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Original article

SATISFACTION WITH ANATOMY EDUCATION AND PERCEIVED EFFECTIVENESS OF LEARNING METHODS AMONG FIRST-YEAR AND SENIOR MEDICAL STUDENTS: A CROSS-SECTIONAL QUESTIONNAIRE STUDY AT THE FACULTY OF MEDICINE IN SKOPJE

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Abstract

Introduction: Anatomy education is evolving in response to reduced contact hours and the increasing use of digital tools.

Aim: To assess student satisfaction, perceived effectiveness of teaching methods and preferred study timing among first-year students and senior medical students.

Materials and methods: An online cross-sectional questionnaire was completed by first-year and senior (years 4-6) medical students at the Faculty of Medicine in Skopje. Likert-type responses were analyzed using non-parametric tests and ordinal logistic regression adjusted for gender, with Holm–Bonferroni correction. Open-ended responses were analyzed thematically.

Results: Responses were received from 134(67.0%) first-year and 87(43.5%) senior students. Among first-year students, 51.5% were satisfied with lectures and practical classes, while 85.1% had independently developed effective study strategies. Only about one third of students felt that the curriculum matched their learning style. Perceived effectiveness differed significantly across seven teaching methods (p<0.001). 3D computer programs received the highest ratings (90.3%), followed by cadavers and plastinated specimens (75.4%) and face-to-face lectures (69.4%). Synchronous online lectures received the lowest ratings (17.9%). Senior students studied less often after theoretical lectures (32.2% *vs*. 59.0%; OR 0.37, 95% CI 0.23-0.62) but more often after practical classes (62.1% *vs*. 48.5%; OR 2.02, 95% CI 1.23-3.31). Visual learning (46.9%) and regular repetition (35.7%) were the most frequently reported effective strategies.

Conclusions: Students preferred visual, hands-on and 3D-based resources and often developed their own study strategies. Integrating digital tools with cadaver-based teaching and providing early study guidance may improve anatomy education.

Keywords: anatomy education; medical students; student satisfaction; learning preferences; 3D anatomy; cadavers

Introduction

Anatomy is one of the foundations of medical education, since a sound knowledge of the structure of the human body is needed for clinical examination, interpretation of imaging and safe practice in procedures and surgery[1]. Over the past decades, however, anatomy

teaching has changed considerably. Many medical schools have reduced the hours devoted to anatomy, integrated it with other basic and clinical subjects and introduced new teaching tools, while the traditional model of lectures combined with cadaver dissection or demonstration has been questioned[2,3].

Technology has widened the choice of resources available to students. Three-dimensional anatomy applications, virtual dissection tables, online atlases and educational videos are now widely used alongside atlases, textbooks and prosected or plastinated specimens[4,5]. The shift to online teaching during the COVID-19 pandemic further increased the use of recorded and synchronous online lectures, and it raised the question of which methods students actually find effective[6]. At the same time, the quantity of material that students are expected to master in a short time means that many of them must develop their own study strategies, often with little guidance from teachers.

Students' perceptions are an important source of information for improving the teaching of anatomy. Satisfaction with teaching, the perceived effectiveness of different methods and the way students organize their study may influence their motivation and engagement. Students' views of anatomy, including its relevance and their motivation to study it, have been shown to change with experience during the curriculum[7]. First-year students have just started to learn anatomy and are able to evaluate the teaching they currently receive, whereas senior students can look back on anatomy from the perspective of clinical training and judge how useful it has been. Studies that compare these two groups directly are less common, and data from South-East European medical schools are scarce.

Therefore, the aim of this study was to assess satisfaction with anatomy education, the perceived effectiveness of different teaching and learning methods and the preferred timing of study among first-year and senior medical students at the Faculty of Medicine in Skopje, to compare the views of the two groups, and to explore, in their own words, what they consider to be the most effective way of learning anatomy.

Materials and methods

Study design and participants

A cross-sectional questionnaire study was carried out at the Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, North Macedonia, in the 2023-2024 academic year. The survey was part of a wider project, and the views of the same students on the relevance of anatomy education to clinical practice have been reported separately[8]. Two groups of students were invited by text message to take part: 200 first-year students and 200 senior students from the fourth to the sixth year of study . The message explained the purpose of the study and stated that participation was voluntary and that the data collected were anonymous. The questionnaire was completed online in March and April 2024. The study was approved by the Research Ethics Committee of the Faculty of Medicine in Skopje (No. 03-4422/7, 19 September 2024) At the faculty, anatomy is taught during the first three terms of the study in an integrated course that combines lectures, cadaver dissection, prosected and plastinated specimens, radiological anatomy and computer-based learning.

