Anatomy Teaching Models Before and During the COVID-19 Pandemic: Teaching Models Assessment

Modelos de Enseñanza de la Anatomía Antes y Durante la Pandemia de COVID-19: Evaluación de los Modelos de Enseñanza

Nikola Vucinic[1]; Sara Strbac[2]; Nikolina Pupovac[1]; Dragana Radosevic[1]; Milica Prtina[2,3] & R. Shane Tubbs[4,5,6]

SUMMARY: The COVID-19 pandemic immediately changed teaching anatomy from in-person to online. Our study aimed to compare the results of anatomy exams, examine the students' attitudes to these two different teaching models, and propose a more desirable model. In the retrospective part of the study, the anatomy exam results of 211 students studying in person in 2018/2019 (before the pandemic) and 214 students studying online in 2020/2021 (during the pandemic) were analyzed. The cross-section study comprises a comprehensive survey of the students' attitudes towards in-person - 136 students, and online teaching model - 118 of the respective academic years. 76.3 % of the students passed the anatomy exam after in-person teaching, compared to only 49.1 % after online teaching. The survey showed that within the in-person model, teachers were more available (χ^2(2, N=254) = 39.705, p < .001), examinations were useful for knowledge assessment (χ^2(2, N=254) = 7.307, p = .026), students were more satisfied with the exam (χ^2(2, N=254) = 9.587, p = .008), more confident about their knowledge (χ^2(2, N=254) = 23.464, p < .001), and overall appreciated the quality of this model more (χ^2(2, N=254) = 50.263, p < .001) than the online group. About half of the students in the online group believed that remote studying prevented the spread of COVID-19. Attitudes expressed in open-ended questions were more positive about in-person than online teaching, where the absence of in-person practical exercises received the most significant criticism. The in-person model was shown to be undisputedly superior. However, teaching aids, such as voice-over PowerPoint presentations and video recordings of practical exercises, applied in online teaching should be incorporated into future teaching models.

KEY WORDS: Anatomy; Undergraduate education; Assessment; Recommendation; Pedagogy.

INTRODUCTION

Anatomy is considered one of the most important subjects studied in medical school (Pupovac *et al*., 2020; Boulos, 2022). Depending on the course type, topographic or systematic anatomy is taught in undergraduate studies. Thorough knowledge of anatomy is an essential prerequisite for further studies of other subjects. There are different approaches to teaching anatomy. Cadaveric dissection has been a "gold standard" in medical curricula for hundreds of years (Hildebrandt, 2010). It is widely accepted as a method that helps students understand the three-dimensional relationships between anatomical structures (Ghosh, 2017). Also, our experience has shown that independent work in dissection and preparation makes it easier for students to retain anatomical facts for longer and to develop manual skills. However, although rated very highly, this teaching method is only sometimes applicable due to the difficulties related to obtaining cadavers. Consequently, students are sometimes only shown already prepared cadaveric structures (prosection), or not even that but anatomy atlases and paintings. Different multimedia resources and special computer programs can also be used in teaching. However, due to financial constraints that medical schools in developing countries face, these are not widely accessible.

[1] Department of Anatomy, Faculty of Medicine Novi Sad, University of Novi Sad, Novi Sad, Serbia.
[2] Faculty of Medicine Novi Sad, University of Novi Sad, Novi Sad, Serbia.
[3] Department of ENT and Maxillofacial Surgery, Clinic for Pediatric Surgery, Institute for Child and Youth Healthcare of Vojvodina, Novi Sad, Serbia.
[4] Anatomical Sciences, St. George's University, St. George's, GRD.
[5] Neurosurgery and Structural & Cellular Biology, Tulane University School of Medicine, New Orleans, USA.
[6] Neurosurgery and Ochsner Neuroscience Institute, Ochsner Health System, New Orleans, USA.

Every form of teaching anatomy was affected during the COVID-19 pandemic. The spreading of the pandemic had a severe impact on health, social, and education systems (Sadeesh *et al.*, 2021). In-person teaching, in conditions of worsening epidemiological situation, posed a severe challenge in most countries (Daniel, 2020). The global pandemic threat caused most classes to be canceled in many parts of the world (Boulos, 2022). Online teaching appeared to be the only alternative to prevent the long-term cancelation of teaching programs (Srinivasan, 2020), so teachers were forced to make a rapid switch without sufficient time for preparation. Some faculties conducted real-time online lectures via different platforms (Zoom, Google Meet, etc.). Teaching anatomy is specific because the structures must be shown, so there was a constant dilemma about which method of presenting would be reliable and most effective. The authors of one recent study emphasize that, regardless of efforts to maintain classes, there was a significant decline in the quality of education (Franchi, 2020). Another study reports that, unlike in-person teaching, the online model has a few benefits, such as unrestricted availability and saving time for commuters. However, this model has several disadvantages, such as isolation from the community and loss of motivation for learning (Panchabakesan, 2011). Students' feedback is undoubtedly critical to assess their achieved and maintained level of knowledge.

