Article

Perceptions of Digital Device Use and Accompanying Digital Interruptions in Blended Learning

Juliana Pattermann [1],*, Maria Pammer [2], Stephan Schlögl [3] and Laura Gstrein [1]

1   Department Business & Management, MCI-The Entrepreneurial School, 6020 Innsbruck, Austria;
    lm.gstrein@mci4me.at
2   Department Business Administration Online, MCI-The Entrepreneurial School, 6020 Innsbruck, Austria;
    maria.pammer@mci.edu
3   Department Management, Communication & IT, MCI-The Entrepreneurial School, 6020 Innsbruck, Austria;
    stephan.schloegl@mci.edu
*   Correspondence: juliana.pattermann@mci.edu

Abstract: Using various digital devices, and being faced with digital interruptions is a given for students not only in traditional university classes but also in blended learning courses. Hence, this study (N = 201) at an Austrian university of applied sciences investigated students' perceptions of digital device use and the digital interruptions that they face during webinars and on-campus sessions. Results show that students primarily use the same types of digital devices during webinars and on-campus sessions, i.e., computers for course-related (CR) activities, and smartphones for non-course-related (NCR) activities. Results further indicate that while the majority of students are aware of the interruptive impact that NCR activities have on their learning, the effect on others seems to be a blind spot. The reasons for NCR activities are manifold. Moreover, results suggest that students have difficulties in assessing the actual time spent on NCR activities during webinars.

1. Introduction

Before the COVID-19 pandemic hit and changed learning settings all around the world, laptops, tablets, and mobile phones had already become students' permanent companions in university classrooms. As technology becomes more compact and portable, higher-education institutions need to pay more attention its effects on learning processes [1–4].

While strategies on how to deal with the use of digital devices in traditional classrooms (e.g., laptop bans) are frequently discussed [2], university programs are conducted in a blended learning model, and their students are dependent on these devices. Broadbent describes blended learning in the context of her study as "the adoption of educational web-based technology (e.g., a learning management system) for online learning, which is used in combination with face-to-face located instruction from teaching practitioners" [5] (p. 25). In other words, blended learning can be considered to be the combination of synchronous online sessions (webinars), synchronous face-to-face (on-campus) sessions, and asynchronous independent learning. Thus, owning or at least having access to a digital device is one of the major requirements for students to participate and complete courses in a blended learning program.

Despite the several advantages of digital devices for learning in higher education, such as having quick access to online information, taking pictures of important content during class [6], taking notes and organizing content, or downloading necessary resources [7], the downsides of digital media usage in class cannot be ignored: prior research disclosed that students who use digital devices in class show worse overall performance compared to students who do not use the respective technologies [2,8–10]. However, although the data about the exact user behavior vary, there is much proof for the distracting effect of media

use while learning [9,11]. Considering that, in a webinar, instructors do not have all their students within their full range of vision (and/or hearing) at all times, they can never know whether students are actually following the content, are lost, are distracted by their phones, or are simply watching another video.

As a consequence, we need to accept that digital devices play a relevant role in class (online and on-campus), and that students might use them not only to participate in webinars and take notes, but also to interrupt themselves or disrupt others. Aiming at a better understanding of students' awareness levels and behavior in a pre-COVID-19 period, the presented study in this paper thus investigates the following research question: how do students perceive the use of digital devices and accompanying digital interruptions faced during webinars and on-campus sessions?

Our report of this investigation is structured as follows: Section 2 introduces the main topics and concepts we used to frame this study. Section 3 refers to the research design, and outlines the sampling method, the instruments, and data collection and analysis. Section 4 presents the results and analysis, followed by the discussion of the results in relation to theory and previous studies in Section 5. Lastly, Section 6 draws a conclusion, acknowledges the limitations of this study, and introduces possibilities for future research.

2. Digital Devices and Digital Interruptions

Digital devices pose many advantages for learning, yet they are also a source of interruption. While these interruptions can occur for several reasons [12], McFarlane emphasized in 1997 that computers are a more prevalent source of interruption than the person themselves, another person, or animate or inanimate objects [13]. Since then, the number of applications that run on digital devices has substantially grown (e.g., instant messaging, social media, emails, shopping, and reading the news online), increasing the potential for digital interruptions even further [12,14,15]. At the same time, however, this diversity in applications allows for individual study preferences and consequently supports different learning strategies. According to Biggs' students' approaches to learning (SAL) theory [16], this variety in learning approaches is central to individual learning progress. Others even refer to it as the reason "why students are more or less successful in their learning" [17] (p. 3). Hence, in order to promote and facilitate learning, the faculty needs to recognize SAL and offer support for individuality [18]. To what extent the lecture format (i.e., webinar vs. on-campus) affects SAL and the respective use of digital applications, however, is less researched.

2.1. Use of Digital Devices in University Classrooms

The incorporation of digital devices in the university classroom has several benefits. For example, it allows forstudents to deepen their knowledge or question presented facts with the use of additional online content, and to support their learning with taking pictures of important matters [6]. Thus, digital media, defined as "always-on, socially interactive, technologically mediated communication artefacts" [19] (p. 86), offer a variety of ways to improve student learning.

Initiatives such as Anywhere Anytime Learning [20] or Bring Your Own Device [21,22] have promoted the complementary nature of digital devices to traditional teaching and learning tools. Digital devices that might be used for course-related (CR) work include laptops, tablets, desktop computers, hybrid devices, and smartphones [23,24]. Educational technologies such as learning management systems, game-based learning platforms, or polling tools can enhance the learning experience, but students need access to suitable technologies. Students increasingly use e-books instead of hard copies due to the given cost advantages [25], which requires them to use digital devices in class.

