BMC Medical Education

RESEARCH Open Access

From pandemic to earthquakes: crisis-driven challenges in distance anatomy education

Asli Beril Karakas[1*]

Abstract

Purpose Distance anatomy education has gained increasing relevance due to global crises such as the COVID-19 pandemic and natural disasters, including the 2023 Kahramanmaraş earthquakes. These disruptions have raised concerns regarding student motivation, accessibility, and the overall effectiveness of online learning. This study explores vocational health sciences students' perceptions of distance anatomy education, with a focus on engagement, learning outcomes, and accessibility.

Methods This cross-sectional study, conducted at the Atatürk Vocational School of Health Services, Kafkas University, included 748 students from four health-related programs. Theoretical anatomy education was delivered synchronously via Microsoft Teams, while practical Components were provided asynchronously through a dedicated YouTube channel. Using a validated 50-item survey, this study examined students' motivation, perceptions of anatomy's importance, course adequacy, accessibility, and effectiveness of distance education.

Results Motivation levels varied significantly across departments, with Home Patient Care students reporting the highest engagement. Male students perceived distance education as more effective than female students, while students living at home had better accessibility and learning experiences than dormitory residents. The YouTube channel played a crucial role in supporting practical anatomy education. Correlation analysis revealed strong associations between accessibility, motivation, and perceived effectiveness.

Conclusion The study highlights the need for blended learning models, digital infrastructure improvements, and interactive strategies to enhance distance anatomy education. Future research should explore hybrid approaches integrating hands-on components and advanced digital tools to optimize learning outcomes.

Keywords Distance learning, Anatomy education, Vocational health education, Motivation, Accessibility, Blended learning

*Correspondence:
Asli Beril Karakas
asliberilkarakas@gmail.com
[1]Department of Anatomy, Faculty of Medicine, Kastamonu University, Kastamonu 37200, Turkey

Introduction

Anatomy education, a cornerstone of health sciences, is fundamental for understanding the human body's structure and functions. It serves as the basis for clinical decision-making, practical applications in healthcare, and preparing vocational health students to provide quality patient care in real-world scenarios [1].

The COVID-19 pandemic forced a sudden transition to distance learning in health sciences vocational schools, significantly altering educational practices. This abrupt shift posed unique challenges for anatomy education, which traditionally relies on direct engagement and interactive instruction [2–4]. Anatomy education, in its traditional format, emphasizes comprehensive theoretical instruction and direct engagement with instructors to help students grasp complex three-dimensional anatomical relationships [5, 6].

Students in programs such as emergency medical services, home care, geriatric care, and anesthesia faced distinct challenges adapting to online anatomy education. The absence of hands-on experiences, a critical component in anatomy education, particularly affected their learning process. These challenges highlighted the vital role of theoretical education in ensuring foundational knowledge [7]. Institutions responded by offering online lectures, video-based content, and interactive digital tools. Although these resources were helpful, they could not fully replicate the depth and engagement of face-to-face learning [3, 8].

Theoretical anatomy education focuses on building foundational knowledge, which is essential for vocational health students who apply this understanding in diverse practical settings [1]. However, the lack of interaction with instructors and peers in virtual environments raised concerns about the effectiveness of distance education in fostering a deep understanding of anatomical concepts [3, 5]. Many students reported difficulties engaging with online content due to unreliable technology and limited internet access, further complicating the learning process. Despite these obstacles, some students appreciated the flexibility that online learning provided, enabling them to balance education with other responsibilities [1, 3, 7].

Blended learning models that integrate online instruction with occasional interactive elements have been proposed to enhance student engagement and comprehension [3, 8]. Advanced technologies such as augmented reality (AR) and virtual reality (VR) offer promising opportunities to improve theoretical anatomy education by enabling interactive and visually rich experiences. However, the high costs and technical barriers associated with these technologies remain significant challenges for widespread implementation. These limitations are particularly evident in regions facing compounded hardships, such as those affected by natural disasters [5, 8–10].

