMR) model [3]. Students had to adapt their learning, too. Although digitization attempts in higher education (HE) teaching were discussed before the pandemic, full scale digital teaching and learning were never adopted due to various factors [4], which the current paper refers to barriers. When digital teaching became inevitable due to the pandemic, the need for research insights into barriers to digital HE increased. The increased digital teaching provided an opportunity to analyze and understand these barriers. As previous research on the methods to overcome these barriers was quite limited, the most common institutional reaction to a barrier is avoidance or the adoption of ad hoc countermeasures [5].

The pandemic will probably permanently change HE, making a return to old habits increasingly unlikely [6]. Therefore, in the aftermath of the pandemic, more structured and strategic studies are required to overcome barriers. Even if ERT is different from online learning [2], lessons learned from the pandemic may help to develop methods and ways to overcome certain barriers. In addition, an evaluation of possibilities for overcoming barriers in an ERT situation, in which most physical activities were converted into an

online substitution, will help reach a higher level within the SAMR model [3]. In general, the presence of barriers requires various stakeholders to perceive and resolve them. To overcome the barriers, several studies have focused on approaches adopted by certain HEIs and governments [7], while others were simply case studies [8]. However, research that included recommendations to overcome the barriers via a systematic analysis based on a large cross-country sample is still quite limited. HEIs should use the pandemic experience to improve future digital teaching approaches. Therefore, empirical recommendations are significant for the development of HEI strategies. Students have a significant stake in the development of these recommendations. The shift in HEIs to "student-as-consumer" and the increasing competition for students among HEIs [9] necessitate the inclusion of the students' views in the feedback process [10].

Thus, the following research question (RQ) was determined:

RQ: According to students, how can the barriers to adopting digital higher education teaching, which evolved during the COVID-19 pandemic, be overcome?

To answer the RQ, we first present an overview of the barriers that were identified in a previous literature review [11]. The study methodology is discussed in Section 3. We adopted a four-phase approach to consolidate insights available in the literature based on empirical data. The findings are presented in Section 4 and discussed in Section 5. The final section includes conclusions and implications, where the limitations of the study and the outlook are discussed.

2. Background

Our research drew on two areas of research. The first area gives a general background on HE and experiences from COVID-19. The second area contains the specific literature on barriers to digital HE teaching, which we used during our analysis.

2.1. Experiences from COVID-19 and Research on Barriers

Researchers generally use the technological, pedagogical, content knowledge (TPACK) model to discuss how to use technology in the classroom. The essential idea behind the model is integrating the three components into seamless units of course elements [12]. With ERT, we can argue that the integration was disrupted due to the focus on getting the technology to work. Currently, the literature is evolving, taking experiences from the recent pandemic into account and giving an outlook on future needs. Researchers and opinion leaders claim that digital HE teaching will have an accelerated future after COVID-19 as it has the potential to deliver courses effectively. Still, future development needs to focus on the quality of online offers [13,14]. Quality needs to be seen from the perspective of the learners to come to conclusions about which digital course designs foster or hinder teaching. In addition, the teachers need to be supported to be able to deliver quality content, meaning teachers need to be taught [15]. Other conclusions address the general education of health-related courses in the general curriculum and digitally extending mental health and medical services for students [16]. Further studies see the need for better internet connections and better socio-economic development as prerequisites for digital teaching [17]. The creation of enhanced resilience in HE is another consideration. A framework incorporating the phases of responding, recovering, and reimagining can guide future work [18]. Students and teachers have different perceptions of the situation. While teachers have struggled to produce additional teaching materials, students have wished for more activities to keep up with the topics being taught. Interestingly, when problems occurred, both groups were flexible in adapting to different technologies [19]. Research on information systems (IS) can help this domain in several ways. It can help implement direct measurements in the case of crises on an operational level and can support research on digital HE transformation on a strategic level [20].

Studies on barriers and advancement can be classified into different streams. One stream of studies centers on researching the impact of technology on students' individual learning results [21] and tolerance of digital systems [22]. Following the concepts of drivers

and barriers [23], these studies often encompass suggestions for the instructional design of blended learning courses and their acceptance [24]. Another smaller stream of research emphasizes challenges facing faculties or departments within the organization [25,26]. Organizational challenges often originate from the resistance to change within organizational units [27]. Therefore, faculty support in institutions is missing [26,27]. Insufficient resource allocation resulting in a lack of time and technical equipment is another organizational challenge for teachers. Usually, the digitalization of teaching leads to adaptations to curricula, which teachers often see as critical [28]. In addition, external barriers impact the digital transformation of HE. Political and economic pressure to adapt to global requirements exists. However, HEIs are regularly incapable of keeping up with the speed imposed by these external pressures [28].