In cooperation with the Educause Center for Analysis and Research (ECAR), Brooks and Pomerantz [23] conducted an international survey with 43,559 participants from 124 institutions, highlighting that 95% of all participating students owned at least two digital devices [23], such as a laptop, tablet, desktop computer, or smartphone. In another

ECAR study, Galanek, Gierdowski, and Brooks [24] looked at the usage frequency of digital devices and their perceived impact on academic success. They found that 98% of students did not only use their laptops, but almost as many students (94%) considered the device to be very or extremely important for their success [24]. Students' mindsets have also changed, so that mobile-phone or laptop usage in class is no longer perceived as signaling a lack of respect or attention [21,22]. May and Elder [26] even found that 40% of the study participants thought it was acceptable to send text messages during class. Hence, it does not come as a surprise that students stay in contact with their peers via social media and texting applications during phases of self-study and class [27].

2.1.1. Laptop/Tablet Use

Laptops bring many functionalities and advantages to a university classroom. Students bring them to class to "connect with the lecture" [26] (p. 7), take notes [8], and generally engage in class activities [28]. They provide note-taking applications (e.g., Microsoft OneNote, Evernote, Apple Notes), note storage, and constant access to class materials [7]. Houle, Reed, Vaughan, and Clayton [29] observed that students are aware of "the usefulness of the laptop as enhancing their own participation in the course" [29] (p. 89).

However, students use laptops not only for course-related activities but also for off-task or non-course-related (NCR) activities. With a multimethod approach, Ragan, Jennings, Massey, and Doolittle [28] examined students' laptop usage in class. In an online survey, 59% of students brought their laptops to class, mostly to take notes and engage in off-task activities such as social media or surfing the web [28]. While laptops provide many advantages for class time, they also present a major source of distraction [26]. Kay, Benzimra, and Li [30] asked their students to rate the frequency in which they engaged in distracting activities during class. About two-thirds of the students stated that they most frequently engage in emailing and web surfing, closely followed by social media activities, instant messaging (IM), and playing games [30].

This distracting nature of laptops in class not only leads to increased multitasking [2], but also to potentially lower academic performance [2,3,7,31,32]. Aguilar-Roca, Williams, and O'Dowd [8] found a performance difference between students who took notes on their laptops and those who used paper, showing that the latter scored significantly better in tests and received significantly more A grades. Sana, Weston, and Cepeda [33] used an experimental setting to analyze the consequences of laptop use for NCR tasks in class and found that students who were asked to engage in NCR activities while being in a lecture scored 11% lower than their peers did [33]. Even though Carter, Greenberg, and Walker [7] found evidence that unrestricted use of laptops and tablets had a negative impact on academic performance, Elliot-Dorans [1] countered this by showing that forbidding students to use their devices did not help them to improve their performance.

2.1.2. Mobile Phone Use

Mobile phones are not only used for making calls, but also for texting, sending emails, participating in video conferences, engaging in social media channels, taking pictures and sharing videos, and using other software-driven applications, as laptops are [34]. A study carried out by Lepp et al. [34] shows that, on a daily basis, students used 278.67 min on their mobile phones and sent 76.68 messages on average. While this figure gives no indication as to the number of texts sent during class, Kay, Benzimra, and Li [30] reported that 80% of students stated that they were "on-task" often or regularly while using their digital devices during a lecture. Texting is now so mundane that students "simply text irrespective of circumstances and rules" [35] (p. 26), even during class.

Even though students also use their mobile phones for activities related to the content of the class [6], the negative effects on learning prevail [9–11,36].

2.2. Students' Perceptions and Awareness of the Use of Digital Devices

While university faculties understand the implications of technology use in the classroom, students' awareness of their own behavior and their perceptions about respective effects vary [26,33,37].

May and Elder [26] observed that students exhibit "poor awareness of how media multitasking affects their learning" [26] (p. 10). In an exploratory study, Clayson and Haley [35] found that 68% of their respondents were convinced of their ability to actively participate in class and text at the same time, even though this behavior was negatively correlated with their grades. Generally, students tend to underestimate their time used for NCR activities in class and its impact. For example, Kraushaar and Novak [11] showed that students' estimation regarding their time spent on instant messaging in class was too low by 40%. In a study by Kirschner and Karpinski [38], 73.8% of students did not perceive any impact of Facebook on their learning and some even saw a positive effect. These findings contradict McCoy's [37] outcomes proposing that the majority of students is well aware of the negative impact of digital devices on their attention in class. Given their opposing character, these previous findings suggest that first, students have an inaccurate impression of their own interrupting behavior, and second, that they are not capable of fully estimating the consequences of their behavior.

2.3. Concept of (Digital) Interruptions

An interruption can be described as a new, additional action that interferes with an ongoing action [39]. Despite this new action, there is the intention of returning to the first activity later [40–42]. Contrary to distractions, which can only be triggered by external stimuli [43], the sources of interruptions can be both, external and internal [40,44].

External aspects causing interruptions, such as a ringing phone, are usually unintended, out of the respective person's control, and a compulsion to shift one's attention to the new stimulus [40,44,45]. However, internal interruptions describe a process of self-interruption due to physical needs, such as the urge to eat something, mental state, or thoughts, as, for example, the desire to check social media [40]. When an external interruption occurs due to an external trigger, one must reorganize and keep in mind the current goal to resume it at a later point [45]. Internal interruptions, on the other hand, lead to a suspension of the current goal because of a conscious decision to stop the primary task [45]. As they require active decision making prior to the interruption itself, they are more disruptive than external interruptions [44]. While external interruptions cannot be controlled, self-initiated interruptions may either be controllable or uncontrollable [40].

Reasons for internal interruptions are difficult to observe [40], pose some challenges regarding classification, and few studies have focused on them. Boredom, frustration, and low-workload moments [44–46] are possible reasons for self-interruption. Students often justify this self-interrupting behavior on grounds of its self-inflicting nature and argue that "they should be allowed to do whatever they wanted as long as it did not negatively affect other people" [47] (p. 107). In addition to the origin of and reasons for interruptions, the point in time when the interruption occurs is decisive [44]. To this end, a variety of studies showed that interruptions during low-workload moments are less disruptive than during high-workload moments [44,48].

Overall, several studies indicate that interruptions negatively impact the performance of the main activity in four major ways [44,49–52]. First, finishing the main task is more time-consuming [44,53]. Second, the longer an interruption is, the more challenging it is to come back to the original task [44]. Third, even if the main task is continued, the interrupted action is more prone to error [51,53]. Fourth, the additional time required for the main task can cause stress and anxiety [53,54].

