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Synchronous vs. asynchronous education: Questionnaire-based survey in dental medicine during the COVID-19 pandemic**

Introduction: The rapid establishment of digital teaching in the dental curriculum, which was necessary in the progress of the COVID-19 pandemic, now poses new challenges for both students and teachers. The aim of this study was to assess the impact of the sudden introduction of synchronous and asynchronous online teaching on dental students.

Methods: The evaluation of digital teaching was conducted via online survey using the survey program SoSciSurvey. Dental students at the MHH in the 2nd, 4th, 6th, 8th and 10th semesters were questioned (n = 204, mean age: 23.6 ± 3.7 years, male/female ratio: 28 %/72 %). By means of a sum value calculation over 21 Likert-type items, as well as the evaluation of core aspects (content, technical quality, interaction potential with the lecturer, clarification possibilities of questions, general orientation on the digital platform) according to school grades, the satisfaction of the students was recorded. The statistical evaluation was carried out with the software RStudio.

Results: The evaluation of the sum scores showed a mean of 66.9 points (median 68.5) for preclinical students (2nd, 4th semester, asynchronous teaching concept) and 79.4 points (median 81) for clinical students (6th, 8th, 10th semester, synchronous teaching concept). The difference of 12.5 points (median 12.5) between both teaching concepts is statistically significant ($p < 0.001$). The grading of the core aspects also showed statistically significant differences with regard to content and orientation on the digital platform.

Conclusion: The questionnaire-based survey of dental students at the MHH revealed that students were more satisfied with synchronous online teaching than with asynchronous teaching. However, whether there is a fundamental superiority of the synchronous teaching format over the asynchronous approach cannot be answered by the data collected.

Keywords: covid-19 pandemic; dentistry; digital teaching; synchronous and asynchronous learning; questionnaire-based survey

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1. Introduction

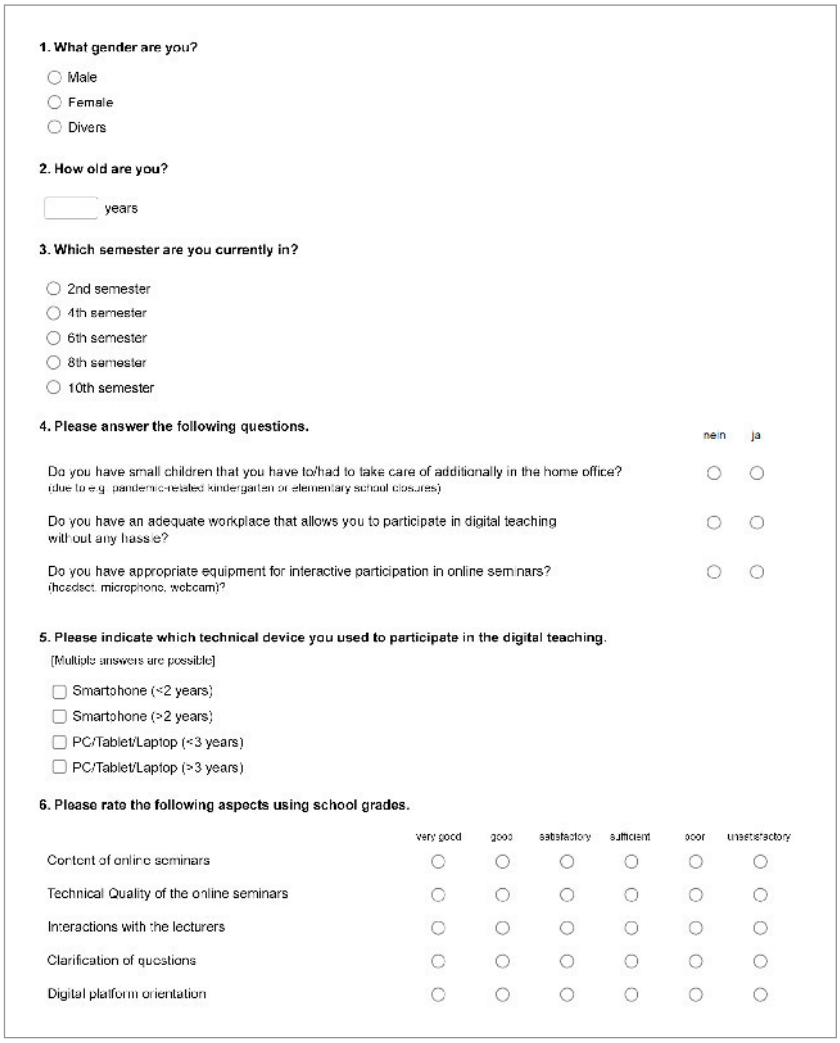
The COVID-19 pandemic, as well as the measures taken to contain it, are showing far-reaching socioeconomic effects [34]. In addition to the currently much-discussed economic cuts, the education sector has also been affected to a considerable extent [55]. General bans on contact and attendance in the sense of "social distancing" prohibit the implementation of "classical teaching approaches" in the form of face-to-face instruction at schools and universities [59]. However, this form of teaching plays an elementary role in the training of future dentists in particular, since a large part of the training takes place in a practical manner at preclinical simulation units and on patients in the clinical treatment courses. This training step, which takes place under the supervision and control of the dental teaching staff, is elementary to the acquisition of manual skills. Theoretical knowledge required to perform dental treatment is taught at Hannover Medical School by "blended learning" [4]. In its basic orientation, this concept consists of a hybrid of conventional face-to-face teaching and teaching content which is available online [7, 15, 38]. This teaching concept allows a clear temporal structuring of the student's daily routine; in addition, the student is comprehensively supported in his self-study by the provision of digital teaching information without time constraints [17, 30]. During the COVID-19 pandemic, the original teaching content of face-to-face courses was completely digitized at short notice at the start of the semester on 20.04.2020 in order to be able to offer the students adequate distance teaching in the absence of practical teaching units. This teaching method is characterized by the use of one and or more technical means to bridge the physical separation between lecturer and students [18, 26]. However, in contrast to medical and dental students in preclinical semesters, this "distance learning" should not be asynchronous for students in clinical semesters, but should continue on a synchronous way for clear organization of the daily routine and continuity of direct, simultaneous interactivity between students and teaches [12, 44]. An overview of different modalities of synchronous and asynchronous teaching is shown in Figure 1. During the planning process, different providers of web conferencing systems were compared with the aim of finding a practicable, user-friendly and privacy-compliant software that allows online seminars to be espediently used in teaching. The online seminars allow to follow the scheduled timetable, also virtual attendance tools can be used to document student attendance, which is necessary, for example for the acquisition of the qualification in radiation protection [60]. In addition, despite physical isolation, a sense of social cohesion can still be created through interaction opportunities with the lecturer and fellow students. An overview of all advantages and disadvantages of synchronous and asynchronous teaching is shown in Table 1. The basic assumption that students can generally be classified as technology-savvy "digital natives" due to their young age cannot be readily accepted due to the heterogeneity within the student body [5, 50]. Neverthe-

