VIA MEDICA

O R I G I N A L   A R T I C L E

Anatomy education and clinical practice: students' views

Niki Matveeva, Julija Zhivadinovikj Bogdanovska, Biljana Zafirova, Elizabeta Chadikovska, Ace Dodevski, Biljana Trpkovska, Biljana Bojadzieva Stojanoska, Anamarija Paunkoska

Institute of Anatomy, Faculty of Medicine, 'Ss Cyril and Methodius' University in Skopje, North Macedonia

Background and objectives: This study was aimed at evaluating students' perspectives on the relevance of anatomy education to clinical practice throughout their studies at the Faculty of Medicine in Skopje.

Materials and methods: The study was designed as a cross-sectional, questionnaire-based investigation and took place at the Faculty of Medicine in Skopje at the University of "Ss Cyril and Methodius", R. North Macedonia. The questionnaire form included demographics, five-point Likert items, and open-ended questions. Questionnaire data was collected from volunteer student participants, currently and not currently involved in anatomy education, consisting of 134 first-year and 87 fourth- and fifth-year students during March and April 2024.

Results: Junior students agreed that their anatomy education helped them achieve some important goals for clinical practice, such as adopting and applying medical terminology and the ability to visualise a three-dimensional human body map. Senior students were less convinced that the structures and concepts acquired during anatomy education were relevant to clinical practice, or that they helped them acquire clinical knowledge and skills effectively, or to understand the principles of evidence-based medicine. Junior students and their senior colleagues disagreed as to whether anatomy education succeeded in developing their self-confidence, teamwork, and communication skills.

Conclusions: Both groups of students had similar preferences and suggestions for redesigning anatomy courses to focus on essential elements that are functionally and clinically relevant. This can be achieved through traditional and modern teaching methods, small group work, and the establishment of learning outcomes within clinically relevant contexts. (Folia Morphol 2025; 84, 3: 690–701)

Keywords: medical education, anatomy education, clinical practice, questionnaire, survey, medical faculty

INTRODUCTION

Anatomy has been an essential component of medical education since time immemorial. While current trends may indicate a reduced emphasis on teaching anatomy, it continues to be a crucial part of preclinical medical education, with clinical anatomy becoming increasingly significant [16, 22]. Introducing clinically focused anatomy topics during

lectures and using different teaching methods can contribute to developing well-prepared doctors for modern clinical practice. Clinicians emphasize the need for customized anatomy education to equip students for effective participation in clinical practice. The perspectives of clinicians whose specialisms are closely associated with a strong understanding of anatomy centre on high-quality and clinically oriented anatomical education. However, students may not always appreciate the significance of anatomy in cultivating professional and teamwork skills [21]. There is an ongoing discussion about the depth and breadth of anatomical knowledge required and the most effective teaching approaches [10, 23]. Nonetheless, there is consensus that anatomy topics should have clinical relevance, and a combination of teaching methods is most effective. The optimal approach to teaching anatomy is to integrate multiple complementary pedagogical resources [8]. The modern anatomy curriculum faces a significant challenge in preparing students for safe medical practice, especially those in the later years of their study who may have been distanced from anatomy for some time.

This raises the question of whether they are adequately prepared to begin safe medical practice, and if the existing anatomy curricula meet their needs and prepare students for safe and modern medical practice. Survey studies have revealed differing opinions on the role of anatomy education among students, staff, and clinicians [17, 26]. Questionnaire-based survey studies, designed for medical students, can provide valuable data for the improvement of anatomy education.

Our present survey was based on a questionnaire for medical students, evaluating the level of agreement with statements regarding the role of anatomy education in clinical practice, along with open-ended questions allowing students to formulate their own suggestions and recommendations. The survey included different groups of students currently and not currently involved in anatomy education, aiming to evaluate their perspectives on the relevance of anatomy education throughout their medical studies. The responses of the two student groups differed due to variations in their motivation, personal experiences, and expectations.

This study was aimed at assessing students' perspectives on the relevance of anatomy education to clinical practice throughout their medical studies.

MATERIALS AND METHODS

This study was designed as a cross-sectional, questionnaire-based investigation and took place at the Faculty of Medicine in Skopje at the University 'Ss Cyril and Methodius', R. North Macedonia. It included 221 volunteer medical undergraduates who responded to an online appeal during the 2023–2024 academic year. The study sample consisted of 134 (67%) first-year students participating in anatomy education and 87 (43.5%) fourth- and fifth-year medical students who had already been involved in clinical practice as part of their medical studies. Approval for the study was obtained from the institutional Research Ethics Committee (No.03-4422/7; 19.09.2024). The educational programs at the Faculty of Medicine are nationally accredited by the Higher Education Accreditation and Evaluation Board from the Agency for Quality in Higher Education of the Republic of North Macedonia (AQHE) (https://www.enqa.eu/membership-database/ /heaeb-higher-education-accreditation-andevaluation-board/Decision no. 08–74/4 from 19th of July 2024). In our Medical Faculty, anatomy education is provided to students during the first two years of their undergraduate medical studies, which covers the first three terms through an integrated curriculum. The curriculum integrates theoretical lectures, practical cadaver-based teaching through dissection activities, and the use of prosecuted and plastinated specimens. Additionally, students and educators have access to radiological anatomy using medical imaging and computer-based learning. During the first term, students are introduced to anatomy, focusing on the locomotor system, including the systematic and topographic anatomy of the upper and lower extremities. In the second term, students learn about the systematic and topographic anatomy of the thoracic, abdominal, and pelvic cavities. Finally, in the third term, the systematic and topographic anatomy of the head and neck, along with the central nervous system, are covered.

