

Teaching medical microbiology during the COVID-19 pandemic: perceptions of medical undergraduates and the effects of online learning

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Abstract

Background:

The coronavirus disease 2019 (COVID-19) pandemic has imposed unprecedented hurdles to health care systems and medical faculties alike. Lecturers of practical courses at medical schools have been confronted with the challenge to transfer knowledge distantly. We sought to evaluate the effects of an online learning alternative to the traditional medical microbiology course.

Methods:

During the summer term 2020, medical students at the University of Saarland, Germany, participated in an online-only course in medical microbiology. Teaching content comprised clinical scenarios, theoretical knowledge and instructive videos on microbiological techniques. Test performances, failure rates, and student evaluation, including open-response items, of the course during the summer term 2020 were compared to the summer term 2019.

Results:

Student performance was comparable between both the online-only group and the comparator for both the written (average grades 7.6 vs. 7.3; $p=0.1985$) and the oral exam (33.6 vs. 33.4, $p=0.7749$). Failure rate did not significantly differ between the online-only group and the comparator group (2.4% vs. 3.3%). While lecturer expertise was graded similarly high from students of both groups, students from the summer term 2020 gave lower grades for interdisciplinarity, possibilities for interaction, and the extent to which the educational objectives were defined. Main critiques formulated within the open-response items concerned organizational deficits.

Conclusions:

Online-only courses in medical microbiology are a feasible teaching option, especially in the setting of a pandemic, leading to similar test performances in comparison to traditional courses. The lack of interaction and sustainability of acquired manual skills warrant further research.

Background

The coronavirus disease 2019 (COVID-19) pandemic, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is arguably one of the biggest crises of modern times, with a multitude of repercussions on societal, economic, and medical systems [1]. A considerable fallout has affected school and University education alike. In many countries, primary and secondary schools were closed during the first pandemic wave in spring 2020 [2–4], and the majority of Universities were equally overrun by the inciting incident [5]. Without a ready-made alternative plan, medical faculties suspended on-site education and were forced to hastily provide provisional materials in online platforms [6]. While the predominantly theoretical contents of pre-clinical courses can be regarded as more easily adaptable to an

online format, lecturers of practical courses struggle substantially pertaining to distant transfer of knowledge and manual skills [7]. As such, medical (or clinical) microbiology is a subject containing both theoretical knowledge and practical skills. Moreover, it is a subject that is not only critical for diagnostic purposes, but also to the understanding of diseases caused by emerging pathogens such as bacteria, fungi or viruses. Thus, it carries an inherent importance for medical students and hence future physicians, especially in face of future potential pandemics and the already prevalent shortage in microbiologists and infectious disease specialists [8, 9].

Although some literature on adapted medical education has cumulated since the beginning of the pandemic [10–14], data on the specific hurdles to implement online or distant learning in medical microbiology during the COVID-19 pandemic are scarce. Previously, additional online-learning for medical microbiology had been shown to be beneficial for student performance in a before-and-after study from Dublin [15] in the pre-pandemic era. Here, we sought to evaluate student perceptions and the effects of an online-learning alternative to the traditional medical microbiology course from a single center in Germany during the first wave of the COVID-19 pandemic in 2020.

Methods

During the summer term 2020 (April – July 2020), medical students at the University of Saarland, Germany, participated in a novel, online-only course in medical microbiology, delivered via modular object-oriented dynamic learning environment (Moodle™). Teaching content comprised lectures with audio recording; clinical scenarios, including high-resolution imaging of agar plates and Gram stains; and instructive videos on microbiological techniques (see Supplemental Figure S1-S4). Techniques that were video-captured included: performance of a Gram staining; catalase, coagulase, and oxidase tests; doing streak and spread plating. Photographs and videos were captured with a Panasonic Lumix DMC GH4 (Panasonic Corporation, Kadoma, Japan), and a Sigma 18–35 mm f/1.8 lens (Sigma Corporation, Setagaya, Japan), adapted with a MFT T Speed Booster XL (Metabones, Kowloon, Hong Kong). Videos were edited with iMovie (Apple Inc., California, USA).