		Timing	
		Synchronous Teaching	*Asynchronous Teaching*
Modality	*Online*	Online seminar	Learning Management System
	Offline	Face-to-face	Printed, sent out

Figure 1 Learning modalities of synchronous and asynchronous teaching in comparison, modified from [12].

	Synchronous Teaching		**Asynchronous Teaching**
	synchronous online (online seminar)	**synchronous offline (face-to-face)**	**asynchronous online/ offline**
Advantages	– lecturer presence (verbal) – real time feedback – everyday structuring – spatial independence – ability to archive – increased question motivation	– instructor presence – real time feedback – everyday structuring – collaborative exchange – real "face-to-face" interaction – lower drop-out rate	– individual time management – arbitrary access/ flexibility – indirect interaction possible – promotion of self-study – learning diversification – self paced study – considered communication
Disadvantages	– physical isolation – drop-out rate increased – need for: – technical equipment – technical know-how – technical painting functions, if applicable – reduced non-verbal, extra-/paralinguistic signals	– spatial limitations – spatial dependence – travel distance/ mobility costs – one time experience – strict time planning – time window for questions limited – asking questions is not anonymous	– no multilayer interaction – responses delayed – time investment increased

Table 1 Advantages and disadvantages of synchronous and asynchronous teaching, modified from [1, 3, 11, 25, 29, 37, 39, 52, 54].



1. What gender are you?

- Male
- Female
- Divers

2. How old are you?

years

3. Which semester are you currently in?

- 2nd semester
- 4th semester
- 6th semester
- 8th semester
- 10th semester

4. Please answer the following questions.

	nein	ja
Do you have small children that you have to/had to take care of additionally in the home office? (due to e.g. pandemic-related kindergarten or elementary school closures)	○	○
Do you have an adequate workplace that allows you to participate in digital teaching without any hassle?	○	○
Do you have appropriate equipment for interactive participation in online seminars? (headset, microphone, webcam)?	○	○

5. Please indicate which technical device you used to participate in the digital teaching.

[Multiple answers are possible]

- ☐ Smartphone (<2 years)
- ☐ Smartphone (>2 years)
- ☐ PC/Tablet/Laptop (<3 years)
- ☐ PC/Tablet/Laptop (>3 years)

