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Barriers in Times of Digital Teaching and Learning – a German Case Study: Challenges and Recommendations for Action

SPECIAL COLLECTION: LEARNING FROM LOCKDOWN

ARTICLE

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ABSTRACT

The Covid-19 pandemic has raised significant challenges for universities. Digital inclusion "of all learners regardless of their circumstances, learning prerequisites and needs" is a major challenge (Walgenbach, Compes & Lambrich 2019: 9, authors' translation). Starting with accessibility and related concepts such as digital inclusion and digital divide, we intend to create a wider view of barriers in the context of digital teaching and learning. Barriers in online learning environments also arise for people who have previously studied without any barriers (e.g. technical equipment is missing, lack of digital skills). New barriers have been added, and others have been mitigated. For example, the compatibility of family and work has improved in part through asynchronous online formats (Knoblich 2020; Hassel 2020). Digital teaching and learning should enable students to expand their study opportunities and flexibility, not limit them (Traus et al. 2020). This article addresses these and other challenges by quantitatively surveying students and lecturers at the RheinMain University of Applied Sciences about the digital "Corona Semester". As the results show, a barrier rarely comes alone – students who face one barrier in the digital semester also face others. The article provides initial strategies for dealing with new barriers. Our findings point to a low-barrier learning design and financial or technical support measures. We conclude by pointing out that the establishment of a culture of openness is important if we are to support every student in the learning process in the best possible way and enable (digital) participation and learning.

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INTRODUCTION

With the widespread impact of the coronavirus pandemic on university education and with classes being moved to online learning, all students and teachers were confronted with a new teaching mode. Flexible ways of studying and teaching were established in universities worldwide. Online and blended learning approaches open up opportunities, but can also lead to unforeseen barriers for students (Pearson et al. 2019). The present article focuses on the barriers which affected all students at RheinMain University of Applied Sciences in relation to online learning, thereby broadening the universal understanding of the term barrier. New barriers have been added due to the online formats for many students, and others have been mitigated. For example, the compatibility of family and work has improved in part through asynchronous online formats (Knoblich 2020; Hassel 2020). However initial studies show that students with other responsibilities or obligations (e.g. students with children) have a higher sense of stress due to online teaching during the Covid-19 pandemic (Zimmer, Lörz & Marczuk 2021). Many of the previous discussions about barriers in teaching and learning so far have focused on accessibility for disabled students. Against this background, we have distilled some broader-based views. We understand barriers in a broader sense as hurdles for all students in the context of online learning. Vedder (2011) characterised the "typical" German student based on statistical key figures from a social survey of the German Student Union: Early 20s, single, childless, financially secure, full-time student, academic background, and without a migration background. We see a different student body in practice: working part-time, studying in German as a second language, caring for relatives or children. A student's everyday life is not "normal", and this creates individual hurdles. If we look at the terms barrier and disability, it becomes apparent that these terms are closely related. The German Social Code IX §2 para.1 defines disability as follows:

"People with disabilities are people who have physical, mental, intellectual or sensory impairments which, in interaction with attitudinal and environmental **barriers**, are likely to prevent them from participating in society on an equal basis for longer than six months." (SGB IX 2016: 1; authors' translation and emphasis). The definition of barriers is more a question of one's own and society's view, circumstances and the available technology rather than a personal characteristic. Alternative views on disability, for example the social model of disability, stress the environmental barriers in society which prevent the full participation of people with disabilities. The model implies that people are disabled by barriers in society, not by their impairment or difference (Goering 2015: 135). For example, the use of technology can either remove barriers such as hearing aids, glasses, prostheses or create new barriers. Furthermore, nowadays students encounter different types of barriers that can prevent equal participation in society, for example socio-economic status or socio-cultural background. Unequal access to information and communication technologies, i.e. the digital divide, is another fundamental problem for digital teaching (Breitenbach 2021). In this context, this research aims to broaden the view on barriers in education, focusing on new barriers that emerged in three 'Corona Semesters' of digital learning. In doing so, we assume that equal participation in learning cannot be guaranteed due to the circumstances of digital learning caused by the coronavirus pandemic. This research discusses barriers to digital learning. We present the results of the survey at RheinMain University of Applied Sciences and give recommendations on how to deal with these barriers.

THEORETICAL FRAMEWORK OF THE RESEARCH

We approach accessibility from a general understanding to the specific. At first, the term accessibility and related concepts such as digital inclusion and digital divide serve as the basis for the article.