In-person lectures and practical exercises are traditionally performed at the Department of Anatomy, Faculty of Medicine Novi Sad, Serbia. Topographic anatomy is the basis of the curriculum in our department. Students study anatomy in the following areas: upper limb, lower limb, thorax, abdomen, pelvis, head and neck (Part 1 and Part 2), sense organs and central nervous system. Lectures are given with the aid of PowerPoint presentations. It is a two-semester course with 135 hours of theory and 150 hours of practical exercises. Each exercise starts with an introductory, non-interactive lecture in front of the blackboard with pre-drawn chalk drawings of an anatomic region/structure in focus (Fig. 1). Next, students are shown specimens, i.e., macerated bones, wet and plastinated body parts, and plastic specimens. During the second half of the practical exercise, students learn independently, with specimens, before the review is done with the teacher. The acquired knowledge is evaluated in a partial exam after each anatomy area. A partial exam typically consists of fifteen marked structures in pictures. Students are expected to correctly identify details and the structures to which the detail belongs. A passing grade at any partial exam merits one bonus point for the particular area and could later be used in the exam. The exam consists of a test, a practical, and an oral part. The test and the practical part of the exam consist of eight topographical areas. A student must obtain at least 60 % correct answers for each location to pass. In the practical part of the exam, wet, plastinated, and plastic specimens are commonly used.
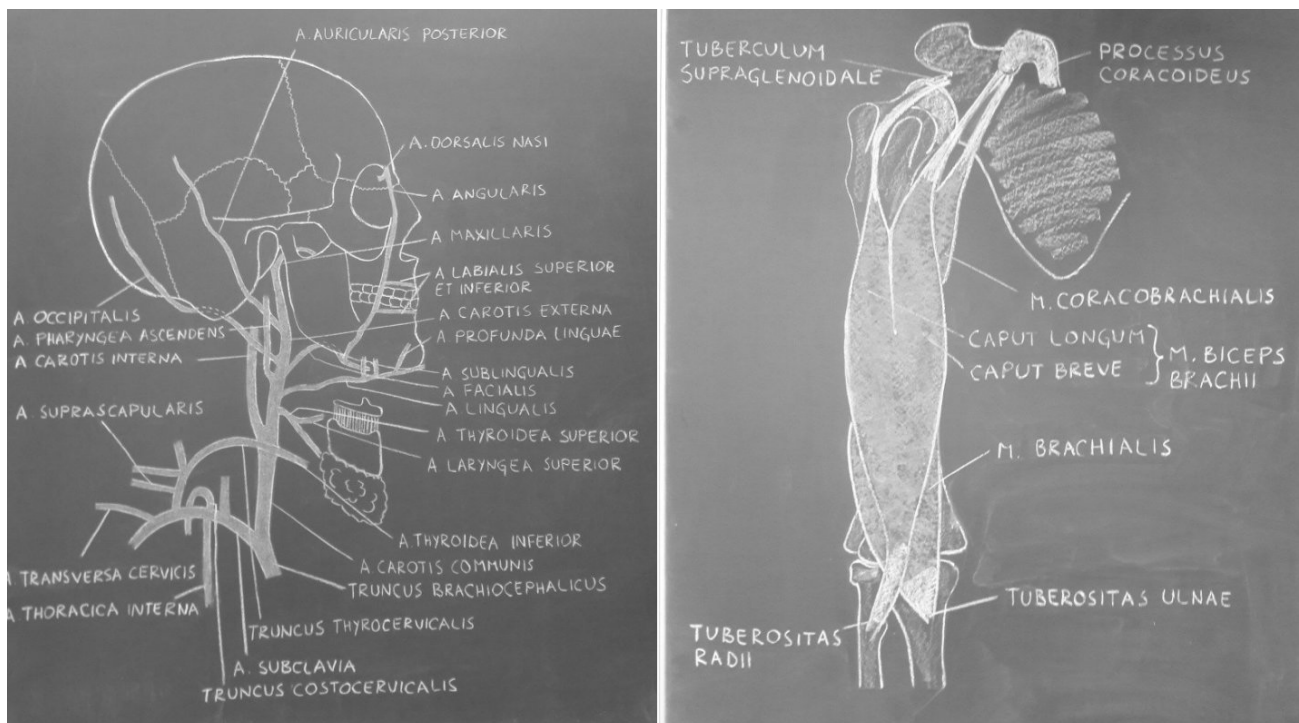

Fig. 1. A teacher drew some drawings on the blackboard during the in-person practical exercise.

However, due to the pandemic, this typical teaching program was abandoned, and innovative teaching methods had to be implemented for the 2020/2021 group of students. All in-person contact was terminated. Instead of standard procedures, new models were used - lectures in the form of voice-over PowerPoint presentations and video recordings of practical exercises (Fig. 2A), both of which were uploaded on the online platform of the University of Novi Sad, photographs of specimens with labeled structures (Fig. 2B), and teaching consultations via e-mail. We aimed to enable the students to learn continuously, to adhere to the curriculum, and to maintain their attention and interest. As soon as the restrictions were minimally relaxed in the second semester, students attended practical exercises in the Department of Anatomy. They were allowed to see the specimens and their photographs with labeled details. However, since the teachers were still absent, students could not ask questions directly, so this sometimes led to incorrect conclusions on the student's part. The partial examinations started very late, mid-second semester, making the schedule very tight. Unlike the 2018/2019 group of students, who had separate preliminary examinations for each area, the online group had to take examinations two by term, except the one on the thorax, which posed an additional challenge for students. The organization of anatomy exams remained unchanged, except for the oral part, which was now performed in the written form of an essay, with the teacher reading in the absence of students. As for the assessment criteria in the exams, they were unaffected by the pandemic conditions.

Two utterly different teaching models were applied before and during the pandemic. In addition, the transition from in-person to online had to be made within a very short time. Therefore, assessing the differences affecting the exam results and students' knowledge of anatomy is essential.

Our study aimed to compare the anatomy exam results of students of Integrated academic studies in Medicine before and during the COVID-19 pandemic, analyze the students' attitudes towards the two anatomy teaching models applied, and propose a teaching model that would be most effective and desirable in the future.

MATERIAL AND METHOD

The study was designed to include two parts: retrospective and cross-section study. It was conducted at the Department of Anatomy, Faculty of Medicine Novi Sad, Serbia. In the retrospective phase, the results of entrance exams of 213 students who enrolled in 2018/2019 and 209 students enrolling in 2020/2021 were examined. The subsequent results of the anatomy exams of 211 students (2018/2019) and 214 students (2020/2021) were also analyzed. The overall results were analyzed, comprising the entrance exam and the student's final high school grades. For this purpose, the official school final entrance ranking lists of both examined groups were used. Analysis of preliminary and final exam results enabled the calculation of the overall passing rate for individual partial examinations and final anatomy exams. The exam protocol of the Department database provided this information.

The cross-section study involved 254 students of Integrated academic studies of Medicine (68 male and 186 female) at the Faculty of Medicine Novi Sad, University of Novi Sad, Serbia, out of which 136 students were enrolled in 2018/2019, and 118 students entered in 2020/2021. Filling
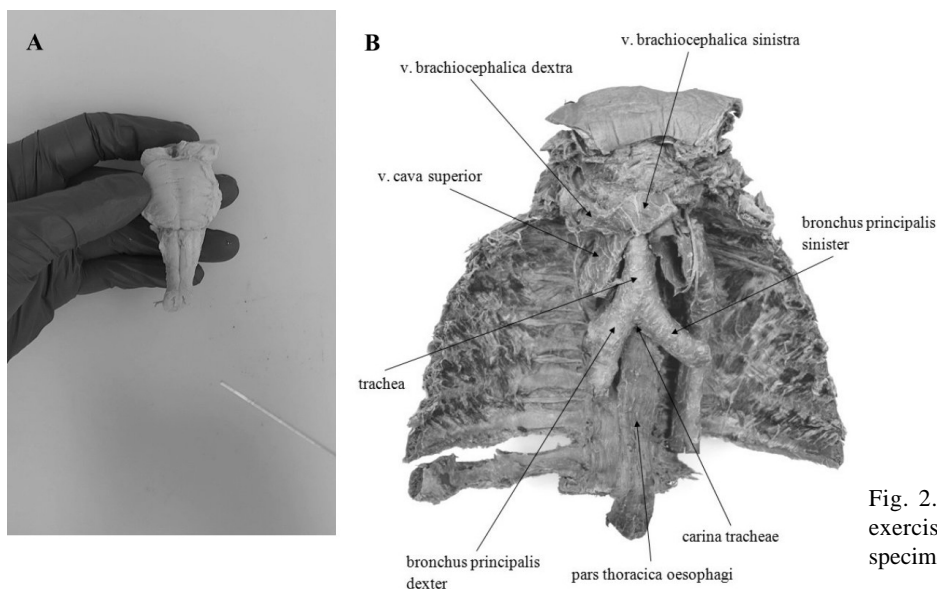