6. Please rate the following aspects using school grades.

	very good	good	satisfactory	sufficient	poor	unsatisfactory
Content of online seminars	○	○	○	○	○	○
Technical Quality of the online seminars	○	○	○	○	○	○
Interactions with the lecturers	○	○	○	○	○	○
Clarification of questions	○	○	○	○	○	○
Digital platform orientation	○	○	○	○	○	○

Figure 2a (Descriptive legend see under Figure 2b)

less, it must be noted that digital technologies are successively opening up all areas of life in a subtle, pervasive and invisible way, making a differentiation between virtual and real spaces increasingly untenable [27]. In addition to "lifelong learning", "ubiquitous learning", which is characterized by the convergence of learning locations and is also referred to as "seamless learning" when using mobile, digital devices, is becoming increasingly important in order to be able to develop new knowledge in a time-efficient manner [10, 56]. The simple exchange of learning locations is, of course, not yet an innovation driver itself, nor are digital teaching methods necessarily superior to conventional ones. However, if digital media are used adjuvantly to traditionally proven concepts, taking adequate, didactic methods into account, it can be assumed that synergistic effects have the potential to sustainably improve teaching [53]. As there are currently no findings on student perceptions of dental teaching preformed only digitally at the time of the COVID-19 pandemic, the aim of this study was to capture student perspectives using a questionnaire. The null hypothesis which was set forth is that there is no difference between the examined teaching formats (asynchronous vs. synchronous) in terms of satisfaction measured by a sum score containing 33 questionnaire items and the evaluation of core aspects using school grades.

2. Methods

During the present study on the qualitative evaluation of asynchronous and synchronous digital teaching at Hannover Medical School (MHH) at the time of the COVID-19 pandemic, 359 dental students were invited by e-mail to complete an online questionnaire. The questionnaire was sent via the MHH e-mail distribution list, and all students received the questionnaire at the same time. In addition to a cover letter, each e-mail contained an individual serial number that allowed for one-time participation. The students were informed about the aim and the procedure of this study, the voluntary nature, as well as the whereabouts and the handling of their data by the participant information preceding the questionnaire. Consequently, informed consent can be assumed when answering the questionnaire. The survey instrument used was the MHH-internally hosted program SoSci-Survey (SoSci Survey GmbH, Munich, Version 3.2.05-i) to increase implementation objectivity. The online survey of students took place over a period of 3 weeks (25.05.2020–15.06.2020). A positive vote of the ethics committee of the Hannover Medical School is available (No. 9192_BO_K_2020).

2.1 Participants and software for online seminars

At the MHH, dental student are teached basic natural science subjects up to the preliminary dental examination after the 5th semester, with minor deviations, analogous to the students of human medicine in the model study program "HannibaL" (Hanoverian integrated professionally oriented adaptive curriculum). As a consequence, the two preclinical semesters (2nd and 4th) were educated with conventional or lectures including sound on the teaching platform "ILIAS" (Integrated Learning, Information and Work Cooperation System) in accordance with the requirements for asynchronous online teaching in medicine. The ILIAS system is the technical basis for e-learning at the MHH since the introduction of the HannibaL model study programme in the winter term of 2005/2006. In contrast to the 2nd and 4th semesters, dental teaching content for the 6th, 8th and 10th semesters was taught synchronously

7. Please comment on the following statements

	Do not agree at all	rather disagree	un-decided	rather agree	fully agree	I cannot judge
Access to the online seminars was easy.	○	○	○	○	○	○
The program used was clear and easy to use.	○	○	○	○	○	○
The program used allows for full interaction with the instructor.	○	○	○	○	○	○
The online seminar was fully audible.	○	○	○	○	○	○
The image quality always made it possible to read every word on the digital lecture slides.	○	○	○	○	○	○
It was easier to ask questions out of the anonymity at home.	○	○	○	○	○	○
Detached from clinical courses/seminars/internships, the concentration level is higher in the online seminars.	○	○	○	○	○	○
The free choice of location, the omission of practical courses and the absence of lab work/seminars/ practicals increases the motivation and the possibility to participate in online seminars.	○	○	○	○	○	○
I was less distracted.	○	○	○	○	○	○
Creating structured notes is easier during the online seminar than in a face-to-face event.	○	○	○	○	○	○
With increased opportunities for interactivity, I am motivated to prepare for the online seminars.	○	○	○	○	○	○
The possibility to work from home improves the "work-life balance" compared to the traditional classroom teaching.	○	○	○	○	○	○
The current situation allows for more intensive self-study.	○	○	○	○	○	○
The comprehensive and early availability of lecture slides on the ILIAS teaching platform was beneficial.	○	○	○	○	○	○
Digital teaching makes me feel more prepared in terms of course content.	○	○	○	○	○	○
I prefer to learn as part of a team and am now afraid of being left behind.	○	○	○	○	○	○
In the context of digital teaching, I have improved my ability to organize myself to be in the right "place" at the right time.	○	○	○	○	○	○
Digital teaching makes me feel isolated.	○	○	○	○	○	○
The online seminars are well structured and clearly understood.	○	○	○	○	○	○
Online seminars allow for discussion.	○	○	○	○	○	○
I made intensive use of all the lecture slides made available on ILIAS.	○	○	○	○	○	○

