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Source / Izvornik: **Annals of Anatomy - Anatomischer Anzeiger, 2023, 246**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

https://doi.org/10.1016/j.aanat.2022.152043

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:105:056794

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Annals of Anatomy 246 (2023) 152043

Contents lists available at ScienceDirect

Annals of Anatomy

journal homepage: www.elsevier.com/locate/aanat

Research article

In the eye of the beholder – how course delivery affects anatomy education

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ARTICLE INFO

Article history:
Received 29 August 2022
Received in revised form 17 November 2022
Accepted 8 December 2022
Available online 20 December 2022

Keywords:
Anatomy
COVID-19
Hybrid courses
Medical education
Student evaluation of teaching
Student perception

ABSTRACT

Background: The COVID-19 pandemic caused major shifts in students' learning strategies as well as teaching environments that profoundly affected the delivery of anatomy courses in medical schools. The Department of Anatomy at the University of Zagreb School of Medicine had a unique experience where the anatomy course in 2019/2020 was first taught in-person before transferring to an online course delivery, while the inverse happened in 2020/2021. The core curriculum, course material and examination criteria were the same in both academic years. The aim of the study was to determine whether course delivery affected students' perceptions of the course and whether it impacted students' engagement and success.
Methods: The students' perceptions of the course were assessed via an anonymous course survey (student evaluation of teaching, SET). The questions in the SET assessed the usefulness of teaching modalities rather than students' satisfaction. Most questions were in the form of statements to which students responded with their level of agreement on a five-point Likert scale. Differences between responses in 2019/2020 and 2020/2021 were analyzed using the Mann-Whitney test. Effect size was estimated using Cliff's delta and association between responses was assessed using Spearman's *r* coefficient.
Results: Students' perceptions were significantly affected by changes in course delivery. Students' success and engagement were higher in 2019/2020 when in-person teaching preceded online teaching. Furthermore, students' views on course organization and the usefulness of continuous assessment were more positive in 2019/2020. Finally, students' perceptions of the usefulness of online materials and activities were more positive in 2019/2020. All comparisons between the two academic years were statistically significant ($P \leq 0.0001$ for all comparisons, Mann-Whitney test).
Conclusions: Students' perceptions of the anatomy course were dependent on the teaching environment they were exposed to at the beginning of the course. A transfer from in-person to online course delivery was more successful than vice-versa. This has important implications for structuring hybrid courses in medical education in the future.

1. Introduction

In most medical schools, anatomy is one of the fundamental subjects of medical education. The topics of re-evaluating anatomy curricula and the approach to teaching anatomy to medical students have become increasingly relevant. The recent COVID-19 pandemic pushed these topics to the forefront of discussion, since numerous medical schools had to adapt to at least a partial transition to online teaching (Puljak et al., 2020).

In the transition to online teaching, several key themes were identified: the continued relevance of cadaver work (Iwanaga et al., 2021; Banovac et al., 2021; Wilhelm et al., 2022; Chang et al., 2022), the detrimental effects of the lack of in-person interaction in remote teaching (Chang et al., 2022; Banovac et al., 2021; Cuschieri and Calleja Agius, 2020), the significant impact of pre-recorded online lectures for theoretical portions of the course (Wilhelm et al., 2022; Banovac et al., 2021; Cheng et al., 2021; Cuschieri and Calleja Agius, 2020), the importance of an adequate infrastructure for both in-

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https://doi.org/10.1016/j.aanat.2022.152043
0940-9602/

person and online teaching (Turana et al., 2022; Cheng et al., 2021), and the utilization of various other digital resources, (Singal et al., 2021b) such as augmented reality (Henssen et al., 2020), interactive software, and media related to anatomical dissection (Iwanaga et al., 2021; Naidoo et al., 2020; Herr and Nelson, 2020; Brassett et al., 2020; Longhurst et al., 2020; Pather et al., 2020). Significant reductions in time devoted to cadaver work were reported as well as a corresponding increase in computer-based assessment and in-house produced digital content (Attardi et al., 2022; Schulte et al., 2022). Adaptations of ethical guidelines for the use of cadaveric materials in online teaching as well as adaptations of safety guidelines for body donor programs were also implemented in many leading institutions (Lemos et al., 2021; Onigbinde et al., 2021; Attardi et al., 2022). Anatomy teachers managed to broaden their pedagogical approaches and integrate new teaching modalities in their curricula (Papa et al., 2022; Attardi et al., 2022; Boulos, 2022). Overall, substantial changes brought by the COVID-19 pandemic had a profound impact on the medical education community as a whole and posed significant challenges to medical educators worldwide (Luong et al., 2022).

Student engagement is broadly defined as a "sustained connection a learner has towards any aspect of learning" (Groccia, 2018). It is usually framed in a multidimensional perspective encompassing behavioral, affective, and cognitive aspects. Positive cognitive engagement has often been characterized as one of the key aspects of learning (Grijpma et al., 2022; Groccia, 2018). Therefore, it is important to understand how cognitive aspects of student engagement are affected by curricular changes. This is especially relevant in anatomy courses, which are traditionally focused on practical work and in-person classes, since these teaching modalities are particularly impacted by transitioning to an online course delivery. Even outside the context of the COVID-19 pandemic, a rising prevalence of various forms of hybrid and blended curricula has been observed in higher education (Bashir et al., 2021; Nascimento Cunha et al., 2020). Organizing such curricula without compromising the quality of teaching and learning was identified as a widespread challenge (Bashir et al., 2021). The peculiar circumstances that arose at the authors' institution (University of Zagreb School of Medicine, UZSM) provided an opportunity to further investigate this.