Fig. 2. Screenshot of video of practical exercise (A) and labeled photography of specimen (B).

in a questionnaire, the students gave feedback on the teaching model applied to their group. 2018/2019 students attended traditional in-person classes, while 2020/2021 students had only online courses due to the COVID-19 pandemic. The questionnaire consisted of a certain number of close-ended questions related to lectures, learning materials, the pace of learning, teachers/teaching assistants' availability, knowledge evaluation, confidence about the acquired knowledge, and finally, assessing the applied model. The last question was open-ended, asking for suggestions for teaching model improvements (Table I).

The study also involved students who repeated the year and were now studying online during the pandemic. However, students who transferred from another school were not involved in the study.

IBM SPSS 20.0, which works in a Microsoft Windows environment, was used for data processing. The results are shown in table and graphic form. Descriptive statistics are presented (frequencies and percentages for categorical data, arithmetic mean, and standard deviation for quantitative data). To compare students' attitudes to the teaching models applied before and during the pandemic, χ^2 test for categorical data was used. When the assumptions were not met for applying χ^2 test, the data was analyzed using descriptive statistics. A qualitative analysis of respondents' answers was conducted for the open-ended question. To determine whether the two observed student groups differed in results when entering the school, a t-test for independent samples was performed. The results of partial examinations and exam periods of the two groups were analyzed. In addition to comparing the two groups of students, variations in success rates could be followed, too.

The authors state that every effort was made to follow all local and international ethical guidelines and laws regarding the use of human cadaveric donors in anatomical research (Iwanaga *et al*., 2022). The study was approved by the Ethics Committee of the Faculty of Medicine, the University of Novi Sad (NO.: 01-39/110/1; the date of approval: 28.11.2023). Informed consent was obtained from all participants (Iwanaga *et al*., 2022).

Table I. Questions from a survey of attitudes about the applied anatomy teaching model. *A questionnaire filled out by students taking anatomy online included an additional question about whether the remote teaching method helped prevent the spread of the COVID-19 epidemic.

1	I attended the lectures regularly.
2	Study materials were always available.
3	During the academic year, it was more difficult for me to study continuously.
4	Professors/teaching assistants were always available for enquiries during in-person/online classes.
5	Partial examinations were an appropriate method for assessing knowledge.
6	I am satisfied with how the exam was organized.
7	I am confident about my knowledge acquired through in-person/online teaching.
8	In-person/online lectures and practical exercises are a quality form of teaching.
9	Online method has helped prevent the spread of the COVID-19 epidemic*.
10	Your observations, remarks, comments regarding the in-person/online teaching of anatomy.

RESULTS

Analysis of students' success enrolling in the school

The total number of points that can be achieved when enrolling in the school is 100. It has been established that the average number of points for students who entered the School of Medicine in 2018/2019 was 84.85. The number of points ranged from 77 to 99. The average number of points obtained by the students who entered in 2020/2021 was 86.76 points, with the number of points ranging from 78 to 99. The results of the t-test of independent samples showed that there was a statistically significant difference between the two groups of students in terms of the achieved average number of points when enrolling in the School of Medicine (t(420)=-3.554, p<.001). Students who enrolled in 2020/2021 (M=86.76, SD=5.48) achieved higher points than those who enrolled in 2018/2019 (M=84.85, SD=5.56).

Analysis of students' success in anatomy partial examinations and anatomy exams

The success of students (expressed as the percentage of those who passed) of the two observed groups in eight partial examinations (upper limb, lower limb, thorax, abdomen, pelvis, head and neck Part 1, head and neck Part 2, sense organs and central nervous system) is shown in Fig. 3. Students who enrolled in the School of Medicine before the COVID-19 pandemic were more successful in six partial examinations.
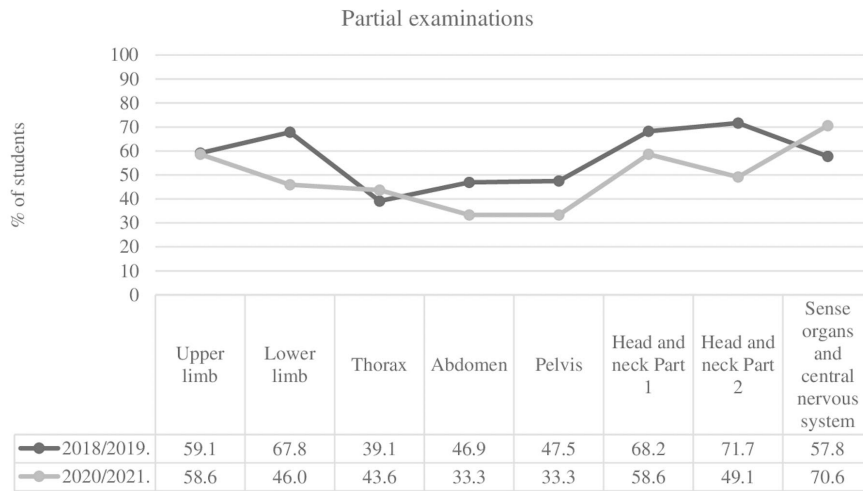
Fig. 3. Success of group 2018/2019 and 2020/2021 students in partial examinations (% of those with a passing grade).

Looking at the results of both groups over time, we notice that there is a visible fall in the next three after the first two examinations, only to rise again in the last three examinations.