Figure 2b Questionnaire with 33 items with closed questions to collect basic information (age, gender, current semester, technical equipment of the home office, disturbing factors) and 21 Likert-type questions to evaluate online teaching, 5-point scale ("I cannot judge" = 1, "do not agree at all" = 2, "rather disagree" = 3, "undecided" = 4, "rather agree" = 5, "fully agree" = 6). The response options to statements 16 and 18 had to be recoded ("strongly disagree" = 6, "strongly disagree" = 5, "undecided" = 4, "strongly agree" = 3, "strongly agree" = 2).

using online seminars. The open source video conferencing application "Jitsi meet" (Emil Ivov; Version 2.10 Build 5550) was used for very few courses, but in direct comparison with "Microsoft Teams" (Microsoft Corporation, Redmond, Washington, USA, Version 1.3.0) it proved to be less suitable for groups of 20 or more participants. Consequently, the open source programm was only used to instruct small groups in the phantom head course of conservative dentistry, but not as a teaching instrument for significantly more participants in lectures within the semester or lectures across all semesters. The program "Microsoft Teams" was used for all other lectures within the Clinic of Dental, Oral and Maxillofacial Medicine (phantom head course of conservative dentistry, course of dental prosthodontics I, integrated clinical course, dental diseases I, clinic of dental, oral and maxillofacial diseases I, orthodontic treatment course II), with the lectures being held according to a timed lecture plan. The students had to log in independently at the respective start time of the course, and attendance was checked using the chat function of the program.

2.2 Questionnaires

In order to assess student perception and satisfaction with asynchronous as well as synchronous teaching at the time of the COVID-19 pandemic, a fully standardized questionnaire (cf. Fig. 2) with 33 items was developed, as existing instruments for assessing learning environments, such as the Dundee Ready Education Enviroment Measure (DREEM), the Dental Student Learning Enviroment Survey or the Dental Clinical Learning Environment Instrument (DECLEI) were not sufficiently satisfactory [21, 28, 43]. Thus, in addition to the literature review, feedback from students and the opinions of two experts from the dental faculty at MHH were relevant for item development. In addition to closed questions to collect basic information (age, gender, current semester, technical equipment, disruptive factors), 21 Likert-type questions for the multifaceted evaluation of online teaching could be answered by means of a 5-point scale ("do not agree at all" = 2, "tend to disagree" = 3, "undecided" = 4, "tend to agree" = 5, "fully agree" = 6) and an additional "don't know" category ("cannot judge" = 1). Based on the coding of these ordinally scaled questions, a sum value was formed, which as a global parameter indicates the students' satisfaction with the online teaching that took place. Out of the 21 question items, two statements (16. I prefer to learn in a team and am now afraid of missing the connection; 18. I feel isolated due to digital

