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Digitalizing Higher Education in Light of Sustainability and Rebound Effects—Surveys in Times of the COVID-19 Pandemic

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Abstract: The COVID-19 pandemic has focused attention not only on health and social issues, but on the issue of digital transformation as well. Within a very short time, universities had to convert their courses to digital formats and university life was reduced to a minimum. To shed light on how the COVID-19 pandemic has affected universities, we investigated the following questions: How was this transformation accomplished? What advantages and disadvantages did it bring with it? How sustainable was this transformation? and What can the future of higher education look like? This study is based on the responses to two questionnaires for university staff and students conducted at the Chemnitz University of Technology between mid-July and September, 2020 (n = 369), and between February and March, 2021 (n = 252). Both questionnaires were analysed using descriptive statistics and qualitative content analysis. The results show wide variations in response to digital teaching and learning. Digital teaching and working/learning from home have brought both multiple benefits and multiple challenges at the same time. Working and learning from home was perceived as both enriching and overwhelming—even for the same individual. Respondents appreciated the flexibility associated with digital teaching, even though digital teaching was perceived as imposing excessive demands. This study reveals striking gaps in our knowledge and our actions linking digital transformation and sustainability and highlights how digital teaching can be further developed.

Keywords: COVID-19 pandemic; digital consumption behaviour; digital transformation; higher education institutions; rebound effects

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1. Introduction

Universities play a crucial role—both as pioneers and role models—in the field of sustainable development [1]. The definitions and conceptualizations of sustainable universities within the literature are broad [2–4], but a common trend in these conceptualizations is a shift in focus—from the operational level alone to the links between operational and strategic aspects [5]. In a comprehensive model, Velazquez et al. (2006) consider both levels and identify strategies for different areas (education and teaching, research, outreach and partnerships, and campus sustainability) in which universities can act and which need to be considered together in order to pursue the long-term goal of a sustainable university [6]. Lukman and Glavič (2007) emphasize that sustainability also includes ecological, economic and social components that universities need to consider as well [3]. Education and teaching have taken on new relevance during the COVID-19 pandemic, which presents us with an opportunity to sustainably design digital teaching and to put universities on a new path towards sustainability.

The COVID-19 pandemic has accelerated the process of digital transformation that had already been underway at universities, bringing new challenges as well. Universities had to rapidly make two shifts: face-to-face courses had to be adapted to a digital format, and courses in subjects requiring social interaction, human technology and machine interaction—such as medicine, the natural sciences, engineering and music—had to be

extensively redesigned [7,8]. Digital teaching presents challenges, opportunities and advantages. Among the challenges is designing examinations to meet legal requirements and avoid technical problems [7], whereas the opportunities and advantages include digital teaching formats [9] that are flexible for both students and teachers (e.g., video formats). Digital teaching can also save time because it eliminates commutes for both groups [10]. Although the sustainable design of digitization in research is gaining more attention, progress is still slow [11–14]. One product of this increased attention is a new term, "digitainability", a neologism of the words "digitization" and "sustainability". This new terminology makes it easier to summarize and explore the links between sustainability and digitization [15].

Digitization can trigger beneficial virtuous feedback loops and comes with both opportunities and risks. As Estermann et al. (2020, p. 4) note, digitization "can lead to efficiency surplus; however, this is often accompanied by an increased demand and thus increased consumption of raw materials. For the environment the greatest opportunities of digitization arise in the area of energy; the greatest risks arise in the consumption of resources and the disposal of digital devices" [16] (p. 4). In this study, we examined the ecological as well as the social aspects of sustainability. Ecology studies have shown that using different search engines, platforms and digital services is linked to serious increases in greenhouse gas emissions—even using video cameras in meetings has an impact on emissions [17]. Digital services increase electricity demand enormously; therefore, green electricity purchases are not only highly relevant, but the rebound effects they might cause also need to be considered [18]. The social dimension of sustainability considers aspects such as quality of life, basic needs, social resources, equal opportunities and participation [19]. During a lockdown, when businesses and offices are closed, being able to work and learn at home undisturbed is incredibly valuable. Living in cramped quarters—with thin walls, children not allowed to leave the house and frequent interruptions—can make concentrating and being productive incredibly difficult. Zickerick et al. (2020) showed that the brain's working memory handles distractions better than interruptions [20]. With all these different shifts and consequences, sustainability—as it relates to digital teaching—is an incredibly rich and complex field of study, with many unanswered questions.

In this study, we were interested in understanding how digital teaching and social-ecological sustainability converge as well as diverge, and how universities—as pioneers and role models—can design and shape digital teaching in the most-sustainable way. To better understand these interests, we wanted answers to the following research questions (RQ):

RQ1: How was the transformation of university teaching into digital formats accomplished?
RQ2: What were the advantages and disadvantages of this transformation?
RQ3: How sustainable was the transformation?
RQ4: What will the future of higher education look like?

2. Theory

2.1. Digital Universities in Times of the COVID-19 Pandemic

The COVID-19 pandemic has required universities to shift teaching from face-to-face lectures and courses to online and digital formats. Suddenly, because of COVID-19, digital transformation at universities was incredibly relevant and ushered in enormous changes for both university staff (as researchers as well as teachers) and students. The terms "university staff", "teaching staff", "teacher", "employee" and "lecturer" are all used interchangeably in this text, and refer to professors or lecturers teaching full-time or part-time. Researchers became interested in investigating how teaching was being transformed into digital formats, particularly the ad hoc conversion to digital teaching concepts. Recent studies have reported on the effects of this conversion on workload, teaching quality, self-motivation and discipline, psychological stress, and exchange and communication, among other things (for a summary of three studies, see [10,21]). As for how to design teaching in the future, these studies indicate that more digital teaching should be offered, but that it should not completely displace face-to-face teaching [22]. The goal should be more flexible teaching and learning opportunities, such as hybrid learning and combining

synchronous and asynchronous teaching [23]. An important consideration in all of these changes is that the new teaching formats be adapted to and accommodate students' and teachers' different backgrounds, skill levels and available digital resources [24]. Properly designed digital courses can be an opportunity for introducing students to new digital tools and helping them to organize their schedules independently, flexibly and responsibly [25]. Target relationships between digitization and sustainability can be located on the spectrum between complementary and competitive [26]. However, as promising and challenging as these opportunities are, how sustainable are they?

2.2. Digitization and Digital Transformation

There is no common definition for the term digitization. An early definition was the "transformation of information from an analogue to a digital format" [26] (p. 2). More recently, it has been described as a "form of (partial) automation made possible by the use of information technology (IT)" [26] (p. 2). Digitization is always accompanied by a transformation process. For our purposes, we see digitization as developing and applying digital and digitized technologies and combining them with all other technologies and methods. These transformations not only profoundly impact all economic, social and societal systems; this transformative force is increasing as well [11]. Digitization as a megatrend is linked to a wide range of fundamental and ethical challenges. Digital transformation is a holistic, radical and long-lasting process of change for society (a socio-technical transformation), which triggers numerous ethical issues [12]. Digitization and digital transformation are also highly relevant to the question of sustainable development, especially during pandemics; the COVID-19 pandemic has made clear that not everyone in society has access to digital tools and communication technologies, nor do they have the same level of skills to use them. DiMaggio and Hargittai (2001) suggested that these digital inequalities have five dimensions: technical means (software, hardware); autonomy of use (location of access, freedom to use the medium for one's preferred activities); use patterns; social-support networks (availability of other persons to turn to for support); and skill (one's ability to use the technology or device effectively) [27,28]. Another inequality is in the differences in the quality and intensity of use of the digital tools [29]. Successful digital learning settings need high-speed Internet and available technical devices, and the financial means to purchase them. Neither of these can be assumed, because both financial constraints and supply bottlenecks during global pandemics impact how effectively individuals can participate in digital learning. Additionally, using digital services profoundly increases electricity demand and consumption, making it even more relevant to the issue of sustainable development [13]. Although digital competencies and support networks directly impact how successful digital teaching is during pandemics, neither can be turned on with the flip of a switch—instead, they need to be built up first.

2.3. Sustainability

Similarly to digitization, sustainability has many different definitions and meanings. The notion of sustainability encompasses a set of values for dealing with resources, people, animals, plants and nature, as well as taking the present and the future into consideration when making decisions. It is both a political and an economic guiding principle [12,30–32], equally addressing the three dimensions of ecology, society and the economy, and the interdependencies among each [33]. Embedded in these three dimensions are issues of law, politics, technology and culture. The related concept of sustainable development addresses issues of intergenerational as well as intragenerational justice [12]. Its social dimension places people at the centre and makes them responsible for themselves, their social environment and future generations. The core elements of the social dimension of sustainability are dignity, self-determination and existence—specifically, intentionally designing jobs and education, and integrating fair pay, equality and inclusion. The COVID-19 pandemic has made us aware that physical and mental health issues are both priorities in the concept of sustainability. Although the Sustainable Development Goals (SDGs)

already include health, the COVID-19 pandemic has demonstrated how fundamental human health is to all other sustainability areas and for implementing the SDGs [34]. Recent approaches to the SDGs have also considered how interdependent these goals are. The action required to achieve all the SDGs affects existing synergies, and achieving one involves contradictions and trade-offs with others; therefore, a better way to approach and achieve the SDGs is to work on them together in transformation areas rather than working on each one individually and in isolation [35,36]. Digital transformation has the capacity to both promote and inhibit sustainable developments.

Of all the SDGs, SDG 4 (quality education) is particularly important. Agbedahin (2019) showed the relevance of education for the achievement of the other SDGs as well as for sustainable development and Agenda 2030 [37]. An analysis of 37 global UN reports by Vladimirova and Le Blanc (2016) showed that except for SDG 14 (life below water), education influences all other SDGs [38]. Education is so important to the other SDGs that the SDSN Australia/Pacific (2017) refers to it as one of the "bedrocks of SDGs" [39] (p. 11). Education is a core mission of universities; therefore, they play a special role in implementing this SDG [40]. Universities are where some leaders, politicians and other future decision makers are educated, and because these professional positions carry great responsibility, equipping these individuals with the appropriate knowledge about sustainability and sustainable development is particularly relevant [41].