CONCEPTIONAL DEFINITIONS: ACCESSIBILITY, DIGITAL INCLUSION AND DIGITAL DIVIDE

Starting with a legal definition of accessibility, according to the Federal Government Commissioner for Matters relating to Persons with Disabilities (2020, para. 1), "accessibility means comprehensive access and unrestricted opportunities to use all designed areas of life". The Federal Agency for Accessibility (para. 1, authors' translation) refers to the Disability Equality

Act (BGG) and explains that accessibility exists, "when people with and without disabilities can equally use a human-designed environment" (Federal Government Commissioner for Matters relating to Persons with Disabilities 2020, authors' translation). The U.S. Department of Education (2020: 2) definition of accessible is: that "a person with a disability is afforded the opportunity to acquire the same information, engage in the same interactions, and enjoy the same services as a person without a disability in an equally effective and equally integrated manner, with substantially equivalent ease of use." One focus of accessibility research is the design of technologies that have the ability to enable or to exclude users. Another approach to accessibility comes from the pedagogical field and addresses whether certain learning activities exclude certain people from learning. There are multiple concepts of accessibility worldwide. However, in the pedagogical context and with regard to our article, it is relevant to recognise that particular types of learning activities create specific barriers (Coughlan et al. 2019). Higher education institutions strive for equal access to teaching materials and teaching scenarios to enable self-determined participation in everyday university life (Knoblich 2020). The broader consideration of the term accessibility is also reflected in the approach to promoting accessibility models in education, e.g. Open Universities and Open Educational Resources (OER) (Coughlan et al. 2019).

In the pandemic situation, regular face-to-face teaching had to be switched to online teaching. In the online learning environment, students' ability to use educational resources effectively has become crucial to their learning performance and to make social connections with other students (Gan & Sun 2021: 4841). Therefore, unequal access to information and communication technologies, i.e. the digital divide, is a fundamental problem for digital teaching (Breitenbach 2021). There is no unified definition of digital divide, but the frameworks of digital divide generally specify four areas of importance: attitudes, access, skills and types of usage. While access to technology is less a problem in the developed world, skills and usage gaps still exist (Gan & Sun 2021: 2840). Digital technologies and their use within seminars in distance learning can have positive benefits for the learning process, e.g. new ways of interaction for learners and teachers. However, Lane (2009: 7) states that "the *availability* (physical access), *accessibility* (usability), and *acceptability* (social empowerment)" of such learning formats can be difficult for students who are unfamiliar with them. Lane further argues that openness, characterized through the open educational resources movement, may actually increase the digital divide. Lane suggests that the teachers' and learners' contexts, their motivation for the learning environment, their digital and educational skills as well as the support they receive can all help to narrow the gaps in the digital divide (Lane 2009).

Another concept covered in the discussion about the digital divide is digital inclusion: The concept of digital inclusion considers the activities which are necessary to enable all individuals and communities, including the most disadvantaged, to have access to and use of Information and Communication Technologies (ICTs). Nowadays, gaps still remain between individuals, organizations, and communities in their access to and use of digital technologies. Such inequalities have been exposed globally by the Covid-19 pandemic, making it more important to investigate them (Kumar, Subramaniam & Zhao 2021). As Gan and Sun (2021: 4838) argue, the frameworks of digital inclusion and digital divide can be discussed in close relation with each other because: "...digital inclusion focuses on the degree of having access to and utilizing technologies, it is closely related to digital divide, which focuses on the gap in technology access and use". According to Gan and Sun (2021: 4840), digital inclusion can be definded as a broader concept that describes the ability of an individual to use technology support in order to participate in society. What limits people also changes with society and technology, among other things. Accessibility is subject to change over time, and particular barriers have changed over time. For example, digital inclusion "of all learners regardless of their circumstances, learning prerequisites and needs" (Walgenbach, Compes & Lambrich 2019: 9; authors' translation) is a major challenge in the current scientific debate. Barriers in digital teaching also arise for people who have previously studied or taught without any barriers (e.g. technical equipment is missing for the digital semester, lack of digital skills).

However, the heterogeneity of students has increased and with it the variety of hurdles in teaching (Breitenbach 2021). With regard to the focus of our article, the hurdles in the learning environment need to be identified to enable non-discriminatory access for all learners. Only

in this way can equal opportunities be ensured and all learners concentrate on the content of their studies rather than being forced to spend time and energy on removing obstacles.