In the field of HE research, barriers are repeatedly connected to specific teaching scenarios, which limit the generalizability of study results. Systematic research offering guidance for the identification of barriers and recommendations for overcoming them is still in a nascent state.

2.2. Stakeholder and Barrier Model

Faculty, students, and academic institutions are stakeholder groups that play various roles in addressing different challenges in HEIs [29]. Our first stakeholder group is teachers, which refers to faculty members instructing classes in HEIs in the current study. These individuals include tutors, student assistants, and professors. The second stakeholder group includes students, who are referred to as learners in HEIs. The third stakeholder group is the HEI itself, represented by its academic institutions. This group includes the management, administration, and support units. As an HEI is part of the local community, we follow the author Bozkurt [30], who added a fourth stakeholder group, the industry. To broaden the perspective, we aggregated industry and the government (I&G) [31]. Both stakeholders strive for high-quality education and employable graduates. "The inclusion of student voice in efforts toward educational reform" [32] is emphasized in much of the scientific literature [33]. Following this call, the authors of the current study identified the barriers students experience from a survey conducted in a previous study [11]. These barriers are discussed in eight categories: *technical resources, interaction, skills, didactics, workload, health, personal readiness, and framework conditions.* Each category has at least two coded subcategories. An overview of this classification is presented in Table 1.

Table 1. Barriers to digital higher education teaching during the COVID-19 pandemic. [34].

Category	Subcategory (Code)	Number of Mentions
Technical resources	Lack of technical resources (TR1)	102
	Insufficient internet connection (TR2)	119
Interaction	Lack of social interaction (I1)	192
	Lack of discussion and participation (I2)	56
	Invisible reactions (I3)	48
	Miscommunication (I4)	62
	Low possibility to ask and get help (I5)	65
Skills	Lack of digital competencies (S1)	36
	Lack of self-management (S2)	10
Didactics	Limited possibilities for lecture design (D1)	29
	Lack of practical exercises (D2) Lack of skill	13
	transfer (D3)	3
	Lack of knowledge transfer (D4)	11
Workload	Higher workload (W1)	7
	Laborious group work (W2)	30

Table 1. *Cont.*

Category	Subcategory (Code)	Number of Mentions
Health	Higher stress level (H1)	4
	Isolation (H2)	19
	Bodily discomfort (H3)	11
	Concentration problems (H4)	66
Personal Readiness	Lack of flexibility (PR1)	15
	Lack of trust (PR2)	5
	Lack of motivation (PR3)	130
	Fear of change (PR4)	7
Framework Conditions	Insufficient institutional framework (FC1)	46
	Insufficient learning environment (FC2)	27

Technical Resources are conceived by students as a barrier when technical resources and/or internet connections are inadequate. Students considered that *interaction* was seriously disrupted in digital HE teaching during the COVID-19 pandemic, as they articulated in various subcategories, such as the lack of social interaction, discussion, and participation, invisible reactions, miscommunication, and the low possibility to ask and obtain help. Digital HE teaching requires that both teachers and students have certain *skills*. For example, problems associated with the lack of digital competencies were observed and, students noted the lack of self-management strongly required by digital teaching. Digital HE also requires specific *didactics*. The current didactic concepts in conventional teaching could not be transferred during the pandemic, but they should be adapted for the use in novel conditions. Students considered this to be a barrier due to the limited possibilities for lecture design and the lack of practical activities as well asskill and knowledge transfer. Students' *workload* was altered by the COVID-19 pandemic [7,35,36]. Digital HE led to a higher workload [37], and digital teaching increased the students' assignment workload. Frequently, students were required to participate in group work; thus, this barrier was included in the laborious group work subcategory. Students' *health* was negatively affected by digital HE teaching during the pandemic due to higher stress levels. Social distancing restrictions forced students to study and work at home during the pandemic [8]. Therefore, this group was socially isolated. Staying at home often also led to bodily discomfort, according to students. Furthermore, students experienced concentration problems. Digital teaching was introduced immediately during the pandemic, and students did not have time to adjust. This fact was included in the *personal readiness* barrier, which included the lack of flexibility, trust, motivation, and the fear of change subcategories. External conditions could also act as a barrier to digital HE teaching; this factor was included in *framework conditions*, which includes insufficient institutional framework and insufficient learning environment as subcategories.