Focusing on digital interruptions, laptops and other digital devices are used in either productive or distractive ways [2,11]. Kay and Lauricella [4] concluded that social networking and IM are the foremost interrupting activities during class. Besides social media, IM, and online surfing, Kay, Benzimra, and Li [30] observed another significant type of

interruption: 41% of students regularly used mobile devices during class for emailing. In 2015, email checking seemed to be one of the most common activities [55]. Other types of interruptions include shopping, checking sport scores [56], reading the news, watching videos, and chatting [15].

3. Context and Methods

We conducted this study with two cohorts of first-semester business administration bachelor's students at a university of applied sciences in Austria (pre-COVID-19). The respective blended learning program was based on synchronous online sessions (webinars in the evenings), synchronous on-campus sessions, and asynchronous independent learning. Each course consisted of six webinars (1 webinar = 120 min), a full day on campus (360 min), and a significant amount of guided self-study.

Studying the use patterns of digital devices and digital interruptions in a blended learning setting, we adopted a similar categorization of types of interruptions as that of Ravizza et al. [15]. That is, we looked for the previously highlighted interrupting activities and investigated their frequency and duration during class. We focused on time spent on laptops, since students of this blended learning program are explicitly encouraged to use private computers instead of mobile phones to participate in class.

In order to answer the question of how students perceive the use of digital devices and accompanying digital interruptions faced during webinars and on-campus sessions, we developed the following set of assumptions, all of which were deduced from the previous work discussed above:

Assumption 1a. *Students primarily use the same type of device (e.g., their laptop or tablet) for CR activities during webinars and on-campus sessions (cf. Section 2.1.1).*

Assumption 1b. *Students primarily use the same type of device (e.g., their smartphone) for NCR activities during webinars and on-campus sessions (cf. Section 2.1.2).*

Assumption 2a. *Students perceive the use of computers for NCR activities during webinars as interruptive to their own learning (cf. Section 2.3).*

Assumption 2b. *Students perceive the use of computers for NCR activities during on-campus sessions as interruptive to their own learning (cf. Section 2.3).*

Assumption 3a. *Students perceive the use of computers for NCR activities by other students during webinars as interruptive (cf. Section 2.3).*

Assumption 3b. *Students perceive the use of computers for NCR activities by other students during on-campus sessions as interruptive (cf. Section 2.3).*

Assumption 4. *Students use their computers for NCR activities during webinars more than during on-campus sessions (cf. Section 2.2).*

To evaluate these assumptions, students first completed a self-assessment questionnaire after the third webinar of a course (Survey 1) and a second questionnaire at the end of the on-campus day (Survey 2), which marked the end of the course. Questionnaires included mainly quantitative data elements, but were enriched by some open-ended questions, for which we used thematic content analysis to expand on the quantitative results [57].

3.1. Sample

In total, we asked 211 first-semester students to participate in this study, of whom 176 completed Survey 1, and 144 Survey 2 (a total of 201 distinct students completed either Survey 1 or Survey 2). Table 1 provides an overview of the gender distribution of the sample.

Table 1. Gender distribution of sample (n = 201 distinct students).

	Cohort 2018	Cohort 2019	Total
Female	43.69%	45.92%	44.78%
Male	56.31%	54.08%	55.22%

Descriptive analysis of the data showed that participants were between 19 and 55 years old (M = 27.6 years, SD = 6.775), and the majority (i.e., 83.6%) had never studied at the tertiary level before. Participants also reported an average of 8 years of work experience (SD = 6.91 years) and that they currently work an average of 33.88 h per week next to their studies.

3.2. Instruments

In Survey 1, we asked students about the types of digital devices that they use during webinars. Next, we focused on their self-estimated use of digital devices for course-related (CR) and non-course-related (NCR) activities during webinars based on a survey instrument by Ravizza, Uitvlugt and Fenn [15]. To this end, we inquired on their estimated usage of digital devices for the following interrupting activities: checking social media, sending SMS, messaging on WhatsApp, shopping online, reading the news or checking sport scores, watching videos, playing games, and other activities. Next, several questions were asked to establish an understanding of the students' learning environment (e.g., location and in the company of someone or alone). Types of and reasons for interruptions were investigated by a mixture of closed and open-ended questions. Furthermore, we inquired on the students' perception of how their digital device usage for NCR activities affected their own and their peers' learning during webinars and on-campus sessions [15]. Survey 2 asked the same questions but slightly reworded, so as to fit to a physical classroom setting. A pilot test with five participants from various backgrounds (i.e., academic faculty, business professionals, and students) was conducted for each questionnaire to identify ambiguous formulations, guarantee sufficient clarity and full understanding of all used terms, and test whether the surveys were suitable to investigate previously outlined assumptions. An excerpt of the final questionnaires is available in the Supplementary Materials (File S1).

3.3. Data Collection and Analysis

We informed the students before the beginning of courses Accounting and Controlling I (Cohort, 2018) and Fundamentals of Law (Cohort, 2019) about the survey. These two courses were chosen due to their early position in the curriculum during the first semester, their similar structure, and comparable assessment mode, namely, a final written exam. Survey 1 was conducted after the third of six webinars, and Survey 2 took place at the end of the on-campus day. We used frequency analysis to explore students' engagement in NCR activities.

After reading through the answers to the open-ended questions, we started an inductive coding process. Our team focused on keywords, nominal phrases, and sentence parts, and only allocated one code per selected text unit. We developed a separate coding scheme with main and subcategories for webinars and on-campus sessions (Supplementary File S2). Exemplary answers were selected to represent each category. Memos were written to summarize the meaning of each code to avoid a lack of consistency in coding and to ensure inter- and intrarater reliability [58]. Next, two of the researchers coded the answers independently and compared their allocations. Lastly, we adapted the coding scheme as a consequence of our varying agreements on the basis of oral discussions and in accordance with the literature (Supplementary File S3).