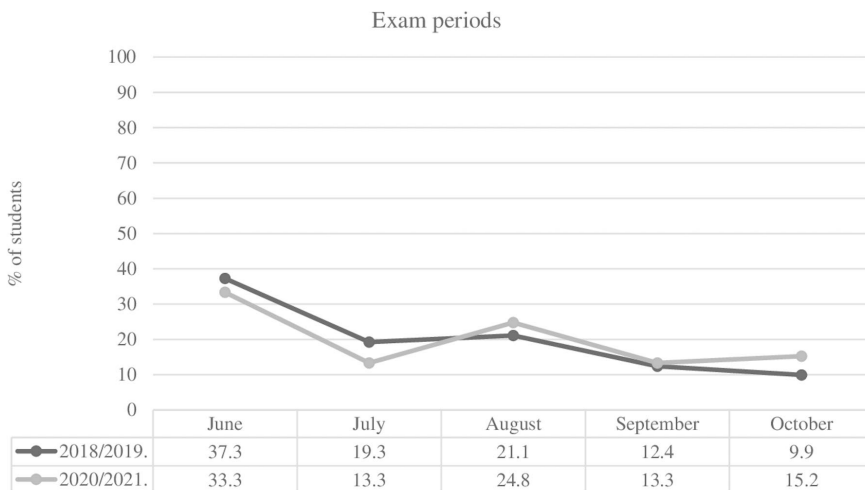The anatomy exam results of students of the two observed groups are presented in Fig. 4.

Fig. 4. Results of students of group 2018/2019 and 2020/2021 in the exam periods (% of those with a passing grade).

It can be noticed that the students of the 2018/2019 group were more successful in the June and July exam period (56 % passing versus only 46 % in the 2020/2021 group), while the students of the 2020/2021 group showed better results in the three remaining exam periods. About a third of the students in both groups passed the anatomy exam in June.

As for the overall exam passing rate, 76.3 % of 2018/2019 students passed anatomy at the end of the academic year, compared to only 49.1 % of 2020/2021 students.

Analysis of students' attitudes toward in-person and online anatomy teaching models

The average age of respondents who completed the questionnaire was 24.74 for the 2018/2019 group, compared to 22.00 for the 2020/2021 group.

Analyzing the data obtained from the completed questionnaires, it was established for the first statement (Fig. 5) that about two-thirds of the students attended online lectures regularly. At the same time, this was the case with about 55 % of students who attended in-person lectures. The proportion of students with no opinion was small (less than 3 %).

Whether they had classes before or during the pandemic, 90 % of students stated that study materials were always available. As with the previous statement, a small percentage had no opinion regarding this issue (Fig. 6).

Analyzing the data presented in Fig. 7, it can be seen that 66 % of students who attended classes during the pandemic pointed out that it was more difficult for them to study continually. At the same time, more than half of the respondents in the 2018/2019 group stated that this was not the case.

It was determined that there is a statistically significant difference between students' responses before and during the COVID-19 pandemic regarding the availability of teachers for inquiries during classes (Table II). Namely, observed relatively, the results indicate that among the students in in-person classes, there were statistically significantly more of those who stated that the teachers were always available for inquiries. On the other hand, among those who had online courses, there were statistically
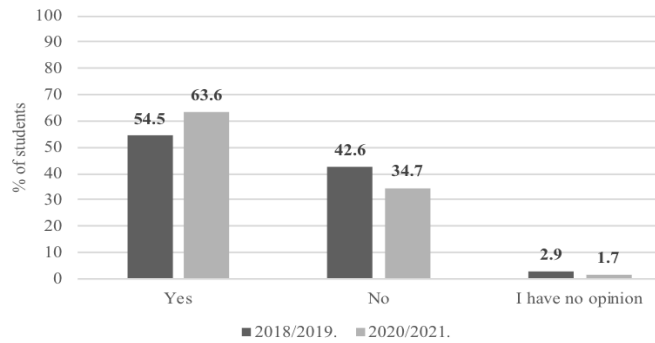
Fig. 5. Distribution of responses of two groups of students to the statement - *I attended the lectures regularly.*
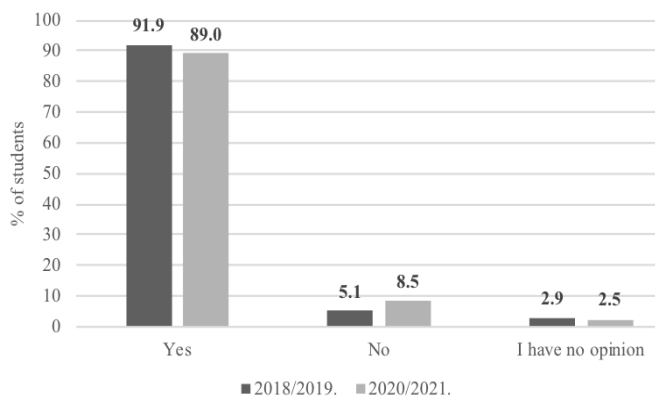

Fig. 6. Distribution of responses of two groups of students to the statement - *Study materials were always available.*
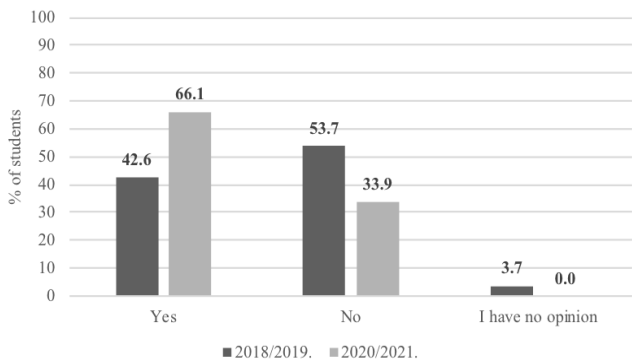

Fig. 7. Distribution of responses of two groups of students to the statement - *During the academic year, it was more difficult for me to study continually.*

significantly more of those who had no opinion or disagreed with the statement. The calculated value of Cramer's V indicator = .395 showed a moderate association between the variables.

The analysis of the obtained data revealed a statistically significant difference between the responses of the two observed groups of students regarding the attitude to the usefulness of partial examinations $\chi^2(2, N=254) = 7.307$, p = .026. Namely, observed relatively, the results indicate that among the in-person group, there were statistically significantly more students who stated that partial examinations were an appropriate method for assessing knowledge, while among the online group, there were statistically significantly more those who disagreed with that statement (Table III). The calculated value of Cramer's V indicator = .170 showed a moderate association between the variables.

It was found that there is a statistically significant difference between the responses of the group of students before and during the COVID-19 pandemic regarding satisfaction with the organization of the exam. The results indicate that, although there were overall more positive than negative responses, the proportion of dissatisfied students was statistically significantly higher among online students (Table IV). The calculated value of Cramer's V indicator = .194 showed a moderate association between the variables.