Due to a combination of external factors, including COVID-19 restrictions, the regular anatomy course at the UZSM was reorganized as a hybrid course in the academic years 2019/2020 and 2020/2021. In 2019/2020 the course started with traditional (contact, in-person) classes and was then transferred online around the middle of the course, while in 2020/2021 the course started online and then transferred to in-person teaching. However, the core curriculum, the teaching staff, the core teaching materials, all the learning outcomes as well as the principles of continuous and final assessment remained the same. This allowed for a unique comparison between these two academic years and allowed an evaluation of how the course delivery affected anatomy education.

The main goal of this study was to determine whether course delivery affected students' perceptions of the course and whether it impacted students' engagement and success. Therefore, the students' views on the usefulness of various course components were analyzed. In addition, the extent of students' commitment to learning the course material was evaluated, rather than their satisfaction with the course or faculty. Finally, these factors were compared between the two academic years and their impact on students' overall success in the course was assessed.

2. Methods

This study was conducted at the end of the 1st year Anatomy course (Integrated Undergraduate and Graduate Program of Studies in Medicine) at the UZSM (for a detailed description see Appendix A) (Banovac et al., 2021), as part of a regular online course evaluation survey (student evaluation of teaching, SET) during the academic years 2019/2020 and 2020/2021. The study was approved by the Ethics Committee of the UZSM (380–59–10106–21–111/100). The SET was both voluntary and anonymous. The students were informed that the analysis of the SET could be used in potential publications.

2.1. Comparison between academic years 2019/2020 and 2020/2021

In 2019/2020, the first part of the course was held in-person, while the second part of the course was held almost entirely online. In 2020/2021, this was reversed, with the first part of the course held entirely online, and the second part held in-person (Supplementary Figure 1). Due to epidemiological restrictions, in-person classes in 2020/2021 included predominantly practical work, whereas in-person classes in 2019/2020 also included traditional lectures and seminars. A further difference was the inclusion of webinars in 2020/2021, which were not featured in 2019/2020. Nevertheless, the core material taught to the students was the same in both academic years, as were the teaching staff, the textbook, atlases, learning outcomes, exam material, and examination criteria.

2.2. Study design

The study was conducted via a questionnaire in the form of an online SET. This version of the questionnaire was designed in the academic year 2019/2020 by the teaching staff of the Department of Anatomy and Clinical Anatomy and tailored to be relevant to the curriculum at the UZSM (Supplementary Table 1) (Banovac et al., 2021). The majority of the analyzed questions were the same in 2019/2020 and 2020/2021, however, in 2020/2021, several specific questions were added to the survey to expand on certain relevant findings (Questions 13, 15 and S1 – S3).

The questionnaire was made available to students online immediately after classes ended, but before the final (oral) exam was completed. The answers were anonymized by the algorithm integrated in the Learning Management System (LMS) used by the author's institution.

In 13 questions, students were required to choose a score on a five-level Likert response scale that best represented their level of perceived agreement with a given statement, with 1 representing complete disagreement and 5 representing complete agreement. The scale reliability (internal consistency) of the questionnaire was assessed using Cronbach's alpha. Cronbach's alpha for the entire questionnaire was 0.80 in 2019/2020 and 0.83 in 2020/2021, both of which were consistent with acceptable scale reliability.

In 6 questions, students were required to choose multiple answers from a predefined list of options. In one question, students were required to write the number of hours spent studying anatomy. To submit the questionnaire, every question had to be answered.

2.3. Data analysis

Quantitative data analysis was performed using GraphPad Prism, version 9.3.1 (GraphPad Software, La Jolla, CA, USA).

Responses to questions in the form of Likert items were analyzed as ordinal data. Responses to questions in the form of predetermined lists were analyzed as categorical data. Responses to questions in which students wrote the number of hours spent studying anatomy were analyzed as ratio data (continuous variables).

Student responses from 2019/2020 were compared to student responses from 2020/2021 (except for questions added in the 2020/2021 survey). The t-test was used for ratio data and the Mann-Whitney test was used for ordinal data. To compare the responses given by the same students (in the same academic year) to Questions

11 and 12, the paired Wilcoxon rank test was used. Cross-tabulation was used to analyze categorical data.

Cohen's *d* was used to estimate the effect size of the differences for ratio data, while Cliff's delta was used for ordinal data (Appendix B) (Lakens, 2013; Vargha and Delaney, 2000).

Contingency tables and the chi-square test were used to evaluate the differences in the frequencies of certain responses as well as the differences in pass rates on the final exam.

The association between responses given by the same students to different questions was assessed using Spearman's correlation coefficient *r* (Mukaka, 2012).

For all statistical tests, $P < 0.05$ was considered statistically significant. For mean scores and Spearman's *r*, 95% confidence intervals (CI) were calculated.

3. Results

The target population for this survey were the first-year medical students at the UZSM who actively participated in the Anatomy course throughout the entire course duration in the academic years 2019/2020 and 2020/2021. In 2019/2020, 325 out of 340 students completed the survey (response rate: 95.58%), while in 2020/2021, 295 out of 304 students completed the survey (response rate: 97.04%). The two analyzed student groups were comparable based on demographic data as well as their scores on the standardized entrance exam (Supplementary Table 2).

The analysis of the SET was divided into three categories. In the first category, students' success in the course, engagement and perceptions of course demand were analyzed. In the second category, students' views on course organization, quizzes and exams were assessed. In the third category, a comparison between in-person and online teaching was done.

3.1. Students' success in the course, students' engagement and students' perceptions of course demands

Students' success was evaluated by analyzing their results on the final exam. The following parameters were analyzed: the average passing grade, the average number of exam entries (attempts at passing the exam) and the pass rate. On average, better results were achieved on the final exam in 2019/2020 than in 2020/2021. The average passing grade was higher in 2019/2020 (3.85) than in 2020/2021 (3.52), while the average number of exam entries was lower in 2019/2020 (1.39) than in 2020/2021 (1.50). The pass rate was also significantly higher in 2019/2020 (89.58%) than in 2020/2021 (82.35%) ($P = 0.0066$, chi-square test).