To develop a questionnaire about the relevance of anatomy education to clinical practice, we followed a three-phase process: **Phase I:** Needs analysis and planning; **Phase II:** Questionnaire development, and **Phase III:** Validation and reliability evaluation [2]. The questions were formulated following detailed consultations with the faculty's Anatomy education staff. We also sought feedback from student delegates, considering their input, whether positive or negative, during the preparation of the questionnaire. The

questionnaire for first-year medical students focused on their expectations, as they have not yet started clinical practice. However, the questionnaire for senior students allowed them to express their agreement with statements based on their own experiences and readiness for clinical practice. The statements and open-ended questions were prepared in Macedonian. Most of the survey statements used a Likert scale response format, where respondents rated their level of agreement on a scale of 1 to 5.

The questionnaire's first section requested general demographic data, while the second section consisted of statements for students to rate their agreement. The third section included open-ended questions for students to express their opinions on the negative aspects of the anatomy curriculum and to suggest improvements (see Tab. 1). Students were encouraged to answer the open-ended questions, and the questionnaire was tested in a pilot study with a small number of students, with revisions based on the feedback received. First-, fourth-, and fifth-year medical students were all informed about the questionnaire via a text message that included an explanation of the study's purpose, the voluntary nature of participation, and the anonymity of the data collected. The questionnaire data was collected digitally in March and April 2024 from the first-year students, and in April 2024 from the fourth- and fifth-year students. Google Forms was used to administer the questionnaire. The data was then exported from Google Forms to Microsoft Excel (Microsoft Corp., Redmond, WA, USA), and the Statistical Package for Social Sciences SPSS V 26 (IBM Corp, Armonk, NY, USA) for analysis. Descriptive statistics (frequencies and percentages) were used to present the results. For analyzing Likert-item-based categorical data, Chi-square analysis supported by Monte Carlo simulation was used, with a statistical significance level of 0.05. The internal consistency of the items in the second section was measured using Cronbach's alpha. For analyzing the qualitative data in the third section of the questionnaire, the thematic analysis method was used. This involved identifying and grouping themes in the data, based on the responses to open-ended questions. The researchers read the responses multiple times, noting key themes in each participant's response. These key themes were then grouped into final categories, with each participant's response included in the appropriate category.

RESULTS

The study contacted 200 first-year students and 200 fourth- and fifth-year students from the Faculty of Medicine in Skopje. A total of 134 (67%) first-year and 87 (43.5%) fourth- and fifth-year medical students participated in the questionnaire. The average age of the first-year students was 19.63 [standard deviation (SD): 1.2, Min: 18, Max: 26)], and the average age of the fourth- and fifth-year students was 23.6 (SD: 1.43, Min: 21, Max: 29). Demographic details of the participants are set out in Table 2. Gender demographic characteristics of the participants were in accordance with the student population at the Faculty of Medicine in Skopje.

Students' level of agreement with statements

The Cronbach's alpha value obtained was 0.6 for the first-year medical students. The results of the second section of our questionnaire, which pertains to first-year medical students, are set out in Table 3 and Figure 1. The students' level of agreement with the statements is summarized based on the results of the statistical analysis as follows.: St 2.1.1: It was found that theoretical and practical anatomy lessons help first-year medical students to adopt and apply medical terminology, which is particularly important for their future clinical practice ($p = 0.000$). St 2.1.2: The majority of the students thought they could always visualise a three-dimensional map of the anatomical structures of the human body ($p = 0.000$). St 2.1.3: The students were opposed to the statement that anatomy education improved their self-confidence, their teamwork, and communication skills; the majority of them disagreed with, or were neutral regarding, this statement ($p = 0.007$). St 2.1.4: The majority of first-year medical students disagreed with or were neutral regarding the statement that forgotten anatomical knowledge could come back easily with a small amount of repetition ($p = 0.000$). St 2.1.5: The majority of junior students agreed with the statement that they could see clearly that anatomy would be a part of their clinical practice from the beginning of their medical studies ($p = 0.000$). St 2.1.6: Additionally, the majority of them thought that their knowledge and interest in anatomy would influence their future career choice ($p = 0.000$).

The Cronbach's alpha value for the group of fourth- and fifth-year medical students was 0.806. The results from the responses of the students to the second section of our questionnaire are set out

Table 1A. Questionnaire forms for assessing students' perceptions of relevance of anatomy education to clinical practice throughout their medical studies; **B.** Questionnaire form for fourth- and fifth-year medical students.

(a) Questionnaire form for first-year medical students	Contents
Section 1.1 (S1.1). Demographic data	Q. 1.1.1: Gender Q. 1.1.2: Age
Section 2.1 (S2.1) Statements 2.1	St. 2.1.1: Anatomy theoretical and practical lessons have helped me adopt and apply medical terminology. St. 2.1.2: I have a three-dimensional map of the human body in my mind that I can always visualise. St. 2.1.3: Anatomy education has improved my self-confidence, teamwork, and communication skills. St. 2.1.4: Forgotten anatomical details are easily retrieved with a little reminder. St. 2.1.5: It is evident to me that anatomy will be an integral part of my clinical practice from the start of my medical studies. St. 2.1.6: My knowledge of and interest in anatomy will influence my future career choice.
Section 3.1 (S3.1). Open-ended questions	Q. 3.1.1: What are the major deficiencies in anatomy education from your perspective? Q. 3.1.2.: What suggestions or ideas do you have for enhancing and progressing anatomy education?
(b) Questionnaire form for fourth-- and fifth-year medical students	Contents
Section 1.2 (S1.2). Demographic data	Q. 1.2.1: Gender Q. 1.2.2: Age
Section 2.2 (S2.2) Statements 2.2	St. 2.2.1: The anatomical structures and concepts we have learned are relevant in scope and content to my clinical practice. St. 2.2.2: Anatomy education has helped me connect basic to clinical medicine. St. 2.2.3: I have begun to realize the importance of anatomy for clinical practice in the final years of my studies. St. 2.2.4: I have forgotten much of the anatomy I learned in the first years of my studies. St. 2.2.5: I have a three-dimensional map of the human body in my mind that I can always visualise. St. 2.2.6: Forgotten anatomical details are easily retrieved with a little reminder. St. 2.2.7: I frequently use my knowledge of anatomy to effectively gain clinical knowledge and skills. St. 2.2.8: The anatomy topics that are relevant to clinical practice are remembered permanently. St. 2.2.9: Anatomy education has enhanced my understanding of the principles of evidence-based medicine and my ability to think critically and analytically. St. 2.2.10: Anatomy education has improved my self-confidence, teamwork, and communication skills. St. 2.2.11. My knowledge and interest in anatomy will influence my future career choice.
Section 3.2 (S3.2). Open-ended questions	Q. 3.2.1: What were the major deficiencies in anatomy education from your perspective? Q. 3.2.2.: What suggestions or ideas do you have for enhancing and progressing anatomy education?