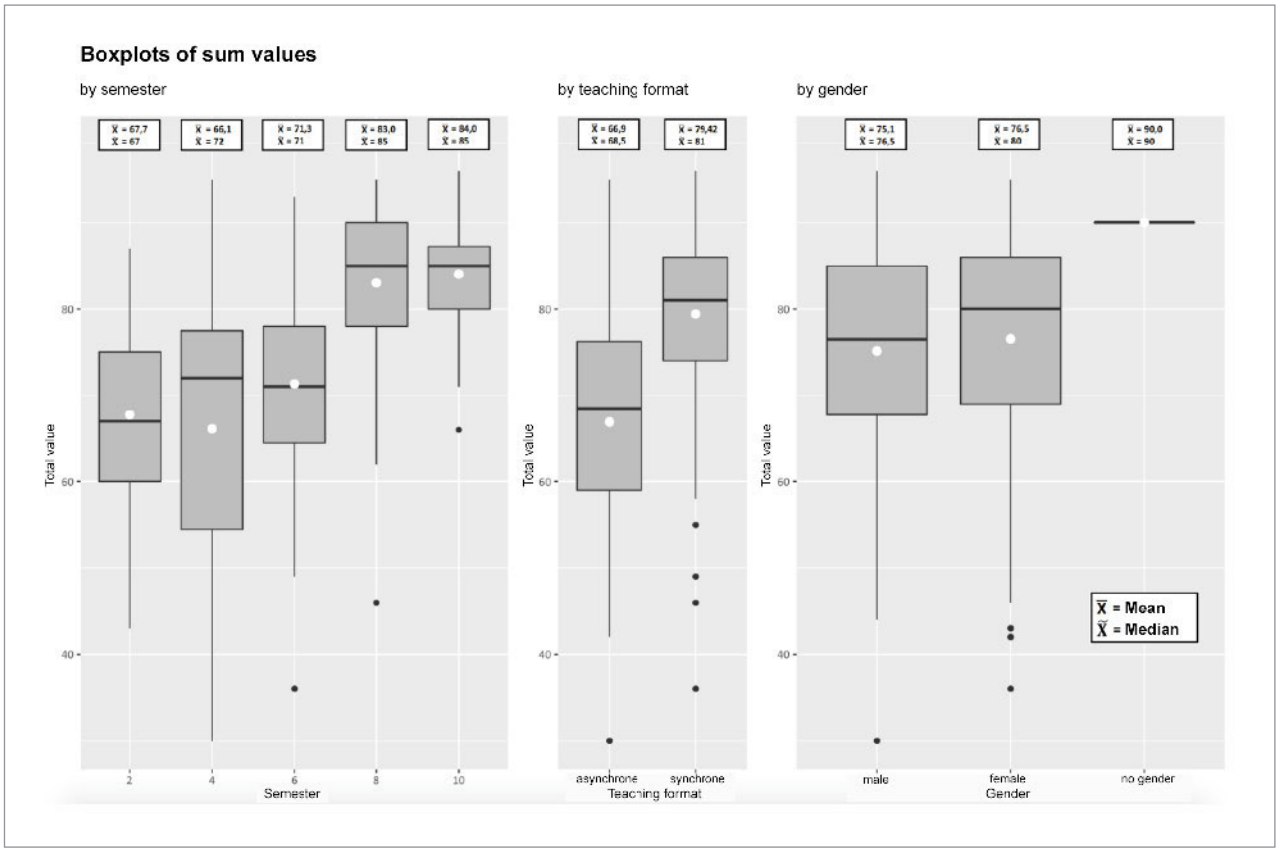


Figure 3 Results of summative value calculation by semester, teaching format, and gender.

teaching) had to be recoded due to their negative connotation ("do not agree at all" = 6, "rather disagree" = 5, "undecided" = 4, "rather agree" = 3, "fully agree" = 2). As a result of the findings of a factor analysis (cf. paragraph 2.4), 5 items (6, 14, 17, 20, 21) were excluded from the sum value calculation. An increased total score in the evaluation was interpreted as meaning that the implementation of digital teaching tended to be perceived more positively by the students. A score of 80 had to be reached ("tend to agree", 16 × 5) to conclude a positive perception. A maximum of 96 points could be achieved ("fully agree", 16 × 6). The final questions allowed the students to evaluate the teaching carried out using classic school grades ("very good" = 1, "good" = 2, "satisfactory" = 3, "sufficient" = 4, "poor" = 5, "insufficient" = 6) with regard to the following aspects: Content, technical quality, interaction potential with the instructor, the clarification options for questions, and general orientation on the digital platform.

2.3 Statistical analyses

Statistical analysis of the questionnaire was performed using RStudio software (RStudio PBC; Boston, Massachusetts, USA, version 1.2.5033) and R (version 3.6.3) [41, 46]. Furthermore, the distribution functions of the data were analyzed using the Kolmogorov-Smirnov test and, for non-normally distributed data, the Mann-Whitney-U-test was used to test for differences in central tendency (significance level $\alpha = 0.05$). Individual questions were analyzed by Chi-square test. The following R packages were used for data analysis and creation of graphs: "tidyverse" [57], "likert" [9], "HH" [20], "colorspace" [58], "lattice" [47], "lavaan" [45], "psych" [42].

2.4 Factor analysis

An exploratory factor analysis was conducted to investigate the internal structure of the questionnaire. Using principal component analysis with orthogonal varimax rotation, 4 factors were initially extracted in the course of data reduction. Following the interpretation criteria defined by Schönrock-Adema et al. (point of strongest bend in the scree plot, eigenvalue criterion > 1.5, minimum 3 items per factor, factor loadings ≥ 0.5 per item), one factor as well as 5 questions (6, 14, 17, 20, 21) had to be excluded from the sum value calculation [49]. The first factor describing the seminar structure includes 6 items (1, 2, 3, 4, 5, 19). The second factor includes the items (12, 13, 15, 16, 18) and summarizes extrinsic, person-related characteristics, while the third factor (7, 8, 9, 10, 11) bundles intrinsic characteristics. Overall, the three-factor model can explain 54 % of the total variance. Finally, the confirmatory factor analysis applied to validate the given factor structure yielded an acceptable model fit (CFI = 0.94, RMSEA = 0.064) [8, 24].