Students' engagement was evaluated by analyzing Questions 1, 2 and 14 (Table 1, Supplementary Table 1 and Fig. 1). On average, students in 2019/2020 more readily agreed with the statement that they regularly used the available online material in learning than students in 2020/2021 (Question 1; $P < 0.0001$, Mann-Whitney test; Fig. 1 A). Students in 2019/2020 also claimed to have put more effort into learning the exam material (Question 2; $P = 0.0001$, Mann-Whitney test; Fig. 1B), but claimed to have spent less time per day learning anatomy (Question 14; 4.95 ± 1.77 h/day vs. 5.29 ± 2.16 h/day; $P = 0.0359$, t-test; Cohen's $d = 0.1701$; Fig. 1 C).

Students' perceptions of course demand were evaluated by analyzing Question 3 (Table 1 and Fig. 1). Students in 2019/2020 found the course less demanding than students in 2020/2021 (Question 3; $P = 0.0001$, Mann-Whitney test; Fig. 1D). In fact, in 2019/2020, a total of 34.66% of students disagreed (Likert scores 1 and 2) with the statement that the course was too demanding, while only 25.15% agreed (scores 4 and 5) with this statement. This shifted significantly in 2020/2021, when only 17.63% of students disagreed, and 42.72% agreed with this statement.

3.2. Students' views on course organization, quizzes and exams

Students' views on course organization were evaluated by analyzing Questions 4 – 7 (Table 1 and Fig. 2). Students were asked to evaluate whether the course organization helped them learn the required exam material. While generally favorable sentiments were expressed regarding the helpfulness of the course organization in 2019/2020, this significantly declined in 2020/2021 (Question 4; $P < 0.0001$, Mann-Whitney test; Fig. 2 A). Students were further asked to evaluate the appropriateness of the course workload (Question 5; Fig. 2B), the clarity of learning outcomes (Question 6; Fig. 2 C), and the usefulness of learning outcomes (Question 7; Fig. 2D). For all these aspects, more favorable sentiments were expressed in 2019/2020 than in 2020/2021 ($P < 0.0001$ for all questions, Mann-Whitney test). The usefulness of the learning outcomes was directly associated with students' perceptions of the clarity of the learning outcomes (2019/2020: Spearman $r = 0.5301$, 95% CI: 0.4445 – 0.6061, $P < 0.0001$; 2020/2021: Spearman $r = 0.5654$, 95% CI: 0.4797 – 0.6403, $P < 0.0001$).

Students' views on quizzes and exams were evaluated by analyzing Questions 8, 9, 10 and 13 (Table 1 and Fig. 2). Students were asked to assess the usefulness of frequent online quizzes (Question 8; Fig. 2E) and whether the quizzes and partial exams tested the course material covered in class (Question 9; Fig. 2 F). A tendency for more negative responses to these questions was observed in 2020/2021 compared to 2019/2020 ($P < 0.0001$ for both questions, Mann-Whitney test). A similar pattern was present when students were asked whether the exam material was clearly defined (Question 10; $P < 0.0001$, Mann-Whitney test; Fig. 2 G).

Since the frequent online quizzes were not proctored, the students were asked whether they completed the quizzes on their own (without external help) and with commitment (Question 13). This was assessed only in 2020/2021. Most responses (69.83%) to this question were positive (scores 4 and 5), while a minority were either neutral (15.93%, score 3) or negative (14.24%, scores 1 and 2). These responses were significantly associated with responses to Question 8 (Spearman $r = 0.2851$, 95% CI: 0.1734 – 0.3896, $P < 0.0001$) where students evaluated the usefulness of mandatory quizzes. This indicates that students who were less committed to completing the quizzes on their own tended to find them less useful.

Among students who were committed to completing the quizzes on their own (scores 4 and 5 in Question 13), 66.02% found them useful (scores 4 and 5 in Question 8), while 16.99% did not find them useful (scores 1 and 2) and a neutral response was given by another 16.99% of students (score 3). In contrast, among students not committed to completing the quizzes on their own (scores 1 and 2 in Question 13), only 28.57% found them useful, while 57.14% did not find them useful and a neutral response was given by 14.02% of students. This difference in frequencies was also found to be statistically significant ($P < 0.0001$, Chi-square test). Among the students who gave a neutral response regarding commitment to completing the quizzes on their own (score 3 in Question 13), 53.19% found them useful, 29.79% did not find them useful and a neutral response was given by 17.02% of students.

3.3. Comparison between in-person and online teaching

In-person and online teaching were compared by analyzing Questions 11, 12, 15, 16 and 17 (Table 1, Supplementary table 1 and Fig. 3). Students were asked how well they could self-assess their knowledge during contact and online classes (Questions 11 and 12; Table 1). In 2019/2020, students found it easier to self-assess their knowledge during online classes than students in 2020/2021 (Question 11, $P < 0.0001$, Mann-Whitney test). In contrast, in 2019/2020, students found it more difficult to self-assess their knowledge during contact classes than students in 2020/2021 (Question 12,

Table 1
Student responses to questions in the form of statements. Students' agreement was measured on a five-level Likert scale. For each question, the first row represents the data for 2019/2020, while the second row represents the data for 2020/2021. The mean ranks are derived from the Mann-Whitney test. Cliff's delta is presented in absolute values.