It has been established that there is a statistically significant difference between the responses of the two groups of students regarding their confidence about the knowledge acquired through the two models of teaching $\chi^2(2, N=254) = 23.464$, p < .001. The obtained results suggest that among the students who attended anatomy classes in-person, there were statistically significantly more those who stated that they were confident about their knowledge, while among the students who had online courses, there were statistically significantly more those who were insecure of their understanding (Table V). The calculated value of Cramer's V indicator = .304 showed a moderate association between the variables.

Table II. χ^2 test differences between the replies of the two observed student groups to the statement - Professors/teaching assistants were always available for inquiries during in-person/online classes.

Group	N	Professors/teaching assistants were always available for inquiries during classes			χ^2	p
		Yes	No	I have no opinion		
2018/2019	136	123	3	10		
2020/2021	118	66	16	36		
Total	254	189	19	46	39.705	<.001

N – number of respondents, χ^2 – statistic, p – statistical significance.

Table III. χ^2 test differences between the replies of the two observed student groups to the statement - Partial examinations were an appropriate method for assessing knowledge.

Group	N	Partial examinations were an appropriate method for assessing knowledge			χ^2	p
		Yes	No	I have no opinion		
2018/2019	136	96	31	9		
2020/2021	118	64	43	11	7.307	.026
Total	254	160	74	20		

N – number of respondents, χ^2 – statistic, p – statistical significance.

Table IV. χ^2 test differences between the replies of the two observed student groups to the statement - I am satisfied with how the exam was organized

Group	N	I am satisfied with how the exam was organized			χ^2	p
		Yes	No	I have no opinion		
2018/2019	136	104	17	15		
2020/2021	118	71	32	15	9.587	.008
Total	254	175	49	30		

N – number of respondents, χ^2 – statistic, p – statistical significance.

The obtained data showed that there is a statistically significant difference between replies of in-person and online students regarding the quality of both types of classes χ^2(2, N=254) = 50.263, p < .001. The findings suggest that among the online students, there were statistically significantly more of those who did not appreciate the quality of lectures and practical exercises compared to in-person students, among whom there were statistically significantly more of those who believed that the quality of lectures and practical exercises was satisfying (Table VI). The calculated value of Cramer's V indicator (= .445) indicates a high association between the variables.

About half the students believed that the online teaching model helped prevent the spread of the COVID-19 pandemic (51.7 %), about 14.4 % thought that it did not, and a surprisingly large percentage of students (33.9 %) had no opinion regarding this issue.

Qualitative assessment of in-person anatomy teaching

Out of the 136 students who filled out the survey, 88 gave their observations, remarks, and comments related to in-person anatomy teaching. The total number of responses is higher than the number of respondents since some of them

Table V. χ^2 test differences between the replies of the two observed groups of students to the statement - I am confident about my knowledge of anatomy.

Group	N	I am confident about my knowledge of anatomy			χ^2	p
		Yes	No	I have no opinion		
2018/2019	136	102	21	13		
2020/2021	118	54	45	19	23.464	<.001
Total	254	156	66	32		

N – number of respondents, χ^2 – statistic, p – statistical significance.

Table VI. χ^2 test differences between the replies of the two observed student groups to the statement - In-person/online lectures and practical exercises are a quality form of teaching.

Group	N	In-person/online lectures and practical exercises are a quality form of teaching			χ^2	p
		Yes	No	I have no opinion		
2018/2019	136	127	5	4		
2020/2021	118	66	43	9	50.263	<.001
Total	254	193	48	13		

N – number of respondents, χ^2 – statistic, p – statistical significance.

had more than one comment. All the responses were categorized as follows: positive (82 comments), negative (11 comments), and suggestions for improving teaching (15 comments).

Positive comments prevail. The most significant number of students (29) highlighted the satisfying quality of lectures and practical exercises. Some students stated that this approach contributed to greater motivation and interest, and they described the classes as stimulating and encouraging. A large number of positive comments – 25, were related to the dedication, availability, and engagement of professors, teaching assistants, and student-demonstrators. In addition, a large number of students (24) appreciated the high level of organization in the Department of Anatomy. In contrast, four students saw the in-person classes as the only possible way to organize quality teaching of this subject.

Regarding negative comments, four students believed that the main disadvantage of in-person studying was the inability to view the material multiple times since the lectures and practical exercises were not recorded. One student commented that the in-person model could have worked better since the information was given too quickly without possibly going over it again. Video material would enable multiple viewing, thus enhancing the learning process. Three students found the exam too stressful and demanding and claimed the assessment criteria were uneven and strict (a difficult test requiring at least 60 % of correct answers in each area). Two students believed that the scope of lectures should be reduced while the scope of practical exercises should be increased. One student stated that some teaching assistants should have been more available, and one complained about the study material.

The largest number of suggestions for improving the quality of teaching – 6 concerned the proposal to make the examinations more comprehensive by introducing some theoretical questions. Other responses referred to improving the standard of lectures, greater availability of teaching assistants, enabling video access to certain specimens, greater student activity in practical exercises, and linking exercises with clinical practice.

Qualitative assessment of online anatomy teaching

Of the 118 students who filled out the survey, 73 gave observations, remarks, and comments on online anatomy learning. The total number of responses is greater than the number of respondents since some gave more than one response. All responses were categorized as positive (44 comments) and negative (61 comments).

Comments underlining the shortcomings of online teaching and its repercussions on the learning process and exam preparation prevail. In the opinion of 16 students, the biggest drawback was the absence of practical exercises in-person. It made studying for the practical exam extremely difficult. They appreciated online lectures but stated that practice has to be done in- person. One student blamed the lack of in-person practical exercises for his inadequate knowledge of anatomy. Students were generally okay with online practical exercises, but deemed them unsuitable for this subject. Sixteen students complained about being left alone when some ambiguities needed clarifying. Fourteen students considered an online model to be inadequate. Some believed online studying made the subject difficult to understand and could have been more productive. Principally, it was a good idea, but in-person teaching was seen as superior. Seven students found the inconsistency of practical exercises and lectures and material needing to be posted more timely annoying. Namely, the students stated that the practical exercises did not start before the second semester, were not coordinated with the lectures, and were "crammed" into a short period. This made learning and mastering the material difficult. Irregular practical exercises and examinations in the last two months before the exam made the students feel stressed and under pressure. Three students believed the exam should have been more accessible due to the specific situation in which the teaching was organized.