3. Results

At the end of the survey period (25.05.2020–15.06.2020), the response rate was 56 % (response: 204/total questionnaires being send: 359) of the students surveyed (2nd

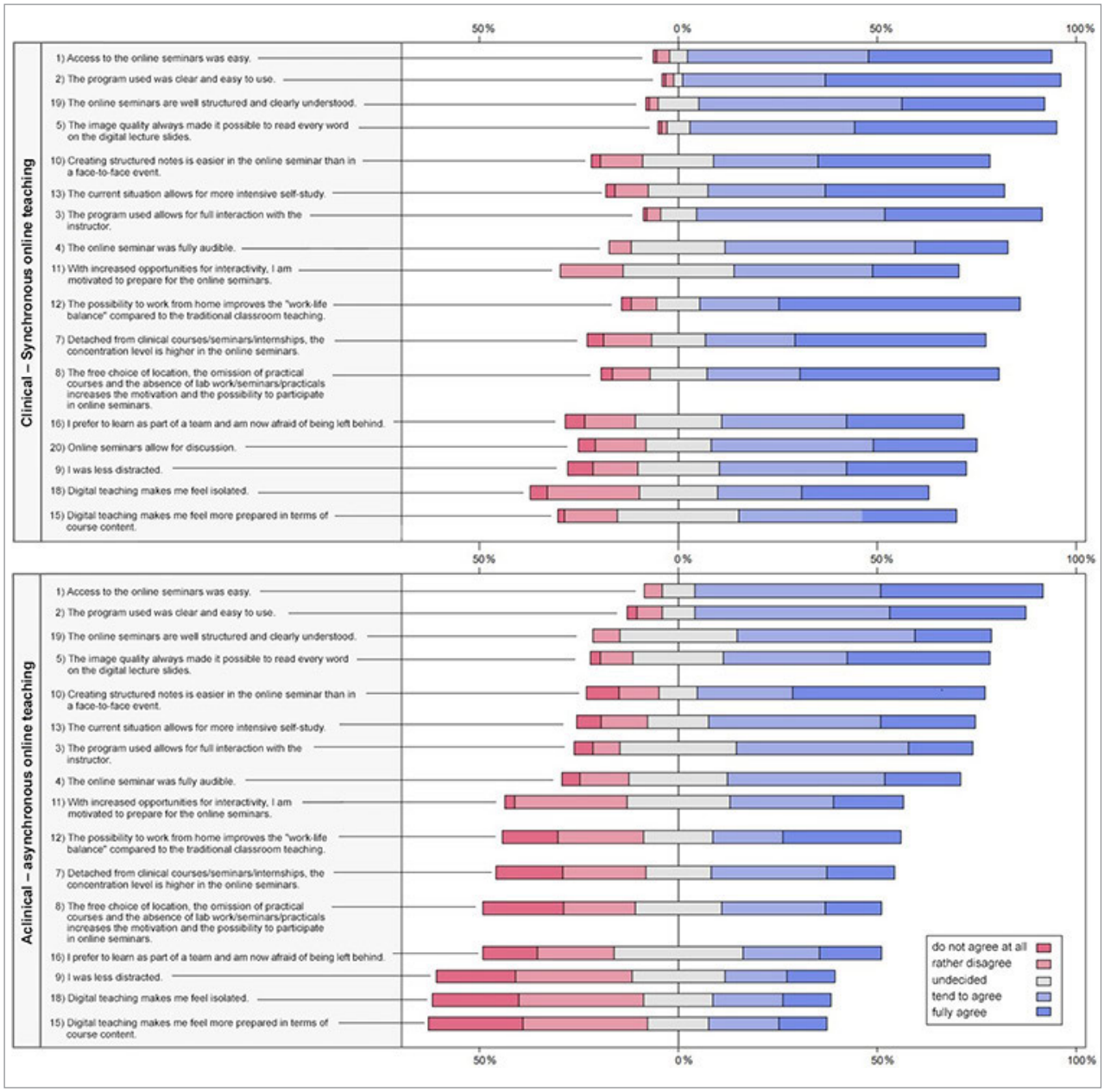


Fig. 1–4, Tab. 1 and 2: M. Crome

Figure 4 Comparison of online teaching questions in preclinical (asynchronous) and clinical (synchronous) settings.