We look at different framework conditions changed by the pandemic to determine whether the circumstances affect students. The focus here is on the changed learning situation, learning conditions at home that are differently suited to digital study and the changed contact opportunities. In this research, we take up the idea that accessibility is provided when people with and without disabilities can use a human-designed environment equally successfully. Our focus is on an equal use of an environment (regardless of disability), especially the learning environment in higher education. In our case study we consider the first "Corona Semester" and raise the question of whether digital teaching provides equal access to learning for all students. However, what are the hurdles in everyday university life and specifically in digital teaching? This will be explored and explained in the next section.

WHAT ARE THE BARRIERS TO DIGITAL TEACHING?

The learning situation at higher education institutions changed significantly from the summer semester 2020, particularly with regard to the delivery of teaching, individual mastery of learning material and examination conditions. Digitisation changes temporal and spatial flexibility, and thus previous barriers are reduced, but at the same time, students face new barriers (e.g. technical barriers, no workplace at home) (Knoblich 2020). Furthermore, Jones and Shao (2011) find that the digital native generation does not use or expect newer technologies than the digital immigrant generation. Some of the new barriers are explained in more detail below. A study in Austria states that the "Corona Semester" has caused at least four new barriers to home learning at university for around 80% of students (Schmölz, Geppert & Barberi 2020).

In the following section, seven types of barriers are introduced which are relevant for this study: *Having a part-time job, caring for relatives, caring for children, remote place of residence, communication barriers* and *technical barriers*. According to our intention to create a wider view of barriers in digital teaching and learning – we focused on examining these social and organizational aspects of barriers which are especially relevant in the online semester for all students, thereby widening the perception of barriers in teaching and learning. First of all, the barriers will be introduced with reference to various study requirements that have changed perceptions about barriers in the digital semester 2020.

Part-time job

In a survey by Munich University of Applied Sciences on the living and study situation during the coronavirus pandemic in 2020, around 61% of the 275 participating students stated that they financed their studies through a part-time job. Other studies state a range between 50 and 65% (Gosch & Franke 2020). Internationally, 61.7% of students reported losing their jobs because of the coronavirus crisis (Aristovnik et al. 2020). According to Traus et al. (2020), almost every second student feels psychologically burdened by the financial situation. Reasons for less money are the loss of part-time jobs and less financial support from parents because they are on short-time work (Traus et al. 2020). Home-learning can make it easier to reconcile studying and working.

Caring for relatives

Students who are responsible for caring for relatives have to manage the time they have available for their studies better, or have a greater challenge attending courses, than students who do not have this task. For example, attending a long seminar or a block course can be a major time constraint (Breitenbach 2021).

Childcare

According to the Mannheim Corona Study (Möhring et al. 2020), around 90% of legal guardians looked after their children alone at home. In the short term, this presented parents with great challenges in organising care and also teaching their children themselves (Möhring et al. 2020). Reconciling family and studies is a central component of gender equality policy

in the German higher education system. Some higher education institutions have already made targeted use of digitalisation and online learning to improve the compatibility of family and studies (Kortendiek et al. 2016). This is because students' everyday lives with children are determined by their children and not by their studies (Schulmeister & Metzger 2011). In her study, Hildebrandt (2018) investigated the extent to which the compatibility of family and studies in veterinary medicine at the University of Veterinary Medicine Hannover is influenced by digitalisation. She states that digitalisation brings greater flexibility in terms of both space and time and that it is precisely the times from 20:00 to 0:00 that are used by the majority of respondents with children. The provision of online learning materials (slides, lecture recordings) is the basis for overcoming minor hurdles in reconciling family and studies.

Remote place of residence

This spatial flexibility also benefits students who live further away from their university and travel long distances to and from lectures. 56% of the respondents (n = 2350) in the nationwide online survey for the 2020 summer semester said they were pleased that they no longer had to travel to their place of study. This would enable them to attend more additional courses (Traus et al. 2020; Breitenbach 2021).

Social life

Students experience the limited contact resulting from coronavirus as stressful (Boros, Kiefel & Schneijderberg 2020). This concerns general contact with other students, exchanges in study groups and also communication with teachers. On the other hand, the contact situation of students also includes their family relationships. Students with children in particular, but also students with disabilities, are comparatively dependent on a functioning family network to successfully complete their studies (Marczuk, Multrus & Lörz 2021). Stegbauer (2020) classifies the privilege of being able to reduce contacts without suffering restrictions as a new dimension of inequality that only became visible through the Covid-19 pandemic. Students with children and students with disabilities are especially likely to be affected by this new dimension of social inequality. The majority of students complain about the lack of social life (between 70 and 80%). Students miss campus life in particular, such as eating together in the canteen and having a chat in the corridors. Studying is more than just attending classes (Traus et al. 2020; Gosch & Franke 2020). Isolated digital learning results in numerous negative aspects. Self-motivation, self-discipline and self-initiative become more important, which means that one has to adjust his/her own learning habits efficiently to minimise stress and the feeling of work overload (Aristovnik et al. 2020).