Table 2. Demographic parameters of student participants by gender.

| Gender			
Year of medical studies	Male n [%]	Female n [%]	Total n [%]
First-year students	32 (23.9)	102 (76.1)	134 (100)
Fourth- and fifth-year students	24 (27.6)	63 (72.4)	87 (100)
Total	56 (25.3)	63 (72.4)	221 (100)

in Table 4 and Fig. 2. The students' level of agreement with the statements is summarized below: St. 2.2.1: Students held opposing opinions about the relevance of the anatomical structures and concepts they learned to their clinical practice (p = 0.157); St. 2.2.2: The majority of students believed that anatomy education helped them connect basic to clinical medicine (p = 0.003); St. 2.2.3: The majority of students agreed that they began to realize the importance of anatomy in clinical practice during their fourth and fifth years of medical studies (p = 0.000); St. 2.2.4: The majority of senior students agreed that they have forgotten a lot of the anatomy they learned in the first year or two of their studies (p = 0.000). St. 2.2.5: The majority of students had self-confidence in their ability to visualise a three-dimensional map of the anatomical structures of the human body (p = 0.000); St. 2.2.6: Senior students stated that forgotten anatomical details come back easily with a little reminder (p = 0.005); St. 2.2.7: Senior students stated they often use their knowledge of anatomy to effectively acquire clinical knowledge and skills, but many were undecided about this statement (p = 0.002); St. 2.2.8: The majority of senior students agreed that the topics of anatomy related to their clinical practice are permanently remembered (p = 0.000); St. 2.2.9; Students had opposing opinions regarding the statement that anatomy education enhanced their understanding of the principles of evidence-based medicine and the

Table 3. Distribution of first-year medical students' agreement levels with statements (St. 2.1.1–St. 2.1.6) in Section 2 (S. 2.1) of questionnaire form (n = 134).

Statements 2.1	Strongly disagree % (n)	Disagree % (n)	Neither agree nor disagree % (n)	Strongly agree % (n)	Agree % (n)	Total	p**
St. 2.1.1	0.7 (1)	8.2 (11)	21.6 (29)	38.1 (51)	31.3 (42)	100 (134)	0.000
St. 2.1.2	0.7 (1)	6 (8)	16.4 (22	39.6 (53)	37.3 (50)	100 (134)	0.000
St. 2.1.3	11.26 (15)	20.1 (27)	26.9 (36)	27.6 (37)	14.2 (19)	100 (134)	0.007
St. 2.1.4	9 (12)	24.6 (33)	20.1 (27)	34.3 (46)	11.2 (15)	100 (134)	0.000
St. 2.1.5	3 (4)	6 (8)	16.4 (22)	49.3 (66)	25.4 (34)	100 (134)	0.000
St. 2.1.6	3.7 (5)	11.9 (16)	21.6 (29)	35.1 (47)	27.6 (37)	100 (134)	0.000

S — Section; St — statement; ** Chi-square test with Monte Carlo simulation.
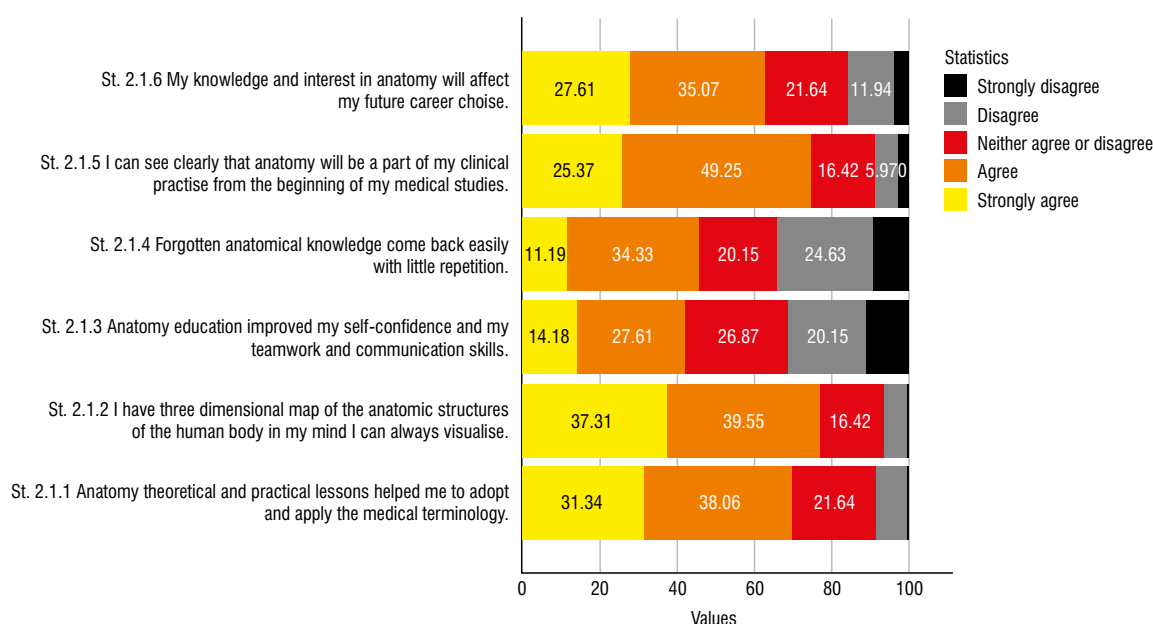
Figure 1. Distribution of first-year medical students' agreement levels with statements (St. 2.1.1–St. 2.1.6) in Section 2 (S. 2.1) of questionnaire form (n = 134).

ability to think critically and analytically (p = 0.007); St. 2.2.10; The majority of senior students, similar to their first-year colleagues, disagreed with the statement that anatomy education has improved their self-confidence, teamwork, and communication skills (p = 0.084).; St. 2.2.11: Students in the final years of medical studies disagreed that anatomy education would affect their future career choice (p = 0.033).