Questions		Frequency distribution (%) for scores chosen as responses to statement							Mean score	95% CI for mean score	Mean ranks	Cliff's delta
		1	2	3	4	5	1 and 2	4 and 5				
1	**I regularly used the available on-line material in learning.**	0.00	3.37	15.34	33.44	47.85	**3.37**	**81.29**	**4.26**	4.16 – 4.35	346	**0.24**
		0.68	9.49	26.10	33.56	30.17	**10.17**	**63.73**	**3.83**	3.72 – 3.94	271	
2	**I have put a great deal of effort into learning the required exam material.**	0.00	1.23	7.98	24.54	66.26	**1.23**	**90.80**	**4.56**	4.48 – 4.63	334	**0.16**
		1.02	5.08	15.59	24.41	53.90	**6.10**	**78.31**	**4.25**	4.14 – 4.36	285	
3	**This course was too demanding/challenging.**	9.20	25.46	40.18	21.78	3.37	**34.66**	**25.15**	**2.86**	2.75 – 2.97	273	**0.25**
		4.07	13.56	39.66	31.19	11.53	**17.63**	**42.72**	**3.33**	3.21 – 3.44	352	
4	**The course was organized in a manner that helped me learn the exam material and understand the underlying anatomical concepts.**	3.07	6.13	21.17	42.94	26.69	**9.20**	**69.63**	**3.84**	3.75 – 3.96	372	**0.42**
		8.81	23.39	32.20	26.78	8.81	**32.20**	**35.59**	**3.03**	2.91 – 3.16	243	
5	**The course workload was appropriate for the course level.**	2.45	4.60	17.18	31.90	43.87	**7.05**	**75.77**	**4.10**	3.99 – 4.21	369	**0.40**
		4.41	12.88	36.61	32.30	13.90	**17.29**	**46.20**	**3.38**	3.27 – 3.50	246	
6	**The learning outcomes were clearly defined.**	1.53	5.52	18.40	43.87	30.67	**7.05**	**74.54**	**3.97**	3.87 – 4.07	343	**0.22**
		3.73	9.83	29.83	37.97	18.64	**13.56**	**56.61**	**3.58**	3.46 – 3.70	275	
7	**The learning outcomes helped me learn the required course material.**	3.68	11.04	21.78	30.37	33.13	**14.72**	**63.50**	**3.78**	3.66 – 3.91	367	**0.38**
		11.53	26.10	29.15	21.36	11.86	**37.63**	**33.22**	**2.96**	2.82 – 3.10	249	
8	**Frequent quizzes contributed to my successfully mastering the required exam material.**	3.68	6.44	11.66	24.23	53.99	**10.12**	**78.22**	**4.18**	4.07 – 4.31	355	**0.30**
		11.53	13.56	16.27	29.93	28.81	**25.09**	**58.74**	**3.51**	3.36 – 3.66	261	
9	**The quizzes and partial exams tested what was covered in classes.**	1.53	8.90	18.71	36.81	34.05	**10.43**	**70.86**	**3.93**	3.82 – 4.04	367	**0.39**
		5.76	20.34	33.22	30.51	10.17	**26.10**	**40.68**	**3.19**	3.07 – 3.31	248	
10	**The exam material is clearly defined in this course.**	0.92	6.75	19.33	35.58	37.42	**7.67**	**73.00**	**4.02**	3.90 – 4.11	349	**0.26**
		3.73	12.88	31.19	31.86	20.34	**16.61**	**52.20**	**3.52**	3.40 – 3.64	269	
11	**During contact classes, I could easily assess my knowledge and progress at any given time.**	1.23	4.91	20.25	36.20	37.42	**6.14**	**73.62**	**4.04**	3.94 – 4.14	294	**0.11**
		0.68	2.37	16.95	32.88	47.12	**3.05**	**80.00**	**4.23**	4.14 – 4.33	329	
12	**During on-line classes, I could easily assess my knowledge and progress at any given time.**	6.75	21.17	32.52	26.99	12.58	**27.92**	**39.57**	**3.17**	3.06 – 3.30	347	**0.25**
		15.93	28.14	33.90	16.95	5.08	**44.07**	**22.03**	**2.67**	2.55 – 2.80	270	