Regarding positive comments, most of them (14) emphasized high-quality lectures and practical exercises. Students stated that the online teaching was much better, that the Department had excellent lecturers who delivered interesting lectures, and that the learning process was easier. Next, nine students appreciated the high quality of the study material (presentations, video recordings, video lectures). In the students' opinion, the posted materials made preparing and taking the exam easier. Eight students highlighted the dedication, engagement, and availability of professors, teaching assistants, and student- demonstrators. Seven students positively valued the availability of materials at all times; it enabled them to listen to and view the lectures and practical exercises at their convenience, repeating the video when needed. Distance education was favored by four students, giving them more time to study since the schedule did not limit them. Two students pointed out the excellent organization of teaching.

DISCUSSION

The COVID-19 pandemic accentuated the age-long dilemma of how to best teach anatomy (Turney, 2007). Anatomists are divided over how their classes should be

delivered. In general, only one type of teaching is predominantly favored – in-person (Zhang *et al.*, 2020; Totlis *et al.*, 2021; Brandão *et al.*, 2022) or online (Boulos, 2022; Brown *et al.*, 2023), but the combination of these two has not yet been widely perfected (Potu *et al.*, 2022). However, the COVID-19 pandemic has inadvertently created an opportunity to assess the value of anatomy teaching models in groups of students attending in-person or online courses.

Their entry exam results were examined to establish a potential initial difference between the two groups of students. It was shown that students who enrolled in 2020/2021 achieved a significantly higher number of points in the entrance exam than those who enrolled in 2018/2019. On the other hand, 2018/2019 students showed better results in more partial examinations, and more than three-quarters of them passed anatomy compared to only about half of the 2020/2021 group. This means that the teaching model seriously influenced students' results in anatomy exams. Our students' exam results were inconsistent with the anatomy exam results of students from Alexandria, Egypt (Boulos, 2022). Their students of the online model achieved better results in the final test than after in-person classes. The study authors suggested one possible reason – the online students were less stressed doing the exams from the comfort of their homes, unlike those who took the exams at the School of Medicine.

Comparing in-person with online teaching in our study, five survey questions revealed a remarkable difference in favor of the in-person model: teachers were always available for inquiries during classes, partial examinations were an appropriate method for knowledge assessment, students were satisfied with how the exam was organized, students were confident about their knowledge of anatomy, the lectures, and practical exercises were seen as a quality form of teaching. A large yet not statistically significant difference was seen in the fact that the online students attended lectures more regularly but found it more challenging to study continuously during the academic year. The two groups of students ranked almost equally regarding the high availability of study materials. Examinations were seen as beneficial by 86.3 % of Egyptian students (Boulos, 2022), compared to 63 % of our students. Our students proposed a modification of the exam by incorporating a theoretical part. A periodic comprehensive knowledge check is helpful for students since it gives them constant objective insight into their knowledge and helps them adjust their learning style and pace to the results. The next question focused on the efficiency of online lectures. Among the Egyptian students, the satisfaction index was lower – 57/100 %. When asked about online studying to prevent the spread of COVID-19, 79 % of Egyptian students answered positively.

In contrast, in our study, that number was lower (51.7 %), which may be explained by a different understanding of epidemiological restrictions. Our open-ended questions also showed more positive attitudes towards in-person than online teaching. Most of the students pointed out high-quality lectures and practical exercises. According to the students, in-person teaching provided conditions for more permanent, better quality, in-depth, and coherent knowledge. The teaching methods of professors and teaching assistants helped students master the material within the required time, thus meeting the exam criteria. The readiness to cooperate and the availability of teaching staff also contributed to students acquiring the material well and preparing for the exam. A significant advantage of in-person studying was the possibility of clearing any ambiguities on the spot and developing effective study routines. It should be noted that students recommended linking the material with clinical matters. Attitudes of our students about interactions during in-person teaching are probably best illustrated by the following comment from the survey:

"The best type of teaching is where students can immediately ask what they need during the class and be shown what they don't understand because anatomy is a subject that is much easier to learn that way".

Students appreciated the teachers' hand drawings on the board, which helped them memorize facts more easily. Many students valued the presence of student-demonstrators, i.e., fourth to sixth-year students who helped them prepare for the exam through revision. One valuable observation was that simple revision was crucial for learning anatomy, so more people should be engaged in practical exercises so that students can utilize class time effectively. Moreover, the revision was made fun of by games such as 'There can be only one,' where details were labeled on specimens, and the students had to give correct answers not to drop out. Getting the winner would take a few rounds, and all the students would partake in revision. Also, to facilitate the students' focus during long lectures, our teachers make occasional amusing breaks by recounting their personal experiences related to the topic at hand or anatomy studies in general.

Our online students found it easier to acquire practical knowledge of anatomy with in-person practical exercises in the presence of a teacher. Some studies found a decline in student-teacher interaction in online anatomy sessions (Attardi *et al.*, 2018; Yoo *et al.*, 2021). A sound pedagogical approach could significantly increase students' confidence, primarily through practical exercises and elective oral examinations, a common practice in our department. A few authors claim that peer interaction at school is significant, especially for the 1st year students who have never before

dealt with a demanding course such as anatomy. It is an essential way for students to obtain helpful information, see how they measure up, and get extra motivation for learning (Boulos, 2022). Our students believed that anatomy cannot be studied independently and remotely but in- person if one wants to acquire thorough and permanent knowledge. A certain number of our online group students emphasized a high quality of lectures and practical exercises, with disadvantages only related to the model itself, as can be seen in the following comments:

"Material on the platform was well done, but it feels different from in-person lectures. It didn't feel like I was studying at Faculty, so my learning time was significantly reduced".

"Practical exercises in the form of videos are acceptable only as a supplementary method".

Online lectures were the same PowerPoint presentations used in the in-person model. Still, they improved with recorded voice and were available on the platform during the academic year. Recorded practical exercises were entirely new for our department and required much more effort and digital skills from the teacher. According to our students, what was appreciated in the online model was the possibility of reviewing the recorded materials and the time saved by not going to school. The same advantages in large percent were emphasized by Brazilian students (Brandão *et al*., 2022). The impressions of their students fully coincide with those of our students regarding the inability of the online model applied during the COVID-19 pandemic to replace the value of in-person teaching. Likewise, 90.9 % of Brazilian students believed that the practical part is important for anatomy studies (Brandão *et al*., 2022). Australian and New Zealand students stated that the inaccessibility of cadavers was the biggest drawback of online teaching after the law was passed that altogether banned the use of cadavers in classes due to the possible transmission of the virus during the COVID-19 pandemic in the two countries. The students also needed help navigating online courses, probably because they were in different time zones, and some had limited or weak Internet connections (Pather *et al*., 2020).