Students' responses to open- ended questions

The responses to open-ended questions in the Questionnaire from the first-year medical students were analyzed and grouped based on the topics they covered. The results are set out in Table 5 for question Q3.1.1 (What are the major deficiencies in anatomy education from your perspective?) and in Table 6 for question Q3.1.2 (What suggestions or ideas do you have for enhancing and progressing anatomy education?). The rate of response for Q3.1.1 was 30.6%, with 41 students answering, and for Q3.1.2, it was 93.3%, with 125 students answering. The comments for the question 'What are the major deficiencies in anatomy education from your perspective?' are shown in Table 5a.

These comments covered five main themes, with the most numerous comments focusing on the extensive and highly detailed material to learn, as well as the demanding and long-lasting practical lessons requiring prior study of the topics. Students were more inclined to provide suggestions for improving

Table 4. Distribution of fourth-and fifth-year medical students' agreement levels with statements (St.2.2.1–S2.2.11) in Section 2 (S 2.2) of questionnaire form (n = 87).

Statements 2.1	Strongly disagree % (n)	Disagree % (n)	Neither agree nor disagree % (n)	Agree % (n)	Strongly agree % (n)	Total	p
St. 2.2.1	13.8 (12)	20.7 (18)	27.6 (24)	24.1 (21)	13.8 (12)	100 (87)	0.157
St. 2.2.2	5.7 (5)	17.2 (15)	23 (20)	32.2 (28)	21.8 (19)	100 (87)	0.003
St. 2.2.3	5.7 (5)	26.4 (23)	25.3 (22)	31 (27)	11.5 (10)	100 (87)	0.000
St. 2.2.4	1.1 (1)	10.3 (9)	28.7 (25)	23.0 (20)	36.8 (32)	100 (87)	0.000
St. 2.2.5	2.3 (2)	12.6 (11)	19.5 (17)	31 (27)	34.5 (30)	100 (87)	0.000
St. 2.2.6	8 (7)	14.9 (13)	21.8 (19)	33.3 (29)	21.8 (19)	100 (87)	0.005
St. 2.2.7	5.7 (5)	20.7 (18)	33.3 (29)	23 (20)	17.2 (15)	100 (87)	0.002
St. 2.2.8	3.4 (3)	12.6 (11)	18.4 (16)	34.5 (30)	31 (27)	100 (87)	0.000
St. 2.2.9	10.3 (9)	23 (20)	32.2 (28)	23 (20)	11.5 (10)	100 (87)	0.007
St. 2.2.10	26.4 (23)	26.4 (23)	20.7 (18)	10.3 (9)	16.1 (14)	100 (87)	0.084
St. 2.2.11	21.8 (19)	32.2 (28)	18.4 (16)	16.1(14)	11.5 (10)	100 (87)	0.03

*S — Section St — statement; **Chi-square test with Monte Carlo simulation.
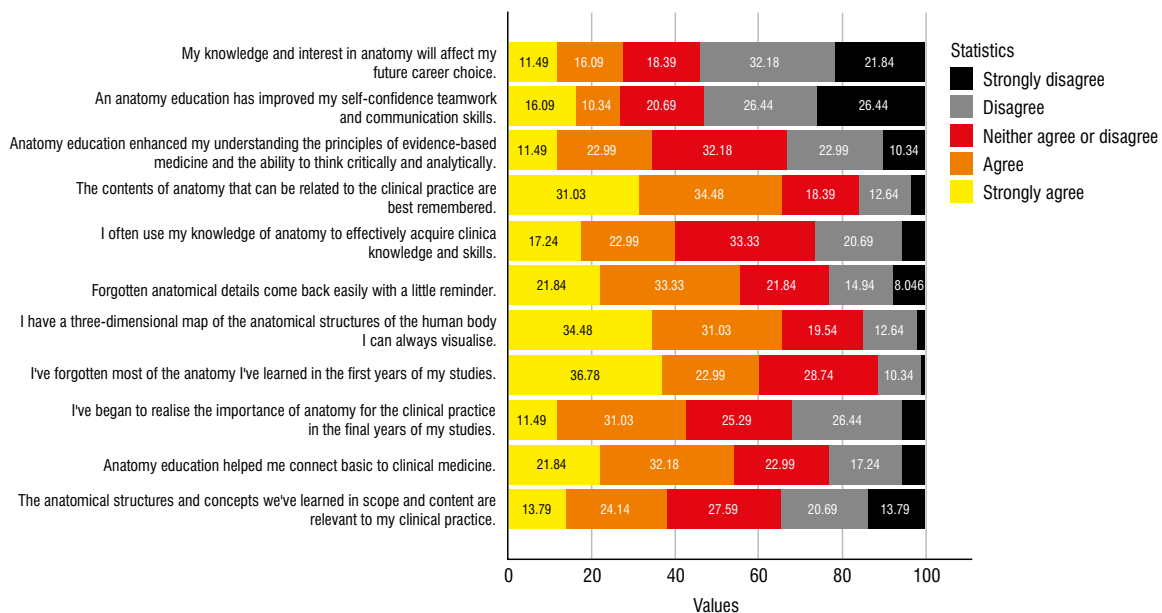
Figure 2. Distribution of fourth-and fifth-year medical students' agreement levels with statements (St. 2.2.1–St 2.2.11) in Section 2 (S 2.2) of questionnaire form (n = 87).

the anatomy curriculum. The majority of these suggestions involved integrating practical lessons with theoretical lectures, conducting small group work, and using different teaching practices to make lessons more engaging and effective. Many junior students also emphasized prioritizing clinically relevant topics over unnecessary details, along with recommending greater use of 3D anatomy platforms and video recordings.