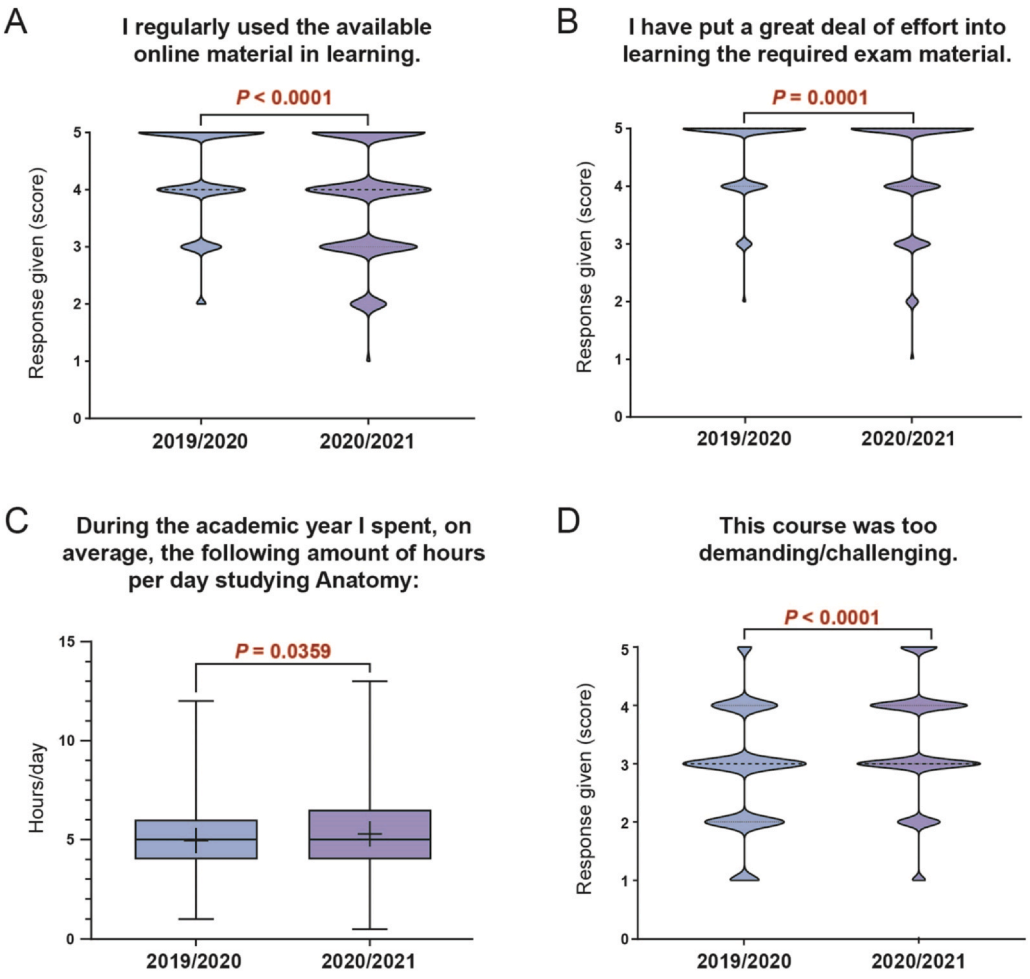

Fig. 1. – Comparison of students' responses to questions pertaining to their engagement with the course and their perception of the course demands. Violin plots showing a smoothed distribution of students' responses to Questions 1 (**A**), 2 (**B**), and 3 (**D**). The thick dotted lines in the violin plots represent the median of the responses to each question, while the thin dotted lines represent the first and third quartiles. The size of the bulge in a violin plot is proportional to the frequency of students who chose the grade displayed on the y-axis. The *P*-value is shown on the plots (Mann-Whitney test). (**C**) Box and whiskers plot showing students' responses to Question 14. The upper and lower borders of the boxes represent the first and third quartiles, while the middle line represents the median. The plus ("+") sign represent the mean and the error bars represent the minimum and maximum values. The *P*-value is shown on the plot (t-test).

P = 0.0091, Mann-Whitney test). Overall, students' self-assessment capability was significantly lower during online classes in both academic years (Questions 11 and 12, $P < 0.0001$ for both years, Wilcoxon rank test, Fig. 3 A). The difference in self-assessment capability was more pronounced in 2020/2021 (Cliff's delta = 0.71) than in 2019/2020 (Cliff's delta = 0.43).

The reasons underlying the difficulties in students' self-assessment capability during online classes were further explored – students who disagreed with the statement in Question 12 (scores 1 and 2) were asked a follow-up question (Question 15; students could choose up to three answers; Fig. 3B). This was assessed only in 2020/2021. Two leading reasons for this difficulty in self-assessment were identified: lack of face-to-face interaction (81.54%) and ease of following contact vs. online classes (66.15%).

Students were also asked to evaluate which online materials and activities helped them the most in covering the course material (Question 16; students could choose up to three answers; Fig. 3 C). In both academic years, the following online materials and activities were identified as most useful: additional textbook elaborations, pre-recorded video lectures and frequent mandatory online quizzes. However, in 2020/2021 these materials were overall found to be less useful than in 2019/2020.

Finally, students were asked which segments of contact classes they missed the most during online teaching (Question 17; students could choose up to three answers; Fig. 3D). Students in both academic years reported to have missed practical classes to a similar degree (81.90% in 2019/2020 and 81.69% in 2020/2021). In contrast, in 2019/2020 students missed seminars (25.54% vs. 48.47%) and classical lectures (3.07% vs. 48.14%) substantially less than in 2020/2021.

Some of these concepts were expanded on in the 2020/2021 SET (Appendix C and Supplementary Figure 2).

Overall, the following key differences between students in 2019/2020 and 2020/2021 were identified by analyzing the SET. Firstly, students' success and engagement were higher in 2019/2020 when in-person teaching preceded online teaching. Secondly, students' views on course organization and the usefulness of quizzes were more positive in 2019/2020. Thirdly, students' perceptions of the usefulness of online materials and activities were more positive in 2019/2020.

4. Discussion

In this study, the effect of different modalities of course delivery on medical students' views of the course is presented. This was evaluated by assessing students' perceptions of the usefulness of different teaching modalities, rather than their satisfaction with the course. It was demonstrated that the changes in course delivery