The challenges of distance education were further exacerbated by unique regional factors. The university where this study was Conducted, located in eastern Turkey, primarily serves students from the ten provinces most affected by the February 6, 2023, Kahramanmaraş-centered earthquakes. This crisis necessitated a renewed reliance on online education, amplifying the difficulties already posed by the pandemic and highlighting the need for resilient and adaptable educational strategies. Moreover, as Turkey is a seismically active country, the recurrence of such disasters underscores the necessity of being consistently prepared for disruptions in traditional education. Establishing robust digital infrastructure, enhancing accessibility, and developing contingency plans for distance learning are crucial to ensuring uninterrupted education during future crises.

This study explores the perspectives of vocational school of health services students on distance anatomy education, focusing on their experiences, challenges, and preferences within a theoretical framework. The aim of this study to provide practical insights for creating more effective and accessible anatomy education strategies tailored to the needs of health sciences vocational programs.

Materials and methods

This study was carried out at the Atatürk Vocational School of Health Services of Kafkas University during the spring semesters of the 2021–2022 and 2022–2023 academic years. The research specifically targeted students enrolled in the following programs: Anesthesia, Emergency and First Aid, Home Patient Care (daytime and evening education), and Elderly Care. A total of 748 students participated in the study, distributed as follows: Emergency and First Aid (150), Home Patient Care (day classes: 146, evening classes: 146), Elderly Care (156), and Anesthesia (150).

Although the study included students from different vocational health programs, the anatomy curriculum followed a largely standardized structure across departments to ensure comparability. Core theoretical topics—musculoskeletal, cardiovascular, respiratory, nervous, digestive, urogenital, and endocrine systems—were taught in all programs.

Program-specific emphases varied as follows: (i) Anesthesia—expanded coverage of the respiratory and nervous systems in relation to airway management, intubation, and regional anesthesia; (ii) Elderly Care and Home Patient Care—greater emphasis on the musculoskeletal and cardiovascular systems relevant to mobility and chronic disease management in geriatric care; (iii)

Emergency and First Aid—a targeted focus on the musculoskeletal and cardiovascular systems for trauma and acute-care scenarios. Despite these differences in emphasis, the overall structure and content remained comparable across departments; consequently, all participants studied a shared set of fundamental anatomical systems and principles.

The survey was administered face-to-face in a classroom setting to maximize participation and overcome potential technical barriers such as internet access issues. To ensure accurate and honest responses, students were informed that their answers would remain completely anonymous and unlinked to their identities. This approach aimed to foster a safe and unbiased environment, promoting candid feedback. Data collection was scheduled shortly before final exams to capture students' comprehensive experiences throughout the semester.

Participation in the study was entirely voluntary, and informed Consent was obtained from all participants. The survey was designed to be Completed within 15 min, striking a balance between thoroughness and feasibility during the exam period. A self-report method was used, ensuring confidentiality and encouraging participants to provide honest and accurate responses.

Throughout the study period, theoretical anatomy education was delivered entirely through distance learning via the Microsoft Teams platform. The theoretical anatomy component was conducted synchronously, allowing real-time interaction between instructors and students, and all sessions were recorded to enable students to review the lectures at a later time. In contrast, the practical component was conducted via a dedicated YouTube channel named *Dr. Asli Beril Karakas* (accessible at: [https://www.youtube.com/@KralAnatomi]), which was created and managed by the author of this study. This enabled students to engage with the Content at their own pace, reinforcing their understanding through repeated exposure to instructional materials. The channel Covered all anatomy topics taught during the semester and included practical sessions featuring anatomical models and real bones. Students were encouraged to use the channel as a complementary resource for both theoretical and practical learning. Originally launched as a public channel in 2018, it attracted significant engagement over the term, with approximately 16,000 subscribers, 147 uploaded videos, and a total of 1.3 million views. Figure 1 provides a permanent visual reference of the YouTube channel's homepage, independent of the external link. Including this screenshot ensures long-term accessibility for readers, as external links may change or become inactive over time.