The open-ended responses from the Questionnaire form for fourth- and fifth-year medical students were analyzed and categorized based on themes. The findings were summarized in Table 7 for the question 'What are the major deficiencies in anatomy education from your perspective?' and Table 8 for the question 'What suggestions or ideas do you have for enhancing and progressing anatomy education?'. The response rate for the question 'What are the

Table 5. Distribution of first-year medical students' answers to question Q3.1.1 in Section 3.1 (S 3.1) of questionnaire form (n = 134).

Themes	Comments count (n)
1. The material to learn is very extensive and highly detailed, essential elements of clinical significance should take priority	10
2. Large amount of material to process during the long practical lessons	9
3. The course is very intensive and demanding, leaving insufficient time to prepare for colloquiums and exams	8
4. Sometimes, there is a lack of alignment between the theoretical and practical courses	8
5. The preliminary tests are stressful and difficult, with an excessive focus on unnecessary details	7

Table 6. Distribution of first-year medical students' answers to question Q3.1.2 in Section 3.1 (S 3.1) of questionnaire form (n = 134).

Themes of recommendations	Comments count (n)
1. Integrating theoretical and practical anatomy courses through interactive teaching methods and working in small groups	47
2. Emphasis on clinically important subjects and fundamental elements in theoretical and practical anatomy courses	16
3. Providing continuous support for theoretical and practical anatomy courses through medically-proven 3D anatomy platforms and video recordings	15
4. Focusing anatomy knowledge assessment on understanding the material and developing logical and analytical thinking. Avoiding unnecessary and stressful preliminary tests	13
5. Remodeling anatomy curriculum to increase learning time and to ensure that teachers and laboratories are always available to students	9

Table 7. Distribution of fourth- and five-year medical students' answers to question Q3.2.1 in Section 3.2 (S 3.2) of questionnaire form (n = 87).

Themes	Comments count (n)
1. The learning material is very extensive and highly detailed, but it does not highlight clinically relevant topics	22
2. There are numerous stressful assessments of anatomy knowledge, including tests, oral exams, and practical examinations. The preliminary tests are difficult and highly detailed	11
3. Sometimes, there is a lack of alignment between theoretical and practical courses, as well as insufficient communication with the students	8

Table 8. Distribution of fourth- and five-year medical students' answers to question Q3.2.2 in Section 3.2 (S 3.2) of questionnaire form (n = 87).

Themes of recommendations	Comments count (n)
1. The integration of theoretical and practical anatomy courses, using problem-based learning and small group sessions	26
2. Theoretical and practical anatomy courses should be revised to emphasize essential elements and their clinical relevance	20
3. Providing continuous support for theoretical and practical anatomy courses through medically-verified 3D anatomy platforms, video recordings and medical images accessible to students	14
4. Adjusting the assessment of anatomy knowledge to emphasize understanding of material, logical and analytical thinking	14
5. Introducing clinical anatomy in the fourth or fifth year of medical studies	6

major deficiencies in anatomy education from your perspective?' was 46%, with 40 students answering. For the question 'What suggestions or ideas do you have for enhancing and progressing anatomy education?', the response rate was 90%, with 78 students answering. 64 comments were given for the question 'What are the major deficiencies in anatomy education from your perspective?'. The comments were categorized into three themes. The most common themes included comments about extensive and detailed learning material, as well as comments about the numerous knowledge assessments, and the stressful nature of exams. Many senior students offered suggestions covering diverse topics to improve

the anatomy curriculum. Most of the suggestions were related to integrating practical lessons with theoretical lectures, replacing theoretical teaching with practical interactive teaching, and conducting teaching in small groups. Also, many senior student comments highlighted the importance of avoiding unnecessary details and focusing on essential clinically relevant topics. Suggestions such as continuous use of 3D anatomy platforms and video recordings, as well as changing the way in which anatomy is examined, were also put forward. Some senior students recommended incorporating clinical anatomy into the final years of integrated medical studies.

DISCUSSION

Our study aimed to collect information from medical students about the long-term nature of anatomical education and its outcomes throughout their medical studies. In the first year, learning anatomy is fundamental, while in the final years, applying anatomy knowledge during clinical practice dominates. As students progress through their studies, they build up a solid foundation of anatomical knowledge, followed by processes of forgetting and storing data in their long-term memory. They eventually apply this knowledge in clinical settings. The anatomy knowledge gained in the early years provides the basis for clinical training and practice. This knowledge is restructured throughout medical studies, and clinically important topics are reinforced and appropriately applied during clinical practice. To develop a modern and effective anatomy curriculum, it is important to consider the perspectives of medical students, educators, and clinicians. Previous studies have focused on the perspectives of individual categories (e.g. students or educators), while others have compared the views of diverse groups involved in anatomy education [9, 15, 20]. In this study, the perspectives of two groups of students (first and final-year medical students) were evaluated to understand the process of acquiring and applying anatomical knowledge from their point of view.