An American study (Brown *et al*., 2023) gave an advantage to online teaching during the COVID-19 pandemic compared to the "face-to-face" model before COVID-19, quite contrary to the results of our study. The American study introduced a virtual reality (VR) model that facilitates collaboration between teachers and students in a shared virtual reality environment focused on anatomical data. Students can explore anatomical content in three dimensions, perform virtual dissections, and explore radiological examinations such as magnetic resonance imaging (MR) and computed tomography (CT). A few interesting comments were given by students who found wearing head-mounted displays (HMD) during sessions inconvenient, as they needed help to take notes simultaneously. Additionally, several studies (Stepan *et al*., 2017; Moro *et al*., 2017) have shown that VR increases student motivation and engagement in neuroanatomy and general anatomy classes. VR platforms can be an effective tool in education, but only with the permanent presence of teachers. Attardi & Rogers (2015) designed an online laboratory where teachers taught Netter's 3D anatomy to students who always had the option to communicate with professors through a chat window. The students who participated in the online laboratory and listened to lectures in- person at the school achieved the same results and concluded that the results were based on previous academic knowledge. Some authors evaluate the application of modern technologies as an act of dehumanization of medicine, criticizing its insufficient orientation towards students and seeing it justified only as a supplement to the classical methods of dissection and demonstration on cadaveric material (Srdic Galic *et al*., 2017). However, the main limitation of the described new, fully digital models is their high cost (Boulos, 2022).

Most Bahraini students (57.4 %) favored a combined learning model that includes elements of in-person and online models (Potu *et al*., 2022). The main advantages of the in-person model that the students noticed were a better understanding of the spatial orientation of organs and systems and better visualization of anatomical relations between structures. Students also favored the online model because of the effective utilization of demonstration time and lower stress associated with learning. Some even recommended social networks (Facebook, Twitter, YouTube) to be used to post study material and educational videos, thus making studying easier. Students would use social networks to learn something new, even in their leisure time, without feeling pressured (Iwanaga *et al*., 2021).

As an advantage of our study, we would like to mention many respondents, which amounts to information given by 425 students in the retrospective part and 254 students in the cross-section study. We compared two groups of students, one that studied entirely in-person and the other online. Limitations, however, are reflected in the fact that the students we examined are now in their sixth (2018/2019) and fourth (2020/2021) years of studies. This means they based their answers on the recollection of events from a few years back, which may have affected the reliability of their memory.

CONCLUSIONS

In-person teaching is clearly shown to be superior in comparison to online education, according to students' results in anatomy exams as well as students' attitudes. To transmit knowledge, teachers must establish a good rapport with students; only the in-person model lends itself to that purpose. Attending in-person lectures and practical exercises should be mandatory. However, the pandemic situation has shed some light on the more than beneficial aspects of online teaching which definitely ought to be embraced. Providing additional, affordable, and constantly available learning resources is essential. The main recommendations for future hybrid model would be to create voice-over lectures, videos of practical exercises, photographs of specimens with labeled structures next to the actual structures, and on-the-board drawings during classes. In-person practical exercises should focus on demonstration and repetition, while knowledge should be continuously checked practically and theoretically. Our thoroughly described methods may increase the quality of anatomy teaching and be applicable in low and middle-income countries.

VUCINIC, N.; STRBAC, S.; PUPOVAC, N.; RADOSEVIC, D.; PRTINA, M. & TUBBS, R. S. Modelos de enseñanza de anatomía antes y durante la pandemia de COVID-19: Evaluación de los modelos de enseñanza. *Int. J. Morphol., 43(2)*:410-421, 2025.

RESUMEN: La pandemia de COVID-19 generó un cambio inmediato en la enseñanza de anatomía de presencial a la enseñanza en línea. Nuestro estudio tuvo como objetivo comparar los resultados de los exámenes de anatomía, examinar las actitudes de los estudiantes hacia estos dos modelos de enseñanza diferentes y proponer un modelo más deseable. En la parte retrospectiva del estudio, se analizaron los resultados de los exámenes de anatomía de 211 estudiantes que estudiaron en persona en 2018/2019 (antes de la pandemia) y 214 estudiantes que estudiaron en línea en 2020/2021 (durante la pandemia). El estudio transversal comprende una encuesta exhaustiva sobre las actitudes de los estudiantes hacia el modelo de enseñanza presencial (136 estudiantes) y en línea (118 de los respectivos años académicos). El 76,3 % de los estudiantes aprobaron el examen de anatomía después de la enseñanza presencial, en comparación con solo el 49,1 % después de la enseñanza en línea. La encuesta mostró que, en el modelo presencial, los profesores estaban más disponibles (χ^2(2, N=254) = 39,705, p < ,001), los exámenes eran útiles para la evaluación de conocimientos (χ^2(2, N=254) = 7,307, p = ,026), los estudiantes estaban más satisfechos con el examen (χ^2(2, N=254) = 9,587, p = ,008), tenían mayor confianza en sus conocimientos (χ^2(2, N=254) = 23,464, p < ,001) y, en general, apreciaban más la calidad de este modelo (χ^2(2, N=254) = 50,263, p < ,001) que el grupo en línea. Aproximadamente la mitad de los estudiantes del grupo en línea creían que el estudio a distancia prevenía la propagación de la COVID-19. Las actitudes expresadas en las preguntas abiertas fueron más positivas respecto de la enseñanza presencial que respecto de la enseñanza en línea, siendo la ausencia de ejercicios prácticos presenciales la que recibió las críticas más significativas. El modelo presencial demostró ser indiscutiblemente superior. Sin embargo, los recursos didácticos, como las presentaciones de PowerPoint con voz en off, y las grabaciones en vídeo de ejercicios prácticos, aplicados en la enseñanza en línea deberían incorporarse en los futuros modelos de enseñanza.

PALABRAS CLAVE: Anatomía; Educación de pregrado; Evaluación; Recomendación; Pedagogía.

REFERENCES

Attardi, S. M.; Barbeau, M. L. & Rogers, K. A. Improving online interactions: lessons from an online anatomy course with a laboratory for undergraduate students. *Anat. Sci. Educ., 11(6)*:592-604, 2018.

Attardi, S. M. & Rogers, K. A. Design and implementation of an online systemic human anatomy course with laboratory. *Anat. Sci. Educ., 8(1)*:53-62, 2015.