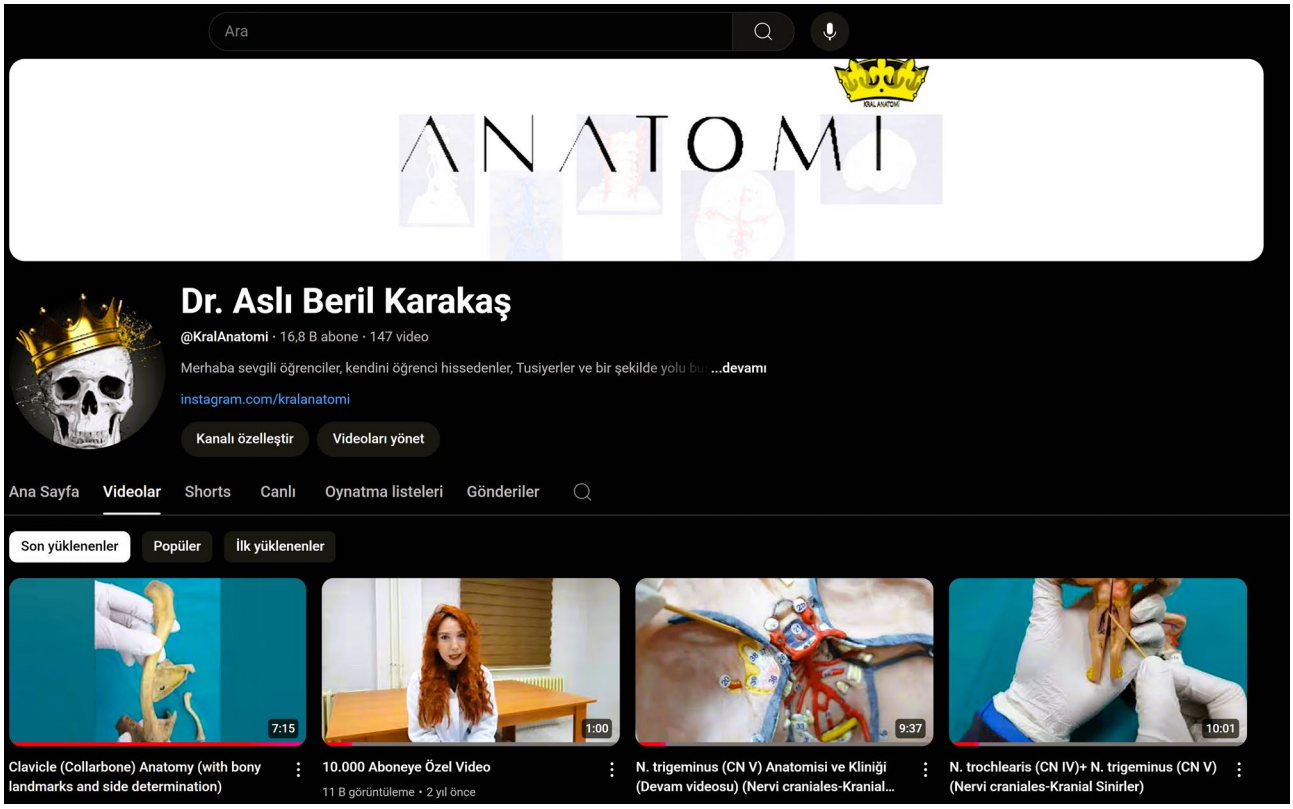

Fig. 1 Screenshot of the YouTube channel Dr. Aslı Beril Karakaş (@KralAnatomi) used for theoretical and practical anatomy instruction during distance education

During the final class before the examinations, a comprehensive summary of the entire anatomy curriculum was presented using cadaver-based teaching. This session aimed to reinforce students' understanding, address any remaining uncertainties, and provide a holistic review of the course content. The final exams were conducted face-to-face to ensure academic integrity, provide a secure testing environment, and allow for a thorough evaluation of both theoretical and practical knowledge.

The survey consisted of 50 items designed by the author, guided by an extensive review of the literature to ensure alignment with the study's objectives. The detailed structure of the survey is presented in Additional File 1. A group of two experts in statistics and public health evaluated the questions to ensure their content validity, providing feedback on clarity and relevance. The survey was divided into two main sections: the first 16 items gathered sociodemographic information (e.g., age, gender, program of study, and access to technology), while items 17–50 utilized a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The Likert scale measured various dimensions derived from factor analysis, including the following:

Motivation and engagement: This dimension evaluated students' enthusiasm and willingness to attend anatomy classes, including their perceived progress and changes in attitude toward the course. For example, students were asked to respond to statements such as, "I attended anatomy classes eagerly throughout the semester," *"By the end of the semester, my perspective on anatomy improved positively," and "I found that viewing cadavers helped in understanding the anatomy topics discussed."*