Although sustainability has many positive effects, it also has negative ones as well, including rebound effects [42,43]. Rebound effects occur when increases in productivity or efficiency increase demand [44]. The increased demand can potentially reduce the savings (e.g., in energy, costs) from improved productivity completely. At their worst, rebound effects can even lead to increased overall consumption. Rebound effects are subdivided into direct, indirect and structural. Direct rebound effects are those in which efficiency improvements lead to additional demand for the same good. Indirect rebound effects, on the other hand, occur when the reduced costs from one area increase the demand for other goods, with the efficiency savings spent elsewhere. Direct and indirect rebound effects occur on the individual level, whereas structural rebound effects are those that take place at the macroeconomic level [44]. The most extreme form of rebound effect is backfire, which occurs when an efficiency surplus is not only partially offset by savings, but is overcompensated. For example, when energy efficiency increases result in a net increase in energy consumption, i.e., post-efficiency consumption that exceeds the original consumption [44], backfire can occur, for example, when data centres expand. However, backfire is not inevitable; data centres can use natural resources efficiently and responsibly without affecting their availability, security and performance [45].

Rebound effects also have temporal and psychological aspects that affect resource consumption and have environmental and social impacts as well [44]. One such aspect is moral hazard, which occurs when environmentally friendly products or services are used more intensively. For example, driving an e-car a short distance to the bakery instead of walking because it is perceived to be less ecologically harmful. Another aspect is moral leaking, which happens when efficiency increases lead people to neglect their previously mindful behaviours. An example is neglecting to switch off lights because they use energy-saving lamps. A third aspect of rebound effects is moral licensing, which is when ethical or sustainable consumption in one area leads to unethical or unsustainable consumption in another area [46]. These temporal and psychological aspects of rebound effects explain why Longo et al. (2017) state that increased knowledge and information about sustainability and ethical consumption can have positive effects, and at the same time, can be a source of dilemma, tension and paralysis [47].

2.4. Digitization and Sustainability in Academia

To realize—instead of reduce—the potential of the two megatrends of digital transformation and sustainability, the two need to be considered together. Digitization and digital transformation are central to the 2030 Agenda; they are essential to several SDGs, and they

have great potential [1]. In addition, they both affect—and are influenced by—academia, because education is increasingly shaped by developments in technology [48]. At universities, (digital) teaching is particularly affected by change processes resulting from digital transformation. Here, sustainability as well as interdependencies must be considered, because designing digital teaching draws from various media, including the five groups of digital media Persike and Friedrich (2016) identified: classical media (e.g., digital presentation tools, but also e-mails, databases and texts); social media (e.g., blogs and forums); interactive media (e.g., simulations, educational games); electronic testing systems; and audio/video-based media and tutorials [49]. Higher education institutions contribute to achieving SDG 4; therefore, any switch from face-to-face teaching to digital teaching formats must maintain (and ideally increase) the quality of teaching and knowledge transfer. To ensure this happens, university staff and students need to have a level of digital competence so they can use digital media effectively [48,50]. Recent studies have reported that staff and students lack this competence so essential for successful learning [51,52]. For digital teaching to be sustainable, professors and staff need to include three elements when designing digital courses: (i) delivering learning content; (ii) activating learners; and (iii) mentoring learners [53], and they need to also include overlapping aspects of different sustainability dimensions that reinforce and support one other.

The three areas in which sustainability has the greatest potential are decarbonization, dematerialization and the renaturation of ecology [54]. In this respect, the digital transformation can make a major contribution to sustainable development [55]. This positive contribution to sustainability is not a given [12,55], however, because digitalization and the use of digital technologies relies on a growing number of electronic devices and cloud and streaming services that contribute to increasing global energy consumption [42,56]. In addition, the production of digital end devices causes enormous environmental and social damage along the entire value chain, including e-waste. For digital transformation to be truly sustainable, students should not have to purchase new products to participate, and the digital products they use should be part of the circular economy. One particular pitfall of digital transformations is incomplete transformation processes, because they tend to exacerbate energy and resource problems (Hilbert and Prakash, 2016, p. 22). For example, when businesses or government agencies transition to so-called paperless offices, they often still simultaneously use paper and electronic infrastructure, which thus has a double impact on the environment [57]. Achieving the promise of greater ecological sustainability therefore requires that transformation processes be completed. For digitization to deliver on its potential and reduce as much as possible the negative effects that result from it, decision-makers need to consider the context of digitization as well as its use and design [12].

2.5. The Study's Framework

In addition to the advantages of increased flexibility, accessibility and time savings, digital teaching also has even greater sustainability potential, such as reduced costs and increased savings, as well as more efficient, reduced or different uses of space, which would be welcome in cities where space is scarce [58]. In terms of its environmental impact, digital teaching can reduce individual motorized transport [10]. Exploiting this potential, however, requires equipment, willingness and competence. To implement digital teaching and ensure that students, teachers and universities participate, they need basic technical equipment [10]. Research has shown that students are willing to use digital media for academic learning if teachers and universities successfully implement it (Bond et al., 2018) [52]. In addition, students and teachers need the skills to use digital media, and universities need to consider individual-level factors such as a second job, parenthood and physical as well as mental or sensory impairments that could affect whether and how teachers and students will use it [10].

To avoid the danger of rebound effects, universities—at the institutional/organizational level—need to define the scope of their sustainable actions when carrying out digital trans-

formation processes [58]. Digital teaching is susceptible to rebound effects; therefore, it needs to be designed so that it actually achieves its high potential for saving resources, time and transport and results in efficiency gains, instead of having those gains partially offset because events overlap or technical infrastructure is lacking. In addition to these considerations, universities should also take into account the environmental effects of digital teaching. The latest research results, for example, show that streaming via mobile networks produces significantly more greenhouse gas emissions than streaming via fibre or copper cable; thus, it is significantly more harmful for the climate (Available online: https://www.bmu.de/en/pressrelease/video-streaming-data-transmission-technology-crucial-for-climate-footprint/, accessed on 1 September 2021). When planning digital teaching and streaming content for digital consumption, universities should consciously choose their network connection to avoid these harmful effects. These considerations are also relevant for binge watching (binge watching is the extended watching of films or series; see Spangler (2013). Netflix survey: binge watching is not weird or unusual. Variety. Available at: http://variety.com/2013/digital/news/netflix-survey-binge-watching-is-not-weird-or-unu-sual-1200952292/, accessed on 1 September 2021). Taken together, all these considerations beg the question of how to implement digital teaching in the future to achieve the highest possible positive sustainability effects. In this study, we therefore focus on the social and environmentally sustainability concepts presented above because they are particularly relevant in academic contexts.

Another precondition for successfully implementing digital teaching is ensuring that teachers and students have a quiet workplace in which to concentrate when working from home. Creating a physical boundary can help individuals separate private and work life (Fedakova and Istonova, 2017) [59], but a quiet workplace alone does not automatically lead to concentrated and productive work, because other factors influence whether this can be achieved. Technical equipment and Internet bandwidth also play decisive roles in whether students can comprehend content and follow a lecturer's content. We expect that people who had already set up a quiet workspace and had the necessary technical equipment and sufficient bandwidth before the pandemic would rate digital learning offers more positively. Based on these explanations, our relative hypotheses RH1 to RH 3 are as follows:

RH1: *Being able to set up a quiet workplace at home and/or working productively from home is positively related to having the necessary technical and/or digital equipment.*

RH2: *Working productively from home is positively related to having sufficient bandwidth.*

RH3: *The ability to concentrate or work productively at home is positively related to individuals' advocating for having or participating in more digital events in the future.*

We also assumed that digital consumption would increase because teachers and students would have more available time [60]. Not having to travel to university will also result in greater social exchanges among colleagues or fellow students and will increasingly take place digitally. Alternatively, using digital media will compensate for leisure time.

RH4: *There is a positive relationship between time saved by not having to travel to university and increased digital consumption.*

We also expected that being able to concentrate at different locations, such as at home, on university premises or on the way to the university, will be associated with whether students, teachers and staff assess various digital learning options as being sustainable and promoting learning. We also believe that these assessments will be associated with individuals' direct social interactions.

RH5: *Individuals' assessment of digital teaching and learning options as promising sustainable teaching events is negatively related to: (i) having good concentration skills; or (ii) having productive learning experiences; and (iii) teaching at university locations; or (iv) teaching on the way to the university.*

Turning to the ecological impact of digital teaching, we also assume that mobility and digital consumption play a central role and may be interrelated. The impact of the travel and time savings achieved by eliminating (part of, or all) commuting, and its effect on the ecological impact of digital teaching, depends on two factors: (i) Prior to the COVID-19 pandemic, what modes of transportation were used to travel to and from university? This prior transport factor is essential, because traveling to work by bicycle can have positive health effects for employees and students without having a negative ecological effect. Traveling by car, on the other hand, can have various negative effects that a home office eliminates (e.g., long travel time, stress caused by traffic, resource consumption, emissions and other environmental effects); The second factor (ii) is 'How was this travel time used?'; furthermore, 'How was the time "gained" (by not having to travel) used?'. This factor is significant because it relates to (digital) consumption. If, prior to the SARS-CoV-2 pandemic, individuals commuted by train, they could conceivably have used that time to stream music or videos during the journey.

Equally conceivable is that the time gained from not having to travel was used for digital consumption.

Another factor to consider in domestic digital consumption is whether green electricity was purchased, because it plays a role in terms of ecological impact. If more than 56% of the participants used green electricity, a ratio that corresponds to the proportion of the electricity mix used by TU Chemnitz, we would not expect an energy rebound effect for the direct power supply of digital end devices. An interesting question—although beyond the scope of our study—is that in purely arithmetical terms, the energy saved in mobility travel time may have been offset by the power supply at home. These considerations lead to the following hypothesis:

RH6: *There is a negative relationship between the purchase of green electricity at home and energy rebound effects.*

Finally, being aware of sustainability and having knowledge about digitization and digital transformation are significant for ecology, because both directly and indirectly impact individuals' consumption decisions (and the dilemmas associated with these decisions) [47] and whether their decisions have unintended rebound effects. Sustainable consumption depends on a large number of factors and possible cause–effect relationships; therefore, a wide range of effect relationships are conceivable here [28,61]. General or tendential relationships are not to be expected for the time being in view of the results of the studies (including [29,46,47])—we nevertheless hope for the following relationship:

RH7: *There is a negative correlation between knowing about sustainability effects/being aware of sustainability and digital consumption.*

Figure 1 shows the correlation hypotheses.