To analyze anatomical education in terms of its clinical relevance, the study considered the different cognitive factors influencing the perceptions of the two groups of students. The first group's perceptions were based more on expectations, while the second group's perceptions were primarily based on experience. The voluntary participation rate of first-year medical students in the questionnaire was 67%, while the participation rate of fourth and fifth-year students was 43.5%. So, junior students currently involved in anatomical education showed a greater need to share their ideas and thoughts. Junior students found that anatomy education helped them learn and apply medical terminology. Both junior and senior students gained self-confidence from using 3D anatomy platforms, especially in the ability to visualise 3D maps of the body's structures. Although there is no evidence showing that computer-based learning is superior to traditional dissection methods, it is a useful supplement for visualizing anatomical structures [6, 14, 24]. Anatomy practical laboratory sessions involve cadaver dissection and prosection (pre-dissected specimens), which enhance students' understanding of topographical anatomy and provide a three-dimensional visualization of structures. A cross-sectional study involving 250 undergraduate medical students who participated in cadaveric dissection during their first year found that the majority felt that dissection deepened their understanding (91.8%) and offered a three-dimensional perspective of anatomical structures (92.4%) [13]. Furthermore, the dissection experience contributed significantly to anatomy knowledge retention and long-term memory. During the dissection process, students experienced the practical application of their anatomical knowledge, which instilled in them a sense of responsibility as future physicians.

Junior and senior students in our study had mixed or negative views on whether anatomy education improved their self-confidence, teamwork, and communication skills. This suggests a need for a student-centered curriculum that emphasizes small group work and problem-based learning to enhance interactivity, communication, and teamwork skills. Problem-based learning requires students to apply critical thinking, collaborate with colleagues, and gain self-respect and satisfaction from solving problems. Many publications recommend problem-based courses to produce confident, practically-minded physicians [1, 25]. However, reduced public funding for higher education hinders the implementation of these changes. Our students expressed a strong preference for practical anatomy laboratory lessons, even suggesting that anatomy lectures be integrated into anatomy practical sessions. The atmosphere in the anatomy laboratories appeared to be much more conducive to student engagement, allowing material to be presented through various teaching

methods. This approach enabled more students to receive feedback and participate actively, fostering a more personalized learning experience. Universal Design for Learning (UDL) is a pedagogical framework developed by the Centre for Applied Special Technology (CAST) in the United States during the 1990s. It aims to transform and design curricula to be inclusive for all types of learners within a single teaching environment. A study conducted at a single institution in Ireland found that 91% of first-year undergraduate healthcare students — majoring in medicine, dentistry, occupational therapy, and speech and language therapy — believed that UDL had been implemented in the anatomy laboratory sessions. However, only 52% felt that UDL had been effectively applied in the anatomy lectures [7].

In the current study, senior and junior students offered different perspectives on the impact of anatomy education. Most senior students were undecided about whether anatomy education improved their understanding of evidence-based medicine and enhanced their critical thinking skills. They agreed that forgotten anatomical details were easily retrieved. On the other hand, junior students were undecided, or disagreed on this point. This could be because these students are still learning and have not yet stored a lot of information in their long-term memory. The study also highlighted the need to improve anatomical knowledge among students, as poor understanding of anatomical variations could lead to increased risks during medical procedures and misinterpretation of results [11]. Additionally, while junior students felt that anatomy would influence their future career choices, senior students did not share the same opinion, as they believed that other factors and experiences would play a greater role in shaping their professional decisions. Overall, both groups of students recognized the importance of anatomy as the foundation for clinical examination in an integrated medical curriculum. Cadavers, skeletons, preserved specimens, X-rays, CT scans, MRI, and multimedia programs are valuable resources used in anatomy courses to enhance students' understanding of the anatomical basis for clinical examination. To achieve these goals using multimodal teaching approaches can be a valuable supplement to existing educational tools. A cross-sectional study involving 250 first-year medical students enrolled in a neuroanatomy course examined the effectiveness of stained versus unstained brain sections in helping students identify specific neuroanatomical structures. The results showed a strong preference among participants for the stained brain sections. Thematic analysis of the open-ended responses revealed several reasons for this preference, including enhanced visual distinction, improved spatial understanding, and increased confidence, engagement, and interest [18]. Teaching methods that boost student interest and enhance self-confidence and engagement can have a long-term impact on clinical performance and the application of anatomical knowledge.

Studies have suggested that greater emphasis on clinical anatomy education in the gross anatomy curriculum leads to improved performance in final examinations [28]. The senior students in the current study expressed a need for the anatomical structures and concepts learned to be more relevant to clinical practice. It is crucial to emphasize clinically relevant topics to enhance the modern anatomy curriculum. According to senior students, knowledge of anatomy is frequently used in acquiring clinical knowledge and skills while examining the cardiovascular, respiratory, abdominal, and urogenital systems through inspection, palpation, percussion, and auscultation.

In addition to physical examination, anatomical knowledge is essential for interpreting radiological images, establishing diagnoses, performing clinical and surgical procedures, and understanding anatomical pathology [17, 27].

The senior students often forgot most of the anatomy they had learned in their first years of study, but stated that anatomy topics related to clinical practice were permanently remembered. The longitudinal nature of anatomy education has been presented in preclinical and clinical studies. An anonymous cross-sectional survey conducted in Poland assessed the recognition of anatomical structures among undergraduate medical students and physicians. The results revealed that anatomical knowledge significantly declines over time, with anatomical structure recognition being up to 25% lower in highly trained physicians compared to pre-clinical medical students [12]. To address this issue, it would be beneficial to provide senior students with thematically tailored anatomical education that runs parallel to the other courses during the clinical phase of their medical studies.

Students' views in the open question section matched those of students in the second section of the applied questionnaire in our survey. The method

of thematic analysis was used to evaluate open-ended questions in the third section of the questionnaire [5]. The answers were organized concerning the topics covered. The main flaws for both groups of students were the extensive and detailed material to be learned during the theoretical and practical courses in anatomy. In students' opinions, knowledge assessment was done by numerous exams, the preliminary tests being particularly stressful for students. To overcome student fears during exams, students often participate in practice exams and quizzes to strengthen learning and to help assess understanding of anatomy concepts. Many online platforms offer anatomy quizzes. Modern trends favor anatomical examinations aimed at assessing topographic and/or applied anatomy knowledge, including visual resources such as body specimens or images, radioactive images, and/or clinical photographs [19].