Importance of Anatomy and Suggestions: This factor assessed the importance of anatomy in students' academic programs and its perceived value in clinical and professional applications. Items in this category included statements such as, *"Anatomy is an essential course for my program," "The clinical knowledge provided in anatomy lessons is important for my profession," and "I believe the anatomy knowledge I have gained will be useful in my professional life."*

Sufficiency of Course Content: This dimension measured students' satisfaction with the adequacy of course hours, content coverage, and perceived learning outcomes. For instance, students were asked to evaluate statements like, *"I think the allocated time for anatomy lessons is sufficient," "The course content in anatomy lessons was adequate," and "I find the anatomy education we received sufficient for now and the future."*

Sufficiency of course content: This dimension measured students' satisfaction with the adequacy of course hours, content coverage, and perceived learning outcomes. For instance, students were asked to evaluate statements like, *"I think the allocated time for anatomy lessons is sufficient," "The course content in anatomy lessons was adequate," and "I find the anatomy education we received sufficient for now and the future."*

Accessibility in Distance Education: This factor focused on the ease of accessing live and recorded lectures during distance education and their impact on learning. Example items included, *"I did not experience issues following live anatomy lessons during distance education," "I watched the recorded live sessions to reinforce my learning," and "I had no problems accessing the live recordings of anatomy lessons."*

Effectiveness of Distance Education: This dimension evaluated the overall effectiveness of distance anatomy education, including the quality of materials, teaching methods, and comparisons to face-to-face learning. Students responded to statements such as, *"The materials used in anatomy lessons during distance education were well-prepared," "The distance education anatomy lessons were effective," and "Distance education anatomy lessons were equivalent to face-to-face learning."*

To validate the survey instrument, a pilot study was conducted with a small group of students ($n = 72$) prior to the main study. Feedback from the pilot study informed minor revisions to ensure clarity and alignment with the research objectives. Initially, the survey Consisted of 54 items; however, 4 items were removed during exploratory factor analysis due to low reliability coefficients and inconsistencies. These items either did not align with the conceptual framework or disrupted the factor structure, as they exhibited weak or cross-factor loadings.

The removed items were:

- *I have always found anatomy courses intimidating.*
- *I would prefer to choose a different profession instead of this one.*
- *I believe anatomy is a difficult course.*
- *The number of students in the classroom makes it difficult for me to understand the course.*

These items were excluded because their weak Correlations with other items within the same factor, or significant cross-loadings across multiple factors, Complicated the interpretation of results. Additionally, certain items, such as those addressing emotional reactions or general perceptions of the profession, were deemed less relevant to the primary focus of the survey. Removing these items

improved the internal consistency and validity of the scale, resulting in a final survey instrument with 50 items.

The methodology of this study was carefully designed to ensure the collection of reliable and accurate data while maintaining clarity and consistency throughout the process. Employing a validated survey and involving a diverse sample of students enhanced the credibility of the findings. Furthermore, conducting the survey face-to-face improved data quality by allowing immediate resolution of any uncertainties or misunderstandings during the process.

Data analysis

The data obtained from the study were analyzed using IBM SPSS 21.0 statistical software. To evaluate the structural validity of the survey, exploratory factor analysis (EFA) was applied. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.858, confirming the suitability of the sample size for EFA. Bartlett's test of sphericity ($x^2(378) = 2376.875$; $p < 0.05$) demonstrated significant inter-item Correlations. EFA revealed that the survey items were grouped into five sub-factors with eigenvalues greater than 1, Collectively explaining 59.23% of the total variance. Reliability analysis using Cronbach's Alpha yielded sub-group reliability values ranging from 0.646 to 0.878, indicating acceptable reliability for the survey instrument.

The Kolmogorov-Smirnov test was performed to assess the normality of the data distribution. Since p-values were < 0.05, the data were determined to have a non-normal distribution, and nonparametric tests were subsequently applied. Levene's test was conducted to assess the homogeneity of variances, confirming data homogeneity with p-values > 0.05. For comparative analyses, the Mann-Whitney U test was utilized for two-group comparisons, while the Kruskal-Wallis test was applied for comparisons involving three or more groups. To examine relationships between variables, the Spearman correlation coefficient was calculated. Mean and standard deviation values were reported for all quantitative data, with statistical significance set at $p < 0.05$.