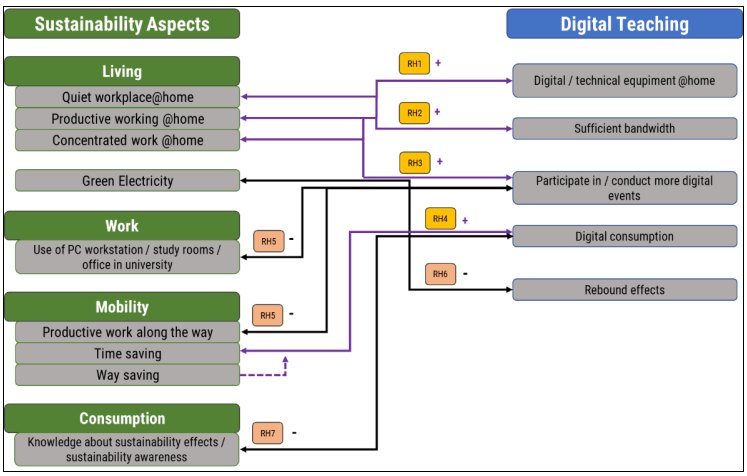

Figure 1. The correlation hypotheses.

3. Methodological Design

To map the effects and relationships between digitization and sustainability as they relate to academic teaching, we conducted a survey at the Chemnitz University of Technology, Germany, between mid-July and the end of September, 2020, and between January and March, 2021. The aim of the survey was to investigate social and ecological aspects of digital teaching contexts and how they relate to sustainability and inclusive, sustainable teaching. The COVID-19 pandemic represented an extreme scenario that could capture acute effects, because teaching had to be converted into digital formats at short notice. Table 1 shows the methodological design, see also [62].

Table 1. Methodological design.

Research design	Longitudinal designNon-experimental research methods: Survey research and correlational study	- Limesurvey survey with pre-structured question blocks and open-ended question areas; - First and second COVID-19 pandemic semesters; - Survey period from mid-July to end of September, 2020, and January to March, 2021; - Target group: Students and staff or teachers of the Chemnitz University of Technology.
Data collection	Questionnaire/written (digital) survey	- Digital questionnaire (voluntary participation); - Topic: digitization and sustainability in teaching; - Likert scale and dichotomous scales—nominal- and ordinal-scaled items.
Data evaluation	Descriptive statistics and qualitative content analysis	- Descriptive statistics and qualitative content analysis; - Contingency and correlation analysis with SPSS; - Qualitative coding according to Mayring (2016) → Analysis technique: Summary.

We chose to conduct a quasi-longitudinal study design based on non-experimental research and quantitative methods. We supplemented this quantitative approach with qualitative content analysis [63]. A longitudinal design allowed us to observe the variables over time and detect patterns of similarity and change and to detect whether we could make causal inferences about an event [63]. The survey was distributed to students and lecturers at the Chemnitz University of Technology during the first and second lockdown semesters of the COVID-19 pandemic. Participation was voluntary and only possible after users were authenticated via the university intranet. We assured users that all their responses were anonymous; therefore, we cannot be certain that individuals did not participate in the survey twice. Thus, the samples of the two surveys are not identical, and it is possible that a person who participated in the second survey did not participate in the first survey. Nevertheless, our results are comparable, because the distribution and access to both surveys was identical and both samples are similar in size and composition. In the first sample, we received 369 complete responses from students and staff (347 in German, 22 in English). In the second sample, we received 252 complete responses from students and staff (236 in German, 16 in English, see Table 2). Furthermore, the population of the survey (all scientific employees and students at Chemnitz University of Technology) did not change significantly during the entire period of the study. Assuring participants' anonymity was not only performed for data-protection purposes, but also to honour respondents' openness, honesty and cooperation in disclosing personal attitudes and sensitive information. Assuring anonymity can enable both the disclosure of unbiased views and behaviours and encourage the deliberate manipulation of data. We do not assume that our data were manipulated, because the survey lasted about 20 min and approximately 30% of all respondents only partially completed the questionnaire.

Table 2. Respondent groups.

Proportion	Survey 1 (S1)	Survey 2 (S2)
University employees	95	93
Bachelor Students (BA)	142	92
Master Students (MA)	132	67
N	369	252

The chosen non-experimental research methods of survey research and correlational study serve for collecting standardized information and test correlation hypotheses as well as identifying potential relationships [63]. Our goal was to describe the relationships between digital changes in teaching and sustainability, not to determine and test interrelationships, which was outside the scope of the study. A written survey provides a picture of opinions. Our written survey was designed to capture the opinions of as many people as possible in a short amount of time. The questionnaire was based on the above-described concepts of social and environmental sustainability. We thoroughly pre-tested the survey with several people in different functional units of the university. We incorporated appropriate feedback and corrected comprehension problems caused by wording issues. The Chemnitz University of Technology has an international student and staff population; therefore, the questionnaire was offered in German as well as in English. The data were transferred to SPSS and analysed with descriptive statistics—using univariate descriptive statistics for frequencies and frequency distributions as well as multivariate descriptive statistics (see also Table 1). The qualitative data—textual feedback—were transferred to a text program, coded, and summarized according to Mayring [64]. The main aim of analysing the qualitative statements was to identify the frequency with which participants mentioned the aspects under study. This analysis was important for gaining initial insights into participants' emphasis of each advantage, disadvantage and challenge. To analyse these statements, we inductively formed categories for each coding unit during a first material run and developed the initial version of the category system. After the first material run, we conducted a second and third material run for each survey in order to generalize the categories into main categories according to the rules of summarization [65], and thus to complete and adjust the initial category system. Next, to interpret the results, we calculated the frequencies (quantitative) of the categories and related them with the total number of responses.

Compared to an interview, the higher the degree of standardization of a questionnaire, the less time it should take to record the relevant sustainability aspects in the context of digital teaching, which should reveal valid tendencies because of the higher number of cases. The questionnaire was composed of four sections. First, sociometric data, including organizational assignment of affiliation as university employees, students (bachelor or master) or faculty. The next section collected information about learning or working at home and at the university. Questions in this section included: "The time I saved by not having to go to the university, I could use for (digital) consumption" and "I prefer to work or learn paperless", as well as the options to contact university staff and teaching alternatives. The degree of agreement was recorded using a 5-point Likert scale with a spectrum from *do not agree at all* to *rather disagree* to *partly agree*, *rather agree* and *strongly agree*. Additional questions captured different venues of productive learning and working with dichotomous response options: "I can focus on my tasks and be productive in my work" and "I tend to get easily distracted while I am studying or working". Multiple-choice options allowed participants to select different options to the question, "What are sustainability-conscious digital courses in your opinion?":

- Solely self-study: upload of the materials and the possibility of consultation in the case of questions;
- Auditory: presentation of materials with an auditory explanation;
- Visual: presentation of materials by means of video;
- Self-test;
- Use of digital forum functions;
- Formation of learning groups;
- Blended learning design: combination of digital and classroom elements;
- Interactive documents: web-based training;
- Other.

Finally, qualitative challenges, as well as the advantages and disadvantages of digital courses, were surveyed. This block of questions focused on the spatial and technical equipment of digital teaching. The questions addressed whether participants had options for a quiet workplace and their use, availability or purchase of technical equipment influenced their perception of digital events. In addition, participants were asked about their financial means for acquiring new devices, whether they focused on sustainability in procurement and their availability for sufficient bandwidth. Furthermore, the survey inquired about aspects of sustainability, such as the participant's purchase of green electricity and sustainability effects of products. In this block, dichotomous (yes–no) or nominal-scale levels were primarily used. The last block of questions addressed their usage and consumption behaviour as well as their mobility behaviour and attendance at the university. Nominal- and ordinal-scale levels were used here. The entire questionnaire can be found in the Supplementary Materials of this paper.

4. Results

The results of survey 1 (S1) and survey 2 (S2) are presented in the order in which the four sections appeared in the questionnaire. In almost every section, we identified respondents' ambivalence in answering behaviour. This ambivalence is especially obvious in the contingency and correlation analysis (see Tables 10 and 11).

4.1. Learning and Working at Home and at the University during the COVID-19 Pandemic

The place where learning or working takes place is an important factor that determines how effectively (digital) learning and working succeeds. Whether one learns or works in a home office, in one's own office or in the library, and whether one learns or works alone or together with others, can have immense impacts on learning or working success. Having social interactions was important to university employees and students alike. In the first survey, 74.7% (n = 95) of employees and 75.9% (n = 274) of students reported that they lacked direct contact with colleagues or fellow students. In the second survey, these results changed only slightly: 77.4% (employees, n = 93), 76.7% (students, n = 159).

For students, personal contacts were particularly important for learning and working (see the last item and percentages in bold in Table 3). In the first survey, more than 90% of the students stated that they worked or studied in groups, and more than 70% of the students stated that they could concentrate well while doing so. In the second survey, fewer students reported working in groups (BA: 73.9%; MA: 85.1%), but more respondents reported being able to concentrate well (BA: 82.4%; MA: 78.9%). A similar trend was seen among employees, but with generally lower levels of agreement. Only about half of the employees surveyed reported working in groups (S1: 54.7%; S2: 50.5%). Almost two-thirds (63.5%) in the first survey and more than four-fifths (82.4%) in the second survey reported being able to concentrate well in these groups.

Table 3. Places and conditions of concentration.

Question Item	Tendency	Survey 1				Survey 2			
		University Employees (n = 95)	**Students (BA) (n = 142)**	**Students (MA) (n = 132)**	**Total (n = 369)**	**University Employees (n = 93)**	**Students (BA) (n = 92)**	**Students (MA) (n = 67)**	**Total (n = 252)**
Within my premises there is a possibility to use or temporarily set up a quiet workplace	Yes	89.5% (out of 100% *)	86.6% (out of 100% *)	83.3% (out of 100% *)	86.2% (out of 100% *)	83.9% (out of 100% *)	92.4% (out of 100% *)	77.6% (out of 100% *)	85.3% (out of 100% *)
Concentrate well and be productive at home	Yes	76.8% (out of 100% *)	68.3% (out of 100% *)	70.5% (out of 97.7% *)	71.5% (out of 98.92% *)	84.9% (out of 100% *)	69.23% (out of 98.1% *)	66.6% (out of 98.5% *)	74.4% (out of 99.2% *)
Concentrate well and be productive in university office	Yes	94.7% (out of 100% *)	87.80% (out of 28.9% *)	93.44% (out of 46.2% *)	92.89% (out of 53.39% *)	89.8% (out of 95.6% *)	90.9% (out of 23.91% *)	89.3% (out of 41.8% *)	89.9% (out of 55.2% *)
Concentrate well and be productive in learning spaces	Yes	82.35% (out of 35.79% *)	82.52% (out of 72.5% *)	88% (out of 75.8% *)	84.81% (out of 64.23% *)	62.1% (out of 31.2% *)	88.46% (out of 56.52% *)	95.8% (out of 71.6% *)	85.3% (out of 51.2% *)
Concentrate well and be productive at computer pools	Yes	78.38% (out of 38.95% *)	70.59% (out of 47.9% *)	80.25% (out of 61.4% *)	76.34% (out of 50.41% *)	74.1% (out of 29% *)	75.75% (out of 35.87% *)	80% (out of 59.7% *)	77% (out of 39.7% *)
Concentrate well and be productive on the train	Yes	51.61% (out of 65.26% *)	30.2% (out of 74.6% *)	32.99% (out of 73.5% *)	40.34% (out of 71.82% *)	46.9% (out of 52.7% *)	40% (out of 76.09% *)	34.6% (out of 77.6% *)	40.4% (out of 67.9% *)
Concentrate well and be productive on public transport	No	91.38% (out of 61.05% *)	96.4% (out of 78.2% *)	98.95% (out of 72% *)	96.21% (out of 71.54% *)	91.2% (out of 55.9% *)	91.2% (out of 73.91% *)	96% (out of 74.6% *)	91.2% (out of 67.5% *)
Concentrate well and be productive in the car/while car pooling	No	93.44% (out of 64.21% *)	95.79% (out of 66.9% *)	95.65% (out of 69.7% *)	95.16% (out of 67.21% *)	90.5% (out of 63.4% *)	90.5% (out of 68.5% *)	93.5% (out of 68.7% *)	93.5% (out of 66.6% *)
Concentrate well and be productive within groups	Yes	63.46% (out of 54.73% *)	73.28% (out of 92.3% *)	70.73% (out of 93.2% *)	70.59% (out of 82.92% *)	82.4% (out of 50.5% *)	82.4% (out of 73.9% *)	78.9% (out of 85.1% *)	74.4% (out of 68.25% *)

* proportion of participants who use this place to work or study.