The previously described characteristics of the two student year groups concerning age and gender represent the total student population's characteristics. The overall population's diversity in work and educational experience, and current working hours is reflected in the sample. Therefore, nonsampling bias could be excluded. A nonresponse bias was also

excluded, as 83% (n = 176) of the two student cohorts responded to Survey 1 and 68% (n = 144) to Survey 2.

4. Analysis and Results

Our goal was to investigate the participants' use of digital devices and to explore the digital interruptions they face during webinars and on-campus sessions. A better understanding thereof can help lecturers in blended learning settings to support their students in overcoming distracting behavior and reducing the time of non-course-related activities. We first established an understanding of the participants' learning environment and focused on the types of digital devices they use during webinars and on-campus sessions. Next, we examined the perceived effects that non-course-related activities that are carried out with digital devices have on learning. Third, we explored the use of digital devices, relevant digital interruptions, and the extent to which students engage in NCR activities during webinars and during on-campus days.

4.1. Learning Environment

As webinars took place after typical working hours, 85.8% of the students indicated that they were always or very often alone in a room when they participated in the webinars, whereas 14.2% of the participants answered that they were never, rarely, or only sometimes alone. Of the participants, 94.9% indicated that they typically joined the webinars from home, and only 2.8% from the office.

During webinars, 59.43% of the students took notes on paper; 22.64% on their laptops; 13.21% using either a desktop computer, a tablet, a smartphone, or a hybrid device; and 4.72% did not take notes at all. During the on-campus day, 59.32% of them took notes on paper; 27.68% used their laptops; 7.34% either a tablet, a smartphone, or a hybrid device; and 5.65% refrained from taking notes.

4.2. Types and Use of Digital Devices

In this particular blended learning program, webinars are typically hosted using a web conferencing platform. To this end, 85.8% of the participants indicated that they used their laptops to log in, followed by 6.8% using their desktop computers, 5.7% using a hybrid device, and 1.7% using a tablet or smartphone.

To compare the difference between the use of digital devices for CR and NCR activities during webinars and on-campus sessions, we asked students to select one of the following devices that they primarily use: desktop PC (only in Survey 1), laptop, tablet, smartphone, hybrid device, or other.

For course-related activities during webinars, 80.1% of the participants indicated that they used their laptops, followed by 7.4% using a desktop PC, 6.3% a smartphone, 5.7% a hybrid device, and 0.6% a tablet. During the on-campus day, students primarily used their laptops (83.3%) to engage in CR activities, followed by 6.9% using a hybrid device, 5.6% a smartphone, and 4.2% a tablet (see Table 2). These numbers show that the use of digital devices for CR activities during webinars is similar to its use during on-campus lectures, so that Assumption 1a is clearly supported (cf. Section 3).

Regarding non-course-related activities, 54.5% of the students stated that they used their smartphones during webinars and 34.1% that they used their laptops, while the remaining 11.4% opted for one of the other previously listed devices. During the on-campus day, 67.4% of the students resorted to their smartphones for NCR activities, 27.8% to their laptops, and 4.8% used one of the other devices (cf. Table 2). Although there seems to be a slight difference between the use of digital devices for NCR activities during webinars compared to their use during on-campus lectures, Assumption 1b (cf. Section 3) still seems to be supported.

Table 2. Primary use of digital devices for CR and NCR activities during webinars and on-campus sessions.

		Webinar (%) [1]	On-Campus (%) [2]
Course-related activities	Desktop PC	7.39%	0%
	Laptop	80.11%	83.33%
	Tablet	0.57%	4.17%
	Smartphone	6.25%	5.56%
	Hybrid device	5.68%	6.94%
	None	0%	0%
	Not answered	0%	0%
Non-course-related activities	Desktop PC	4.55%	0%
	Laptop	34.09%	27.78%
	Tablet	2.27%	2.78%
	Smartphone	54.55%	67.36%
	Hybrid device	2.84%	2.08%
	None	0.57%	0%
	Not answered	1.14%	0%

[1] n = 176; [2] n = 144.

4.3. Perceived Effects of NCR Activities on Learning

When investigating the perceived impact of NCR activities on students' learning, 75.66% of them stressed that it somewhat or strongly disrupted their learning of course material during webinars, whereas only 60.42% indicated that it disrupted them during the on-campus day (see Table 3). These numbers support both Assumption 2a (students perceive the use of computers for NCR activities during webinars as interruptive to their own learning) and Assumption 2b (students perceive the use of computers for NCR activities during on-campus sessions as interruptive to their own learning).

Table 3. Student perception of impact of own computer use for NCR activities on own learning.

Perceived Impact of Computer Use for NCR Activities on Own Learning	During Webinars (%) [1]	During On-Campus Sessions (%) [2]
It strongly helps my learning of course material.	2.84%	3.47%
It somewhat helps my learning of course material.	5.68%	9.03%
It makes no difference to my learning of course material.	15.34%	25.69%
It somewhat disrupts my learning of course material.	55.68%	45.14%
It strongly disrupts my learning of course material.	19.89%	15.28%
Not answered.	0.57%	1.39%

[1] n = 176; [2] n = 144.

We also investigated the perceived effect of other students' computer use on learning. To this end, nearly three quarters of students perceived that other students' use of computers for NCR activities during webinars as well as on-campus sessions made no difference to their learning (cf. Table 4). Consequently, neither Assumption 3a nor Assumption 3b (Section 3) are supported by the analytical results. Nonetheless, nearly one-quarter of student perceived a somewhat or strongly disrupting effect during webinars (23.87%) and during on-campus sessions (23.61%).

Table 4. Student perception of impact of computer use by other students for NCR activities on own learning.

Perceived Impact of Computer Use by Other Students for NCR Activities on Own Learning	During Webinars (%) [1]	During On-Campus Sessions (%) [2]
It strongly helps my learning of course material	0.57%	1.39%
It somewhat helps my learning of course material	2.84%	2.78%
It makes no difference to my learning of course material	72.16%	70.83%
It somewhat disrupts my learning of course material	19.32%	18.75%
It strongly disrupts my learning of course material	4.55%	4.86%
Not answered	0.57%	1.39%

[1] n = 176; [2] n = 144.