Communication barriers

Many students (around 80%) complain about the lack of direct exchange with the teacher during office hours or in the corridors/after classes and the drop in personal support from the teacher (around 70%). More than 50% would like to have support with content-related questions.

Technical barriers (internet, notebooks)

In 2013, van Deursen & van Dijk divided the digital divide into two orders: the first-order divide causes inequality in terms of access to digital media. On the other hand, the second-order divide evokes inequality in the sophisticated use of digital media. Daub (2020) describes in an article how digitalisation promotes inequality among students, for example, citing students who do not have internet access at home to use a data-intensive web conferencing system. At the University of Duisburg-Essen, 25% of students said they were not sufficiently equipped with terminal devices (Stammen & Ebert 2020). For 14% of the respondents, technical problems were the reason why they attended fewer courses than in the previous semester (Traus et al. 2020).

Despite all the advantages, digitalisation also raises fears among students; stress due to constant accessibility, an increase in the amount of learning material, stress due to group work and a fear that the PC/internet connection will not be sufficient (Gosch & Franke 2020).

RESEARCH QUESTION

As stated above, barriers in digital teaching also arise for people who have previously studied or taught without any barriers. New barriers have been added, and others have been mitigated, for example, the compatibility of family and work has improved in part through asynchronous online formats. The barriers introduced in the section above are considered to be the foundation of our understanding about barriers and accessibility. Therefore this study aims to answer the following question:

> ***What new barriers have emerged in the digital summer semester 2020 and how can they be solved?***

METHOD

The RheinMain University of Applied Sciences evaluated the digital summer semester in 2020. The administration chose an online survey to reach the study group (students and teaching staff) as effectively as possible. The data evaluations do not allow any conclusions to be drawn about individual persons' identities. This was communicated to the participants at the beginning of the survey. The survey period was five weeks. The respondents needed about 30 minutes to complete a questionnaire.

The focus of the survey was "digital teaching and learning". The questionnaire collected general information about the department, subject semester, and degree programme in the first part. The second part included a block of questions about the start of studies for the summer semester 2020, which relates to information and communication. This was followed by a block of questions about the summer semester 2020 compared to the previous semesters, which refers to workload and satisfaction about learning settings. This was followed by a section on the current work or study situation and technical support in digital teaching, in which reference is made to disruptions and technical difficulties. Furthermore, the survey also collected data on information and communication in the digital summer semester and on the implementation of digital teaching. The questionnaire concluded with a collection of questions on digital working methods' advantages and disadvantages.

1,475 students (including 29 international students) and 244 teachers participated in the survey. For the results of this paper, the students' data were used, and the results of the teachers were excluded. ***Tables 1*** and ***2*** show the subject area and semester distribution.

Of the participating students 88% (n = 1,297) were in a Bachelor's programme at the survey time.

Table 1 Sample of the survey (university faculties).

UNIVERSITY FACULTIES (BACHELOR & MASTER)	n	%
Faculty of Architecture	176	11.9
Faculty of Computer Science	389	26.4
Faculty of Engineering	335	22.7
Faculty of Social Sciences	315	21.4
Faculty of Business Studies	260	17.6
Total	**1,475**	**100.0**

For the evaluation, descriptive analyses were first carried out on all items. For this purpose, the evaluation team calculated the mean value, the absolute frequency, and the percentage frequencies of each item's scale values. The questionnaire is predominantly constructed with closed questions that had a 5-point Likert-scale. At the end a set of open questions were asked, but the amount of data has not yet been categorised nor evaluated to this point. Where there are normally distributed scales, correlations can be determined using the standard parametric procedure of product-moment correlation according to Pearson (Bortz 2005). The following guideline values are given for interpreting the correlation coefficients: $.20 \leq r < .40$ corresponds to a weak correlation, $.40 \leq r < .60$ to a medium correlation and $.60 \leq r < .80$ to a strong

SEMESTER OF STUDIES	n	%
1st semester	155	10.5
2nd semester	305	20.7
3rd semester	173	11.7
4th semester	254	17.2
5th semester	143	9.7
6th semester	167	11.3
7th semester	74	5
8th semester	43	2.9
9th semester	26	1.8
10th semester	18	1.2
11th semester	7	0.5
12th semester	19	1.3
Semester on leave	1	0.1
Start of studies only in WS2020/2021	90	6.1
Total	**1,475**	**100**

Table 2 Sample of the survey (Semester).

correlation (Brosius 2013). If the œerror level falls below .05, one can speak of a significant result. If the value falls below .01, one can speak of a highly significant result (Bortz 2005).