Ethical considerations

Ethical approval for the study was obtained from the Kafkas University Ethics Committee (Decision No: 13). All participants were informed about the purpose of the study, and their participation was entirely voluntary. Written informed consent was obtained prior to survey administration, and anonymity was strictly maintained. To minimize response bias, students were encouraged to respond truthfully, and the significance of their contributions to the improvement of anatomy education was emphasized.

Results

This study examines the perspectives of health sciences vocational school students on distance anatomy education, focusing on their experiences, challenges, and preferences during the COVID-19 pandemic and the subsequent periods of online learning necessitated by the February 6, 2023, Kahramanmaraş-centered earthquakes. The findings highlight how these dual crises influenced the design and delivery of anatomy education, particularly in theoretical contexts where face-to-face interaction was severely limited.

The results are structured to address the research objectives, including the reliability and validity of the survey dimensions, the demographic characteristics of participants, and Comparative analyses across key factors such as motivation, the perceived importance of anatomy, accessibility, and the effectiveness of distance education. These findings provide valuable insights into the unique challenges and opportunities of distance anatomy education, particularly in regions affected by natural disasters such as the February 6, 2023, earthquakes, where online learning became a necessity rather than a choice.

Demographic data

This section presents an overview of the demographic characteristics of the participants, including gender, parental marital status, educational background, financial status, and regional distribution. These data are summarized in Tables 1 and 2, while the distribution of gender, department, and accommodation types is illustrated in Fig. 2.

A total of 748 students participated in the study, distributed across the programs as follows: Emergency and First Aid (20.1%), Home Patient Care (Day: 19.5%; Evening: 19.5%), Elderly Care (20.9%), and Anesthesia (20.1%). The majority of participants were female (67.8%), while 32.2% were male.

The highest proportion of participants reported that their parents had attained primary or secondary education, with 81.2% of mothers and 71.5% of fathers falling into this category. Similarly, most participants identified their financial status as "average" (71.0%).

In terms of geographic distribution, a substantial proportion of students resided in the Eastern Anatolia region (57.2%), followed by Southeastern Anatolia (36.2%). Accommodation data revealed that the majority of participants (67.0%) lived in state dormitories, while 33.0% lived at home or with family.

Reliability and validity analyses

The reliability and validity of the scales used in this study were assessed to ensure the accuracy and consistency of the results. Cronbach's Alpha coefficients and exploratory factor analysis (EFA) were employed to evaluate

Table 1 Demographic distribution of participants based on gender, parental marital status, education levels, occupations, and financial status

Category	*N*	%
Gender		
Female	507	67.8
Male	241	32.2
Total	748	100.0
Parental Marital Status		
Together	697	93.2
Separated	51	6.8
Mother's Education Level		
Primary/Secondary School	607	81.2
High School	81	10.8
College	13	1.7
University	47	6.3
Father's Education Level		
Primary/Secondary School	535	71.5
High School	166	22.2
College	17	2.3
University	30	4.0
Mother's Occupation		
Housewife	680	90.9
Private Sector	30	4.0
Government Employee	34	4.5
Retired	4	0.6
Father's Occupation		
Unemployed	128	17.0
Private Sector	89	11.9
Government Employee	55	7.4
Self-Employed	323	43.2
Retired	153	20.5
Financial Status		
Very Poor	13	1.7
Poor	55	7.4
Average	531	71.0
Good	149	19.9
Total	748	100.0

Table 2 Demographic distribution of participants by department, reasons for choosing their department, anatomy course history, devices used for distance education, geographic region, accommodation type, internet access, and type of internet connection

Category	*N*	%
Department		
First Aid and Emergency	150	20.1
Home Patient Care (Evening Education)	146	19.5
Home Patient Care (Day Education)	146	19.5
Elderly Care	156	20.9
Anesthesia	150	20.1
Reason for Choosing Department		
By My Own Choice	599	80.1
At My Family's Request	94	12.6
At the Request of Friends/Relatives	55	7.4
Previously Taken Anatomy Course		
Yes	260	34.8
No	488	65.2
Device Used for Distance Education		
Computer	17	2.3
Phone	659	88.1
Tablet	4	0.5
Computer + Phone	43	5.7
Computer + Tablet	8	1.1
Phone + Tablet	17	2.3
Geographic Region		
Aegean	5	0.7
Marmara	15	2.0
Mediterranean	9	1.2
Black Sea	10	1.3
Central Anatolia	12	1.6
Eastern Anatolia	428	57.2
Southeastern Anatolia	271	36.2
Accommodation		
Home	247	33.0
State Dormitory	501	67.0
Internet Access at Accommodation		
Yes	604	80.7
No	144	19.3
Type of Internet Connection		
Wi-Fi	633	84.6
Mobile	115	15.4
Total	748	100.0