We found somewhat paradoxical responses regarding: (i) respondents' ability to concentrate and be productive in different places (home, university office, library study rooms and PC workstations—see Table 3); and (ii) how easily the respondents were distracted while studying or working (see Table 4). Around 72% of the respondents stated that they could concentrate very well at home; however, almost 70% also reported they were easily distracted at home. A similar picture emerged for students using the university's study rooms. For employees, almost 95% in S1 and just under 90% in S2 said they were able to concentrate well in the office, although in both surveys, more than half (S1: 67%; S2: 58.4%) said they were easily distracted in the office. A similarly ambivalent picture emerged among students who used the public transportation system. In both surveys, more than 90% of students reported being able to concentrate well on public transport (see Table 3); at the same time, however, more than 88% in both surveys also reported being easily distracted (see Table 4).

Table 4. Places and conditions of distraction.

Question Item	Tendency	Survey 1				Survey 2			
		University Employees (n = 95)	Students (BA) (n = 142)	Students (MA) (n = 132)	Total (n = 369)	University Employees (n = 93)	Students (BA) (n = 92)	Students (MA) (n = 67)	Total (n = 252)
Easily distracted at home	Yes	58.9% (out of 100% *)	76.8% (out of 100% *)	70% (out of 98.5% *)	69.75% (out of 99.46% *)	57% (out of 100% *)	70.7% (out of 100% *)	71.6% (out of 100% *)	65.9% (out of 100% *)
Easily distracted in university office	No	67.02% (out of 98.95% *)	90% (out of 28.2% *)	84.38% (out of 48.5% *)	77.27% (out of 53.66% *)	58.4% (out of 95.6% *)	78.26% (out of 25% *)	88.9% (out of 40.3% *)	67.6% (out of 55.2% *)
Easily distracted in learning spaces	No	82.86% (out of 36.84% *)	78.09% (out of 73.9% *)	81.13% (out of 80.3% *)	80.08% (out of 66.7% *)	74.1% (out of 29% *)	83.33% (out of 58.7% *)	85.4% (out of 71.6% *)	82.2% (out of 51.2% *)
Easily distracted at computer pools	No	72.97% (out of 38.95% *)	63.77% (out of 48.6% *)	66.6% (out of 63.6% *)	66.84% (out of 51.5% *)	63% (out of 29% *)	72.72% (out of 35.9% *)	71.1% (out of 56.7% *)	69.4% (out of 38.8% *)
Easily distracted on the train	Yes	57.38% (out of 64.21% *)	75.49% (out of 71.8% *)	81.05% (out of 72% *)	73.25% (out of 69.9% *)	63.8% (out of 50.5% *)	66.2% (out of 77.2% *)	75.9% (out of 80.6% *)	68.6% (out of 68.25% *)
Easily distracted on public transport	Yes	85.45% (out of 57.89% *)	88.11% (out of 71.1% *)	97.70% (out of 65.9% *)	90.94% (out of 65.9% *)	82.9% (out of 44.1% *)	90.8% (out of 70.7% *)	89.6% (out of 71.6% *)	88.3% (out of 61.1% *)
Easily distracted in the car/while car pooling	Yes	89.29% (out of 58.95% *)	88.8% (out of 63.4% *)	94.12% (out of 64.4% *)	90.90% (out of 62.6% *)	82.2% (out of 48.4% *)	91.8% (out of 66.3% *)	87.5% (out of 71.6% *)	87.6% (out of 61.1% *)
Easily distracted in groups	Yes	56% (out of 52.63% *)	60.3% (out of 92.3% *)	59.17% (out of 90.8% *)	59.13% (out of 81.5% *)	64.4% (out of 48.4% *)	46.5% (out of 77.2% *)	47.5% (out of 88.1% *)	51.4% (out of 69.4% *)

* proportion of participants who use this place to work or study.

4.2. Room Conditions and Technical Equipment of Digital Teaching

From an ecological perspective, the purchase or borrowing of electronic devices explicitly for the purpose of conducting or participating in digital teaching are relevant. In the first survey, the highest proportions of new purchases were for headsets (15.7% total), additional monitors (9.2%) and microphones (8.9% total). As the COVID-19 pandemic continued, respondents in the second survey reported an increasing number of new purchases for nearly all devices surveyed (e.g., headsets, 24.2%; notebooks, 19.4%; microphones and second screen, 13.5%). The overview of devices can be found in Table 5.

The questions on the connection between digitization and sustainability revealed knowledge gaps and consumption patterns that can be described as not very sustainable, or even unsustainable (see Tables 6 and 7). When purchasing electronic devices, only slightly more than one-fifth (S1: 21.7%; S2: 23.8%) stated that they paid attention to sustainability seals. Fewer than half (S1: 42.5%; S2: 37.3%) sometimes considered these factors, and just over one-third (S1: 35.8%; S2: 38.8%) did not consider them at all. Although more than half (S1: 61%; S2: 51.6%) did care how the electricity powering the servers of digital consumption was generated (renewable energies or conventional energy sources), only about 36% of the participants obtained green electricity at home. Accordingly, the majority (S1: 85.6%; S2: 78.6%) were not aware of the greenhouse gas reduction strategies of their electronic products and digital service providers, and only about one-fifth (S1: 19.8%; S2: 19%) actively searched for providers with a proactive climate or general sustainability strategy.

Table 5. Frequency distributions of equipment purchase or borrowing per respondent group.

Question Item	Answer	Survey 1				Survey 2			
		University Employees (n = 95)	Students (BA) (n = 142)	Students (MA) (n = 132)	Total (n = 369)	University Employees (n = 93)	Students (BA) (n = 92)	Students (MA) (n = 67)	Total (n = 252)
Notebook	Purchased	3.2%	7.7%	9.3%	7.3%	19.4%	22.8%	14.9%	19.4%
	Borrowed	3.2%	1.4%	0.8%	1.6%	2.2%	1.1%	1.5%	1.5%
Additional Screen	Purchased	11.6%	7%	9.8%	9.2%	19.4%	7.6%	13.4%	13.5%
	Borrowed	5.3%	1.4%	2.3%	2.7%	4.3%	1.1%	4.5%	3.2%
Microphone	Purchased	15.8%	7%	6.1%	8.9%	19.4%	6.5%	14.9%	13.5%
	Borrowed	3.2%	2.8%	1.5%	2.4%	3.2%	0%	1.5%	1.5%
Headset	Purchased	24.2%	14.8%	10.6%	15.7%	34.4%	13%	25.4%	24.2%
	Borrowed	3.2%	2.1%	4.5%	3.3%	4.3%	0%	0%	1.5%
Camera	Purchased	5.3%	4.2%	6.1%	5.1%	22.6%	5.4%	13.4%	13.8%
	Borrowed	2.1%	0.7%	1.5%	1.4%	5.4%	1.1%	0%	2.4%
Tablet	Purchased	7.4%	5.6%	5.3%	6%	5.4%	18.5%	6%	10.3%
	Borrowed	1.1%	2.8%	0.8%	1.6%	4.3%	1.1%	3%	2.7%
Smartphone	Purchased	1.1%	2.8%	3.8%	2.7%	3.2%	2.2%	7.5%	3.4%
	Borrowed	0%	0%	0%	0%	0%	0%	0%	0%
Printer	Purchased	8.4%	7.7%	6.1%	7.3%	8.6%	16.3%	9%	11.5%
	Borrowed	0%	4.9%	5.3%	3.8%	1.1%	0%	1.5%	0.8%
Powerbank	Purchased	1.1%	2.8%	3%	2.4%	3.2%	2.2%	4.5%	3.2%
	Borrowed	0%	1.4%	0%	0.5%	1.1%	1.1%	0%	0.8%

Table 6. Sustainability knowledge and awareness (Survey 1).

Question Item	Survey 1			
	University Employees (n = 95)	Students (BA) (n = 142)	Students (MA) (n = 132)	Total (n = 369)
Purchase: sustainability label/recyclability/sustainable production	Y = 16.8% S = 42.1% N = 41.1%	Y = 19.7% S = 43.7% N = 36.6%	Y = 27.3% S = 41.7% N = 31.1%	Y = 21.7% S = 42.5% N = 35.8%
Origin of energy for servers of digital consumption does not matter	Y = 34.7% N = 65.3%	Y = 43% N = 57%	Y = 37.9% N = 62.1%	Y = 39% N = 61%
Purchase of green electricity	Y = 48.4% N = 51.6%	Y = 27.5% N = 72.5%	Y = 36.4% N = 63.6%	Y = 36% N = 64%
Knowing greenhouse gas reduction strategies of providers	Y = 9.5% N = 90.5%	Y = 16.2% N = 83.8%	Y = 15.9% N = 84.1%	Y = 14.4% N = 85.6%
Active search for providers with proactive climate strategy/sustainability strategy	Y = 17.9% N = 82.1%	Y = 13.4% N = 86.6%	Y = 28% N = 72%	Y = 19.8% N = 80.2%
Sustainability effects of digital consumption	Y = 49.5% N = 50.5%	Y = 51.4% N = 48.6%	Y = 56.1% N = 43.9%	Y = 52.6% N = 47.4%

Y = Yes, N = No, S = Sometimes.