Questionnaire

The questionnaire was prepared and distributed online (Google Forms) in two versions, one for first-year students and one for senior students, and several statements were included in both versions so that the two groups could be compared. The questionnaire was developed using a three-phase approach to educational questionnaires (needs analysis and planning, questionnaire development, and validation and reliability evaluation)[9]. The statements were formulated after consultations with the anatomy teaching staff of the faculty, and feedback from student representatives was taken into account. The questionnaire was tested in a pilot study with a

small number of students and revised according to their feedback. The statements and the open-ended question were prepared in Macedonian. Besides the demographic data (gender, age and year of study), the questionnaires contained statements on satisfaction with anatomy education, on the timing of study (after theoretical lectures, after practical classes with demonstration of anatomical structures, and before colloquia and exams) and on the agreement of the curriculum and teaching methods with the student's learning style. First-year students also rated whether they received useful advice from teachers on how to study anatomy and whether they had to find an effective way of studying on their own, as well as the effectiveness of seven teaching and learning methods: 3D computer programs and platforms, cadavers and plastinated specimens, face-to-face lectures, individual study from textbooks, small-group peer learning, recorded video and audio lectures, and synchronous online lectures. Senior students additionally evaluated whether they were confident that they could renew their anatomy knowledge when needed and whether anatomy education had improved their critical and analytical thinking. All statements were rated on a five-point Likert scale. Both groups also answered the open-ended question "The most effective way to learn anatomy is…".

Statistical analysis

The questionnaire data were exported from Google Forms to Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analyzed with the R statistical software, version 4.3 (R Foundation for Statistical Computing, Vienna, Austria). Responses to the Likert-type statements were coded on a scale from 1 (strongly disagree) to 5 (strongly agree). For senior students, the year of study was determined from the semester or year that each student reported. All participants answered every closed-ended statement included in this analysis, so there were no missing data.

Descriptive statistics (frequencies and percentages) were used to present the distribution of answers for each statement. Because the Likert-type responses are ordinal, the median and interquartile range (IQR) were also calculated, together with the proportion of students who agreed (agree or strongly agree) and who disagreed (disagree or strongly disagree). Means and standard deviations (SD) are given only to allow comparison with other studies.

To determine whether the students in each group tended to agree or to disagree with a given statement, the one-sample Wilcoxon signed-rank test was applied, with the neutral answer[3] as the reference value. The effect size was expressed as $r=Z/\sqrt{n}$, where a positive value indicates agreement and a negative value disagreement. The answers of first-year and senior students to the statements included in both questionnaires were compared with the Mann-Whitney U test (effect size: rank-biserial correlation) and with the Chi-square test of independence on the full distribution of answers (Cramér's V). In addition, ordinal logistic regression adjusted for gender was performed for each of these statements, and the results are presented as odds ratios (OR) with 95% confidence intervals (CI). Effect sizes were interpreted according to Cohen, with values of r of 0.1, 0.3 and 0.5 considered small, medium and large, respectively.

The perceived effectiveness of the seven teaching and learning methods, which was evaluated only by first-year students, was compared with the Friedman test (effect size: Kendall's W), followed by pairwise Wilcoxon signed-rank tests. The same procedure was used to compare the three statements on study timing within each group. Differences according to gender (Mann-Whitney U test) and, among senior students, according to the year of study (Kruskal-Wallis test) were examined in an exploratory manner.

Because several statements were tested within each group, the p-values were adjusted with the Holm–Bonferroni method within each set of tests, and a statistical significance level of 0.05 was used. The internal consistency of the statements was measured with Cronbach's

alpha. Since the alpha value for the statements on teaching methods was low (0.39), these statements were analyzed separately and were not combined into a scale.

The answers to the open-ended question "The most effective way to learn anatomy is…" were analyzed with the thematic analysis method. The responses were read several times and grouped into themes; a single response could be included in more than one theme. The frequency of each theme was compared between the two groups of students with Fisher's exact test.

Results

The questionnaire was sent to 200 first-year and 200 senior medical students at the Faculty of Medicine in Skopje, of whom 134(67.0%) and 87(43.5%) responded, respectively. A total of 221 medical students participated in the survey: 134 first-year students and 87 senior students. The mean age of first-year students was 19.63 years [SD: 1.20, Min: 18, Max: 26], and the mean age of senior students was 23.57 years [SD: 1.44, Min: 21, Max: 29]. Female students accounted for approximatelly three-quarters of both groups. The demographic characteristics of the participants are shown in Table 1. According to the reported year of study, senior group included 27 fourth-year (31.0%), 25 fifth-year (28.7%) and 33 sixth-year students (37.9%), while the year of study could not be determined for 2 students (2.3%). Since none of the statements showed a significant difference between the fourth, fifth and sixth year (Kruskal-Wallis test, all adjusted $p>0.80$), senior students were analyzed as a single group. No significant differences according to gender were found in either group (all adjusted $p>0.13$).

Table 1. Demographic characteristics of the participants

Group	n	Male, n (%)	Female, n (%)	Age, mean ± SD	Age range
First year	134	32(23.9)	102(76.1)	19.63±1.20	18-26
Years 4-6	87	24(27.6)	63(72.4)	23.57±1.44	21-29
Total	221	56(25.3)	165(74.7)	21.19±2.33	18-29

Values are n (%) unless stated otherwise. SD, standard deviation.

Students' satisfaction and learning preferences

The answers of the students to the statements on their satisfaction with anatomy education and on their learning preferences are given in Table 2 and Figures 1 and 2. The level of agreement of first-year students with the statements can be summarised as follows.