Barrier models, such as the one already described herein, open up the possibility for stakeholders to identify barriers more systematically and efficiently. However, identifying barriers is only one side of the coin. To offer successful digital HE teaching, barriers must also be overcome. Therefore, our current study built on the barrier model and proposed recommendations for action.

3. Method

During the course of this study, we addressed the RQ regarding recommendations to overcome barriers to the adoption of digital HE teaching by conducting an exploratory qualitative study. An exploratory study "addresses a question, a problem, or an area of concern that has previously been unresearched or under-researched" [38]. As a common overcoming framework is missing, our study aimed to develop an understanding of how these barriers can be overcome. To this end, our research design was divided into four sequential phases.

In the **first phase,** we collected qualitative data using an online survey instrument. The survey focused on students' perceptions of digital HE teaching and consisted of multiple parts. The survey included questions on socio-demographic variables, perceived barriers to digital HE teaching, and how these barriers could be overcome from students' points of view. All student participants were asked the same open-ended questions: "In your opinion, what are the 3 strongest barriers to digital teaching?" and "How could each of these barriers be resolved?".

In our research, we focused on the population of students who experienced digital HE teaching during the COVID-19 pandemic. To gain insights from the population, we opted for non-probability sampling—more specifically, a convenience sample. Compared to probability sampling, non-probability is more susceptible to bias. However, it is capable of exploring a field [39]. We surveyed students who attended one of three HEIs in Sweden, Türkiye, or Germany during the pandemic. In all three HEIs, digital higher education ERT was adopted to sustain instructions during the pandemic. We included HEIs from different countries to ensure a diverse and cross-country sample. For digital teaching, the overall digital readiness of the country is important. Thus, the countries represent different groups within the Digital Readiness Index (DRI) [40] to avoid a readiness bias. On the DRI, Sweden is in the top 10, Germany in the top 20, and Türkiye in the top 60 of 141 countries. The survey was conducted with undergraduate and graduate students during various terms. Thus, the sample included students who studied in the related HEI before the COVID-19 pandemic and those who started their studies during the pandemic. We aimed to diversify the sample because, according to Yin, diversification allows us to extract the most insights [41]. However, all surveyed students attended elective courses in business programs associated with IS. These courses were instructed on digital media and conducted entirely online during the COVID-19 pandemic. All voluntary and anonymous participants responded to the same online survey questions. In total, 396 students participated in the survey between January 2021 and January 2022. The sample included 40% male and 56% female participants, while 4% of the participants did not indicate their gender. Most participants (84%) were in their 20s.

After finishing the data collection, we analyzed the first open-ended question regarding the perceived barriers to digital teaching in the **second phase**. First, we went through all of the statements to "make sense of the whole set of data" [42]. In sum, we obtained 1190 different statements about barriers through the survey. However, not all statements could be used for the subsequent analysis because the statement was not understandable or some of the participants stated that they did not know of a barrier.. Therefore, 77 statements were excluded. The final statements contained between one and 114 words. The median length of the statements was eight words. Using a digital teaching barrier model [34], we coded the statements deductively [43]. The model we utilized for coding is a model on the barriers to digital HE teaching from the perspective of teachers. Although we did not expect student and teacher experiences to be the same, we viewed the model as a good starting point for the coding process. Adopting the teachers' model would also allow for a comparison of perspectives, although such acomparison is beyond the scope of the current study and, therefore, it is part of a different study [34]. As we could only match 382 statements to the existing barrier model during the deductive coding process, we adapted and extended the model. To do so, we proceeded with the 808 remaining statements using an inductive coding approach [42]. These codes were discussed and categorized during several revisions to ensure inter-coder agreement. Categorization aggregates coded data to set up homogenous constructs, which are heterogenous to other aggregated constructs. Categories are an intermediary step on the way to identifying patterns running through the categories [44]. In our research, these patterns were recommendations and are identified in phase four. Our categorization process resulted in a model of the barriers to digital HE teaching from students' perspectives, containing 25 different barriers divided into eight categories, as presented in Section 2.