4.3. Usage and Consumption Behaviour

We surveyed various aspects of changes in consumer behaviour since start of the COVID-19 pandemic (see Tables 8 and 9). Although respondents reported decreases in the areas of shopping (S1: 33.1%; S2: 45.2%) and social interaction (S1: 67.5%; S2: 73.1%), they reported increases in the areas of e-shopping (S1: 29.3%; S2: 41.3%), streaming (S1: 48.2%; 54.3%), binge watching (S1: 21.7%; S2 23.4%) and downloads (S1: 50.4%; S2: 52.7%).

Table 7. Sustainability knowledge and awareness (Survey 2).

Question Item	Survey 2			
	University Employees (n = 93)	**Students (BA) (n = 92)**	**Students (MA) (n = 67)**	**Total (n = 252)**
Purchase: sustainability label/recyclability/sustainable production	Y = 21.5% S = 38.7% N = 39.8%	Y = 27.2% S = 38% N = 34.8%	Y = 22.4% S = 34.3% N = 43.3%	Y = 23.8% S = 37.3% N = 38.8%
Origin of energy for servers of digital consumption does not matter	Y = 28% N = 58.1% n.a. = 14%	Y = 27.2% N = 45.7% n.a. = 27.2%	Y = 32.8% N = 50.7% n.a. = 16.4%	Y = 28.9% N = 51.6% n.a. = 19.4%
Purchase of green electricity	Y = 45.2% N = 43% n.a. = 11.8%	Y = 26.1% N = 48.9% n.a. = 25%	Y = 38.8% N = 46.3% n.a. = 14.9%	Y = 36.5% N = 46% n.a. = 17.5%
Knowing greenhouse gas reduction strategies of providers	Y = 15.1% N = 79.6% n.a. = 5.4%	Y = 7.6% N = 77.2% n.a. = 15.2%	Y = 11.9% N = 79.1% n.a. = 9%	Y = 11.5% N = 78.6% n.a. = 9.9%
Active search for providers with proactive climate strategy/sustainability strategy	Y = 21.5% N = 72% n.a. = 6.5%	Y = 18.5% N = 54.3% n.a. = 27.2%	Y = 16.4% N = 68.7% n.a. = 14.9%	Y = 19% N = 64.7% n.a. = 16.3%
Sustainability effects of digital consumption	Y = 44.1% N = 41.9% n.a. = 14%	Y = 42.4% N = 37% n.a. = 20.7%	Y = 50.7% N = 37.3% n.a. = 11.9%	Y = 45.2% N = 38.8% n.a. = 15.9%

Y = Yes, N = No, S = Sometimes, n.a. = not answered.

Table 8. Consumption behaviour before and during the COVID-19 pandemic (Survey 1).

Question Item	Answer	Survey 1			
		University Employees (n = 95)	**Students (BA) (n = 142)**	**Students (MA) (n = 132)**	**Total (n = 369)**
Shopping	Increase (I) Unchanged (U) Decrease (D)	I = 5 (5.3%) U = 65 (68.4%) D = 25 (26.3%)	I = 3 (2.1%) U = 92 (64.8%) D = 47 (33.1%)	I = 7 (5.3%) U = 75 (56.8%) D = 50 (37.9%)	I = 15 (4.1%) U = 232 (62.9%) D = 122 (33.1%)
E-Shopping	Increase (I) Unchanged (U) Decrease (D)	I = 24 (25.3%) U = 66 (69.5%) D = 5 (5.3%)	I = 44 (31%) U = 89 (6 2.7%) D = 9 (6.3%)	I = 40 (30.3%) U = 78 (59.1%) D = 14 (10.6%)	I = 108 (29.3%) U = 233 (63.1%) D = 28 (7.6%)
Social Interaction	Increase (I) Unchanged (U) Decrease (D)	I = 6 (6.3%) U = 28 (29.5%) D = 61 (64.2%)	I = 14 (9.9%) U = 30 (21.1%) D = 98 (69%)	I = 15 (11.4%) U = 27 (20.5%) D = 90 (68.2%)	I = 35 (9.5%) U = 85 (23%) D = 249 (67.5%)
Social Media Use	Increase (I) Unchanged (U) Decrease (D)	I = 22 (23.2%) U = 72 (75.8%) D = 1 (1.1%)	I = 74 (52.1%) U = 60 (42.3%) D = 8 (5.6%)	I = 65 (49.2%) U = 61 (46.2%) D = 6 (4.5%)	I = 161 (43.6%) U = 193 (52.3%) D = 15 (4.1%)
Gigabyte	Increase (I) Unchanged (U) Decrease (D)	I = 60 (63.2%) U = 32 (33.7%) D = 3 (3.2%)	I = 89 (62.7%) U = 49 (34.5%) D = 4 (2.8%)	I = 90 (68.2%) U = 36 (27.3%) D = 6 (4.5%)	I = 239 (64.8%) U = 117 (31.7%) D = 13 (3.5%)
Streaming	Increase (I) Unchanged (U) Decrease (D)	I = 31 (32.6%) U = 61 (64.2%) D = 3 (3.2%)	I = 73 (51.4%) U = 64 (45.1%) D = 5 (3.5%)	I = 74 (56.1%) U = 50 (37.9%) D = 8 (6.1%)	I = 178 (48.2%) U = 175 (47.4%) D = 16 (4.3%)
Binge Watching	Increase (I) Unchanged (U) Decrease (D)	I = 10 (10.5%) U = 80 (84.2%) D = 5 (5.3%)	I = 33 (23.2%) U = 92 (64.8%) D = 17 (12%)	I = 37 (28%) U = 85 (64.4%) D = 10 (7.6%)	I = 80 (21.7%) U = 257 (69.6%) D = 32 (8.7%)
Downloads	Increase (I) Unchanged (U) Decrease (D)	I = 35 (36.8%) U = 58 (61.1%) D = 2 (2.1%)	I = 77 (54.2%) U = 62 (43.7%) D = 3 (2.1%)	I = 74 (56.1%) U = 57 (43.25%) D = 1 (0.8%)	I = 186 (50.4%) U = 177 (48%) D = 6 (1.6%)

Y = Yes, N = No, S = Sometimes.

Table 9. Consumption behaviour before and during COVID-19 pandemic (Survey 2).

Question Item	Answer	Survey 2			
		University Employees (n = 93)	**Students (BA) (n = 92)**	**Students (MA) (n = 67)**	**Total (n = 252)**
Shopping	Increase (I)	I = 2 (2.2%)	I = 2 (2.2%)	I = 6 (9%)	I = 10 (3.9%)
	Unchanged (U)	U = 53 (57%)	U = 44 (47.8%)	U = 31 (46.3%)	U = 128 (50.8%)
	Decrease (D)	D = 38 (40.9%)	D = 46 (50%)	D = 30 (44.8%)	D = 114 (45.2%)
E-Shopping	Increase (I)	I = 38 (40.9%)	I = 35 (38%)	I = 31 (46.3%)	I = 104 (41.3%)
	Unchanged (U)	U = 53 (57%)	U = 51 (55.4%)	U = 32 (47.8%)	U = 136 (54%)
	Decrease (D)	D = 2 (2.2%)	D = 6 (6.5%)	D = 4 (6%)	D = 12 (4.8%)
Social Interaction	Increase (I)	I = 1 (1.1%)	I = 1 (1.1%)	I = 5 (7.5%)	I = 7 (2.7%)
	Unchanged (U)	U = 25 (26.9%)	U = 24 (26.1%)	U = 12 (17.9%)	U = 61 (24.2%)
	Decrease (D)	D = 67 (72%)	D = 67 (72.8%)	D = 50 (74.6%)	D = 184 (73.1%)
Social Media Use	Increase (I)	I = 22 (23.7%)	I = 40 (43.5%)	I = 35 (52.2%)	I = 97 (38.5%)
	Unchanged (U)	U = 65 (69.9%)	U = 47 (51.1%)	U = 31 (46.3%)	U = 143 (56.7%)
	Decrease (D)	D = 6 (6.5%)	D = 5 (5.4%)	D = 1 (1.5%)	D = 12 (4.8%)
Gigabyte	Increase (I)	I = 47 (50.5%)	I = 52 (56.5%)	I = 42 (62.7%)	I = 141 (56%)
	Unchanged (U)	U = 45 (48.4%)	U = 26 (28.3%)	U = 22 (32.8%)	U = 93 (36.9%)
	Decrease (D)	D = 1 (1.1%)	D = 14 (15.2%)	D = 3 (4.5%)	D = 18 (7.1%)
Streaming	Increase (I)	I = 37 (39.8%)	I = 58 (63%)	I = 42 (62.7%)	I = 137 (54.3%)
	Unchanged (U)	U = 54 (58.1%)	U = 31 (33.7%)	U = 25 (37.3%)	U = 110 (43.7%)
	Decrease (D)	D = 2 (2.2%)	D = 3 (3.3%)	D = 0 (0%)	D = 5 (2%)
Binge Watching	Increase (I)	I = 14 (15.1%)	I = 25 (27.2%)	I = 20 (29.9%)	I = 59 (23.4%)
	Unchanged (U)	U = 75 (80.6%)	U = 54 (58.7%)	U = 41 (61.2%)	U = 170 (67.5%)
	Decrease (D)	D = 4 (4.3%)	D = 13 (14.1%)	D = 6 (9%)	D = 23 (9.1%)
Downloads	Increase (I)	I = 33 (35.5%)	I = 61 (66.3%)	I = 39 (58.2%)	I = 133 (52.7%)
	Unchanged (U)	U = 60 (64.5%)	U = 30 (32.6%)	U = 27 (40.3%)	U = 117 (46.4%)
	Decrease (D)	D = 0 (0%)	D = 1 (1.1%)	D = 1 (1.5%)	D = 2 (0.8%)

4.4. Contingency and Correlation Analyses

The contingency analyses (Table 10) show respondents' ambivalence about working at home and being productive and their ability to separate work and life. It also shows that both lecturers and students value working and learning at home—even though they struggle with having a limited number of personal contacts and excessive demands—and that they clearly see digital lectures as a viable option for the future. Comparing both surveys, the results show that respondents stress both the challenges as well as the positive effects of digital lectures. What is clear is that digital consumption needs to be managed, because it is related to sustainability impacts. The correlation analyses (Table 11) demonstrate that respondents positively evaluated digital learning formats, even though they struggled with challenges in working or learning at home. In general, the key correlations in the first survey were confirmed by the second.

Table 10. Contingency analyses.