St.1.3: Half of junior students were satisfied with the lectures and practical classes in anatomy (51.5% agreed; $p<0.001$). St. 1.4: Their opinions on colloquia and exams were divided, since 41.0% of the students were satisfied and 28.4% were not, and the answers did not differ significantly from neutral ($p = 0.354$). St. 1.8: Less than half of the students (46.3%) stated that teachers gave them useful advice on how to study anatomy effectively ($p=0.246$). St. 1.9: In contrast, a large majority of students (85.1%) reported that they had to find an effective way of studying anatomy on their own ($p<0.001$), with a large effect size ($r=0.78$). St. 1.10: Only 29.9% of junior students considered that the curriculum and teaching methods matched their learning style, and their answers did not show a significant tendency in either direction ($p=0.741$).

St.1.5-1.7: Regarding the timing of the study, junior students tended to agree with all three statements. The majority preferred to study after theoretical lectures (59.0%; $p<0.001$), while almost half preferred to study after practical classes with demonstration of anatomical structures (48.5%; $p=0.023$). The statement on studying before colloquia and exams yielded in the most divergent responses among students: 53.7% agreed with it and 35.1% disagreed ($p=0.038$).

Senior students evaluated their past anatomy education in a similar manner. St. 2.4: Their satisfaction with anatomy education did not differ significantly from neutral (40.2% agreed; $p=0.131$). St. 2.5-2.7: Only one-third of them (32.2%) preferred to study after theoretical lectures ($p=1.000$), whereas the majority preferred to study after practical classes (62.1%; $p< 0.001$) and before colloquia and exams (59.8%; $p<0.001$). St. 2.8: A considerable number of

Table 2. Students' level of agreement with statements on satisfaction and learning preferences

Statement	Agree, %	Disagree, %	Median (IQR)	Mean (SD)	r	p (Holm)
First-year students (n=134)						
Satisfied with lectures and practicals	51.5	11.2	4(3-4)	3.55(0.98)	0.48	<0.001
Satisfied with colloquia and exams	41.0	28.4	3(2-4)	3.15(1.17)	0.12	0.354
Teachers give useful advice on how to study	46.3	29.1	3(2-4)	3.20(1.22)	0.15	0.246
Had to find my own effective way of studying	85.1	4.5	4(4-5)	4.21(0.86)	0.78	<0.001
Curriculum/methods match my learning style	29.9	29.1	3(2-4)	2.98(1.02)	-0.03	0.741
Prefer to study after theoretical lectures	59.0	15.7	4(3-4)	3.54(1.07)	0.43	<0.001
Prefer to study after practicals with demonstration	48.5	21.6	3(3-4)	3.32(1.16)	0.25	0.023
Prefer to study before colloquia/exams	53.7	35.1	4(2-5)	3.33(1.45)	0.22	0.038
Senior students, years 4-6 (n=87)						
Satisfied with my anatomy education	40.2	20.7	3(3-4)	3.29(1.17)	0.23	0.131
Preferred to study after theoretical lectures	32.2	35.6	3(2-4)	2.97(1.18)	-0.03	1.000
Preferred to study after practicals with demonstration	62.1	11.5	4(3-5)	3.77(1.04)	0.58	<0.001
Preferred to study before colloquia/exams	59.8	18.4	4(3-5)	3.62(1.26)	0.42	<0.001
Curriculum/methods matched my learning style	31.0	44.8	3(2-4)	2.87(1.30)	-0.07	1.000
Confidence in refreshing previously acquired anatomy knowledge	78.2	5.7	4(4-5)	4.10(0.92)	0.74	<0.001
Improved critical and analytical thinking	32.2	42.5	3(2-4)	2.90(1.29)	-0.07	1.000

Agree=agree or strongly agree, disagree=disagree or strongly disagree. IQR-interquartile range, SD-standard deviation, r and p: one-sample Wilcoxon signed-rank test against the neutral value 3 (positive r=agreement), p-values adjusted with the Holm-Bonferroni method within each group (15 statements for first-year and 7 for senior students)

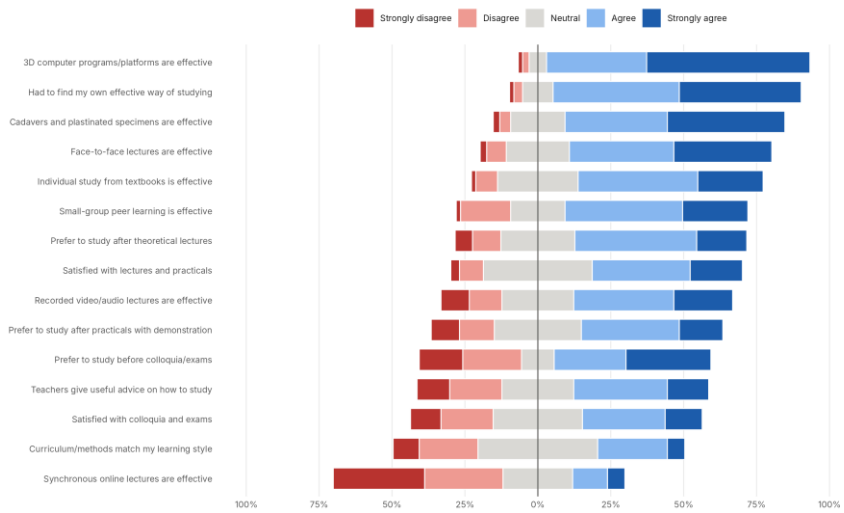

Fig. 1. Distribution of first-year medical students' agreement with the statements (n=134), sorted by net agreement (% agree-% disagree). Neutral answers are split around zero.