RESULTS OF THE STUDENT SURVEY AT RHEINMAIN UNIVERSITY OF APPLIED SCIENCES

In the following evaluation section, the barriers to digital teaching and learning are first considered individually. The evaluation of the results focuses on the exemplary barriers to digital teaching described above. The focus here is on the student survey results from the summer semester 2020 at RheinMain University of Applied Sciences, but there are also references to other study results. This is followed by an analysis and discussion of the connections between individual barriers.

PART-TIME JOB

Concerning the advantages of digital learning, 47.8% of the students surveyed at RheinMain University of Applied Sciences stated that digital teaching methods enable them to combine their studies better with other jobs. The evaluation of the personal financial situation is perceived by 37.9% of the respondents as more strained than before the coronavirus, but 46.9% also stated that they had not had any major financial worries since the beginning of the pandemic. Furthermore, 40.6% of respondents said they were not worried about not being able to finance their studies, but 27.6% felt this was (relatively) challenging. It can be stated that the students' financial situation is very heterogeneous and presumably also depends on the previous financing of studies. The wide range is also dependent on whether a student has a part-time job or support from parents and life partners. However, these aspects could not be explored in more detail with this survey's help.

CARE OF FAMILY MEMBERS AND CARE OF CHILDREN

The barriers "caring for family members and looking after children" are considered together here, as these aspects were not examined individually in the present survey. The statement "I have to take care of my family more often than in the time before the coronavirus pandemic" was fully agreed upon by 17.4% of the respondents. As well, 17% agreed with the statement. In summary, this means that for about 34% of the students they had an additional burden of caring for family members this semester. A differentiation regarding whether this involves caring for adult relatives or children cannot be identified. Möhring et al. (2020) also found in the

Mannheim Corona Study that around 90% of legal guardians look after their children alone at home. Organising this is a significant challenge for single parents (Möhring et al. 2020).

LONG DISTANCE FROM HOME TO THE UNIVERSITY

From the perspective of students of the RheinMain University of Applied Sciences, fewer commutes (travel to campus) (83.1%) and more flexibility in terms of time (76.1%) were perceived as the main advantages of digital learning. According to Traus et al. (2020), this enables higher participation in additional courses. Whether and to what extent the students made use of these opportunities could not be conclusively assessed on the basis of the survey results.

SOCIAL LIFE AT CAMPUS

Above all, the social aspect associated with studying at an actual face-to-face university is lacking for most students. Thus, 44.9% of respondents fully agreed with the statement that they miss campus life (refectory, library, places to stay). Among the disadvantages of digital teaching, as many as 77% of students said they lacked contact, exchange and hanging out with others at the campus.

BARRIERS TO COMMUNICATION

Many students at RheinMain University of Applied Sciences find it challenging to interact with other students and teachers in purely digital teaching settings. More than half of the respondents (52.7%) fully agreed with the statement "I miss my fellow students". 41.7% of respondents also fully agreed with the statement "I miss the personal on-site support from teachers". Hassel (2020) also points out that specific requirements represent substantial hurdles in the current situation of social distancing and online learning. For example, the recognition of content-related performance requirements or the development of subject-related career ideas due to a lack of personal interaction in the teaching context. Also, the existing pressure to perform and take exams is perceived more intensely due to the generally existing uncertainty. For the first-year students, the spatial distance made it difficult to make connections and find their way around the university (Hassel 2020).

TECHNICAL BARRIERS (E.G. INTERNET, NOTEBOOKS)

64.9% of the students surveyed at RheinMain University of Applied Sciences feel technically well equipped for digital teaching (PC, laptop, camera, microphone). However, around a third of respondents also stated that there were a lot of (7.8%) or many (25.8%) technical disruptions in their courses, so teaching could not be carried out efficiently. Kalmbach (2020) points out that, in general, one hurdle in implementing diversity-responsive teaching in higher education is that students have to deal with learning platforms and video conferencing tools. Questions about data protection and data security often arise in this context, confronting both teachers and learners. Digital teaching and its application tools are a new challenge for many participants, some of whom have never worked with digitally enhanced teaching methods before. Acquiring new methods and competencies requires a lot of time and expertise (Kalmbach 2020).