Boulos, A. N. Evaluation of the effectiveness of online education in anatomy for medical students during the COVID-19 pandemic. *Ann. Anat., 244*:151973, 2022.

Brandão, J. M.; Silva, I. A. V.; Moura, T. C.; Zimmermann, D. M. V.; Favaro, W. J. & Appenzeller, S. The teaching of anatomy during the Covid-19 pandemic. *Rev. Bras. Educ. Med., 46(3)*:e125, 2022.

Brown, K. E.; Heise, N.; Eitel, C. M.; Nelson, J.; Garbe, B. A.; Meyer, C. A.; Ivie Jr., K. R. & Clapp T. R. A large-scale, multiplayer virtual reality deployment: a novel approach to distance education in human anatomy. *Med. Sci. Educ., 33(2)*:409-21, 2023.

Daniel, S. J. Education and the COVID-19 pandemic. *Prospects (Paris), 49(1-2)*:91-6, 2020.

Franchi, T. The impact of the Covid-19 pandemic on current anatomy education and future careers: a student's perspective. *Anat. Sci. Educ., 13(3)*:312-5, 2020.

Ghosh, S. K. Cadaveric dissection as an educational tool for anatomical sciences in the 21st century. *Anat. Sci. Educ., 10(3)*:286-99, 2017.

Hildebrandt, S. Lessons to be learned from the history of anatomical teaching in the United States: the example of the University of Michigan. *Anat. Sci. Educ., 3(4)*:202-12, 2010.

Iwanaga, J.; Loukas, M.; Dumont, A. S. & Tubbs, R. S. A review of anatomy education during and after the COVID-19 pandemic: Revisiting traditional and modern methods to achieve future innovation. *Clin. Anat., 34(1)*:108-14, 2021.

Iwanaga, J.; Singh, V.; Takeda, S.; Ogeng'o, J.; Kim, H. J.; Morys, J.; Ravi, K. S.; Ribatti, D.; Trainor, P. A.; Sañudo, J. R.; Apaydin, N.; Sharma, A.; Smith, H. F.; Walocha, J. A.; Hegazy, A. M. S.; Duparc, F.; Paulsen, F.; del Sol, M.; Adds, P.; Louryan, S.; Fazan, V. P. S.; Boddeti, R. K. & Tubbs, R. S. Standardized statement for the ethical use of human cadaveric tissues in anatomy research papers: Recommendations from Anatomical Journal Editors-in-Chief. *Clin. Anat., 35(4)*:526-8, 2022.

Moro, C.; Stromberga, Z.; Raikos, A. & Stirling, A. The effectiveness of virtual and augmented reality in health sciences and medical anatomy. *Anat. Sci. Educ., 10(6)*:549-59, 2017.

Panchabakesan, S. Problems and prospectives in distance education in India in the 21st century. *PEC, 30(1)*:113-22, 2011.

Pather, N.; Blyth, P.; Chapman, J. A.; Dayal, M. R.; Flack, N. A. M. S.; Fogg, Q. A.; Green, R. A.; Hulme, A. K.; Johnson, I. P.; Meyer, A. J.; *et al*. Forced disruption of anatomy education in Australia and New Zealand: an acute response to the Covid-19 pandemic. *Anat. Sci. Educ., 13(3)*:284-300, 2020.

Potu, B. K.; Atwa, H.; Nasr El-Din, W. A.; Othman, M. A.; Sarwani, N. A.; Fatima, A. Deifalla. A. & Fadel, R. A. Learning anatomy before and during COVID-19 pandemic: Students' perceptions and exam performance. *Morphologie, 106(354)*:188-94, 2022.

Pupovac, N.; Eric, M.; Sekulic, S.; Knezi, N.; Vlaski, A.; Hajder, D. & Petkovic, B. Morphological and morphometric analysis of the external aperture of the carotid canal in Serbian population. *Int. J. Morphol., 38(4)*:1026-31, 2020.

Sadeesh, T.; Prabavathy, G. & Ganapathy, A. Evaluation of undergraduate medical students' preference to human anatomy practical assessment methodology: a comparison between online and traditional methods. *Surg. Radiol. Anat., 43(4)*:531-5, 2021.

Srdic Galic, B.; Udicki, M.; Vucinic, N.; Radosevic, D.; Zigic, S.; Drvendzija, Z.; Peric, R.; Krstonosic, B.; Mijatov Ukropina, L.; Stojsic Dzunja, L.; Contemporary anatomy teaching – experiences from the Faculty of Medicine Novi Sad. *Med. Pregl., 70(11-12)*:345-51, 2017.

Srinivasan, D. K. Medical students' perceptions and an anatomy teacher's personal experience using an e-learning platform for tutorials during the Covid-19 crisis. *Anat. Sci. Educ., 13(3)*:318-9, 2020.

Stepan, K.; Zeiger, J.; Hanchuk, S.; Del Signore, A.; Shrivastava, R.; Govindaraj, S. & Iloreta A. Immersive virtual reality as a teaching tool for neuroanatomy. *Int. Forum Allergy Rhinol., 7(10)*:1006-13, 2017.

Totlis, T.; Tishukov, M.; Piagkou, M.; Kostares, M. & Natsis, K. Online educational methods vs. traditional teaching of anatomy during the COVID-19 pandemic. *Anat. Cell Biol., 54(3)*:332-9, 2021.

Turney, B. W. Anatomy in a modern medical curriculum. *Ann. R. Coll. Surg. Engl., 89(2)*:104-7, 2007.

Yoo, H.; Kim, D.; Lee, Y. M. & Rhyu, I. J. Adaptations in anatomy education during COVID-19. *J. Korean Med. Sci., 36(1)*:e13, 2021.

Zhang, Q.; He, Y. J.; Zhu, Y. H.; Dai, M. C.; Pan, M. M.; Wu, J. Q.; Zhang, X.; Gu, Y. E.; Wang, F. F.; Xu, X. R.; *et al*. The evaluation of online course of Traditional Chinese Medicine for Medical Bachelor, Bachelor of Surgery international students during the COVID-19 epidemic period. *Integr. Med. Res., 9(3)*:100449, 2020.

Corresponding author:
Nikola Vucinic, MD, PhD, Associate Professor
Department of Anatomy
Faculty of Medicine Novi Sad
University of Novi Sad
Hajduk Veljkova 3
21000 Novi Sad
SERBIA

E-mail: nikola.vucinic@mf.uns.ac.rs