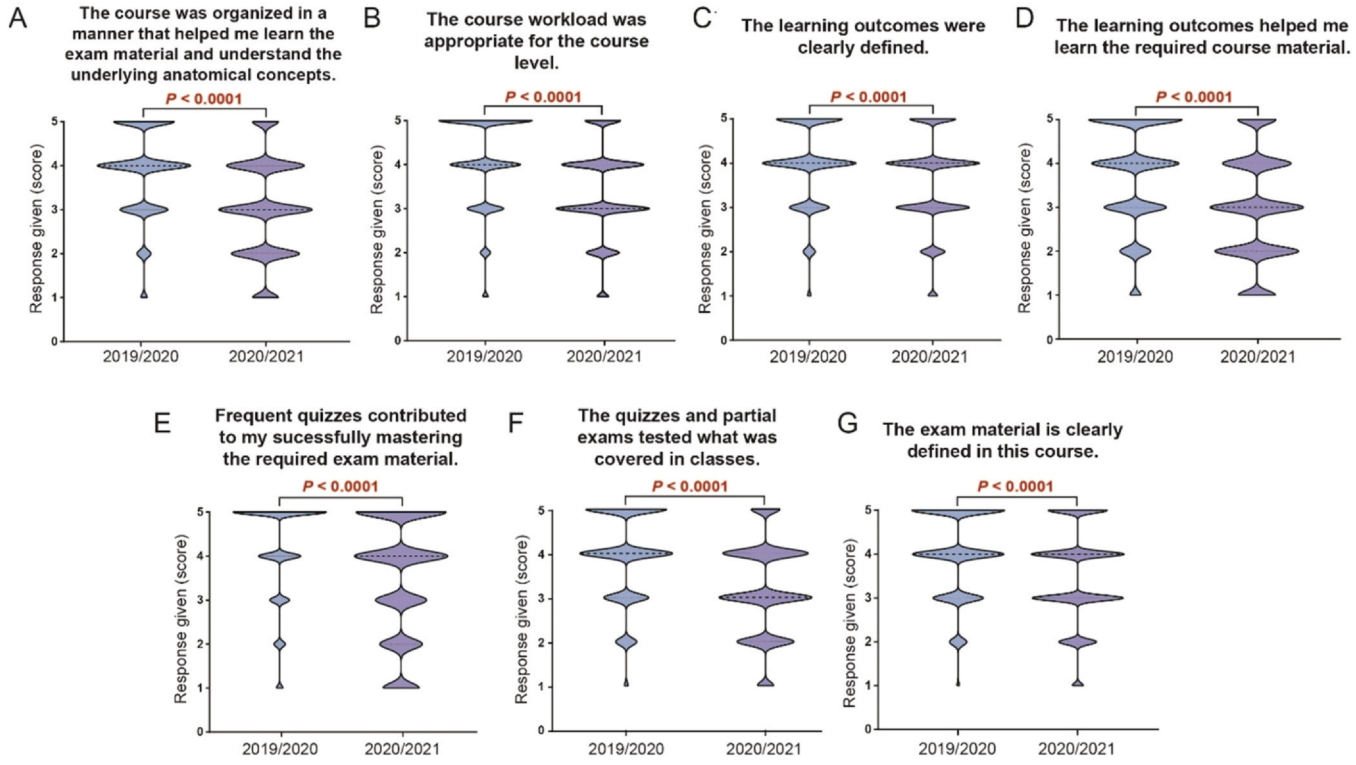

Fig. 2. – Comparison of students' responses to questions pertaining to the organization of the course, the learning outcomes and the continuous assessment. Violin plots showing a smoothed distribution of students' responses to Questions 4 (**A**), 5 (**B**), 6 (**C**), 7 (**D**), 8 (**E**), 9 (**F**), and 10 (**G**). Thick dotted lines in the violin plots represent the median of the responses to each question, while the thin dotted lines represent the first and third quartiles. The size of the bulge in a violin plot is proportional to the frequency of students who chose the grade displayed on the y-axis. The *P*-value is shown on the plots (Mann-Whitney test).

affected students' engagement, which, in turn, may have impacted their performance on the final exam.

4.1. Why a good start matters when studying anatomy

The anatomy course at the UZSM is both detail-oriented and concept-oriented. Therefore, it is necessary that students adapt different learning strategies compared to previous educational levels. This change is usually facilitated by direct interactive feedback with the teaching staff on a continuous basis. During regular contact classes, students are exposed to prosections, anatomical models, and dissection as well as to oral feedback from the teaching staff. Active participation of the teaching staff, especially at the beginning of the course, has been shown to help students develop appropriate studying skills and learning strategies (Brown-Kramer, 2021; Dolan and Collins, 2015; Dunlosky et al., 2013).

In 2019/2020, the first half of the course was taught in-person and students received direct interactive feedback from both the teaching staff and their peers/near-peers, including student teaching assistants (STAs). In contrast, the students in 2020/2021 could not, due to epidemiological restrictions, interact in person with peers/near-peers nor with the teaching staff during the first portion of the course. Therefore, in this crucial adaptation period, they were exposed to a different hidden curriculum than students in 2019/2020. While students in 2019/2020 were additionally influenced by their peers' and near-peers' experiences, students in 2020/2021 had to primarily rely on online communication with the teaching staff. Interaction with peers and near-peers may be especially important for 1st year students, who are not yet experienced in dealing with demanding courses typical for medical studies (Blanch-Hartigan, 2011). Through such interactions, students obtain information on how to approach the course, receive feedback on what learning strategies are successful and determine what the expectations of the teaching staff are from a students' perspective (Lempp and Seale, 2004; Boer and Daelmans, 2020; Hopkins et al., 2016; Lawrence et al., 2018; Mackin et al., 2019; Yazdani et al., 2020).

Furthermore, students in 2020/2021 had to start learning anatomy mostly on their own and received feedback on their level of knowledge almost exclusively through formative and summative testing. Indeed, students in 2020/2021 found it exceedingly difficult to self-assess their knowledge during online classes, much more so than students in 2019/2020, and attributed this mainly to the absence of face-to-face interaction.

Even though a certain amount of difficulty in self-assessment might be expected when classes are held exclusively online, the fact that this effect was much more prominent when the online portion of the course preceded in-person teaching is an important observation. In the presented case, students much more readily transferred from in-person teaching to online course delivery than the other way around. A possible explanation might be that students who were first exposed to in-person teaching acquired the necessary learning strategies and utilized the available course materials more successfully to continue studying anatomy even when classes transferred to a completely online environment. Students who lacked this initial exposure to in-person teaching might have found it more difficult to adapt their learning strategies and fully utilize the available course materials. This is supported by the fact that students in 2020/2021 utilized online materials to a lesser degree than students in 2019/2020, even though they were exposed almost exclusively to online materials during the first half of the course. This suggests that any potential improvement in online course delivery in 2020/2021 did not have a measurable positive impact on students' engagement with online materials.