The recommendations of the students for improving and developing the anatomy curriculum were almost identical in both groups. These recommendations were for a complete fusion of theoretical and practical courses, their performance in practical course laboratories, and the application of different teaching practices in small groups (3D anatomy platforms, video recordings, cadavers, prosecuted specimens). There were also recommendations to restructure anatomy's theoretical and practical courses and knowledge assessment, to reduce unnecessary details, and to focus on essential elements of clinical practice. Senior students stressed the importance of vertical anatomy integration in clinical studies and suggested the integration of clinical anatomy into clinical subjects. Despite the tendency of medical faculties to reduce anatomy courses that has been seen over the last decade, anatomy remains a fundamental subject in the process of training physicians and their support in clinical practice. Highly detailed and extensive anatomy courses should develop into clinically relevant courses, reducing unnecessary detail.

How much basic anatomy knowledge do students need to know and assimilate? This problem is a challenge for anatomists and medical professionals. The core anatomy knowledge for general practitioners may be insufficient for some specialists, such as surgeons and radiologists. Access to anatomy training should be provided to students and residents during the clinical training and practice. Such vertical integration into the clinical medical curriculum should result in better, more competent, and safer physicians

[3]. Some medical specialisms require a more detailed knowledge of anatomy, and so more detailed training in anatomy. Adapting anatomy education thematically and methodologically to meet the needs of residents and medical professionals at all stages of their careers could enhance their proficiency in this critical area.

Modern teaching methods provide better results than traditional teaching methods and, according to current research, stimulate greater interest among students. Traditional teaching methods should not be suppressed because they are 'old-fashioned'; on the contrary, they are compatible with computer-based learning and provide numerous benefits for students. The solution is to integrate all these resources so as to complement one another [4]. Various teaching methods should be used according to how much their use helps students acquire essential and effective anatomy knowledge. The reduction in teaching staff and resources and the reduction in contact teaching hours mean that efforts must be made to optimize the management of teaching time and maximize students' learning results.

Limitations

This study analyses and discusses only students' perceptions at the Faculty of Medicine in Skopje. Integrating students from other medical faculties in our country into multi-center research would produce more comprehensive results. Multi-center research would provide a more detailed understanding of students' views on the relationship between anatomy education and clinical practice and advanced statistical analysis. In our research and analysis, factors that may affect students' answers, such as socio-economic factors, have not been considered. The statements were adjusted and formulated separately for each group of students, relating to the differences in experiences and knowledge between the junior and senior students. There were no comparisons between student groups.

The response rate of senior students was lower than that of their junior colleagues. This is probably due to their busy schedule and the distance between anatomy education in preclinical medicine and current medical education.

CONCLUSIONS

This study included first-year medical students who were currently learning anatomy and fourth- and

fifth-year students who used anatomy knowledge in their clinical practice. The junior students felt that their anatomy education helped them achieve important objectives for clinical practice, such as understanding medical terminology and 3D visualization of the human body. However, senior students were less convinced that the anatomy knowledge was relevant for clinical practice.

Both groups agreed that anatomy education should focus on essential elements and be taught using a mix of traditional and modern methods, in small groups, and in a clinically relevant context.

They also felt that the course should help develop critical thinking and analytical skills and improve self-confidence, teamwork, and communication skills. Understanding the process of acquiring and applying anatomy knowledge from students' points of view will contribute to the development and adaptation of a modern anatomy curriculum relevant to clinical practice.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement

Data is contained within the article or supplementary material. Original contributions presented in the study are included in the article/supplementary material. Further inquiries may be directed to the corresponding author.

Ethics statement

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee for research for studies involving humans at the Faculty of Medicine in Skopje, No. 03-4422/7; 19.09.2024.

Authors' contributions

NM: conceptualization, writing; JZB: resources, formal analysis; BZ: validation; EC: software; AD: methodology; BT: supervision; BBS: formal analysis; AP: investigation.

Funding

Conflicts of interest

The authors declare no conflict of interest.