senior students (44.8%) disagreed that the curriculum had matched their learning style (p=1.000). St. 2.14: Most of them (78.2%) were confident that they could renew their anatomy knowledge when it was needed (p<0.001). St. 2.19: However, only 32.2% agreed that anatomy education improved their critical and analytical thinking, while 42.5% disagreed (p=1.000).
Figure 2 shows that three statements had a negative balance among senior students: the curriculum matching their learning style (net -13.8 percentage points), the improvement of critical and analytical thinking (-10.3) and studying after theoretical lectures (-3.4). In contrast,confidence in renewing anatomy knowledge (+72.5) and studying after practical classes (+50.6) had the most positive balance.

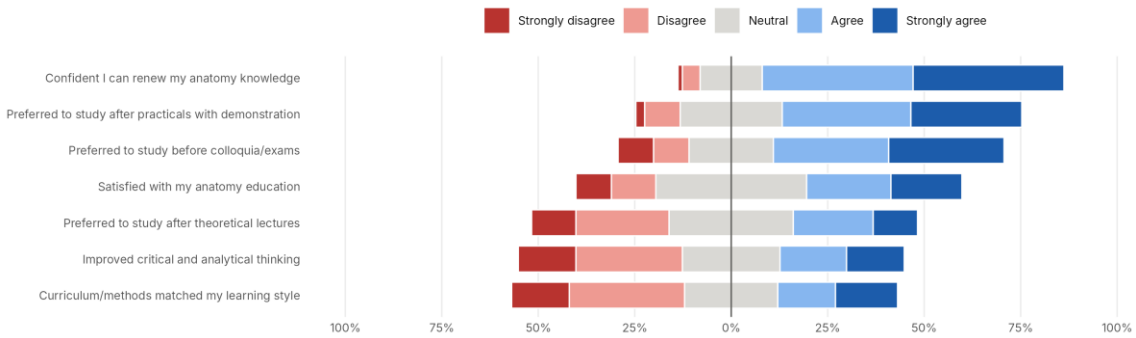

Fig. 2. Distribution of senior medical students' agreement with the statements (years 4–6, n = 87), sorted by net agreement.

Perceived effectiveness of teaching methods

The perceived effectiveness of the different teaching and learning methods, as evaluated by first-year students, is illustrated in Table 3 and Figure 1. The ratings of the seven methods differed significantly (Friedman test, $\chi^2(6)=223.84$, p<0.001, Kendall's W=0.28).

Table 3. Perceived effectiveness of teaching and learning methods among first-year medical students (n=134), ranked by Friedman mean rank

Method	Mean rank	Median (IQR)	Mean	Agree, %	r
3D computer programs and platforms	5.35	5(4-5)	4.41	90.3	0.82
Cadavers and plastinated specimens	4.71	4(4-5)	4.07	75.4	0.71
Face-to-face lectures	4.29	4(3-5)	3.92	69.4	0.65
Individual study from textbooks	4.06	4(3-4)	3.75	63.4	0.61
Small-group peer learning	3.87	4(3-4)	3.65	62.7	0.52
Recorded video/audio lectures	3.64	4(3-4)	3.44	54.5	0.32
Synchronous online lectures	2.07	2(1-3)	2.34	17.9	−0.47

Friedman test: $\chi^2(6) = 223.84$, $p < 0.001$, Kendall's $W = 0.28$. IQR, interquartile range. r: one-sample Wilcoxon signed-rank test against 3 (all adjusted $p < 0.002$)

St. 1.14: Computer-based learning with 3D anatomical programs and platforms was rated as the most effective method, with 90.3% of the students agreeing (p<0.001; r=0.82, large effect). St. 1.17: The study of human cadavers and plastinated specimens was in second place (75.4%; p<0.001), followed by St. 1.11: face-to-face lectures (69.4%; p<0.001). St. 1.15 and St. 1.16: Individual study from textbooks and small-group learning with colleagues were considered effective by about two thirds of the students (63.4% and 62.7%, respectively; both p<0.001). St. 1.13: Video and audio recordings of lectures were rated as effective by 54.5% of the students (p=0.001). St. 1.12: Synchronous online lectures were the only method that the majority of students did not consider effective; only 17.9% agreed and 58.2% disagreed with this statement (p<0.001; r=-0.47, medium effect).

As shown in Figure 1, the statements regarding 3D platforms (net agreement 86.6 percentage points), finding one's own way of studying (80.6) and cadavers and plastinated specimens (69.4) showed the highest net agreement among first-year students. Synchronous online lectures were the only statement with a clearly negative balance (-40.3), while the statement on the curriculum matching the students' learning style was almost exactly balanced between agreement and disagreement (+0.8).