4.4. Relevant Digital Interruptions

To assess the average time that students spend on NCR activities with their computer, we asked them to estimate the number of minutes dedicated to checking social media, reading or writing emails, texting, etc. (Table 5).

Table 5. Average time spent on computer on non-course-related activities.

		Average Time Spent on Computer on NCR Activities					
		Webinar (120 min)			On-Campus (360 min)		
		% of Total Webinar Time	Mean (min)	STD (min)	% of Total On-Campus Time	Mean (min)	STD (min)
Non-course-related (NCR) activities	Check social media	3.93%	4.71	10.52	2.24%	8.08	14.03
	Read or write e-mails	1.45%	1.74	3.71	1.13%	4.08	7.69
	Text	5.28%	6.34	6.60	2.95%	10.61	13.26
	Shop online	0.48%	0.58	2.79	0.09%	0.32	1.40
	Read the news	1.33%	1.59	5.18	1.07%	3.84	6.98
	Check sports scores	0.63%	0.76	2.42	0.21%	0.75	2.50
	Watch videos	0.69%	0.83	5.32	0.10%	0.36	2.93
	Play games	0.38%	0.46	2.24	0.19%	0.69	5.86
	Other activities	2.04%	2.45	4.47	0.91%	3.29	8.94
	Average total of NCR activities	15.06%	18.08	21.12	8.12%	29.23	33.44

It follows that, during an average webinar, students reported that most of their off-task time was spent on checking social media, reading or writing emails, texting, and other unspecified activities. During an on-campus day, they estimated that most of their time off-task during class was dedicated to texting, reading the news, reading or writing emails, checking social media, and other activities. However, the high standard deviations indicate that the behavior of students varies greatly.

In total, students reported to spend on average 15.06% (18.08 min) of an entire webinar on NCR activities, compared to 8.12% of an entire on-campus day (29.23 min). By running a one-tailed t-test, results indicated that students spent significantly more time on digital interruptions during webinars than they did during on-campus sessions ($t(271) = 4.43$, $p = 0.000$).

Surprisingly, when asked to estimate the total percentage of time they spend on NCR activities, they reported having dedicated on average 8.48% of the webinar time and 7.39% of the on-campus day to these interruptions. Here, no significant difference was found between webinars and on-campus sessions ($t(255) = 0.88$, $p = 0.190$). Students' estimates of NCR activities during on-campus lectures were rather stable, whereas their estimates of NCR activities during webinars greatly varied depending on whether they were asked to provide percentages or absolute minutes.

Thus, depending on which approach to self-assessment is considered (estimating the number of minutes or estimating a percentage of time), Assumption 4 (Section 3) may be supported or not.

4.5. Reasons for Interruptions

The open questions of the surveys showed that students have various reasons for spending time on non-course-related activities. During on-campus sessions, students feel internally interrupted by thoughts and worries about their families and about organizational matters, such as plans for the evening or the weekend. Internal interruptions also stem from curiosity about possible incoming messages. Students mention concentration difficulties as a further reason for non-course related activities due to tiredness or the need for a break, for example, "On-campus sessions are very long and sometimes you're losing concentration and the first thing you do is to check your phone for messages". Physical needs, such as the urge to eat something, were additionally mentioned as sources of interruption. One participant indicated that "I want to get to know my peers better as this makes working together easier". This statement is exemplary for participants' strong need to interact with their peers due to the limited time on campus inherent to the blended learning approach, which represents another reason for interruptions.

External interruptions during on-campus sessions can mainly be summarized as family and work issues. The students' statements show the challenges of reconciling work, education, and family. For example, they mention stress at work while being on campus, urgent job-related tasks, and family emergencies interrupting their on-campus sessions. Nonetheless, in addition to individual impact factors, general factors within the classroom play a role as well. For example, noise in the classroom, distractions on other students' screens, the content of which students believe to have prior knowledge, and redundant questions of fellow students seem to lead to non-course-related activities. Furthermore, the teaching style in class is seen as a potential source of interruption: "If the course is boring, then I spend my time on other things".

During webinars, internal interruptions can also cause students to engage with non-course-related matters. Students also indicated that reasons such as participation within the group chat on WhatsApp, concentration difficulties, preknowledge on the presented topic, the feeling of not being able to follow the lecturer, and technical difficulties led them to interrupt themselves during webinars. For example, one participant wrote, "The students often write together on WhatsApp during the webinars, but this is both for course-related and non-course-related stuff. This gives it more of a classroom vibe, both explaining the topics and small jokes on the topics". One statement shows that interrupting behavior is sometimes kept up despite better knowledge: "I'm not happy to say that, but I guess I'm just addicted to social media in some way".

Interruptions by family members play a significant role: "My Children want something or my wife wants something". This reasoning was to be expected, as the majority of the students participate in webinars from home (Section 4.1). In the webinar setting, pressure to interrupt course-related activities due to responsibilities at work is present: "One reason is that if, for example, an e-mail pops up, I want it done immediately. What is done is done." Teaching style seems to play an even greater role in webinars than that during on-campus sessions. Hence, the students list factors such as the lack of focus and structure, missing interaction, too much information on slides, and the lecturer's monotonous voice as reasons for non-course-related activities. Lastly yet importantly, when asked about any distracting behavior of their fellow students in the classroom, participants provided a diverse set of answers. One participant, for example, highlighted that "a lot of unnecessary questions from fellow peers ould have been sent via mail to the lecturer to not take up our already limited webinar time", suggesting that a great number of questions by peers during webinars and the consequent endeavor of lecturers to answer these questions are perceived negatively by other students.

Summarizing the answers to the open-ended questions, students must deal with internal and external interruptions in both webinars and on-campus sessions. What is unexpected, however, is that the reasons for digital interruptions are alike in both contexts.

5. Discussion

Together, results presented above provide important insights into students' perceived use of digital devices and the accompanying digital interruptions they face during webinars and on-campus sessions in the pre-COVID-19 period. They primarily use the same types of digital devices during webinars and on-campus sessions. While they mainly use laptops for course-related activities, they take out their smartphones to engage in non-course-related activities, such as checking social media, texting, and reading or writing emails. Overall, one might ponder why students use one device for each activity, namely, laptops for course-related activities, smartphones for non-course-related activities, and paper for taking notes; this might give them a sense of successful multitasking by simultaneously engaging in several activities [59].