Test performances, failure rates, and student perception and satisfaction of the summer term 2020 students were compared to the summer term 2019 students. Both cohorts were at the same academic time point in terms of academic standard at the beginning of their respective course.

Examinations

The written exam was performed paper-based, in-person and consisted of 10 multiple-choice or open-item questions, covering the topics medical microbiology, infectious diseases, infection prevention and control, and vaccinations (maximum of 10 points). The in-person oral exam included questions to 5 thematic complexes from the domains described above with a maximum score of 40 points. In addition, a written exam on virology has to be taken as well (maximum of 10 points). In total, the pass/fail score is $\geq 60\%$ (36 of 60 points). Of note, students can choose to postpone either written or oral exam to a later

timepoint or term. For the assessment of the failure rate, only students were taken into account that took both written exams and the oral exam.

Evaluation

Course evaluation by the students was assessed using a 5-point likert scale and open text questions using an online platform. Invitations were distributed via e-mail. The open text answers from the students of the summer term 2020 were analyzed concerning their predominant value, either positive or negative, and simultaneously grouped into the following domains: Interaction between students and faculty; practical contents of the course; organizational aspects; and quality of contents.

Statistics

Statistical analyses were performed with GraphPad Prism (Version 8.0; GraphPad Software Inc., CA, USA), utilizing t test for continuous variables and Fisher's exact test for categorical data. The statistical significance level was set at 0.05.

Ethical considerations

All data were obtained during provision of student education. All data analyses were carried out in accordance with relevant regulations. No administrative permissions were required to access raw data used in this study. Course evaluation by students was conducted anonymously and voluntarily. All data used in this study was completely anonymized. Since no individual, identifiable student data including biomedical, clinical, and biometric data were used, no ethical committee approval and no informed consents were necessary.

Results

Exam results

In 2020, 100 students took the written exam, and 86 took the oral exam, and the number of students who took both the written and the oral exam was 84. In 2019, 139 students took the oral exam, and 131 students took the written exam, while 120 students took both exams. The mean score for the written exam was 7.6 (standard deviation, SD 1.7; median 8, 95% confidence interval, CI 6–9) for 2020 and 7.3 (SD 1.8; median 7, 95%CI 6–9) for 2019, respectively ($p = 0.1985$) (Fig. 1A). The mean score in the oral exam was 33.6 (standard deviation, SD, 4.9; median 35, 95%CI 30–38) for 2020, and 33.3 (SD 4.8; median 34, 95%CI 30–37) for 2019, respectively ($p = 0.7265$) (Fig. 1B)

Failure rate

There was no significant difference in the fail rate between both years. In 2020, a total of 2/84 students failed the exam (failure rate 2.4%), compared to 4/120 students in the 2019 summer term (3.3%; $p = 1.0$).

Course evaluation by students

Evaluation was completed by 96 and 32 students for the years 2019 and 2020, respectively. While lecturer expertise was graded similarly high from students of both groups, students from the summer term 2020 gave lower grades for their perception of the course's relevance for the exam; its interdisciplinarity; the motivation of the lecturer; and the knowledge gain they had from the course (Table 1; Figs. 2 and 3). Differences were more distinct for the aspects "quality of the course material and content"; "possibilities for interaction"; "intelligibility and clarity"; and "extent to which the educational objectives were defined" (Table 1; Figs. 2 and 3). We asked for the level of challenge posed by the course perceived by the students. While a similar proportion of students of both 2020 and 2019 regarded the educational challenge of their respective course as adequate (18/31 vs. 56/94; not significant), 19/31 (61.3%) students in 2020 stated that they would recommend the course, compared to 73/90 (81.1%) students in 2019 ($p = 0.0488$).