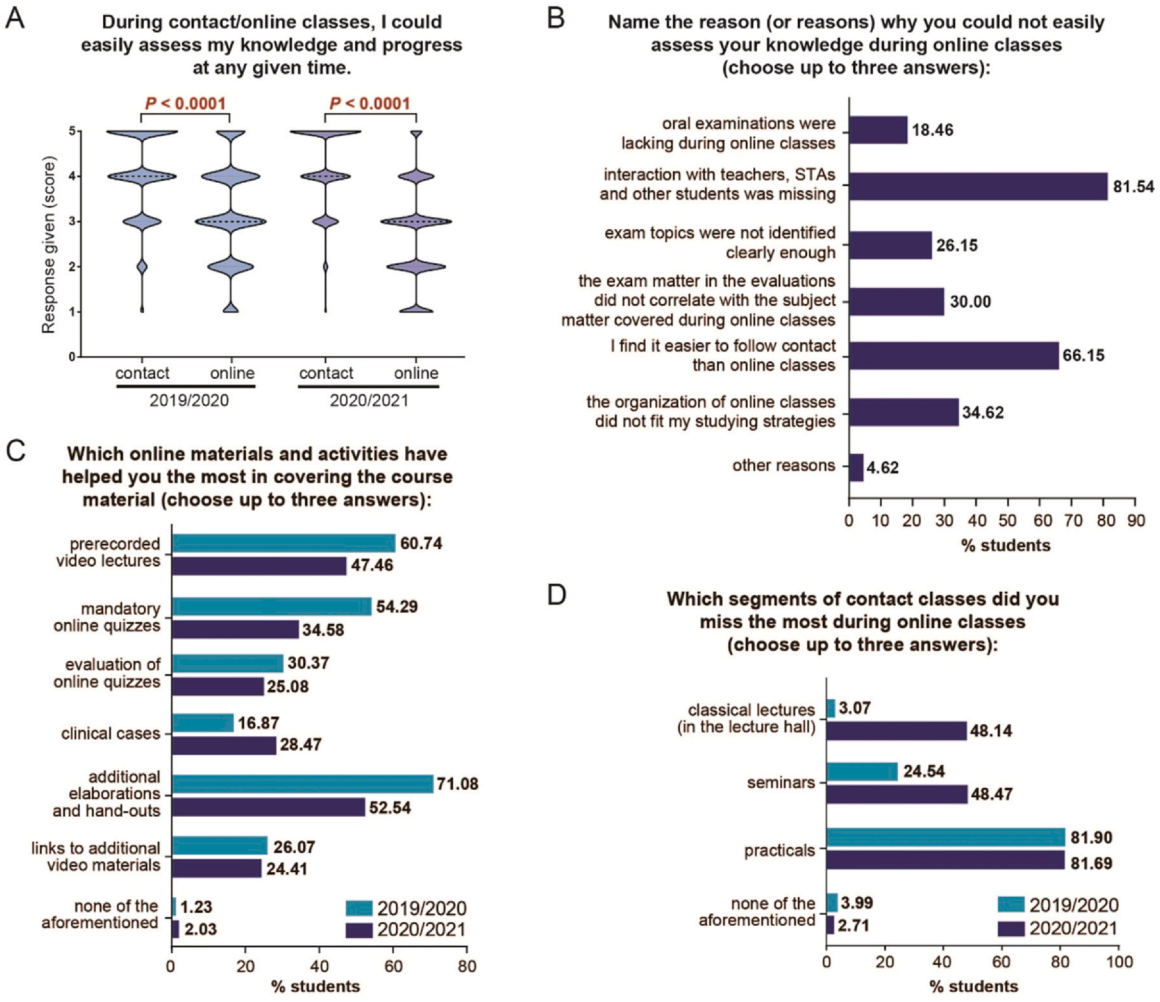

Fig. 3. – (**A**) Violin plots showing a smoothed distribution of students' responses to Questions 11 and 12. The thick dotted lines in the violin plots represent the median of the responses to each question, while the thin dotted lines represent the first and third quartiles. The size of the bulge in a violin plot is proportional to the frequency of students who chose the grade displayed on the y-axis. The *P*-value is shown on the plot (paired Wilcoxon ranked test). (**B**) Bar graph showing the percentages of responses for Question 15 for students in 2020/2021. (**C**) Bar graph showing the percentages of responses for Question 16 for students in 2019/2020 and 2020/2021. (**D**) Bar graph showing the percentages of responses for Question 17 for students in 2019/2020 and 2020/2021. In Questions 15 – 17, students could choose up to three answers.

4.2. Changes in the teaching environment caused a shift in students' perceptions of the course

The analysis of the SET revealed that students' perceptions of the course organization and continuous assessment differed significantly between the two academic years. This was exemplified most prominently by the fact that in 2020/2021, students perceived learning outcomes, course organization, formative assessments and exam material as less clear or less helpful. It is worth noting that the learning outcomes and the exam material were identical in both years. This supports the notion that students' perception of the course was significantly influenced by the differences in course delivery, i.e. the teaching environment (Gotlib et al., 2010).

Furthermore, the fact that students missed traditional (ex cathedra) in-person lectures in 2020/2021, but not in 2019/2020 reveals that students' perceptions are fundamentally shaped by their experiences and overall teaching environment. Namely, when students were first exposed to traditional lectures and then to pre-recorded video lectures, they clearly stated pre-recorded lectures to be superior – only 3% missed traditional lectures and over 60% found pre-recorded lectures to be useful. When students were not exposed to traditional lectures at all, almost 50% of them missed traditional lectures (which they had never experienced) and less than 50% of them found pre-recorded lectures useful.

Based on the analysis of the student feedback, exclusive online content delivery seemed to hinder students' self-assessment of their knowledge, which could have influenced students' capabilities to efficiently allocate their studying hours to topics they were deficient in. This is in line with other studies suggesting that online content delivery could be associated with learning fatigue as well as difficulty concentrating and sustaining motivation for studying (Dost et al., 2020; Regmi and Jones, 2020; Singal et al., 2021a).