In the current research, we extended this research to link the barriers to recommendations for overcoming them. To this end, we analyzed the answers from the second open-ended question in the **third phase** regarding students' recommendations. Existing scientific literature in the field of digital HE teaching lacks a comprehensive model of recommendations to overcome barriers; thus, we coded the statements about recommendations inductively by applying an open coding content analysis technique [42]. As in the second phase, we first went through the statements to obtain an overall impression. From the data, we were able to isolate 987 statements about recommendations. From all these statements, we had to remove statements that were not evaluable. This was the case with statements such as "I do not know" (QS), "none" (QS), "I have no answer on that" (QS), "Not sure there is anything to do with this" (QS), "I don't really think you can change this, it's probably something we have to get used to..." (QS), "I don't think it's possible" (QS), or "Unsure" (QS). In addition, some respondents provided only one keyword, making it impossible to derive a clear recommendation. Excluding these cases, 683 recommendations for action could be utilized. The final statements vary in length from one to 110 words, with a median length of nine words. Due to the open coding of the statements, we derived a list of characterizing codes for each statement. The different codes were aggregated if similar and thematically categorized. In several revisions of the categorization we ensured inter-coder agreement. Following this procedure, 26 different categories representing different recommendations were ultimately identified. Furthermore, our data indicated the responsibility for the execution of the recommendations to specific stakeholders. Thus, we allocated the responsible stakeholder (teachers, students, HEIs, industry and government; see Section 2) to each recommendation. To group the recommendations for action in terms of content and to create a common thread, we oriented towards a classification of socio-cultural digital learning elements [45].

In the **fourth and final phase**, we integrated the coded barrier and recommendation findings from the second and third phases. The barriers and recommendations were surveyed using a single data collection (cf. first phase) and the linkage between both was always preserved; therefore, we could analyze the relationships between both. The relationship among the original statements, coded barriers, and coded recommendations were aggregated into a matrix. The y-axis displays barriers, and the x-axis displays recommendations. Consequently, each cell in the matrix indicates whether a relationship exists between a single barrier and a single recommendation.

4. Findings

The current study revealed 26 recommendations to overcome the barriers in digital HE teaching during the COVID-19 pandemic. Each recommendation was assigned to one of the following socio-cultural digital teaching elements: **technologies, interaction, content, or participants** [45]. An overview of the recommendations and the involved stakeholders is presented in Table 2. Proposed recommendations are discussed below.

Digital HE teaching could not be conducted without **technological facilities**. However, the COVID-19 pandemic emphasized the lack of adequate technological infrastructure in HEIs, complicating the implementation of digital teaching. To overcome these barriers, seven recommendations are presented in the current study. First, *the availability of internet connections should be ensured.* For this purpose, a general expansion of internet availability is needed. During the pandemic, the inadequacy of internet connections became obvious. Better infrastructure could rectify the connection problems in HEI buildings. Furthermore, students' internet access should be facilitated by offering special internet pricing or free internet access. The questioned students (QS) were also aware of the inequality in technical equipment among the students. Thus, it is important to *ensure the availability of technical resources for all users*. This could include free individual or shared technical equipment in HEIs, technical equipment loans for students, financial support for low-income students, and the provision of software or apps. *The use of mobile devices* was also recommended by the survey participants. When all other technical facilities fail, mobile devices can

provide a remedy. In addition, simpler assignments, such as quizzes, can be completed on smartphones. For these emergencies during digital lectures, an IT expert team should "jump in if something is not working" (QS). Thus, every HEI should *provide IT support* for teachers and students. Alternatively, or in addition, *providing manuals* could be helpful, whether in the form of instructions or tutorials on various systems or software.

Table 2. Recommendations.