Open text answers

The main critique concerned organizational aspects (32 negative mentions vs. 1 positive mention), including collision of exam dates with other subjects, short-term delivery of information and content, and time constraints with regards to the exam preparation period. Furthermore, the lack of practice was criticized (2 negative mentions), although it was acknowledged that this was due to the special circumstances. Of note, the possibilities of interaction were graded predominantly positive (2 negative vs. 5 positive mentions) in the open text answers. Similarly, the quality of content received 10 negative and 22 positive remarks. We specifically analyzed mentions of the unique multimedia contents, hereby identifying 16 additional positive mentions.

Discussion

In the present study, which was performed under real-life pandemic circumstances, we showed that an online-only medical microbiology course for undergraduates led to comparable learning outcomes measured by exam results as a conventional course, even though several aspects of the online course were evaluated with significantly lower scores by the students. In addition, the course was met with discontent owing to mainly organizational drawbacks.

The undisputed challenges posed by the COVID-19 pandemic demand for quick and feasible solutions for students of all levels and subjects on a global scale.

In a survey study from California, Sharvini and colleagues had reported that medical undergraduates, although they appreciated the more flexible way of learning, still perceived pre-clinical remote learning overall as disadvantageous pertaining to the lack of participation possibilities [16]. Of note, their study revealed that "quality of instruction" is a recurrent issue, as observed in our study, that merits further attention in order to improve distant learning experiences.

Depending on the geographical background of students, other challenges may also be prevalent, such as technical, infrastructural, or financial issues [17]. Although online elements can not only be beneficial for

student performance in medical microbiology courses as shown previously [15], student perception has been reported to be in favor of a blended approach which combines the advantages of both the self-paced online learning and the in-person instructions in a lab environment [18].

There are several strengths of our study. To the best of our knowledge, this is the first study to assess the hurdles for medical microbiology faculty during the COVID-19 pandemic and the feasibility of an online teaching alternative while simultaneously monitoring the transition from in-person to online teaching formats. Furthermore, our approach contained an in-depth qualitative analysis of students' perceptions, which may help to deliver improved undergraduate education in the terms to come. This is especially true, since further restrictions of on-site teaching are to be expected due to the presence and increasing predominance of SARS-CoV-2 variants, e.g. B.1.1.7, with increased transmissibility and, supposedly, case-fatality encountered in many countries already in late 2020 and early 2021 [19].

Our study has also limitations. First, this is a single center experience from one country, which may limit its generalizability. Second, the non-inferior exam results during the pandemic term may have been influenced by a more generous approach of the examiners than in the previous year, owing to an inherent understanding for the students' difficult situation. Third, we analyzed the summer term 2020, which already dates back several months, while modes and methods of online learning have rapidly evolved since the beginning of the pandemic. Hence, even more modern technologies are available and accepted for both undergraduate and postgraduate teaching [20–23]. Furthermore, course evaluation by the students was voluntary, leading to smaller number of respondents than students taking the respective exams. Last, not least, it has to be acknowledged that the course duration and hence the content had to be reduced, and although the multimedia content was appreciated, manual skills cannot be completely substituted by online learning alone.

The acceptance of online learning observed in our study may partly be explained by generational influences, as well. Students in 2020/2021 are presumably more open, acquainted, and comfortable with (social) media as a platform for knowledge transfer and dissemination than students from previous decades [22, 24–26].

The findings of our study are relevant for faculties and decision-makers in medical education, primarily, but not limited to, medical microbiology. Despite its largely devastating effects, the pandemic can be seen as a "catalyst of change" that also incited innovation, especially pertaining to (digital) education [27].

Conclusions

We showed that online undergraduate teaching in medical microbiology is partly feasible with the right tools, yet efforts have to be made to circumvent subpar organization, lack of face-to-face interaction, and limited participation possibilities. Besides, the lack of skills training is an undeniable issue that needs further focus, especially for subjects with a largely practical content. With the continuously unpredictable pandemic, it is highly conceivable that adaptations to medical curricula will be required both in the short- and medium term. Future studies should therefore focus on identifying the correct balance between

online and on-site training, evaluate the utility of novel tools and formats such as mobile phone applications, while also avoiding possible mismatches that can accrue due to the differences between the mode of teaching and the mode of assessment.