Category Pairs	Φ	Cramer's V	Contingency Coefficient	α	Cases n
Affiliation to faculty—number of days at university per week BEFORE pandemic	0.515	0.195	0.458	0.000	369
	0.633	0.258	0.535	0.000	252
Groups university employees—students (BA)—students (MA)—streaming media daily in hours	0.417	0.295	0.385	0.005	369
	0.500	0.353	0.447	0.004	252
I can focus on my tasks and be productive in my work at home—I used the time saving for digital consumption	0.512	0.512	0.456	0.000	95

Table 10. *Cont.*

Category Pairs	Φ	Cramer's V	Contingency Coefficient	α	Cases n
I can focus on my tasks and be productive in my work at home—constantly working or learning at home makes it difficult for me to separate my private from professional life	0.612	0.612	0.522	0.000	95
I can focus on my tasks and be productive in my work at home—I find working or learning at home rewarding	0.575	0.575	0.498	0.000	95
I can focus on my tasks and be productive in my work at home—the time I saved by not having to travel to the university, I could use well elsewhere	0.424	0.300	0.390	0.000	274
	0.541	0.382	0.476	0.000	159
I can focus on my tasks and be productive in my work at home—working or learning at home quickly makes me feel overburdened	0.439	0.310	0.402	0.000	274
	0.528	0.373	0.467	0.000	159
I can focus on my tasks and be productive at university—I missed the direct personal contact with fellow students, colleagues or teachers during the COVID-19 pandemic	0.710	0.502	0.579	0.000	93
I can focus on my tasks and be productive at university—I missed the usual change in location between the university and my place of residence during the COVID-19 pandemic.	0.590	0.417	0.508	0.000	93
I can focus on my tasks and be productive at the university—constantly working or learning at home makes it difficult for me to separate my private from professional life	0.520	0.368	0.462	0.001	93
I can focus on my tasks and be productive at the university—I find working or learning at home rewarding	0.533	0.235	0.316	0.000	93
I can focus on my tasks and be productive at the university—I consider digital teaching as an appropriate equivalent to classroom teaching	0.585	0.414	0.505	0.000	93
I can focus on my tasks and be productive at the university—I could imagine holding/participating in more digital courses in the future	0.563	0.398	0.491	0.000	93
I can focus on my tasks and be productive at PC workstations—streaming media daily in hours	0.512	0.362	0.456	0.000	252
I am easily distracted at home—constantly working or learning at home makes it difficult for me to separate my private from professional life	0.552	0.552	0.483	0.000	95
I am easily distracted at home—the time I saved by not having to travel to the university, I could use well elsewhere	0.334	0.236	0.317	0.000	274
	0.525	0.525	0.465	0.000	93
I am easily distracted at home—constantly working or learning at home makes it difficult for me to separate my private from professional life	0.430	0.304	0.395	0.000	274
	0.543	0.643	0.477	0.000	93
I am easily distracted at home—working or learning at home quickly makes me feel overburdened	0.388	0.274	0.362	0.000	274
	0.611	0.611	0.521	0.000	159
I am easily distracted at home—I find working or learning at home rewarding	0.444	0.314	0.406	0.000	274
	0.556	0.556	0.486	0.000	159
I am easily distracted on public transport—one-way distance from home to university	0.712	0.503	0.580	0.004	369
Number of days at university per week BEFORE the pandemic—I consider digital teaching as an appropriate equivalent to classroom teaching	0.674	0.337	0.559	0.002	95
I have the possibility to set up a quiet workplace at home—I missed the direct personal contact with fellow students, colleagues or teachers during the COVID-19 pandemic	0.516	0.435	0.524	0.000	93
I have the possibility to set up a quiet workplace at home—I consider digital teaching as an appropriate equivalent to classroom teaching	0.508	0.359	0.453	0.002	93
I have the possibility to set up a quiet workplace at home—streaming media daily in hours	0.553	0.391	0.484	0.000	252
I have the possibility to set up a quiet workplace at home—one-way distance from home to university	0.922	0.652	0.678	0.000	252
I use a camera for digital teaching—consider a combination of classroom and digital teaching to be promising for the future	0.676	0.478	0.560	0.000	95
I use a tablet for digital teaching—I used the time saving for digital consumption	0.524	0.524	0.464	0.000	95
I use a printer for digital teaching—I used the time saving for digital consumption	0.690	0.690	0.568	0.000	95
Problems with bandwidth at home—streaming media daily for hours	0.569	0.285	0.495	0.001	369

Table 11. Spearman's correlation.

Category Pairs	University Employees		Students	
	Survey 1 N = 95	Survey 2 N = 93	Survey 1 N = 274	Survey 2 N = 159
Constantly working or learning at home makes it difficult for me to separate my private from professional life. // I missed the usual change in location between the university and my place of residence during the COVID-19 pandemic.	0.505 **	0.692 **	0.511 **	0.631 **

Table 11. *Cont.*

Category Pairs	University Employees		Students	
	Survey 1 N = 95	Survey 2 N = 93	Survey 1 N = 274	Survey 2 N = 159
Working or learning at home quickly makes me feel overburdened. // I missed the usual change in location between the university and my place of residence during the COVID-19 pandemic.	0.516 **	0.666 **		0.555 **
Working or learning at home quickly makes me feel overburdened. // Constantly working or learning at home makes it difficult for me to separate my private from professional life.	0.653 **		0.637 **	0.674 **
I find working or learning at home rewarding. // Constantly working or learning at home makes it difficult for me to separate my private from professional life.	−0.502 **	0.609 **	−0.598 **	−0.569 **
I could imagine holding more digital courses in the future. // I consider digital teaching as an appropriate equivalent to classroom teaching.	0.522 **	0.669 **	0.771 **	
I consider a combination of classroom and digital teaching to be promising for the future. // I could imagine holding more digital courses in the future.	0.613 **	0.797 **	0.641 **	0.628 **
I missed the usual change in location between the university and my place of residence during the COVID-19 pandemic. // I missed the direct personal contact with fellow students, colleagues or teachers during the COVID-19 pandemic.			0.521 **	0.589 **
The time I saved by not having to travel to the university, I could use well elsewhere. // I missed the usual change in location between the university and my place of residence during the COVID-19 pandemic.		−0.520 **	−0.509 **	−0.635 **
Constantly working or learning at home makes it difficult for me to separate my private from professional life. // I missed the direct personal contact with fellow students, colleagues or teachers during the COVID-19 pandemic.			0.511 **	
I find working or learning at home rewarding. // I missed the usual change in location between the university and my place of residence during the COVID-19 pandemic.			−0.504 **	−0.561 **
I find working or learning at home rewarding. // I missed the direct personal contact with fellow students, colleagues or teachers during the COVID-19 pandemic.			−0.557 **	−0.540 **
I consider digital teaching as an appropriate equivalent to classroom teaching. // I missed the direct personal contact with fellow students, colleagues or teachers during the COVID-19 pandemic.			−0.562 **	−0.594 **
I could imagine holding (or participating in) more digital courses in the future. // I missed the direct personal contact with fellow students, colleagues or teachers during the COVID-19 pandemic.		−0.515 **	−0.567 **	−0.536 **
I find working or learning at home rewarding. // The time I saved by not having to travel to the university, I could use well elsewhere.			0.578 **	0.561 **
I consider digital teaching as an appropriate equivalent to classroom teaching. // The time I saved by not having to travel to the university, I could use well elsewhere.			0.522 **	0.515 **
I could imagine participating in more digital courses in the future. // The time I saved by not having to travel to the university, I could use well elsewhere.			0.547 **	0.607 **
I could imagine participating in more digital courses in the future. // Constantly working or learning at home makes it difficult for me to separate my private from professional life.			−0.540 **	−0.523 **
I find working or learning at home rewarding. // Working or learning at home quickly makes me feel overburdened.			−0.542 **	
I could imagine participating in more digital courses in the future. // Working or learning at home quickly makes me feel overburdened.			−0.520 **	
I consider digital teaching as an appropriate equivalent to classroom teaching. // I find working or learning at home rewarding.			0.551 **	0.656 **
I could imagine holding (or participating in) more digital courses in the future. // I find working or learning at home rewarding.		0.507 **	0.679 **	0.642 **

Table 11. *Cont.*

Category Pairs	University Employees		Students	
	Survey 1 N = 95	Survey 2 N = 93	Survey 1 N = 274	Survey 2 N = 159
I consider a combination of classroom and digital teaching to be promising for the future. // I consider digital teaching as an appropriate equivalent to classroom teaching.		0.511 **	0.563 **	0.516 **
I could imagine participating in more digital courses in the future. // I missed the usual change in location between the university and my place of residence during the COVID-19 pandemic.				−0.552 **
I could imagine participating in more digital courses in the future. // I consider digital teaching as an appropriate equivalent to classroom teaching.				0.769 **
I consider digital teaching as an appropriate equivalent to classroom teaching. // I missed the usual change in location between the university and my place of residence during the COVID-19 pandemic.				−0.572 **
I consider digital teaching as an appropriate equivalent to classroom teaching. // Constantly working or learning at home makes it difficult for me to separate my private from professional life.				−0.566 **
Working or learning at home quickly makes me feel overburdened. // The time I saved by not having to travel to the university, I could use well elsewhere.				−.563 **
Constantly working or learning at home makes it difficult for me to separate my private from professional life. // The time I saved by not having to travel to the university, I could use well elsewhere.				−0.543 **

**, Spearman's rho (ρ)/Correlation is significant at the 0.01 level (2-tailed); just values shown above 0.500 having sig. (2–tailed) 0.000.

4.5. Qualitative Results

Qualitative statements on the advantages, disadvantages and challenges of digital teaching were collected within a free text field in the questionnaire. The main advantages respondents reported were the elimination of commuting (S1: 47.32%; S2: 40.4%), which had positive social and ecological effects. Furthermore, respondents appreciated being able to repeat lecture recordings and having the flexibility to learn at different times and in places (S1: 25.5%; S2: 17.2%) and to learn at one's own pace (S1: 23.15%; S2: 19.7%), and teachers appreciated being able to use their recorded lectures multiple times (S1: 5.7%; S2: 6.9%). Respondent 195 (S1) described the interplay of these advantages as follows:

> "I do not have to commute to the university. I learn more productively because I can also do household duties at the same time as my university assignments and then make better use of my free time. I can organize my day by myself and if I'm still very tired in the morning, I can catch up on a course that was recorded in the evening if necessary, and vice versa. Digital teaching makes me much more flexible, as I have more motivation at home and can therefore work more effectively. (Respondent 195, S1, author's translation)".