Element	Recommendation (Code)	Number of Mentions	Stakeholder Involved
Technologies	Ensure internet access (T1)	48	HEI, I&G
	Ensure the availability of technical resources (TR2)	63	HEI, I&G
	Use mobile devices (T3)	3	Students
	Provide IT support (T4)	5	HEI
	Provide manuals (T5)	5	HEI
	Employ technological facilities in lectures (T6)	10	Teachers
	Keep systems up to date (T7)	10	HEI
Interaction Processes	Enable interpersonal exchange (IP1)	82	Teachers
	Offer counseling for student concerns (IP2)	54	Teachers
	Foster groupwork in lectures (IP3)	18	Teachers
	Organize student learning groups (IP4)	15	Teachers, Students
	Foster interactivity in lectures (IP5)	49	Teachers
	Adjust lecture conditions (IP6)	33	Teachers, HEI
	Implement mandatory attendance (IP7)	7	Teachers, HEI
	Set communication guidelines (IP8)	47	Teachers, HEI
Content	Adjust the lecture design (C1)	41	Teachers
	Offer hybrid formats (C2)	34	Teachers
	Apply the learned knowledge (C3)	2	Teachers, Students
	Establish and communicate a clear lecture structure (C4)	31	Teachers
	Set examination policy (C5)	10	Teachers, HEI
Participants	Change the mindset (P1)	20	Teachers, Students
	Have mutual understanding (P2)	14	Teachers
	Offer training (P3)	37	HEI
	Monitor student progress and performance (P4)	6	Teachers
	Create a clear daily structure (P5)	18	Students
	Ensure an appropriate work space (P6)	21	Students

Such manuals would allow access for both teachers and students freely whenever they need (QS). Current technologies and systems provide various methods to conduct digital teaching that are not fully exploited based on the views of the surveyed students. Several participants emphasized the *employment of technological facilities* in lectures. They mentioned the employment of videoconferencing rooms, the digital presentation of materials via screen sharing, and the development of virtual reality environments. For these accomplishments, *keeping systems up-to-date* is crucial. HEIs should permanently review the "features and quality of various applications employed by students and teachers" (QS) as they might require upgrades or replacements. According to the students, it was the external providers' duty to optimize systemic functions continuously.

The next set of eight recommendations refers to the element of **interaction processes**. During digital teaching, personal interaction decreases between teachers and students, making it even more important to *enable interpersonal exchanges*. The surveyed students observed various possibilities, such as social events, real-life meetings, chat groups, or networking portals. The participants also mentioned *counseling opportunities for students*

concerns, employing various methods. Several participants mentioned Q&A sessions as an additional facility beyond the lectures. Consultation hours, which could allow one-on-one conversations between instructors and students, could also add value by providing teachers with additional insights into the students' mental state. Furthermore, students missed being able to ask teachers direct questions after class. Although easier to do in face-to-face instruction, it is also possible if the lecturers were available after online lectures. Finally, better e-mail interaction between the teachers and the students and prompt teacher responses could be sufficient as well.

To promote further interaction among the students, *group work should be fostered in lectures*. The free selection of group members was especially important for the students (QS), as they could then maintain social contacts beyond group work. In addition, students considered the *organization of student learning groups* to be necessary and helpful: "Lecturer or students could organize study circles where students could talk and discuss" (QS). Furthermore, *fostering interactivity in lectures* was considered a key factor for successful digital teaching. This could be achieved by introducing interactive elements such as "more engaging exercises during class [...]" (QS) and active discussion moderation by the teacher. However, students' openness to participate in discussions is also crucial. Consequently, it could be necessary to *adjust the conditions of the lectures*. The reduction of the class size was especially strongly argued by the students as smaller class sizes would facilitate digital teaching.

Furthermore, students believed that both regular breaks and the reduction of class hours were important. Mandatory attendance could also increase participation in digital lectures, although such a policy should be determined by HEI policymakers. To guarantee good communication during digital lectures, teachers should *set communication guidelines*. Participants frequently suggested keeping cameras on at all timesduring the lectures (QS). Videoconferencing system functions, such as the hand sign symbol or chat, should also be employed to coordinate communications.

The participants mentioned five recommendations related to the **content** element. The present lectures were only conditionally fit for the digital HE teaching format: "Since we left the classroom environment, [the] way of teaching should also change, online classes like a physical classroom is not very useful [...]" (QS). Students realized the need to *adjust the lecture design* and stated that the courses could be changed to fit online learning (QS). This was also the case for educational tasks and assignments, which should be adapted to the virtual world for the students to complete them. The students considered a combination of physical and digital lectures as desirable. This could be achieved by *offering hybrid formats*. Such an approach would lead to "a balance between the conventional and new [lecture formats]" (QS). For example, a combination of face-to-face student presentations and theoretical knowledge instruction with recorded lectures was considered adequate.