4.3. More committed students benefitted more from specific teaching modalities and were more successful on the final exam

One of the key assessment tools provided to students were weekly online unproctored formative quizzes. Students who self-reported that they completed these quizzes independently and with commitment (unaided by the textbook or their peers/near-peers) also reported a significantly higher usefulness of the quizzes compared to students who did not complete the quizzes independently. Thus, students benefitted less from a teaching modality in which they were not fully invested. Other research demonstrated that students distracted by non-lecture activities (e.g. social media) during live or video lectures ("interrupted learners") achieved lower exam scores (Zureick et al., 2018), while students who frequently

utilized online quizzes scored significantly better on knowledge tests (Schulte et al., 2022).

Interestingly, students in 2020/2021 found the course more demanding and self-reported to have put less effort into learning the exam material than students in 2019/2020. This is in line with the fact that they less often used online materials in learning and suggests that overall, students showed less engagement in 2020/2021. It should be noted that students' overall success on the final exam was lower in 2020/2021. In contrast, the same students who self-reported investing less effort in 2020/2021, claimed to have spent more hours per day studying anatomy. This implies that, even though students in 2020/2021 spent more time learning anatomy, the quality of learning (learning strategies and successfulness in covering the course material) was higher in 2019/2020. This also suggests that students' self-assessment on the amount of effort they put into learning is a better predictor of students' success on the final exam than the self-reported number of hours students spent studying anatomy. In other words, effort may be a better measure of students' cognitive engagement than time.

4.4. Finding a broader context – how to structure a modern anatomy course

The results of this study suggest that the interactions between students and teaching staff, STAs, and peers, as predominantly experienced during contact classes and office hours appear to be particularly important in forming students' perceptions of the course. These interactions help in aligning students' perceptions with course expectations. Students also receive feedback on their current level of knowledge from both the teaching staff and their peers/near-peers. This enables students to self-assess their performance more accurately. Self-assessing one's performance is particularly challenging for first-year medical students and the self-assessment becomes more accurate in later years (Blanch-Hartigan, 2011).

This study also revealed that it is difficult to replicate the described stimulative learning and teaching environments in an exclusively online format, at least for a course like human anatomy. The extensiveness and complexity of the subject-matter, as well as the fact that a significant amount of learning typically occurs during practical work, likely make anatomy less suited for exclusive online delivery. Changes in teaching environments during the COVID-19 pandemic have been shown to negatively impact the quality of anatomy education, primarily due to lack of interactive learning and lack of dissection (Shin et al., 2022). Testing- and "Zoom-" fatigues are other potential problems that typically occur in an online teaching environment (Bailenson, 2021; Sievertsen et al., 2016).

Nevertheless, online teaching can be a great aid in anatomy education and can meaningfully supplement practical work (Banovac et al., 2021; Attardi et al., 2022; Longhurst et al., 2020; Boulos, 2022). Most studies concluded that online education must: effectively deliver online instructional information, have a high relevance between online instructional design and student learning, and entice high levels of participation from the students (Regmi and Jones, 2020; Bao, 2020).

It is also important to note that two different student groups (from different academic years) were compared in this study. However, no significant differences were observed between these groups based on their demographic data and their performances on the standardized entrance exam. In contrast, the differences in students' responses on the SET were significant, very consistent and in line with students' success on the Anatomy final exam.

In the presented case, students appeared to utilize the benefits of online learning more effectively when in-person teaching preceded the online portion of the course. Therefore, the timing of in-person and online teaching segments should be carefully considered in future course designs utilizing a hybrid teaching model.

4.5. Strengths and limitations of the study

The main strengths of this study were: high response rates (providing information on the entire population), high internal consistency of the questionnaire, evaluation of usefulness of teaching modalities rather than student satisfaction, and analysis of unique mirrored course deliveries.

The likely limitations of this study were: assessment of respondents' subjective perceptions, limited applicability of the results of the study to vastly different teaching environments, and possible differences between the analyzed student groups that could not be measured.

5. Conclusions

In conclusion, changes in learning and teaching environments affected students' perceptions of the anatomy course. Students' views on the usefulness of different teaching modalities and students' cognitive engagement were significantly affected by the means of course delivery. Furthermore, students' level of commitment to particular teaching modalities was associated with the usefulness of these teaching modalities. It is also important to recognize that the quality of studying outweighed the quantity of studying, since the effort students put into learning was a better predictor of their success than the time spent studying. Overall, the transfer from in-person to online teaching was more successful than vice-versa. This indicates that face-to-face interactions at the beginning of the course are of great importance for anatomy education. These findings have important implications for structuring hybrid courses in the future, since they demonstrated that anatomy courses may be less suited for prolonged exclusive online delivery at the beginning of the course.

Ethical statement

The study was approved by the Ethics Committee of the UZSM (380–59–10106–21–111/100). The study was both voluntary and anonymous. The students were informed that the analysis of the questionnaire could be used in potential publications. The authors have abided to all relevant research and publication ethics guidelines.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Ivan Banovac: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Project administration, **Nataša Kovačić:** Software, Validation, Resources, Writing – review & editing, Visualization, **Ana Hladnik:** Investigation, Resources, Writing – review & editing, **Andrea Blažević:** Investigation, Resources, Data curation, Writing – review & editing, **Ivana Bičanić:** Investigation, Resources, Writing – review & editing, **Zdravko Petanjek:** Conceptualization, Validation, Writing – review & editing, Supervision, **Vedran Katavić:** Conceptualization, Validation, Investigation, Resources, Data curation, Writing – original draft, Supervision, Project administration.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgments

The authors wish to thank Professor Mirza Žižak and the Department for E-learning for their excellent technical support regarding the UZSM's LMS as well as the administrative help by the Office for student affairs.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.aanat.2022.152043.

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