Respondents also saw advantages in terms of less waste (S1: 15.1%; S2: 19.2%), time savings and the resulting better compatibility of family and work life (S1: 9.73%; S2: 12.3%), as well as university buildings being used more efficiently (S1: 3.69%; S2: 1%). In addition, sporadically mentioned were the use of other teaching–learning methods (S1: 1.3%; S2: 3%), increased social inclusion (S1: 1%; S2: 2%), access for many students regardless of the university's space resources (S1: 1%; S2: 0.5%) and the elimination of disruptions by other students (S1: 0.8%; S2: 2%). In the second survey, many more respondents mentioned the possibility of establishing one's own daily structure due to flexibility in learning time and place (13.3%). A small proportion also stated that they saw no advantages at all (S1: 5.7%; S2: 4.4%).

A main disadvantage to digital teaching that respondents mentioned was the lack of personal contact (S1: 47.79%; S2: 47.8%), which has a number of negative effects (feeling of isolation, lack of feedback, limited exchange). In addition, other critical concerns were increased electricity and energy consumption (S1: 16.17%; S2: 16.5%), having to purchase

double the digital equipment (both from a financial and resource point of view) (S1: 9.9%; S2: 3.3%), the lack of technical infrastructure (S1: 6.61%; S2: 4.9%) as well as difficulties in concentrating due to various distractions (S1: 6.25%; S2: 6.6%). Respondents also criticized the quality of teaching and the gaps in knowledge that resulted from digital teaching (S1: 6.25%; S2: 11.5%):

> "I am of the opinion that a lot of knowledge is lost through this purely digital teaching format and that hurdles can arise in some cases. I think lectures can be realized quite well in this format. But seminars and exercises, which live from discourse and joint exchange and in this way additional knowledge is shared and generated, are missing. It is also sometimes a hindrance that in the case of questions or uncertainties, communication does not take place directly on site as in a face-to-face event, but only by e-mail or forum, and an answer can then (understandably) take a few days. (Respondent 64, S1, author's translation)".

Other respondents addressed how engaged university staff were and how it affected the quality of digital teaching:

> "The uploaded lectures are often longer than 90 min and the lecturers can include cuts in the videos, which means that much more content can be covered in the lecture than normal. In addition, it is noticeable that many lecturers only read the slides, or from books word for word, which is actually not in the nature of a digital course. (Respondent 382, S1, own translation)".

Some respondents mentioned the financial and resource disadvantages they faced (such as Internet performance) (S1: 5.14%; S2: 4.9%), as well as the toll digital teaching was taking on their physical and mental health (S1: 3.3%; S2: 7.1%), the increased workload (S1: 3.3%; S2: 3.8%), the separation of professional and private life (S1: 2.9%; S2: 1.1%), energy and resource consumption due to storage and server infrastructure (S1: 2.2%; S2: 1.1%) and increased data traffic (S1: 2.2%). Again, a small proportion said they saw no disadvantages at all (S1: 6.25%; S2: 7.7%). Additionally, in S2, 6.6% of respondents mentioned that the lower rates of student participation were a disadvantage.

Particularly challenging for respondents was maintaining concentration (S1: 29.36%; S2: 29.3%), separating work and private life (S1: 18.84%; S2: 15.9%) and the lack of social interaction (S1: 17.45%; S2: 26%).

> "That the home environment becomes the work environment, which sometimes makes it difficult to separate the place of retreat from the place of work. If you can create a place of retreat from work, it is easier, but not everyone has this possibility at home. In addition, personal contact is sometimes lacking. Still, it's nice to have the opportunity to work from home. (Respondent 474, S1, author's translation)".

This response exemplifies an ambivalence in working from home, and how the same individual could evaluate it both positively and negatively. We discuss these ambivalences in more detail in the Discussion.

Additionally, particularly challenging for respondents was the need to be self-disciplined and organize themselves (S1: 16.9%; S2: 14.2%) and to manage their time (S1: 13.3%; S2: 8.9%). In addition, the respondents complained about the lack of workplace equipment (S1: 9.41%; S2: 14.2%), the scope and organization of the teaching itself (both quantity and quality) (S1: 8.03%; S2: 2.8%), and difficulties with childcare (S1: 6.09%; S2: 10.2%). In addition, respondents sporadically mentioned not doing enough exercise, health consequences, as well as difficulties structuring their day—for example, planning breaks and doing neither too much nor too little (S1: 1.1%). In the second survey, respondents more frequently mentioned time- and organization-related aspects such as structuring one's day (7.3%) and creating a healthy balance between work and leisure time (11%).

5. Discussion

The results of our survey show that the two groups—the university staff and students—responded similarly and differently to the requirements and challenges of digital teaching. Both groups suffered greatly from the lack of communication and social exchange; however, students struggled more. In addition, both groups reported that the digital-learning settings were valuable, and became even more attractive as the pandemic continued. Both the teaching staff and students responded ambivalently to having to rapidly convert from face-to-face teaching to the digital teaching–learning formats that were necessary because of the pandemic restrictions. Digitized teaching for working and learning—both at home and on the university campus—has numerous advantages, disadvantages and challenges. Research has shown that this form of working and learning affects workload, self-motivation and discipline, psychological stress, and exchange and communication [10,21]. The students and teachers and staff in our study found that working and learning in a residential environment was both enriching and overwhelming. They valued the flexibility and time savings that digital teaching enables, but at the same time, digital teaching during a pandemic requires a high degree of self-organization and radically reduces social contacts, outcomes which our respondents found to be excessive—particularly students.

An interesting result when comparing the results of both surveys is that respondents felt that teaching improved over time and that they increasingly accepted having to make arrangements for work, learning at home and reorganizing their work (see Tables 10 and 11 as well as the qualitative analyses). Both surveys also revealed that childcare was a huge problem, and by the time of the second survey, had become worse. Most of the correlations (see Table 11) from the first survey were also found in the second. The stronger correlations for digital lectures in the second survey showed that it had been increasingly accepted, which indicates that either respondents had become more familiar with this mode of teaching, or they had accepted the pandemic restrictions and frameworks. The results of the contingency analysis differed more in terms of other relationships, with some comparable category pairs showing similar results; however, in the second survey, an increased number of relationships showed that respondents had accepted digital teaching with less ambivalence.

5.1. Pandemics and Digital Transformation

Life situations and realities—whether a pandemic or increased learning and working from home—present different challenges that affect the design and perception of digital teaching. Our study revealed that participants had fundamentally ambivalent responses in the areas of concentration, productivity, and distraction at home and in the university environment. Particularly challenging for respondents (see qualitative results) were personal distractions from neighbours, flatmates and children; challenges in time management and self-organization; and a lack of motivation (which other studies have also found; e.g., [10,21–25]). One particular advantage to digital teaching that respondents highlighted was increased flexibility: it made it possible for them to work when they wanted to and at their own pace and, importantly, to engage more intensively with the learning material. Respondents also mentioned that they were better able to integrate family and career and appreciated not having to rely on public transportation or deal with traffic. Interestingly, what respondents perceived as a burden (separating work and private life, not having to change locations, freedom to manage their time), they also perceived as enriching. Students tended to have more problems with self-organization and their housing situation—often because they had only one room or were disturbed by flatmates. For lecturers, childcare and working with children at home were difficult.

For lecturers, digital teaching involves many changes: to their teaching, research, work process and management experiences [52]. However, those changes are not necessarily negative, because they can stimulate new ideas and open up new possibilities. Bischof and von Stuckrad (2013, p. 10), for example, stated that when digital teaching

is enhanced, it can lead to the stimulated "internal differentiation of teaching staff" [66] (p. 10). The authors also stated that "digital formats of knowledge transfer offer windows of opportunity for the development of new didactic concepts and, concomitantly, might suggest new tasks and differentiated functions for academic teaching staff" [66] (p. 10). These conclusions about the opportunities that digital teaching can bring underline the notion that the success of digital teaching also strongly depend on an individual's situation, self-assessment and resilience. The relationships in Tables 10 and 11 make it clear that digital teaching is an option for teaching in the future, but not for all students and lectures. For digital teaching to succeed, it requires that teachers develop vivid and creative learning options and instructional designs for students, and that these options and designs are developed through an ongoing exchange with students. Functional digital learning also needs to include all DiMaggio and Hargittai's (2001) [27] five dimensions (see Section 2) to reach all stakeholders.

Digital media require other considerations as well, such as having the right technology and being able to use it, and importantly, managing interruptions and developing healthy working habits and spaces. Zickerick et al. (2020) showed that interruptions can negatively impact working memory; specifically, they affect individuals' action plans and behaviour [20]. Although individuals are also interrupted during the regular workday in offices, in lockdown situations, these interruptions are felt even more intensively because of complex living conditions. Interruptions during lockdown can negatively impact work behaviour and well-being, and lead to individuals feeling overwhelmed. Digital technologies and media can have other negative effects as well. Gimpel and Schmied (2019) warned that the health consequences range from stress, sleep disturbances, burnout, anxiety, distorted perception and increased susceptibility to being influenced by disinformation [67]. These authors suggest that digital learners need to reduce interruptive situations in their lockdown routine and strengthen their ability to act, and recommend creating notes and checklists to help [67]. Universities can also promote and encourage concentrated and productive work by providing specific training in digital competence, digital equipment and access to it, technical infrastructure and learning spaces. Our respondents found that these elements of digital learning were fundamental and problematic (see Tables 3–5); specifically, some of them had problems with bandwidth. These results confirm RH 1 and RH 2 ("Being able to set up a quiet workplace at home and/or working productively from home is positively related to having the necessary technical and/or digital equipment" and "Working productively from home is positively related to having sufficient bandwidth"). Bandwidth problems can often only be remedied in the medium-to-long term. These problems require intelligent solutions. We recommend that universities provide infrastructure and data volume, and segregated learning rooms that can be disinfected where students "in digital distress" can learn on university premises even during pandemics.

The results showed that both groups suffered greatly from a lack of communication and social exchange (see also Tables 10 and 11). Our results are in line with the recommendations of Alonso-García et al. (2019): when implementing digital teaching, universities must prioritize collaborative learning and implement it in digital spaces [48]. This call for collaboration means that universities need to find creative ways to make sure it happens in a digital environment [68–71]. Good digital teaching involves effort—for teachers and learners. Both groups cited the increased workload that comes with digital learning, a result in line with other studies, such as Aristovnik et al. (2020) [72]. When designing their teaching, teachers should factor in and plan around possible obstacles that are beyond their control. For example, Internet connections in some regions of Germany are poor, and the digital infrastructure available at one's residence may be limited. Hybrid models—linking face-to-face and digital teaching—are a promising way around these obstacles, but to realize positive effects from them, teachers need to reconcile their advantages with their disadvantages and consider sustainability effects when designing them [49]. For example, in the areas of mobility and flexibility, planning digital events directly followed by a face-to-face event makes little sense, nor does planning both types of events on the

same day, because it is neither sustainable nor feasible. The task of the universities is to cooperate with students and teachers to develop, experiment with and implement concepts that consider these elements. When it comes to the respondents in our study, they were in favour of participating in future digital events; thus, RH 3 can be confirmed ("The ability to concentrate or work productively at home is positively related to individuals' advocating for having or participating in more digital events in the future").