Abbreviations

CI: confidence interval

COVID-19: coronavirus disease 2019

SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

SD: standard deviation

Declarations

Ethics approval and consent to participate:

All data were obtained during provision of student education. All data analyses were carried out in accordance with relevant regulations. No administrative permissions were required to access raw data used in this study. Course evaluation by students was conducted anonymously and voluntarily. All data used in this study was completely anonymized. Since no individual, identifiable student data including biomedical, clinical, and biometric data were used, no ethical committee approval and no informed consents were necessary.

Consent for publication: not applicable.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: CP: conceptualization, data curation and analysis, interpretation, writing of the initial draft, review, editing. MS: data curation, review, editing. SLB: conceptualization, review, editing.

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Availability of data and materials: The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

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Tables

Table 1. mean grades (1= very good, 2=good, 3=moderate, 4=weak, 5=very weak) and standard deviation for different items

Item	2020 (n=32)	2019 (n=96)	p-value
"grade the expertise of the lecturer"	1.47 (0.62)	1.27 (0.55)	0.0848
"To what extent do you regard the course as relevant to the exam?"	1.78 (0.70)	1.33 (0.52)	0.0002
"grade the interdisciplinarity"	2.53 (1.19)	1.7 (0.73)	<0.0001
"grade the motivation of the lecturer"	2.59 (1.13)	1.43 (0.61)	<0.0001
"grade the knowledge gain from the course"	2.61 (1.05)	1.66 (0.77)	<0.0001
"grade the quality of the course material and content"	2.91 (1.28)	1.71 (0.8)	<0.0001
"grade the possibilities to ask questions and discuss"	2.91 (1.03)	1.46 (0.67)	<0.0001
"To what extent was the course intelligible and clear?"	3.13 (1.29)	1.7 (0.77)	<0.0001
"How well were the educational objectives defined?"	3.41 (0.95)	1.61 (0.76)	<0.0001