semester (24/78), 4th semester (29/76), 6th semester (49/66), 8th semester (47/64), 10th semester (55/75)). The participation rate of clinical semesters (6th, 8th, 10th) was higher than that of preclinical semesters (2nd, 4th), namely 73 % (151/205) vs. 34 % (53/154). Overall, 72 % (147/204) of the participants were female, 27 % (56/204) male, 0 % diverse. One participant did not indicate his gender. The mean age of all participants was 23.6 ± 3.7 years (2nd semester = 21.8 ± 3.6/4th semester = 22.1 ± 4.2/6th semester = 23.8 ± 3.3/8th semester = 24.2 ± 3.0/10th semester = 26.5 ± 4.5). Regarding the sum value, an average of 66.9 points (median 68.5) could be determined for the preclinical semesters (asynchronous teaching concept) vs. 79.4 points (median 81) for the clinical semesters (synchronous teaching concept). Thus, the difference is 12.5 (median 12.5) points, with a significant difference between the groups (asynchronous vs. synchronous teaching concept; Mann-Whitney-U-test: $p < 0.001$). The sum score calculation is shown in Figure 3. Twelve students, 9 of them female, indicated that they had to care for children at home in addition to their studies due to pandemic-related kindergarten or elementary school closures (4th semester: one female student, 6th semester: 3 female students, 8th semester: 4 female and one male student[s], and one unspecified parent, 10th semester: one female and one male student[s]). Due to the small sample size, it was not possible to assess whether there was a statistical relationship between potential stress due to simultaneous childcare and work performance (distraction potential, ability to concentrate). However, evaluated purely descriptively, 10 of the students with

Teaching format	Content	Clarification of questions	Orientation	Interaction	Technology
Preclinical, asynchronous teaching	2.21 (n = 52)	2.47 (n = 51)	2.42 (n = 52)	2.80 (n = 51)	2.62 (n = 52)
Clinical, synchronous teaching	1.72 (n = 151)	1.74 (n = 151)	1.93 (n = 151)	2.13 (n = 151)	2.14 (n = 151)
Kolmogorov-Smirnov-Test	0.0821	0.0028	0.0929	0.0074	0.0271
Mann-Whitney-U-Test	$p < 0.001$	$p < 0.001$	0.004	$p < 0.001$	$p < 0.001$

Table 2 Grading of online teaching according to the school grading system (mean/n= number of responses evaluated) and statistical evaluation of the comparison preclinical (asynchronous teaching) vs. clinical (synchronous teaching).

children indicated that their work-life balance was improved, and 8 of them also seem to have been less distracted during an online seminar despite the presence of children. Regarding home office conditions, 92% (188/204) of students had a workspace that allowed them to participate in digital teaching without disruption. Furthermore, 90% of the respondents also had the necessary technical equipment (headset, microphones, webcam) to participate interactively in the online seminars. Nevertheless, 4 students stated that they had neither an adequate workstation nor communication hardware (2nd semester: 2 students, 8th semester: one student, 10th semester: one student). 87.7% of the students ("agree" = 91, "strongly agree" = 88) were satisfied with the accessibility of the online seminars, regardless of whether they used an old (>3 years) or a new (<3 years) technical device (PC, tablet, laptop). These conventional devices were used by 98.5% of participants, with 34.3% of students also following the online seminars using smartphones. Eight students (3.9%) indicated that access had not been unproblematic for them. The ability to interact with the lecturer was considered unrestricted by 76.5% of the students and was rated 2.30 across semesters. Nevertheless, discrepancies in two-way interaction appear to be present, as successful answering of questions was rated 1.74 in the clinical, synchronously taught semesters, whereas the preclinical, asynchronous semesters only rated 2.47. This difference turns out to be significant (compare Table 2). Although only 36% of the students stated that they found it easier to ask questions from the anonymity at home, 62.7% were in favor of the fact that they achieved a higher depth of concentration in online seminars and were less often distracted (52.4%). An overview of the responses to questions about online teaching in the preclinical (asynchronous) and clinical (synchronous) settings is shown in Figure 4. In addition, in a direct comparison of the preclinical (asynchronous concept) to the clinical (synchronous concept) setting, a significant difference in central tendency was found in the evaluation of content and orientation (compare Table 2). Looking at the details, there is a statistically significant difference between the presence of equipment (headset, microphones, webcam) and the grading of content, technique as well as general orientation; Mann-Whitney-U-Test: content ($p = 0.00962$), technique ($p < 0.001$), orientation ($p < 0.001$). If equipment is present, significantly better scores were given: Content (mean 1.7 vs. 2.3), Technique (mean 2.20 vs. 2.89), Orientation (mean 1.97 vs. 2.89).