5.2. Sustainability and Academic Digital Transformation

Reducing or changing mobility choices and patterns is a key element of sustainability. During the pandemic, reduced mobility had positive environmental effects at the global, national and local levels [73]. Respondents also cited as a main benefit "Not having to commute provided relief from traffic as well as 'social' relief in terms of saving time and gaining independence". As beneficial as the reduction in mobility and time saving was, this time saving had a detrimental effect in other areas. Digital consumption increased; therefore, RH 4 is supported ("There is a positive relation between time saved by not having to travel to university and increased digital consumption") (Tables 8–10). Overall, we can assume that this increased digital consumption partially offset the reduction in greenhouse gases and other environmental indicators [60]. An interesting question for future research would be investigating how hybrid or large-scale digital teaching at universities during non-pandemic times change individual-level environmental factors and indicators.

RH 5 was not confirmed. Responses which assessed digital teaching and learning options as promising sustainable teaching formats were not negatively related to their good concentration or productive learning and teaching at university locations or on the way to the university (see Tables 5, 10 and 11). The quality of digital courses is independent of whether staff and students have favourable conditions in their home office or at the university, and is independent of their mobility options. These results support the notion that universities should integrate digital courses into their portfolio of future-oriented teaching.

In the area of (ecological) sustainability, responses to our surveys indicate gaps in knowledge and action that need to be closed (see Tables 6 and 7). Although almost half of respondents (slightly more than 50% (S1) and less than 50% (S2)) were aware of essential sustainability effects concerning digital consumption and digital processes—at least in theory—this knowledge was not reflected in their actions. Longo et al. (2017) showed that knowledge does not automatically lead to action [47]. For a university and university education to be sustainable and support sustainable development [74,75], universities need to educate students and staff about sustainability, to integrate it into curricula and to stimulate and create sustainability-oriented routines [76]. Universities can take measures to provide opportunities to transform knowledge into action as easily as possible. Universities can set an example by purchasing green electricity themselves, and for their digital teaching efforts, they can nudge staff and students to stimulate them to purchase green electricity at home [77]. For example, they can offer students a discount on their semester public transit pass if they buy green electricity, and teachers can take surveys in lecture courses using comparisons to encourage this switch. Respondents shifted the primary location of their digital activities to their own living space, and 36% of respondents reported buying green electricity at home (in both surveys, see Tables 6 and 7), RH 6 was confirmed ("There is a negative relation between the purchase of green electricity at home and energy rebound effects"). We can therefore assume that there were energy rebound effects [44], which are to be expected when increased digital consumption occurs entirely at home during a pandemic (see Tables 8 and 9). At the same time, many of the respondents were not aware of how their digital devices and digital usage behaviour affected sustainability (see Tables 6 and 7). Therefore, RH 7 was not confirmed ("There is a negative correlation between knowing about sustainability effects/being aware of sustainability and digital consumption"). What our survey results show is that respondents have a low level of information about the socio-ecological impacts and causal loops of their behaviour and that

digital consumption increased during the pandemic, which suggests there were energy and material rebound effects [61].

Another aspect of sustainability and digital education is the manufacture and use of electronic devices and the consequences both have for society and the environment (including e-waste and human rights) [12,78]. To be sustainable, devices need to be used for a long time and new and duplicate purchases need to be avoided and delayed. As Table 5 indicates, between the two different survey periods there were clear differences in the number of new purchases of digital devices. By the time of the second survey, respondents had purchased a higher number of new digital devices than they had during the first survey. Two possible explanations are that respondents did not have devices that they needed for digital learning, or they realized the equipment they had would not be enough for digital usage and digitized lectures. Overall, the survey showed that consumption increased, but that the number of purchases was not extreme. When it comes to sustainable purchasing, individuals have a responsibility to learn about social–ecological standards and to purchase sustainable products, and universities have an obligation to purchase and provide sustainable digital end devices and establish sustainable social–ecological procurement processes and structures. These recommendations assume that the companies which produce and distribute these devices are transparent about their procurement, manufacturing and value creation structures so that individuals and organizations can make informed decisions. To ensure this transparency, governments need to create a framework which makes it easy to measure progress on sustainability [12,79].

5.3. Limitations

One drawback of the longitudinal setting in our study is that we could not survey the same individuals twice because of data and privacy restrictions. This drawback means that ours was not a truly longitudinal design [63] (p. 59). In fact, although we could chart change, we can draw limited conclusions from the data and results and "cannot address the issue of the direction of cause and effect, because the samples are always different" [63] (p. 59). The cohort, students and lecturers at the Chemnitz University of Technology, was similar, however. Another limitation was our use of scales. Although Likert scales are an established tool used in scientific practice to collect views and opinions [80], they have a limited range of definition and represent ordinal-scale levels, because the distances between the respective response options were not equal nor were respondents' value attributions the same. Additionally, whether to analyse using parametric or non-parametric methods is determined by whether the sample size is within the respective statistical limits, as well as whether distribution is normal or non-normal [81]. However, for showing possible or temporal effects, Likert scales are quite suitable. According to Merdian et al. (2020, p. 124 f.), parametric procedures are suitable if several criteria are met: the scales have several items and are similar, all response options are labelled and unipolar (i.e., do not have pairs of opposites) and increase evenly within the scale, the scales are of equal size, have at least five response options, no extreme response options are given, and the sample size is at least N = 30 [82]. Our survey met all the conditions for parametric analyses.

We faced trade-offs about data collection and the validity of the data, because respondents answered the questionnaire on the Internet and the conditions were not controlled [63]. Internal validity for an Internet survey is therefore difficult to determine. Respondents determined the conditions (when, where and how) when answering the questionnaire. During the pandemic, however, establishing controlled conditions was not possible. In addition, external validity was limited because the study was conducted under the unnatural conditions of a pandemic and because the survey sample population exhibited limited representativeness. However, survey research does not aim for a representative sample, nor was the sample in our survey representative: our survey was made available digitally to all teaching staff and students at the Chemnitz University of Technology. We are not able to determine whether participants were aware of this representation issue, nor whether they recognized the implications. The frequencies and distributions in our results

do not correspond to those of a representative sample; therefore, we cannot make any statements about the population. Instead, our results reflect a trend and give an indication of tendencies.

6. Conclusions

6.1. Practical Implications

Focusing on sustainability in academic digital transformation and the digitization of teaching in its early phases can significantly reduce the environmental impact of digital technologies and services. When linking sustainability to this transformation and digitalization, we should expect rebound effects and blatant gaps in knowledge and action. Only half of the respondents in this sample were aware of the effects that using digital media and services had on sustainability, suggesting that the majority of students and staff do not pay attention to sustainability criteria when purchasing digital technologies and services. A targeted information policy and education is strongly needed to remedy this situation. Universities also need to act as sustainability pioneers by ensuring that the technologies and digital services universities provide are highly sustainable and minimize socio-ecological damage. Furthermore, universities can encourage staff and students to make green electricity purchases by means of nudging or providing other incentives, which would help counteract rebound effects and increased digital consumption that result from digital teaching transformations.

In addition to rebound effects, teaching and learning at home is accompanied by multiple ambivalences. Teachers can help to minimize these ambivalences by designing sustainable blended-learning formats, creating visual digital presentations and incorporating self-tests into digital learning. These formats should be flexible and build in self-directed teaching and learning elements that provide concrete feedback. Hybrid teaching–learning formats are highly attractive, but doing them well requires enormous organizational effort and specific digital services and technologies, such as creating platforms and building up server capacities [27]. To counteract the excessive demands that these formats impose on students and their lack of self-management, universities should develop targeted learning formats; for example, creating learning groups, offering web-based training and promoting students' active use of forum functions. Furthermore, universities can provide support by expanding their offerings of targeted courses for staff and students, including courses on self-management, strengthening and developing digital skills, and (for teachers) how to provide suitable digital services and technologies. Providing learning spaces in the university where students can study during a pandemic can also help overcome some of the hurdles of digitization and provide students with structure and additional options.

6.2. Theoretical Implications

Our study shows that rebound effects can occur, even in academia, when changing conventional ways of knowledge distribution. Our results are consistent with other studies showing that interruptions in digital–learning settings, when home conditions are not calm and are not comparable to office or university conditions, can cause additional stress to both students and lecturers. Clearly, some SDGs—for example, quality education and good health and well-being—are not easily harmonized [35,36], but instead, need clear strategies that focus on both—especially in extreme situations. In line with previous studies, our sample confirms that digital learning settings have environmental and social impacts that need to be addressed early on. Different groups of digital media can impact sustainability and should be smartly linked to instructional digital designs, as indicated by Persike and Friedrich (2016) [44].

6.3. Future Research Directions

To stimulate, implement and further develop sustainable digital progress and changes in the direction of sustainability along all dimensions of digital transformation processes at academia requires a long-term academic financing strategy. Sá and Serpa (2020) stress that

the COVID-19 pandemic should be taken as an opportunity to redesign universities and university teaching to make it more sustainable [83]. According to Castro Benavides et al. (2020, p. 14 f.), the process of digital transformations at universities is a complex netting of different dimensions [84]. The digital transformation of university teaching had to be quickly initiated and implemented during the pandemic; therefore, many dimensions in the netting were both addressed and adapted. As our study shows, this transformation process has intensively begun—despite its many challenges and disadvantages (see our qualitative analysis)—but many adjustments and optimizations still have to be made, both at the individual level and on the part of universities and policymakers. These adjustments and optimizations include expanding broadband connections, providing pandemic-compatible learning spaces and teaching digital skills, as well as creating quiet settings that are suitable for learning by providing equipment and structure. In addition, non-digital and subject- and faculty-specific solutions are needed. Research is needed on potential future-oriented instructional designs [85] that work both during pandemics and in traditional university teaching–learning settings as well. To minimize environmental impacts, researchers and universities need to investigate how nudging and environmental-oriented communication and procurement can mitigate the rebound effects that occur from increased digital consumption and changed consumption and mobility patterns.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su132212912/s1.

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