When taking notes, students employ a similar approach regardless of whether they are at home in front of their laptops or sitting in a classroom on campus. Contrary to Kay and Lauricella [60], who found that students saw the function of note taking as the largest advantage of using laptops in class, almost 60% of our study participants reported taking notes on paper both during webinars and during the on-campus session. We can only guess reasons for this behavior, but an explanation might be that working professionals may appreciate the haptic aspect of writing on paper for a change.

Similar to results reported in Ravizza et al. [15], the participants of our study stated to have spent most of their time on checking social media, texting, reading or writing emails, and reading the news both in webinars and during on-campus sessions. Even though messaging services such as WhatsApp are available on laptops, Clayson and Haley [35] argued that texting on phones is now so normal that students might simply do as they please, not considering the context. Almost one-quarter of students indicated that they felt disrupted by others using their laptops in class (23.7%). A possible explanation for this might be that students stick to their phones as an act of social nicety to avoid distracting others.

We assumed that students would use their computers more during webinars than during the on-campus session for non-course-related activities. When asked to estimate the minutes spent on off-task activities, students' responses indicated that digital interruptions during webinars lasted significantly longer than during on-campus sessions. While the estimation of the total percentage of NCR activities and the percentage calculated from the accumulated minutes for the on-campus day are similar, the participants provided different estimations when asked about webinars. This mismatch was unexpected; one explanation might be that students lack awareness of their self-interrupting behavior when at home and online.

While the majority of the participants are aware of the interruptive impact that NCR activities conducted on their computers have on their learning, but 25.69% of them are convinced that NCR activities have no impact on their own learning when on campus, whereas only 15.34% see no impact during webinars. The effect of their computer use for NCR activities on others seems to be a blind spot, with 70.8% of students not perceiving its impact during the on-campus sessions on others at all.

Although prior studies show that their peers' activities on digital devices catch the students' attention [2,6,33], they do not seem to be fully aware of the related consequences.

The reasons that students mentioned for non-class-related activities are manifold. Some indicated that they felt like getting in contact with other students when online, and others mentioned boredom as a reason for their laptop use. On the other hand, being interested in the topic or having lively discussions keeps them from being interrupted [4]. Taken together, the reasons for non-course-related activities are various and call for further investigation.

6. Conclusions

Developing competencies to critically reflect one's behavior and to apply corrective measures if necessary is an essential part of higher education. This applies to physical and digital contexts alike. Therefore, supporting our students in recognizing potential interruptions is the first important step towards a potential evolvement of self-regulating measures. To inspire these necessary changes in our students, which are increasingly important in a world of national and regional lockdowns, and a departure from traditional teaching methods, lecturers first need to be well aware of students' behavior and potential sources of interruptions.

Thus, this study set out to explore students' perceptions and use of digital devices and accompanying digital interruptions in webinars and on-campus sessions. Our results show that digital interruptions are an issue in both webinars and on-campus sessions. On the one hand, students claim to be somewhat aware of the interrupting potential of digital devices during class time. On the other hand, this awareness has very little impact on students' behavior. The use of digital devices in higher education offers several benefits that students are already well on their way to integrating into their lives. However, considering that social media, emails, and instant messaging easily steal the students' attention from what is happening during class, we as lecturers need to ask ourselves how we can avoid a future in which our teaching becomes the main interrupting element during class time.

These results are based on a study that had been conducted pre-COVID-19. We do not know whether students' behavior has since changed. Another limitation may be seen in the rather small sample of students completing both surveys. All our results are based on students' self-assessment and self-estimations. Pairing reported perceptions with real data from tracking software or an objective performance indicator would allow for a better and more indepth understanding of students' behavior. Furthermore, one issue that was not addressed by this study regards the students' preference for using their smartphones for non-course-related activities. This reasoning and further aspects related to behavioral causes should be explored in additional focus groups and in-depth interview sessions.

Despite these limitations, our study contributes to the groundwork for future research on students' behavior and their dealing with digital interruptions, for which we would push for the development of self-regulation skills as an essential next step in dealing with digital interruptions. Especially when taking the context of COVID-19 into consideration, further studies could focus on the development and validation of specific solutions to support students at different levels (primary, secondary, and tertiary education) in becoming higher-level self-regulated learners.