REFERENCES

1. Albanese MA, Mitchell S. Problem-based learning: a review of literature on its outcomes and implementation issues. Acad Med. 1993; 68(1): 52–81, Doi: 10.1097/00001888-199301000-00012, indexed in PubMed: 8447896.
2. Artino AR, La Rochelle JS, Dezee KJ, et al. Developing questionnaires for educational research: AMEE Guide No. 87. Med Teach. 2014; 36(6): 463–474, Doi: 10.3109/0142159X.2014.889814, indexed in PubMed: 24661014.
3. Bergman EM, van der Vleuten CPM, Scherpbier AJ. Why don't they know enough about anatomy? A narrative review. Med Teach. 2011; 33(5): 403–409, Doi: 10.3109/0142159X.2010.536276, indexed in PubMed: 21355704.
4. Biasutto SN, Caussa LI, Criado del Río LE. Teaching anatomy: cadavers vs. computers? Ann Anat. 2006; 188(2): 187–190, Doi: 10.1016/j.aanat.2005.07.007, indexed in PubMed: 16551018.
5. Braun V, Clarke V. Is thematic analysis used well in health psychology? A critical review of published research, with recommendations for quality practice and reporting. Health Psychol Rev. 2023; 17(4): 695–718, Doi: 10.1080/17437199.2022.2161594, indexed in PubMed: 36656762.
6. Davis CR, Bates AS, Ellis H, et al. Human anatomy: let the students tell us how to teach. Anat Sci Educ. 2014; 7(4): 262–272, Doi: 10.1002/ase.1424, indexed in PubMed: 24249485.
7. Dempsey A, Hunt E, Nolan Y, et al. Healthcare students' awareness of Universal Design for Learning (UDL) in anatomy curricula: An Irish single institution-based study. Transl Res Anat. 2024; 37: 100316, Doi: 10.1016/j.tria.2024.100316.
8. Estai M, Bunt S. Best teaching practices in anatomy education: a critical review. Ann Anat. 2016; 208: 151–157, Doi: 10.1016/j.aanat.2016.02.010, indexed in PubMed: 26996541.
9. Finucane P, Flannery D, McGrath D, et al. Demographic attributes and knowledge acquisition among graduate-entry medical students. Med Teach. 2013; 35(2): 134–138, Doi: 10.3109/0142159X.2012.733833, indexed in PubMed: 23102104.
10. Fitzgerald JEF, White MJ, Tang SW, et al. Are we teaching sufficient anatomy at medical school? The opinions of newly qualified doctors. Clin Anat. 2008; 21(7): 718–724, Doi: 10.1002/ca.20662, indexed in PubMed: 18773486.
11. Henry BM, Tomaszewski KA, Walocha JA. Methods of evidence-based anatomy: a guide to conducting systematic reviews and meta-analysis of anatomical studies. Ann Anat. 2016; 205: 16–21, Doi: 10.1016/j.aanat.2015.12.002, indexed in PubMed: 26844627.
12. Hołda MK, Stefura T, Koziej M, et al. Alarming decline in recognition of anatomical structures amongst medical students and physicians. Ann Anat. 2019; 221: 48–56, Doi: 10.1016/j.aanat.2018.09.004, indexed in PubMed: 30244174.
13. Kalthur S, Pandey A, Prabhath S. Benefits and pitfalls of learning anatomy using the dissection module in an indian medical school: a millennial Learner's perspective. Transl Res Anat. 2022; 26: 100159, Doi: 10.1016/j.tria.2021.100159.

14. Khot Z, Quinlan K, Norman GR, et al. The relative effectiveness of computer-based and traditional resources for education in anatomy. Anat Sci Educ. 2013; 6(4): 211–215, Doi: 10.1002/ase.1355, indexed in PubMed: 23509000.
15. Lazarus MD, Chinchilli VM, Leong SL, et al. Perceptions of anatomy: critical components in the clinical setting. Anat Sci Educ. 2012; 5(4): 187–199, Doi: 10.1002/ase.1281, indexed in PubMed: 22532497.
16. Moxham BJ, Plaisant O. Perception of medical students towards the clinical relevance of anatomy. Clin Anat. 2007; 20(5): 560–564, Doi: 10.1002/ca.20453, indexed in PubMed: 17149736.
17. Orsbon CP, Kaiser RS, Ross CF. Physician opinions about an anatomy core curriculum: a case for medical imaging and vertical integration. Anat Sci Educ. 2014; 7(4): 251–261, Doi: 10.1002/ase.1401, indexed in PubMed: 24022941.
18. Punja R, Punja D. Enhancing the effectiveness of teaching neuroanatomy: a comparative study using stained and unstained brain sections to interpret cross sectional neuroanatomy. Transl Res Anat. 2024; 37: 100358, Doi: 10.1016/j.tria.2024.100358.
19. Sagoo MG, Vorstenbosch MA, Bazira PJ, et al. Online assessment of applied anatomy knowledge: the effect of images on medical students' performance. Anat Sci Educ. 2021; 14(3): 342–351, Doi: 10.1002/ase.1965, indexed in PubMed: 32289198.
20. Sandover S, Jonas-Dwyer D, Marr T. Graduate entry and undergraduate medical students' study approaches, stress levels and ways of coping: a five year longitudinal study. BMC Med Educ. 2015; 15: 5, Doi: 10.1186/s12909-015-0284-7, indexed in PubMed: 25616440.
21. Sbayeh A, Qaedi Choo MA, Quane KA, et al. Relevance of anatomy to medical education and clinical practice: perspectives of medical students, clinicians, and educators. Perspect Med Educ. 2016; 5(6): 338–346, Doi: 10.1007/s40037-016-0310-4, indexed in PubMed: 27785729.
22. Smith CF, Mathias HS. What impact does anatomy education have on clinical practice? Clin Anat. 2011; 24(1): 113–119, Doi: 10.1002/ca.21065, indexed in PubMed: 20949490.
23. Stringer MD, Nicholson HD. Modern approaches to teaching and learning anatomy: modern models are already being applied. BMJ. 2008; 337: a1966, Doi: 10.1136/bmj.a1966, indexed in PubMed: 18838427.
24. Tam MD, Hart AR, Williams SM, et al. Evaluation of a computer program ('disect') to consolidate anatomy knowledge: a randomised-controlled trial. Med Teach. 2010; 32(3): e138–e142, Doi: 10.3109/01421590903144110, indexed in PubMed: 20218830.
25. Tio RA, Schutte B, Meiboom AA, et al. Dutch Working Group of the Interuniversity Progress Test of Medicine. The progress test of medicine: the Dutch experience. Perspect Med Educ. 2016; 5(1): 51–55, Doi: 10.1007/s40037-015-0237-1, indexed in PubMed: 26754310.
26. Turney BW. Anatomy in a modern medical curriculum. Ann R Coll Surg Engl. 2007; 89(2): 104–107, Doi: 10.1308/003588407X168244, indexed in PubMed: 17346399.
27. Vorstenbosch MA, Klaassen TP, Kooloos JGM, et al. Do images influence assessment in anatomy? Exploring the effect of images on item difficulty and item discrimination. Anat Sci Educ. 2013; 6(1): 29–41, Doi: 10.1002/ase.1290, indexed in PubMed: 22674609.
28. Zhang Y, Ji Z, Zhou P, et al. Clinical anatomy teaching: a promising strategy for anatomic education. Heliyon. 2023; 9(3): e13891, Doi: 10.1016/j.heliyon.2023.e13891, indexed in PubMed: 36915571.