Students recommended the *application of the learned knowledge*, which would be possible via "more practical courses [...]" (QS) or "internship[s] in corporations [...]" (QS). Independent of the method of transfer of the lecture to the virtual space, *establishing and communicating a clear lecture structure* became more important. As it is necessary to ensure that every student is aware of the instructional approach, communication efforts in classes should be improved. Additionally, all information should be included in learning management systems. The successful completion of a course usually entails an exam. Students believed that online exams were immature, and they recommended the determination of exam policies. The "exam methodology should be based on online practice" (QS). This could lead to alternative exam methods that employ technical facilities to supervise the exams. However, when this is not possible, the students recommended face-to-face exams.

The **participants** in digital teaching were considered the final element. Six recommendations were proposed by the students. Digital HE learning became a challenge for all involved and led to various prejudices that should be eliminated. The participants recommended a *change in mindset* to be "[...] open to change" (QS). Furthermore, a *mutual understanding* of the situation was considered important. Teachers and students should be

aware of each other's conditions and be more understanding "by not placing too much [of a] burden [. . .]" (QS) on one another. All participants should be aware of connection problems and/or the lack of equipment. However, how to conduct digital lectures or digital discussions could be learned. Therefore, students recommended *training opportunities*. For teachers, the training should achieve a "deeper understanding of digital interaction" (QS) and entail the availability of a higher "number of digital experts" (QS). For students, "digital courses on IT" (QS) and learn-to-learn courses were considered necessary. Furthermore, *monitoring student progress and performance* was recommended, even if it was considered an "obviously hard task" (QS). Evaluations regularly soliciting student feedback on learning could be used for this purpose. The rapid conversion to digital teaching disrupted all previous routines of the participants. Thus, it is important to *create clear-cut daily structures* by developing new routines and study schedules. A basic need for study in both virtual environments and HEIs is the physical space. The students need to have adequate study spaces. For this purpose, certain rooms could be made available in the HEIs, such as "specific single individual study pods in libraries" (QS), to avoid other public spaces such as cafes, lobbies, or trains. At home, it is important to avoid all distractions.

The current and previous study findings were combined in the last phase to recommend certain actions to eliminate the barriers to digital HE teaching during the COVID-19 pandemic. The matrix that assigned the recommendations (x-axis) to respective barriers (y-axis) is presented in Table 3. The row and column labelled "N" represent the number of mentions of the respective barrier or recommended action. These figures are also shown in Tables 1 and 2. New in this table are the numbers within the matrix. Each matrix cell with a number indicates a relationship between a barrier and a recommendation. The numbers are absolute numbers indicating how many times a certain relationship was observed in the data. The numbers range from 58 to 1. For example, the participants in our study named "Enable interpersonal exchange (IP1)" 58 times to overcome the barrier "Lack of social interaction (I1)". In contrast, for the barrier "Lack of self-management (S2)", "Create a clear daily structure (P5)" was mentioned only once. The matrix can be viewed from different directions. If the matrix is read from left to right, it shows which recommended actions can be taken to overcome a given barrier. If, on the other hand, the matrix is read from top to bottom, it shows which barriers are influenced by a given recommendation for action according to the student's point of view. The matrix indicates that various recommendations suggested by the participants could help overcome barriers. A blank cell in the matrix, however, means that the barrier and recommendation were not mentioned in combination.

Table 3. Matrix: Relationships between barriers and recommendations.

			Recommendation																								
			T1	T2	T3	T4	T5	T6	T7	IP1	IP2	IP3	IP4	IP5	IP6	IP7	IP8	C1	C2	C3	C4	C5	P1	P2	P3	P4	P5	P6
		N	48	63	3	5	5	10	10	82	54	18	15	49	33	7	47	41	34	2	31	10	20	14	37	6	18	21
Barrier	TR1	102		49	2	5			1										3					3				
	TR2	119	48	8	1			1							2				11					4				
	I1	192						1	2	58	15	12	6	5	6		8	3	1		1				2			
	I2	56		2				1	2	3		1		11	4		9	4	1							3		
	I3	48							1	1				4			13		3							1		
	I4	62							2	7	10		1		2		2				11				1			
	I5	65							1		24			6	1		7							1		1		
	S1	36					5																		21			
	S2	10								1										1	4						1	
	D1	29						3						1	2			14	1						1			
	D2	13						1										1	2	1	1							
	D3	3																	1						1			
	D4	11											1					1	1		4							
	W1	7																4						2				
	W2	30		1				1		4	2	2	1				1	5								1	1	
	H1	4													1													1
	H2	19								5			1											2			1	1
	H3	11		1											3				3									
	H4	66												11	9		2	4	2		1			1	2		4	5
	PR1	15																					7		4		1	
	PR2	5																					4		1			
	PR3	130						2		3	3	3	5	11	3	7	3	5	5				5	1	3		10	7
	PR4	7																					3		1			
	FC1	46		1					1												9	10	1					
	FC2	27		2													2											7