The pairwise comparisons showed that 3D platforms were rated significantly higher than all other methods (all adjusted $p \leq 0.013$), and synchronous online lectures significantly lower than all other methods (all adjusted $p < 0.001$). There was no significant difference between cadavers and plastinated specimens and face-to-face lectures ($p=0.604$), nor between face-to-face lectures and textbooks ($p=0.604$) or small-group learning ($p=0.093$). Cadavers and plastinated specimens were rated higher than textbooks ($p=0.035$), small-group learning ($p=0.006$) and recorded lectures ($p<0.001$), while face-to-face lectures were rated higher than recorded lectures ($p=0.014$). The detailed results of the pairwise comparisons are given in Supplementary Table S1.

Supplementary Table S1. Pairwise comparisons of the seven teaching and learning methods among first-year medical students (n=134)

Method A	Method B	Mean difference (A-B)	r	p (Holm)
Face-to-face lectures	Synchronous online lectures	1.57	0.66	<0.001
Face-to-face lectures	Recorded lectures	0.48	0.27	0.014
Face-to-face lectures	3D platforms	-0.49	0.36	<0.001
Face-to-face lectures	Textbooks (individual study)	0.16	0.12	0.604
Face-to-face lectures	Small-group peer learning	0.27	0.21	0.093
Face-to-face lectures	Cadavers/plastinated specimens	-0.16	0.12	0.604
Synchronous online lectures	Recorded lectures	-1.10	0.61	<0.001
Synchronous online lectures	3D platforms	-2.07	0.80	<0.001
Synchronous online lectures	Textbooks (individual study)	-1.41	0.67	<0.001
Synchronous online lectures	Small-group peer learning	-1.31	0.63	<0.001
Synchronous online lectures	Cadavers/plastinated specimens	-1.73	0.75	<0.001
Recorded lectures	3D platforms	-0.97	0.61	<0.001
Recorded lectures	Textbooks (individual study)	-0.31	0.19	0.146
Recorded lectures	Small-group peer learning	-0.21	0.12	0.604
Recorded lectures	Cadavers/plastinated specimens	-0.63	0.37	<0.001
3D platforms	Textbooks (individual study)	0.66	0.49	<0.001
3D platforms	Small-group peer learning	0.76	0.51	<0.001
3D platforms	Cadavers/plastinated specimens	0.34	0.28	0.013
Textbooks (individual study)	Small-group peer learning	0.10	0.08	0.604
Textbooks (individual study)	Cadavers/plastinated specimens	-0.32	0.24	0.035
Small-group peer learning	Cadavers/plastinated specimens	-0.43	0.30	0.006

Wilcoxon signed-rank test for paired data, $r=|Z|/\sqrt{n}$, p-values adjusted with the Holm–Bonferroni method across all 21 comparisons. Positive mean difference=method A rated higher.

Comparison of junior and senior students

The comparison of the answers of junior and senior students to the statements included in both questionnaires is presented in Table 4 and Figure 3. The two groups of students differed mainly in the timing of their study. Senior students were less likely to study after theoretical lectures (32.2% *vs*. 59.0%; $U=7530.5$, $p<0.001$, $r=0.29$, small-to-medium effect; OR 0.37, 95% CI 0.23-0.62) and more likely to study after practical classes with demonstration (62.1% *vs*. 48.5%;

U=4596.5, p=0.024; OR 2.02, 95% CI 1.23-3.31). No significant differences were found between the two groups regarding satisfaction with anatomy teaching, studying before colloquia and exams, or the agreement of the curriculum with their learning style.

Figure 3 illustrates that the largest difference between the groups concerned studying after theoretical lectures, where agreement was 26.8 percentage points lower among senior students, while the difference for studying after practical classes was in the opposite direction

Table 4. Comparison of first-year (n = 134) and senior medical students (n = 87) on statements included in both questionnaires

Statement	Year 1 agree, %	Years 4-6 agree, %	Year 1 median (IQR)	Years 4-6 median (IQR)	U	r	p (Holm)	OR (95% CI)
Satisfaction with anatomy teaching[a]	51.5	40.2	4(3-4)	3(3-4)	6572.5	0.13	0.283	0.64(0.39-1.06)
Study after theoretical lectures	59.0	32.2	4(3-4)	3(2-4)	7530.5	0.29	<0.001	0.37(0.23-0.62)
Study after practicals with demonstration	48.5	62.1	3(3-4)	4(3-5)	4596.5	-0.21	0.024	2.02(1.23-3.31)
Study before colloquia/exams	53.7	59.8	4(2-5)	4(3-5)	5256.5	-0.10	0.411	1.33(0.82-2.14)
Curriculum/methods match learning style	29.9	31.0	3(2-4)	3(2-4)	6270.5	0.08	0.411	0.78(0.47-1.27)

U and p: Mann–Whitney U test, p-values adjusted with the Holm–Bonferroni method. r: rank-biserial correlation (positive = higher agreement among first-year students). OR: odds of higher agreement among senior *vs*. first-year students, ordinal logistic regression adjusted for gender; CI, confidence interval; IQR, interquartile range. [a] First-year students: satisfaction with lectures and practical classes; senior students: satisfaction with anatomy education overall.