Figures

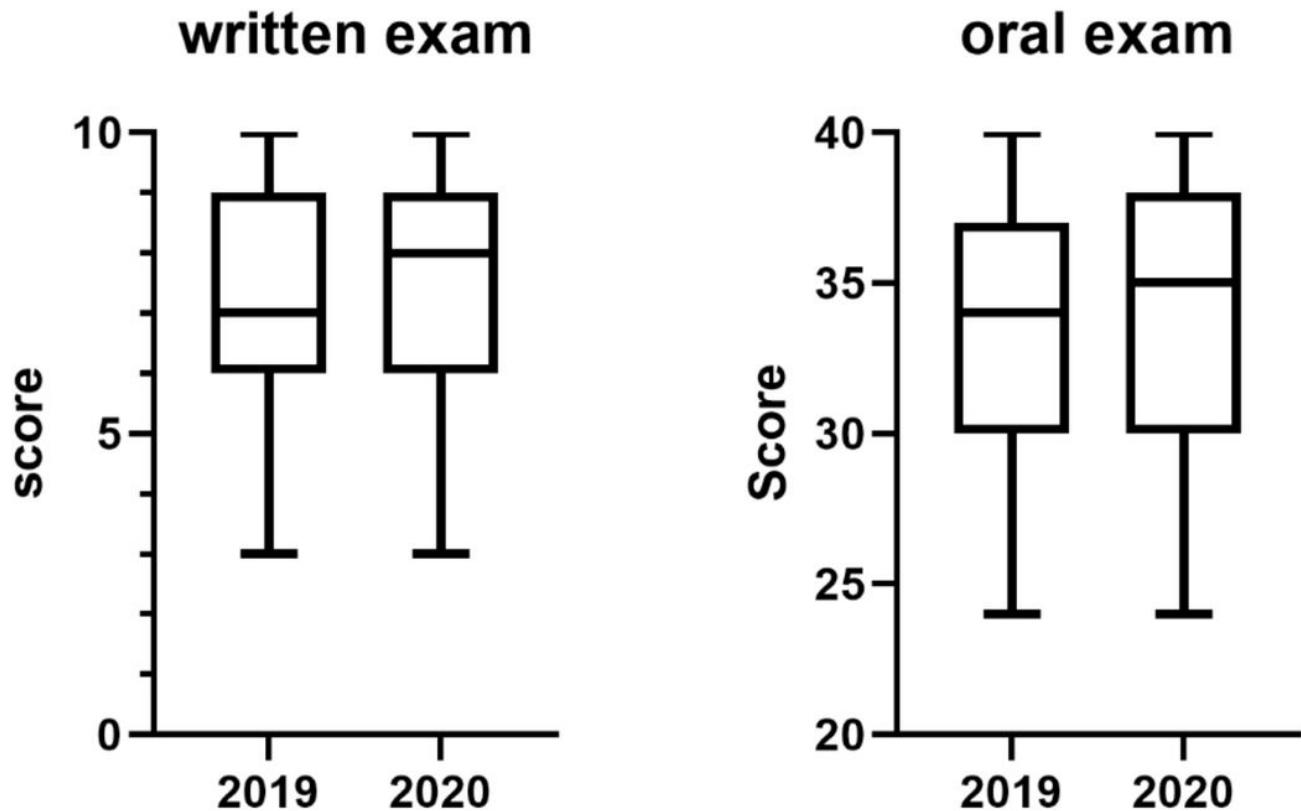


Figure 1

Whisker plots of the exam results for both years, written exam (left), oral exam (right).