5. Discussion

The present study analyzed the methods to overcome the barriers to digital HE teaching that were identified by students during the COVID-19 pandemic. A survey allowed for the elaboration of the actions to overcome certain barriers at once. Each recommended action addressed one or more stakeholder groups in digital HE teaching. Previous studies have revealed that each stakeholder had different demands regarding digital teaching and views on its impact on education [30]. Certain recommendations proposed in the literature went so far as to recommend compensation for teachers who made course content available online or to determine short- and long-term goals for the HEI. I&G requires quality assurance for education, whether on campus or online [30]. Furthermore, they could provide resources to solve barriers such as equipment. In our study, it was evident that certain recommendations could only be realized by the teachers or the students, such as mutual understanding about the lack of technical equipment. Others could not be influenced by these stakeholder groups and were rather associated with HEIs or I&G. However, all stakeholder groups should work in collaboration to overcome barriers to digital HE teaching to ensure high-quality education.

To provide a methodical overview of the recommendations, we categorized them based on sociocultural digital teaching elements (technologies, interaction processes, content, and participants). Most recommendations were associated with interaction processes, followed by technologies, participants, and content. The barriers analyzed in our previous study revealed that interaction was a significant issue for students. The most frequently mentioned issue in the survey conducted with the students was related to the *Interaction* barrier category [11]. This issue, which was strongly perceived as a barrier, was also addressed in various recommendations for action. The most prominent relationship in our data existed between lack of social interaction (I1) and enabled interpersonal exchange (IP1). Other recommendations that could be helpful in overcoming barrier I1 stem from the same group of interaction processes. Other studies have highlighted that many students complained about the deterioration in communication and interactions between students and teachers during the pandemic [46]. Even before the pandemic, interaction and connection with peers and teachers were considered a strong driver of academic success [47] and student engagement [48]. Our research adds to recommendations on the four dimensions of student engagement, which are emotional, behavioral, cognitive, and social [48]. Recommendations on interaction processes in particular foster the social dimension. In addition, the role of teachers has significantly changed in recent decades [49] and changed even further due to online teaching, as students today expect greater availability and one-on-one communication from teachers. This paves the way for a more facilitator-oriented role, which HEIs should embrace in capacity planning. Pedagogical concepts such as flipped classrooms [50] could also support changes to teacher roles, as students take a more active part in developing educational material before meeting the facilitator.

The present study findings emphasized the relationships between barriers and recommendations. Table 3 could be read in two ways. When read from the perspective of the barriers, more than one recommendation was associated with each barrier. In addition, several actions can be adopted to overcome certain barriers. The largest number of recommendations proposed that teaching had positive effects on learning motivation when compared to conventional set-ups [51]. However, in the current study, the survey conducted with the students during the pandemic revealed a different picture. An analysis of the quantitative parts of the survey data revealed that students who started online during the pandemic feared less study success than peers who started on campus [52]. This result shows how easily digital learning can be perceived as engaging or disengaging, which aligns with research on student engagement depicting a complex interaction between the two [48]. The transition to digital teaching and the pandemic-specific factors, such as social distancing and working from home, decreased motivation, leading to another barrier. Certain studies proposed improving student resilience, especially in times of crisis, to eliminate this barrier [53]. Various factors could generally be considered motivators