"A BARRIER RARELY COMES ALONE"

Studies on the summer semester 2020 have looked at individual barriers and evaluated how they affected students. In the following, we will also examine whether there was a connection between individual barriers for students: When confronted with a barrier, did a student had to "struggle" in parallel with others?

Pearson's product-moment correlation was used to check for a correlation between individual barriers (Brosius 2013; Bortz 2005).

Correlations between "less commuting" and "more flexible working" showed a weak correlation (.136**). We had suspected a more significant correlation here. There are no mean values with standard deviations for the items "purchase of technical equipment" and "compatibility of study/work and family" (no 5-Likert scale).

The results from ***Table 3*** show that interesting, albeit primarily weak, correlations (.20 ≤ r < .40) exist. In the table, exciting correlations are marked in blue:

BARRIERS	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) No workplace	3.7	1.4	.						
(2) No technical equipment	4.3	1.2	.409**	.					
(3) Internet stability problems	3.8	1.3	.385**	.424**	.				
(4) Care for family members	3.3	1.5	.156**	.138**	.096**	.			
(5) Stressed financial situation	2.5	1.5	.228**	.247**	.247**	.292**	.		
(6) Purchase of technical equipment	N.A.	N.A.	–.137**	-.176**	–.187**	–.101**	.272**	.	
(7) Compatibility of study/ work & family	N.A.	N.A.	–.261**	–.153**	–.145**	–.161**	–.246**	.172**	.

Table 3 Pearson correlation between individual barriers.

Five-point response scale from 1 = "strongly agree" to 5 = "strongly disagree".

* The correlation is significant at the .05 level (2-sided).

** The correlation is significant at the .01 level (2-sided).

- A lack of work is moderately related to a lack of technical equipment (.409) and internet problems (.385).
- Not having a workplace correlates weakly negatively with the compatibility of study/work and family (–.261).
- A lack of technical equipment is moderately related to unstable internet (.424).
- Caring for family members is weakly related to the stressed income situation (.292).
- The stressed financial situation is weakly related to the need to equip oneself with technical devices (.272).

Therefore, it can be said that a barrier rarely comes alone, and students who are confronted with any given barrier in the digital semester have also had to deal with others. This should be considered, especially in the recommendations for action and offers of support.

To examine this further, the 5-point Likert scale from ***Table 3*** was recoded for the following barriers:

- I do not have a place to work undisturbed.
- I do not have suitable technical equipment (PC, laptop, camera, microphone) for digital events.
- I do not have a stable internet connection for digital events.
- I have to take care of my family more often than in the time before the coronavirus pandemic.
- My financial situation is tighter than in the time before the coronavirus pandemic.

The answers "strongly disagree" and "disagree" were recoded to 0, no barrier, while the answers "partly/partly", "agree", and "strongly agree" were recoded to 1. This was based on the assumption that if students say "partly/partly", they have some form of barrier. Now, does a barrier rarely come alone? Well, one barrier was counted for 25% of all students. However, 75% of all students have either no barrier or two or more (see ***Figure 1***). Only a minority of around 18% of all students do not report a barrier, which leaves 57% with two or more barriers.

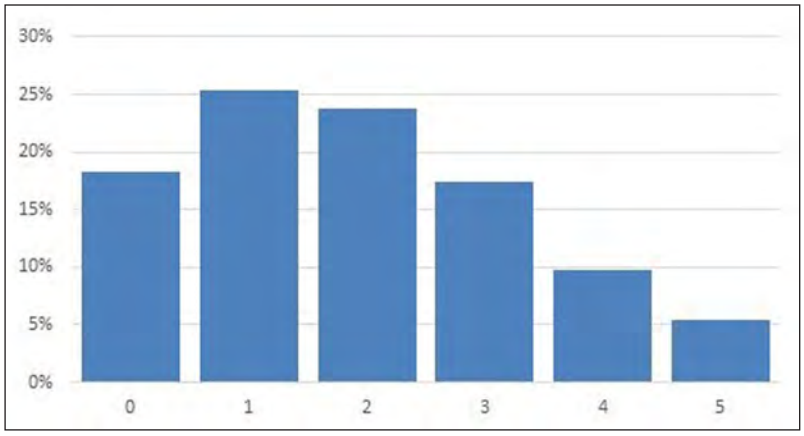

Figure 1 Number of barriers per student in %.