References

1. Elliott-Dorans, L.R. To Ban or Not to Ban? The Effect of Permissive versus Restrictive Laptop Policies on Student Outcomes and Teaching Evaluations. *Comput. Educ.* **2018**, *126*, 183–200. [CrossRef]
2. Fried, C.B. In-Class Laptop Use and Its Effects on Student Learning. *Comput. Educ.* **2008**, *50*, 906–914. [CrossRef]
3. Jacobsen, W.C.; Forste, R. The Wired Generation: Academic and Social Outcomes of Electronic Media Use among University Students. *Cyberpsychol. Behav. Soc. Netw.* **2011**, *14*, 275–280. [CrossRef] [PubMed]
4. Kay, R.H.; Lauricella, S. Investigating the Benefits and Challenges of Using Laptop Computers in Higher Education Classrooms/Étude sur les avantages et les défis associés à l'utilisation d'ordinateurs portables dans les salles de classe d'enseignement supérieur. *Can. J. Learn. Technol.* **2014**, *40*, n2. [CrossRef]
5. Broadbent, J. Comparing Online and Blended Learner's Self-Regulated Learning Strategies and Academic Performance. *Internet High. Educ.* **2017**, *33*, 24–32. [CrossRef]
6. Berry, M.J.; Westfall, A. Dial D for Distraction: The Making and Breaking of Cell Phone Policies in the College Classroom. *Coll. Teach.* **2015**, *63*, 62–71. [CrossRef]
7. Carter, S.P.; Greenberg, K.; Walker, M.S. The Impact of Computer Usage on Academic Performance: Evidence from a Randomized Trial at the United States Military Academy. *Econ. Educ. Rev.* **2017**, *56*, 118–132. [CrossRef]
8. Aguilar-Roca, N.M.; Williams, A.E.; O'Dowd, D.K. The Impact of Laptop-Free Zones on Student Performance and Attitudes in Large Lectures. *Comput. Educ.* **2012**, *59*, 1300–1308. [CrossRef]
9. Wei, F.-Y.F.; Wang, Y.K.; Klausner, M. Rethinking College Students' Self-Regulation and Sustained Attention: Does Text Messaging During Class Influence Cognitive Learning? *Commun. Educ.* **2012**, *61*, 185–204. [CrossRef]
10. Wood, E.; Zivcakova, L.; Gentile, P.; Archer, K.; de Pasquale, D.; Nosko, A. Examining the Impact of Off-Task Multi-Tasking with Technology on Real-Time Classroom Learning. *Comput. Educ.* **2012**, *58*, 365–374. [CrossRef]
11. Kraushaar, J.M.; Novak, D.C. Examining the Affects of Student Multitasking With Laptops During the Lecture. *J. Inf. Syst. Educ.* **2010**, *21*, 241–251.
12. Sykes, E.R. Interruptions in the Workplace: A Case Study to Reduce Their Effects. *Int. J. Inf. Manag.* **2011**, *31*, 385–394. [CrossRef]
13. McFarlane, D.C. *Interruption of People in Human-Computer Interaction: A General Unifying Definition of Human Interruption and Taxonomy*; Naval Research Laboratory: Washington, DC, USA, 1997.
14. Cameron, A.F.; Webster, J. Unintended Consequences of Emerging Communication Technologies: Instant Messaging in the Workplace. *Comput. Hum. Behav.* **2005**, *21*, 85–103. [CrossRef]
15. Ravizza, S.M.; Uitvlugt, M.G.; Fenn, K.M. Logged In and Zoned Out. *Psychol. Sci.* **2017**, *28*, 171–180. [CrossRef] [PubMed]
16. Biggs, J.B. *Study Process Questionnaire Manual. Student Approaches to Learning and Studying*; Australian Council for Educational Research: Hawthorn, MEL, Australia, 1987.
17. González, C.; López, D.; Calle-Arango, L.; Montenegro, H.; Clasing, P. Chilean University Students' Digital Learning Technology Usage Patterns and Approaches to Learning. *ECNU Rev. Educ.* **2022**, 1–28. [CrossRef]
18. Duff, A.; McKinstry, S. Students' Approaches to Learning. *Issues Account. Educ.* **2007**, *22*, 183–214. [CrossRef]
19. Le Roux, D.B.; Parry, D.A. In-Lecture Media Use and Academic Performance: Does Subject Area Matter? *Comput. Hum. Behav.* **2017**, *77*, 86–94. [CrossRef]
20. Milrad, M.; Spikol, D. Anytime, Anywhere Learning Supported by Smart Phones: Experiences and Results from the MUSIS Project. *J. Educ. Technol. Soc.* **2007**, *10*, 62–70.
21. Song, Y. "Bring Your Own Device (BYOD)" for Seamless Science Inquiry in a Primary School. *Comput. Educ.* **2014**, *74*, 50–60. [CrossRef]
22. Song, Y. "We found the 'black spots' on campus on our own": Development of Inquiry Skills in Primary Science Learning with BYOD (Bring Your Own Device). *Interact. Learn. Environ.* **2016**, *24*, 291–305. [CrossRef]
23. Brooks, D.C.; Pomerantz, J. *ECAR Study of Undergraduate Students and Information Technology*; ECAR: Louisville, CO, USA, 2017.
24. Galanek, J.D.; Gierdowski, D.C.; Brooks, D.C. *ECAR Study of Undergraduate Students and Information Technology*; ECAR: Louisville, CO, USA, 2018.
25. Gierdowski, D.C. *ECAR Study of Undergraduate Students and Information Technology*; Research Report; ECAR: Louisville, CO, USA, 2019.
26. May, K.E.; Elder, A.D. Efficient, Helpful, or Distracting? A Literature Review of Media Multitasking in Relation to Academic Performance. *Int. J. Educ. Technol. High Educ.* **2018**, *15*, 1–17. [CrossRef]
27. Felisoni, D.D.; Godoi, A.S. Cell Phone Usage and Academic Performance: An Experiment. *Comput. Educ.* **2018**, *117*, 175–187. [CrossRef]
28. Ragan, E.D.; Jennings, S.R.; Massey, J.D.; Doolittle, P.E. Unregulated Use of Laptops over Time in Large Lecture Classes. *Comput. Educ.* **2014**, *78*, 78–86. [CrossRef]
29. Houle, P.A.; Reed, D.; Vaughan, A.G.; Clayton, S.R. Using Laptop Computers in Class: A Student Motivation Perspective. *J. Learn. High. Educ.* **2013**, *9*, 83–92.
30. Kay, R.; Benzimra, D.; Li, J. Exploring Factors That Influence Technology-Based Distractions in Bring Your Own Device Classrooms. *J. Educ. Comput. Res.* **2017**, *55*, 974–995. [CrossRef]
31. Hembrooke, H.; Gay, G. The Laptop and the Lecture: The Effects of Multitasking in Learning Environments. *J. Comput. High. Educ.* **2003**, *15*, 46–64. [CrossRef]

32. Patterson, R.W.; Patterson, R.M. Computers and Productivity: Evidence from Laptop Use in the College Classroom. *Econ. Educ. Rev.* **2017**, *57*, 66–79. [CrossRef]

33. Sana, F.; Weston, T.; Cepeda, N.J. Laptop Multitasking Hinders Classroom Learning for Both Users and Nearby Peers. *Comput. Educ.* **2013**, *62*, 24–31. [CrossRef]

34. Lepp, A.; Barkley, J.E.; Karpinski, A.C. The relationship between cell phone use, academic performance, anxiety, and Satisfaction with Life in college students. *Comput. Hum. Behav.* **2014**, *31*, 343–350. [CrossRef]

35. Clayson, D.E.; Haley, D.A. An Introduction to Multitasking and Texting: Prevalence and Impact on Grades and GPA in Marketing Classes. *J. Mark. Educ.* **2012**, *35*, 26–40. [CrossRef]

36. Kuznekoff, J.H.; Munz, S.; Titsworth, S. Mobile Phones in the Classroom: Examining the Effects of Texting, Twitter, and Message Content on Student Learning. *Commun. Educ.* **2015**, *64*, 344–365. [CrossRef]

37. McCoy, B. Digital Distractions in the Classroom Phase II: Student Classroom Use of Digital Devices for Non-Class Related Purposes. *Fac. Publ. Coll. J. Mass Commun.* **2016**, *7*, 5–32.