in HE. However, sources of motivation could be quite different for each individual [54]. Thus, various actions could be effective in overcoming the motivational barrier. The action leading to the desired effect depends on the respective circumstances. In contrast, the recommendation to offer hybrid teaching methods could eliminate several barriers [55]. Even before the pandemic, hybrid formats that combined digital and face-to-face teaching were popular as they reportedly exploited the benefits of both online and face-to-face courses [56]. The barriers that could be eliminated or mitigated with hybrid formats are presented in Table 3. However, this would only be possible once the pandemic regulations are relaxed and face-to-face teaching is again possible. Hybrid formats are not a solution during lockdowns. Nevertheless, the students' strong interest in this method demonstrated that they recognized the advantages of digital teaching but still desired face-to-face interaction alongside digital teaching. Although other reports draft lower physical class attendance and engagement post-COVID [57], HEIs should ensure face-to-face learning, for which students considered mandatory attendance a solution.

As education is conducted online, more data are available, which even the students proposed as a recommendation. Learning analytics could provide the tools to monitor student progress and performance. Thus, HEIs should implement such analytics along with an adequate learning management system [58].

The recommendation for the availability of Internet access was associated with inadequate Internet connections. Technical barriers and recommendations score high in Table 3. However, this issue could be considered a basic prerequisite for digital teaching. The pandemic emphasized global connectivity issues. The future of digital learning depends on students calling upon governments and industries to adopt a sustainable approach.

6. Conclusions and Implications

During the COVID-19 pandemic, digital HE teaching changed radically and stakeholders experienced various barriers. While embracing the positive impact of digital teaching [59], these barriers should be eliminated in the future to ensure that negative experiences are replaced with positive practices. The present paper significantly contributed to the literature by identifying the relationships between barriers and recommendations for the elimination of these barriers. Concerning the TPACK model [12], we found barriers and solutions mostly for the areas of technology and pedagogy. Further exploration of how to address conceptual knowledge is needed. Otherwise, students will experience a mismatch among the three domains. According to the SAMR framework [3], a real transformation must address the creation of new tasks through technology. These new tasks might address pedagogy or content knowledge.

The qualitative data collected from 396 students provided insights into the barriers to digital HE teaching during the COVID-19 pandemic and how these could be eliminated. The analysis of the findings led to the development of a matrix that presented the relationship between 28 barrier subcategories and 26 recommendations to eliminate these barriers. Thus, our overview went further than a mere classification of barriers; it included a systematic analysis of the recommendations for action.

Although the data were collected during the COVID-19 pandemic, the findings are valuable for the post-pandemic era, especially for online courses or online degree programs [60]. The matrix in Table 3 provides three different possible applications for this purpose [61]. In the first application, decision-makers can identify barriers in a current online course and determine recommendations for action based on these barriers to improve teaching. In the second application, past actions to eliminate barriers can be critically reviewed based on the matrix. The third application can be put to use even before the implementation of a course design, and the actions recommended by various stakeholders could be adopted proactively to prevent potential barriers. The matrix also provides a solid foundation for researchers to identify different types of barriers and recommendations and directions for future research. Although the matrix displays adequate recommendations for respective barriers, the effectiveness of various recommendations is not clear. For example,

can these relationships be converted into hypotheses? Future studies could measure the relationships between recommended measures and barriers and, thus, provide statistically reliable data on the actual relationships.

As current research on barriers to digital HE teaching has discussed the possible elimination methods, albeit with limited systematic analyses, this paper fills a significant gap in the literature. However, the proposed outcomes are based on student experiences, which is a limitation of the study findings. As the matrix is based on student assumptions, subsequent quantitative studies should verify whether the relationships between barriers and recommendations for action presented in this study are statistically significant and, if so, how strong each relationship is. At this stage, the relationships are provisional and can be used to formulate hypotheses, especially in conjunction with other studies on student engagement. Furthermore, it can be assumed that the matrix would be improved with the consideration of other stakeholders, such as teacher barriers and recommendations. Thus, further research on other stakeholder views is required. The inclusion of other stakeholders, namely including HEIs and I&G, could also improve the study's findings and the matrix. Further research could also investigate each stakeholder's power to influence the barriers.

Nevertheless, the elected methodological approach and broad data collection allowed an overview of the relationships between barriers to digital HE teaching and recommendations for their elimination. The current study's findings could raise awareness about the potential barriers and the necessary countermeasures across the HEIs. After all, only adequate action following the pandemic experience can improve digital HE teaching in the future and cannot remain a solution for a particular crisis.

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