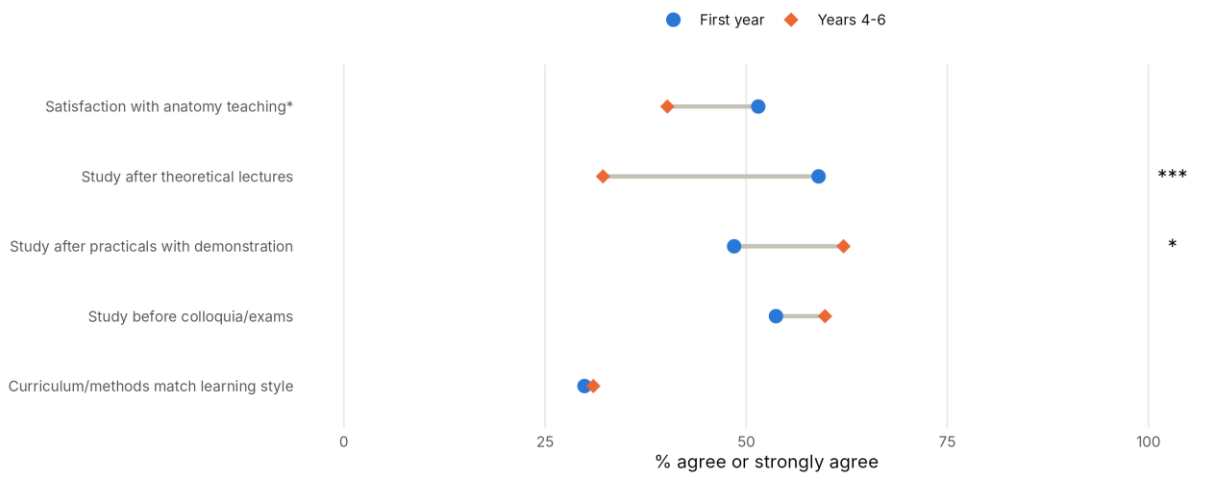

Fig. 3. Percentage of first-year and senior medical students who agreed with the statements included in both questionnaires. *p<0.05, ***p<0.001 (Mann-Whitney U test, Holm-adjusted). Satisfaction statements were worded differently in the two questionnaires.

(13.6 percentage points higher among senior students). The two groups gave almost identical answers on whether the curriculum matched their learning style (29.9% *vs*. 31.0%).

The same pattern was observed within each group. Junior students showed no preference for any of the three study-timing options (Friedman test, $\chi^2(2)=2.78$, p=0.249), whereas senior students did ($\chi^2(2)=27.27$, p<0.001). Senior students preferred studying after practical classes (p<0.001) and before exams (p=0.002) to studying after lectures, while no difference was observed between the last two options (p=0.482).

Students' views on the most effective way to learn anatomy

The answers to the open-ended question "The most effective way to learn anatomy is…" were given by 130 junior (97.0%) and 83 senior students (95.4%), and they were grouped into eleven themes (Figure 4). In both groups, visual learning with the help of atlases, images and visualisation of anatomical structures was mentioned most often (46.9% of all students). The students also frequently emphasized repetition and regular, continuous study (35.7%), practical classes with cadavers and specimens (27.2%), and the use of 3D applications, models and online atlases (24.9%). Educational videos, including those available on YouTube, were mentioned by 19.2% of the students in both groups.