With regard to the disadvantages of digital teaching reported by the students, the Pearson correlation concerning the sum of barriers is r = .34. Perhaps this is somewhat unsurprising, but if students have no real job, poor internet, tight finances, and care for family members, they see more disadvantages in digital teaching than face-to-face teaching. We can conclude that the more barriers someone has, the more disadvantages they tend to see in the digital semester. A further correlation between the workload and the sum of barriers results in r = .21**. Also, not so surprising, those who have more barriers experience a higher workload.

The digital semester under coronavirus has created new barriers. The survey explicitly asked about the change compared to a semester without coronavirus (whether one has to take care of relatives more because of coronavirus, whether the financial situation is tighter because of coronavirus than before). Furthermore, the sum of barriers correlates with the workload. Moreover, students with multiple barriers perceive the digital semester more as a disadvantage than an opportunity.

RECOMMENDATIONS FOR ACTION

The academic landscape is now in its third digital semester. For students in the Bachelor's and Master's programmes, a third or half of their studies differs from what they were used to, some of them now face more or new barriers. To reduce barriers in digital teaching and learning, adjustments are necessary. The following section discusses some possibilities for reducing such barriers.

TECHNICAL EQUIPMENT AND INTERNET STABILITY

To enable students to fulfil tasks and activities equally in both analogue and digital form, from the winter semester 20/21 onwards, RheinMain University of Applied Sciences has offered the opportunity to borrow notebooks. Thirty notebooks were purchased for this purpose; all of them were soon on loan so that the university will increase the number. One option to counteract problems of internet stability is to provide learning content for asynchronous or offline use.

COMPATIBILITY OF STUDIES AND FAMILY/WORK

During the Corona semesters a lot of learning materials were digitalised or digitally produced. The provision of these online learning materials (slides, lecture recordings) allows flexibility for students who have to take care of relatives or who have a part-time job. In this way, students can manage their time more freely, also regardless of location. Digital teaching and learning should enable students to expand their study opportunities, not limit them (Traus et al. 2020). This is one of the barriers that have been reduced by the Covid-19 pandemic. On the other hand, to really benefit from the shift towards more digital material, the students need technical equipment and a quiet place to study. Two things not to be taken for granted, as the evaluation has shown.

LOW-THRESHOLD FINANCIAL SUPPORT FOR STUDENTS

As mentioned above, around 540 students (37%) had financial worries in the summer semester. Traus et al. (2020) recommend higher education institutions support students in a non-bureaucratic way (e.g. social funds, scholarships). Academic success should not depend on financial situation.

SOCIAL INTERACTION

Digital forms of teaching and learning are also new for students and they face new obstacles. The results show the students' desire for more social interaction, which can be implemented in both asynchronous (e.g. questions in a forum) and synchronous phases (live questions via audio or chat) of teaching and learning.

The initial phase of a course in particular is characterised by great uncertainty on the part of the students. The focus at this stage should be on establishing good rapport and fostering motivation on the part of the students through personal engagement. It is advisable to show

students a clear framework at the beginning and offer them the opportunity to get to know each other (Marks 2005). Furthermore, universities should enable students to get together in small groups in video conferencing systems for networking, social interaction and group work (Traus et al. 2020). In this way, virtual spaces can also become places of shared learning.

LOW-BARRIER DESIGN OF TEACHING AND LEARNING CONCEPTS

Even minor adjustments can significantly improve the accessibility of digital teaching and learning opportunities, such as ensuring good sound and video quality and subtitles in videos or by using multiple communication channels for important information.

As the heterogeneity of students has increased and with it the variety of barriers in teaching (Breitenbach 2021), new learning formats would be helpful. Based on the inverted classroom method of teaching, parts of a course that essentially serve purely to impart knowledge can be provided on learning management systems for structured self-study at home, regardless of time and place. Face-to-face events – if possible – or synchronous online meetings can serve as a basis for discussions, for practising and for clarifying questions. As our survey has shown, it is harder to achieve social interaction in a virtual environment than in regular classes. Self-motivation, self-discipline and self-initiative become more important in online classes (Aristovnik et al. 2020). Generally, it is advisable to make content (presentations, scripts, video recordings) available for follow-up.

To keep the students' attention, teachers can include activating elements (e.g. to test knowledge, to initiate reflection), both in the asynchronous and synchronous phases of teaching and learning. These teaching elements activate exchange and interaction and enable teachers to receive feedback on the students' learning process to check prior knowledge or reveal difficulties in understanding. The prerequisite for this approach is to raise teachers' awareness of these special features of digital teaching methods.