4. Discussion

The purpose of this questionnaire-based study was to assess student beliefs regarding ad hoc, synchronous online teaching compared to asynchronous teaching in dentistry at the time of the COVID-19 pandemic. This revealed that dental students, regardless of gender, generally viewed both asynchronous and synchronous online teaching favorably. Since the statistical analysis of the results showed that there is significant difference between the two teaching formats, the null hypothesis has to be rejected. In addition to statistically significant differences in the comparison of the total values, differences could also be observed in the allocation of grades with regard to the ability to interact, clarification of questions and technique (cf. Tab. 2). However, it must be taken into account that students from the preclinical phase were compared with those from the clinical phase of dental studies and therefore the setting was not homogeneous. In addition, the participation motivation of students in preclinical semesters was significantly reduced compared to students in the clinical study section ($\Delta = 39$ %). Furthermore, the more critical view of the asynchronously instructed students can possibly be explained by the fact that the questionnaire was intentionally oriented towards synchronous online teaching, in the form of online seminars, which is why the asynchronously instructed participants could not have found themselves fully reflected in the questions. This consideration is supported by the fact that in the preclinical phase 7% of the questions were marked as not assessable, whereas in the clinical phase the percentage was only 2%. On the other hand, however, it can be argued that this circumstance is due to the different characteristics of the two forms of teaching compared. For example, asynchronous teaching does not provide for real-time feedback, which is why it seems plausible at first glance that the preclinical students were un-

able to answer the questions regarding the feasibility of discussions, as well as the unrestricted ability to interact with the lecturer, in the conventional, synchronous sense. However, it must be noted at this point that the students were offered sufficient communication possibilities through the learning platform "ILIAS" or via e-mail, which would have been ideally suited for asking clearly formulated, targeted questions without time pressure [23]. Thus, it is surprising that the Likert-question to elicit the willingness to ask questions from the anonymity at home was not considered assessable by 22.6 % of the students in the preclinical phase, since especially "distance learning" can be advantageous for shy students, among others [32]. Since the questionnaire design deliberately offered an additional "don't know" category in addition to the content-related response option "undecided" as the scale midpoint, so that students without a relevant attitude would not be forced to make a content-related statement, it cannot be conclusively assessed to what extent any satisficing behavior, ignorance of the communicative possibilities, or lack of question comprehension had an effect [16]. The literature review on asynchronous and synchronous online and face-to-face teaching showed that there is no significant difference between the teaching formats in terms of learning success and student satisfaction [22, 40, 33, 36]. This finding could be confirmed for dentistry by a meta-analysis from the field of orthodontic teaching [31], but is not confirmed by the results of this study, as there was a significant difference between the two teaching formats (asynchronous vs. synchronous). According to this, teaching formats are vehicles for transporting knowledge, each with characteristic properties (compare Table 1), which should be selected depending on the circumstances and the content to be taught, so that they can then have a positive effect on learning success in a specific teaching constellation [36]. However, in terms of learning success, the regular and continuous interaction of students with the learning material is far more important than the chosen teaching format [35]. In this context, oral participation, i.e., direct interaction with the lecturer, but also with fellow students, seems to be closely related to the process of learning [2, 14]. In this respect, this correlation can also be drawn from the evaluation of the preclinical students, where the acquisition of competences was rated worst together with the opportunities for discussion and asking questions. Considering the fact that basic knowledge is taught in preclinical courses, which at most belong to the category of declarative knowledge acquisition, the students' perception seems to be atypical at first glance, since an asynchronous teaching format seems to be beneficial for conveying this content. Thus, just the arbitrary viewing of the content by pausing or rewinding the lectures, completely in the sense of "self-paced-learning", is advantageous [19]. Furthermore, the learning success and the engagement of the students is influenced by the feeling of belonging to a group [6, 13, 51]. This social affiliation is put to the test by the geographical-physical separation during distance learning. Moreover, an asynchronous setting creates a more difficult learning situation due to time delays or a communicative exchange reduced by paralinguistic signals, but the dental students did not consider this particularly isolating. Distraction potential scored significantly worse in terms of evaluation. Why the preclinical students saw themselves significantly more distracted compared to the clinical students cannot be plausibly explained. Similarly, regarding work-life balance, asynchronous online teaching actually still allows students a higher degree of flexibility and convenience compared to synchronous online teaching, as there are no time constraints to adhere to [48]. Interestingly, clinical students taught synchronously according to a strict schedule nevertheless rated their work-life balance significantly more positive than preclinical students did. A possible explanation can be that the students in the preclinical semesters possibly had to invest more time in their self-study and therefore could not use the time saved profitably, for example, by not having to travel to and from the place of study. On the other hand, students in the clinical semesters also indicated that they would invest more time in self-study, which again puts the explanatory approach into perspective.

5. Conclusion

The necessary restructuring of conventional, presentation-based teaching in dental education at the time of the lock-down during the COVID-19 pandemic was rated positively by students overall. Synchronous teaching approaches were rated significantly better than asynchronous teaching approaches. Nevertheless, based on the results of this questionnaire-based teaching study regarding the overall satisfaction of dental students, the respective teaching format should be selected according to the students' learning situation. However, because the external validity of this work is not comprehensively given due to the chosen setting, the results obtained can only be generalized to dental students at the Medical School.

Conflict of interest

The authors declare that there is no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

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60. § 49 Absatz 5 StrlSchV

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