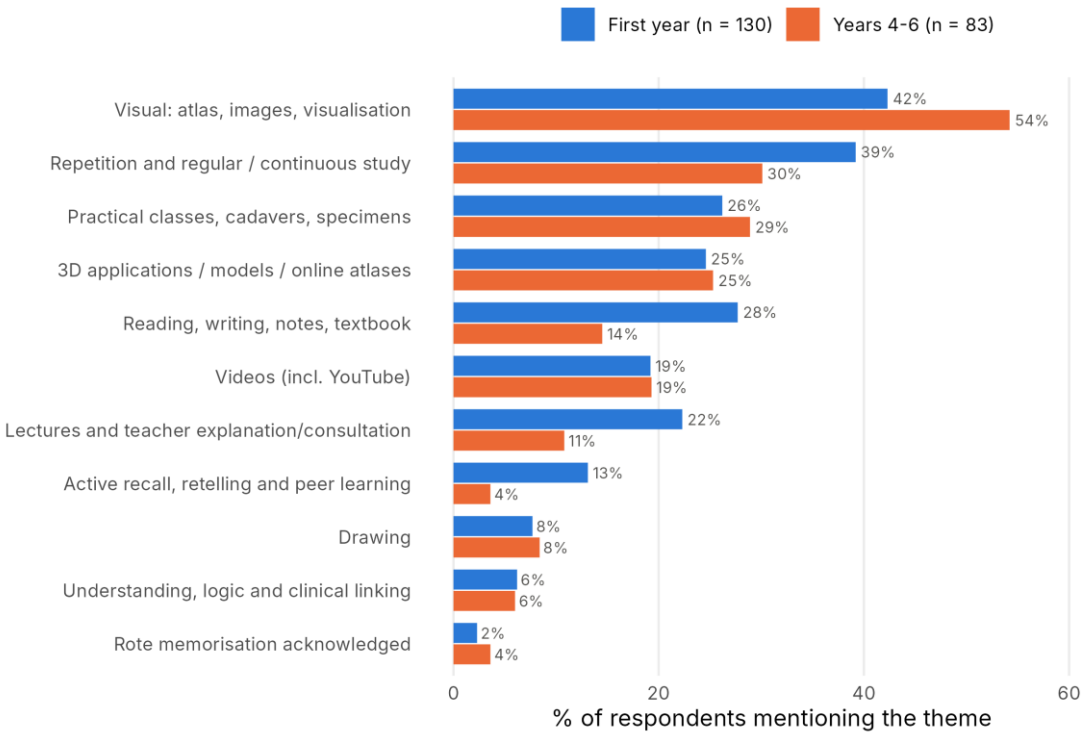

Fig. 4. Themes in the answers to the open-ended question "The most effective way to learn anatomy is…" among first-year (n=130) and senior medical students (years 4-6, n=83). A single answer could be included in more than one theme, so percentages do not sum to 100.

The following answers illustrate the most common themes: *"With an atlas and lots and lots of pictures! Creating an image in your head is key to remembering the structures and their relationships"* (senior student); *"Reading from the book while visualising and labelling the structures with a 3D application, and drawing my own diagrams on screenshots from the app"* (first-year student); *"Learning through reading and retelling, and repeating at certain time intervals so that the information stays in long-term memory as long as possible"* (first-year student); *"Demonstration on new cadavers with preserved color, shape and size of the structures-what I read in the book, I want to see in front of me"* (senior student).

Junior students more often mentioned reading, writing and making notes (27.7% *vs*. 14.5%), lectures and explanations by teachers (22.3% *vs*. 10.8%), and active recall or learning with colleagues (13.1% *vs*. 3.6%). However, none of these differences remained significant after adjustment for multiple comparisons (Fisher's exact test; unadjusted p=0.028-0.043; all adjusted p≥0.34). Only a small number of students referred to understanding and linking anatomy with clinical practice (6.1%), and 2.8% of them stated that anatomy has to be learned by rote.

In summary, most first-year students had to find an effective way of studying anatomy on their own, and only about one third of the students in both groups felt that the curriculum matched their learning style. Computer-based 3D platforms, followed by cadavers and plastinated specimens and face-to-face lectures, were perceived as the most effective teaching methods, while synchronous online lectures were perceived as the least effective. In comparison with junior students, senior students more often reported studying after practical classes and less often after theoretical lectures. In the open-ended answers, visual learning and regular repetition were most frequently described as the most effective ways to learn anatomy.

Discussion

Main findings

This study examined how first-year and senior medical students at the Faculty of Medicine in Skopje evaluated anatomy education and which teaching methods they found effective. Four main findings emerged. First, satisfaction with teaching was moderate, and only about one third of the students in both groups felt that the curriculum matched their learning style. Second, most first-year students had to find an effective way of studying anatomy on their own. Third, 3D computer programs, cadavers and plastinated specimens, and face-to-face lectures were perceived as the most effective methods, whereas synchronous online lectures were perceived as the least effective. Fourth, senior students differed from first-year students in the timing of their study, as they more often studied after practical classes and less often after theoretical lectures.

Satisfaction and study guidance

Only half of first-year students (51.5%) were satisfied with lectures and practical classes, and their opinions on colloquia and exams were divided (41.0% satisfied, 28.4% not satisfied). Senior students, who evaluated their education retrospectively, were similarly ambivalent: 40.2% were satisfied and 20.7% were not, and their answers did not differ significantly from the neutral value. Satisfaction therefore cannot be described as high in either group, although outright dissatisfaction with lectures and practical classes was uncommon (11.2% of first-year students). The most striking finding is that 85.1% of first-year students had to find an effective way of studying anatomy on their own (large effect size, r=0.78), while fewer than half (46.3%) felt that teachers gave them useful advice on how to study. Anatomy involves a large amount of new terminology and spatial information, and students who start the subject without guidance may rely on popular but less effective techniques such as rereading, whereas practice testing and distributed practice have been shown to work better[10]. Short introductory sessions on study strategies at the beginning of the first year could be a simple way of addressing this need.

The agreement of the curriculum with students' learning style was almost identical in the two groups (29.9% and 31.0%), and 44.8% of senior students disagreed with it. Students certainly differ in the way they prefer to learn, but there is little evidence that matching teaching to individual learning styles improves learning outcomes[11]. Teaching the same content in several formats (lectures, specimens, digital resources and small-group work) may nevertheless reach a wider range of students than a single format. It should be noted that this was assessed with one self-reported statement and not with a validated learning-style instrument.