38. Kirschner, P.A.; Karpinski, A.C. Facebook® and Academic Performance. *Comput. Hum. Behav.* **2010**, *26*, 1237–1245. [CrossRef]

39. Miyata, Y.; Norman, D.A. Psychological Issues in Support of Multiple Activities. In *User Centered System Design: New Perspectives on Human-Computer Interaction*; Norman, D.A., Draper, S.W., Eds.; Lawrence Erlbaum Associates, Inc.: Hillsdale, NJ, USA, 1986; pp. 265–284.

40. Baethge, A.; Rigotti, T.; Roe, R.A. Just More of the Same, or Different? An Integrative Theoretical Framework for the Study of Cumulative Interruptions at Work. *Eur. J. Work Organ. Psychol.* **2015**, *24*, 308–323. [CrossRef]

41. Brixey, J.J.; Robinson, D.J.; Johnson, C.W.; Johnson, T.R.; Turley, J.P.; Zhang, J. A Concept Analysis of the Phenomenon Interruption. *Adv. Nurs. Sci.* **2007**, *30*, E26–E42. [CrossRef]

42. Altmann, E.M.; Trafton, J.G. Memory for Goals: An Activation-based Model. *Cogn. Sci.* **2002**, *26*, 39–83. [CrossRef]

43. Jett, Q.R.; George, J.M. Work Interrupted: A Closer Look at the Role of Interruptions in Organizational Life. *Acad. Manag. Rev.* **2003**, *28*, 494–507. [CrossRef]

44. Katidioti, I.; Borst, J.P.; van Vugt, M.K.; Taatgen, N.A. Interrupt Me: External Interruptions are Less Disruptive than Self-Interruptions. *Comput. Hum. Behav.* **2016**, *63*, 906–915. [CrossRef]

45. Adler, R.F.; Benbunan-Fich, R. Self-interruptions in discretionary multitasking. *Comput. Hum. Behav.* **2013**, *29*, 1441–1449. [CrossRef]

46. Salvucci, D.D.; Taatgen, N.A. *The Multitasking Mind*; Oxford University Press: Oxford, NY, USA, 2011.

47. Langan, D.; Schott, N.; Wykes, T.; Szeto, J.; Kolpin, S.; Lopez, C.; Smith, N. Students' Use of Personal Technologies in the University Classroom: Analysing the Perceptions of the Digital Generation. *Technol. Pedagog. Educ.* **2016**, *25*, 101–117. [CrossRef]

48. Monk, C.A.; Boehm-Davis, D.A.; Trafton, J.G. Recovering from Interruptions: Implications for Driver Distraction Research. *Hum. Factors* **2004**, *46*, 650–663. [CrossRef] [PubMed]

49. Gupta, N.; Irwin, J.D. In-Class Distractions: The Role of Facebook and the Primary Learning Task. *Comput. Hum. Behav.* **2016**, *55*, 1165–1178. [CrossRef]

50. Rosen, L.D.; Lim, A.F.; Carrier, L.M.; Cheever, N.A. An Empirical Examination of the Educational Impact of Text Message-Induced Task Switching in the Classroom: Educational Implications and Strategies to Enhance Learning. *Psicol. Educ.* **2011**, *17*, 163–177. [CrossRef]

51. McFarlane, D.C. Comparison of Four Primary Methods for Coordinating the Interruption of People in Human–Computer Interaction. *Hum.-Comput. Interact.* **2002**, *17*, 63–139. [CrossRef]

52. Monk, C.A.; Trafton, J.G.; Boehm-Davis, D.A. The Effect of Interruption Duration and Demand on Resuming Suspended Goals. *J. Exp. Psychol. Appl.* **2008**, *14*, 299–313. [CrossRef] [PubMed]

53. Ratwani, R.M.; Andrews, A.E.; Sousk, J.D.; Trafton, J.G. The Effect of Interruption Modality on Primary Task Resumption. *Proc. Hum. Factors Ergon. Soc. Annu. Meet.* **2008**, *52*, 393–397. [CrossRef]

54. González, V.M.; Mark, G. "Constant, Constant, Multi-tasking Craziness": Managing Multiple Working Spheres. In Proceedings of the 2004 Conference on Human Factors in Computing Systems, CHI 2004, Vienna, Austria, 24–29 April 2004; Volume 6, pp. 113–120. [CrossRef]

55. Kushlev, K.; Dunn, E.W. Checking email less frequently reduces stress. *Comput. Hum. Behav.* **2015**, *43*, 220–228. [CrossRef]

56. Downs, E.; Tran, A.; McMenemy, R.; Abegaze, N. Exam performance and attitudes toward multitasking in six, multimedia–multitasking classroom environments. *Comput. Educ.* **2015**, *86*, 250–259. [CrossRef]

57. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]

58. Bryman, A. *Social Research Methods*, 5th ed.; Oxford University Press: Oxford, UK, 2016; ISBN 978-0-19-968945-3.

59. Demirbilek, M.; Talan, T. The Effect of Social Media Multitasking on Classroom Performance. *Act. Learn. High. Educ.* **2018**, *19*, 117–129. [CrossRef]

60. Kay, R.H.; Lauricella, S. Exploring the benefits and challenges of using laptop computers in higher education classrooms: A formative analysis. *Can. J. Learn. Technol.* **2011**, *37*, 1–18. [CrossRef]