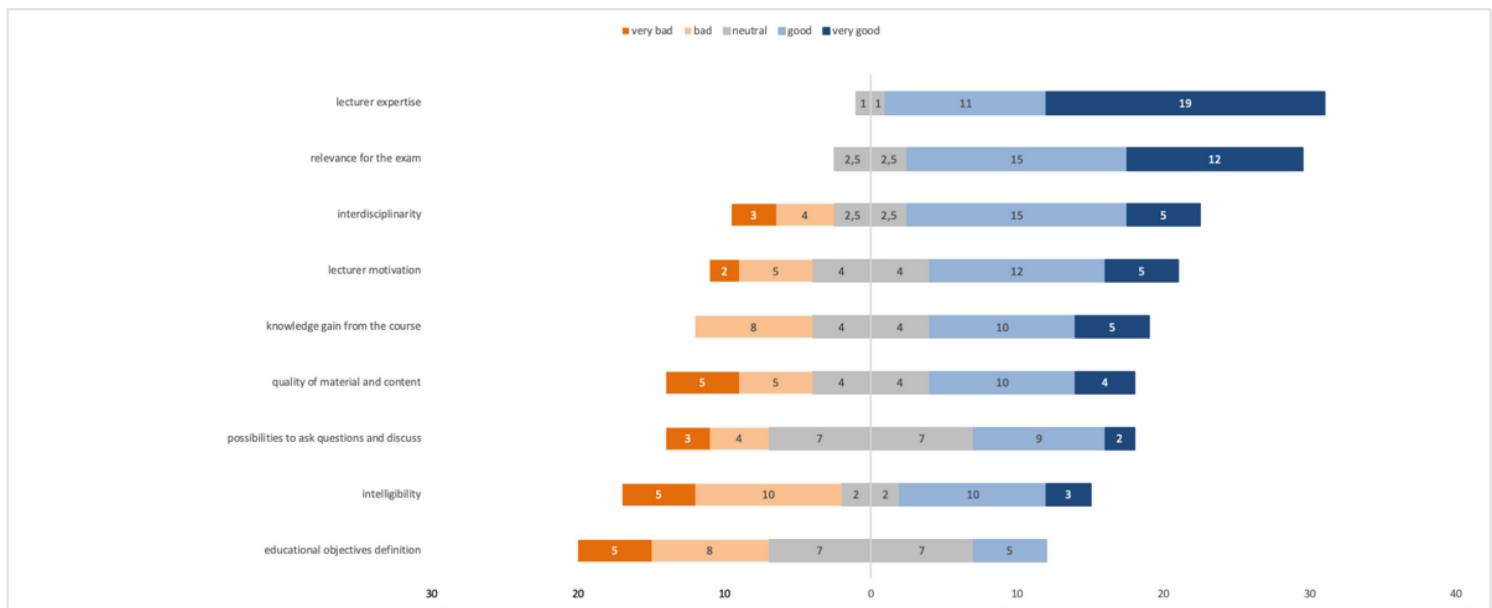


Figure 2

Distribution of the summer term 2020 students and their grading of the different aspects on a 5-point-Likert scale, from very bad (dark orange), to very good (dark blue).

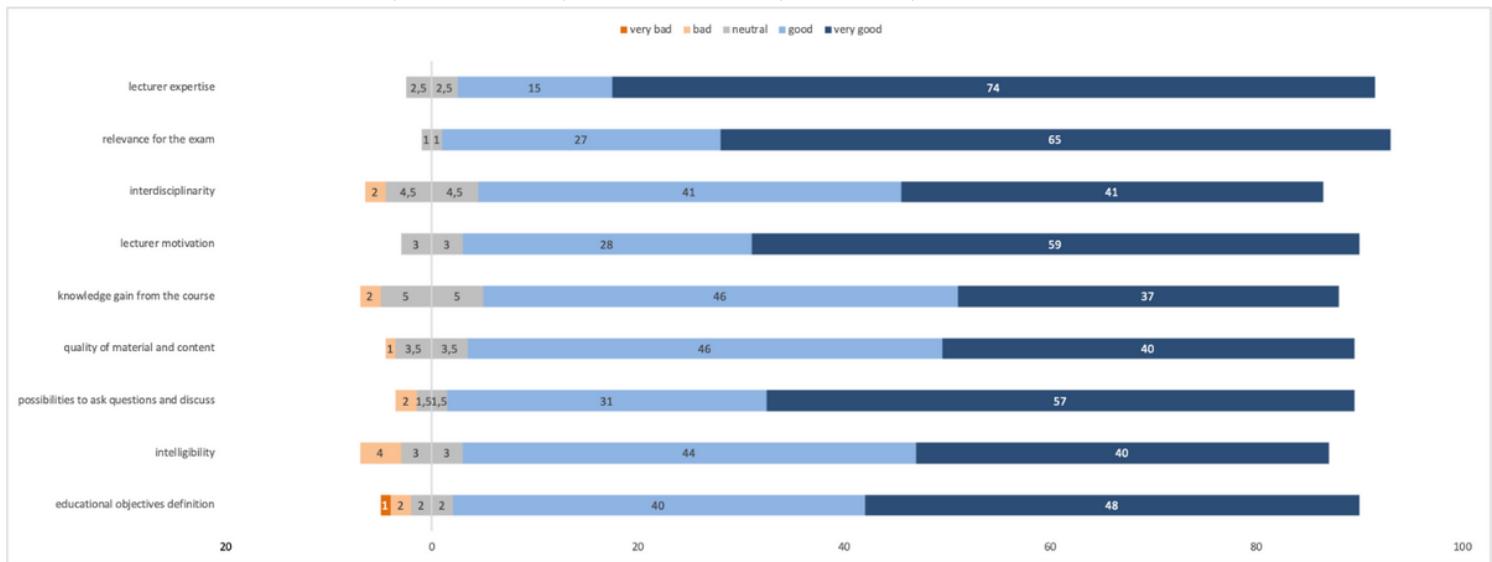


Figure 3

Distribution of the summer term 2019 students and their grading of the different aspects on a 5-point-Likert scale, from very bad (dark orange), to very good (dark blue).

Supplementary Files

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- Papanet.al.SupplementaryMaterial01.03.2021.docx