Perceived effectiveness of teaching methods

3D computer programs were rated significantly higher than all other methods (90.3% agreement). This agrees with the open-ended answers, in which visual learning with atlases, images and visualization was the most frequent theme (46.9% of all students), followed by 3D applications and models (24.9%) and educational videos (19.2%). Three-dimensional programs

allow students to rotate structures, to add or remove layers and to study at their own pace and place, which may be particularly useful for students who are new to the subject. A meta-analysis found that 3D visualization technologies improved spatial knowledge and learner satisfaction compared to other teaching methods[4], and a review reported that most studies found 3D displays beneficial and that student perceptions were positive[5]. However, cadavers and plastinated specimens were rated second (75.4%) and were mentioned by 27.2% of students in their own words; one student wrote that what is read in the book is wanted "in front of me". The difference between 3D programs and specimens was statistically significant, but smaller than the differences between 3D programs and the remaining methods (adjusted p=0.013, r= 0.28). Specimens, in turn, were rated higher than textbooks, small-group learning and recorded lectures. Students therefore seem to see digital and specimen-based learning as complementary rather than competing, which is consistent with reviews of anatomy teaching that support combining specimen-based and digital approaches[12].

Face-to-face lectures were still considered effective by 69.4% of first-year students and did not differ significantly from specimens or textbooks. In contrast, synchronous online lectures were the only method that most students did not consider effective (17.9% agreed, 58.2% disagreed), and they were rated significantly lower than every other method. Recorded lectures, which can be watched at the student's own pace, were rated much higher than synchronous online lectures (54.5% agreement; mean difference 1.10, r=0.61). This suggests that students' reservations may concern the fixed schedule and limited interaction of online sessions rather than the lecture format itself, and that prior experience of online teaching may also play a role[6]. We did not ask for the reasons behind the ratings, so this interpretation should be tested in future studies.

Timing of study and differences between students

Senior students less often studied after theoretical lectures (32.2% *vs*. 59.0%; OR 0.37) and more often after practical classes with demonstration (62.1% *vs*. 48.5%; OR 2.02) than first-year students. In addition, senior students clearly distinguished between the three options, preferring to study after practical classes and before exams to studying after lectures, while first-year students had no preference. With experience, students may learn that structures seen on specimens are easier to remember and that consolidating knowledge in connection with practical sessions is more efficient than reviewing material immediately after lectures, which is in line with evidence that practice testing and distributed practice are more effective than rereading[10]. Assessment also seems to drive study behaviour, since more than half of the students in both groups studied before colloquia and exams (53.7% and 59.8%). Because the design was cross-sectional and senior students answered retrospectively, we cannot determine whether the differences reflect a development of study habits or differences between cohorts, although changes in students' views with experience have also been described in qualitative work[7].

Outcomes of anatomy education

Most senior students (78.2%) were confident that they could renew their anatomy knowledge when needed, which suggests that anatomy education, even though students had to organize their study themselves, left them with the ability to relearn independently. On the other hand, only 32.2% agreed that it had improved their critical and analytical thinking, and 42.5% disagreed. The open-ended answers point in the same direction: students described the most effective learning mainly through visualization, repetition and reading, whereas only 6.1% referred to understanding and linking anatomy with clinical practice. More use of clinically oriented problems and case-based discussions[1] and of active recall[10] in anatomy teaching could address this gap. Active recall and learning with colleagues were mentioned more often

by first-year students (13.1% *vs*. 3.6%), but this difference did not remain significant after correction for multiple comparisons.

Practical implications

Taken together, our results suggest that anatomy teaching in our faculty could be improved by (1) combining 3D platforms with sessions on cadavers and plastinated specimens, (2) offering early and explicit guidance on how to study anatomy, (3) building study around practical classes and linking anatomical structures with clinical situations, and (4) using recorded rather than synchronous online lectures when face-to-face teaching is not possible.

Strengths and limitations

The strengths of this study are the inclusion of both first-year and senior students, the use of non-parametric and ordinal methods suited to Likert-type data, adjustment for gender and for multiple comparisons, and the combination of closed and open-ended questions.

There are also several limitations. The study was done at a single faculty, and the response rate among senior students was lower (43.5% *vs*. 67.0%), so non-response bias is possible, as students with a stronger opinion may have been more likely to respond. The data are self-reported perceptions and do not show whether the methods that students rated as effective actually lead to better learning outcomes. The two groups were different cohorts and not the same students followed over time, and the opinions of senior students may be affected by recall bias. The statements on satisfaction were worded differently in the two questionnaires, and the effectiveness of teaching methods was evaluated only by first-year students. The statements on teaching methods had low internal consistency (Cronbach's alpha 0.39) and were therefore analysed separately and not as a scale. Finally, about three quarters of the participants were female, which reflects the composition of the groups but limits generalization.

Conclusion

First-year students and senior medical students at the Faculty of Medicine in Skopje were only moderately satisfied with anatomy education. Most first-year students had to develop their own way of studying, and only about one third felt that the curriculum matched their learning style. Students rated 3D computer programs, cadavers and plastinated specimens, and face-to-face lectures as the most effective methods, and synchronous online lectures as the least effective, while senior students more often studied after practical classes. These findings suggest that anatomy teaching would benefit from a blended approach that combines 3D platforms with hands-on work on specimens, from early guidance on how to study, and from a stronger link between anatomy and clinical thinking.

Conflict of interest statement. None declared.

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