This study did not consider how students with 'traditional' barriers (e.g. hearing loss, blindness) have experienced the digital semester. Additionally, not all aspects of barriers in digital teaching could be precisely explored since the focus of the questionnaire was on a broader view of the digital Corona semester. These aspects need to be addressed in further studies. Despite these limitations, universities should consider that unequal access to information and communication technologies ("digital divide") is a fundamental problem for digital teaching (Breitenbach 2021), which needs to be considered.

In summary, this research is not about disabilities in the traditional sense, but rather about the new barriers that have emerged in three "Corona semesters" of predominantly digital learning. The focus is to broaden the view on accessibility and draw attention to these barriers. In this context, equal participation in learning cannot be guaranteed due to the circumstances of digital learning caused by the coronavirus pandemic.

CONCLUSION & IMPLICATIONS

The objective target of this research work was the investigation of barriers for students during the "Corona semester". The survey is limited to a middle-sized German University of Applied Science in a middle-sized city. Although we assume that the results of the study are worth considering in a broader context, the problems and possible solutions raised in this article can be found in other countries, too, at least in Europe and North America (Aristovnik et al. 2020). Internet accessibility might be better in other places, but caring for relatives and children or not having a private work and study space are universal problems and not exclusively related to the German cultural background.

Barriers in digital teaching and learning also arise for people who have previously studied or taught without any barriers, for example, due to insufficient technical equipment or a deficit of digital skills. Inequalities have been exposed globally by the Covid-19 pandemic, making it more important to investigate these inequalities. The framework of digital inclusion might be a helpful blueprint for creating a learning environment which enables all students to participate.

However, not only new barriers but also barriers already known could be lowered through digital learning scenarios. Challenges often arise from technical and organisational conditions and restrictions and the different ways of transferring traditional learning content into a meaningful and accessible digital format. In some cases, the compatibility of studies and family/work has improved through asynchronous online formats, whereas many students miss social interaction with teachers and fellow students.

As the results of our study show, a barrier rarely comes alone – students who face one barrier in the digital semester also face others. This should be taken into account especially when offering support services. Adjustments are therefore necessary to reduce the barriers in digital teaching and learning. One option is to design digital teaching and learning scenarios with low barriers and to provide low-threshold financial support for students. To counteract problems of internet stability, teachers can provide learning content for asynchronous or offline use.

At around 10%, the sample of our research data is not representative. Therefore, the result cannot be generalised and should be interpreted with caution as regards derived measures. It could be concluded that the 90% of students who did not participate in the study are precisely those students who had great difficulties in the "Corona semester" with digital learning. Further research with a larger, more comprehensive sample is needed. In addition, more research should look at measures to reduce the barriers that are described above. In addition, further research should draw attention to the skills which students need to effectively complete a study online.

For the meso level of the academic landscape, the results in this study might be of interest, as higher education institutions need to respond to these emerging barriers (Pearson et al. 2019). Further research is needed to be able to deduce concrete prevention and coping mechanisms for these barriers and thus to develop teaching and learning in higher education in its entirety.

Overall, accessibility in the virtual space also requires an openness on the part of the universities to the perception of (newly added) barriers. The digital semester during the Coronavirus pandemic has created new forms of restrictions. Some barriers will hopefully disappear one day together with the Covid-19 pandemic restrictions; others can be countered by the universities (notebook lending, students' self-study/workspaces). It is essential to consider these barriers during digitisation of learning and teaching formats and to keep them as low as possible (e.g. offering videos in a lower resolution for slow internet, asynchronous formats).

To some extent, the Covid-19 pandemic has expanded the digital divide in distance education. Educational institutions and policy makers should consider designing and implementing intervention programs focusing on improving developing the digital skills essential for students to achieve their academic goals. The establishment of a culture of openness is an important step in order to be able to support every student in the learning process in the best possible way and to enable (digital) participation and learning. Technical accessibility and open access to education are essential, however, they rarely form the basis for equal learning. This requires more than just access to learning via learning platforms or web conferencing services. The context and nature of each student's learning must also be taken into account (Coughlan et al. 2019). For teachers, it could be helpful to establish a greater culture of sharing – on the one hand, to reduce the effort required for lesson preparation, and on the other hand, to establish a learning environment in the university that enables all types of students to participate.

ETHICS AND CONSENT

On behalf of all authors, the corresponding author states that there is no conflict of interest. We have received no funding for our work. All participants of the survey have been informed and were willing to participate in the survey and have been anonymised. No personal data was used.

COMPETING INTERESTS

The authors have no competing interests to declare.

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