these measures. The reliability Coefficients and item-specific analyses are presented in Table 3.

Cronbach's Alpha values for the scales ranged from 0.646 to 0.878, indicating acceptable to high reliability. The Importance of Anatomy and Suggestions scale exhibited the highest reliability ($\alpha = 0.878$), followed by Effectiveness of Distance Education ($\alpha = 0.869$) and Motivation and Engagement ($\alpha = 0.791$). These findings suggest that the scales used in the study provided consistent and reliable measurements for the factors evaluated.

Exploratory factor analysis confirmed the structural validity of the survey items. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.858, indicating that the sample size was suitable for factor analysis. Bartlett's test of sphericity ($x^2(378) = 2376.875$, $p < 0.05$) further demonstrated that the Correlation matrix was suitable for identifying latent Constructs. EFA results revealed that the survey items loaded onto five distinct sub-factors, collectively explaining 59.23% of the total variance. These sub-factors included Importance of Anatomy and Suggestions, Effectiveness of Distance Education, Motivation and Engagement, Accessibility in Distance Education, and Sufficiency of Course Content.

These analyses confirm the psychometric robustness of the instrument, supporting its use for evaluating student perceptions of distance anatomy education.

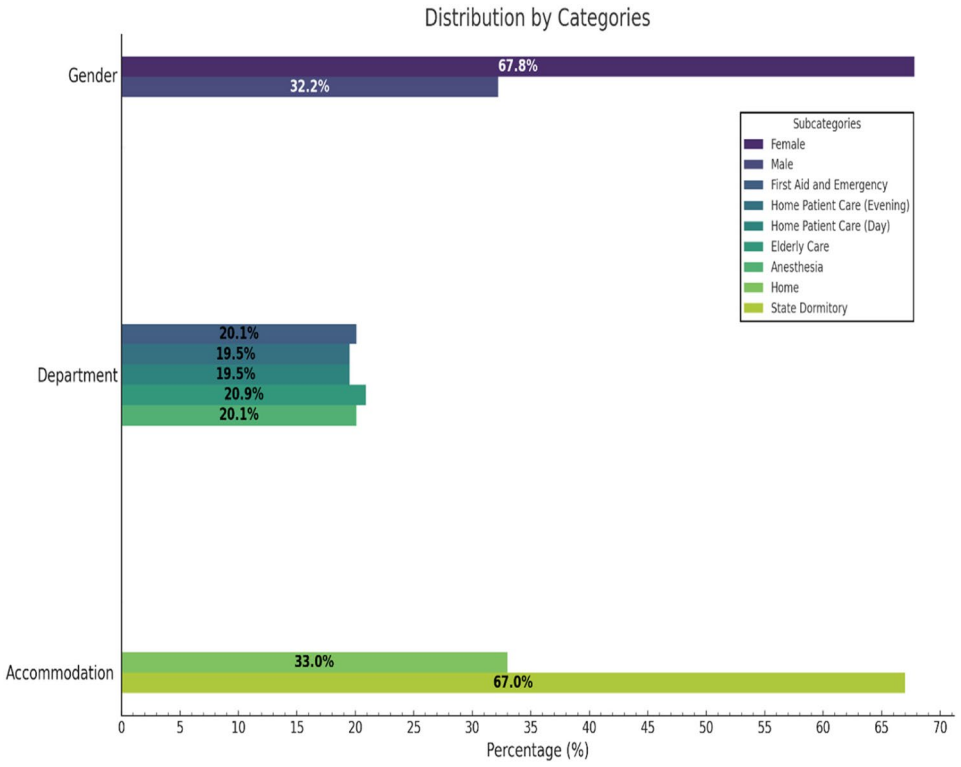

Fig. 2 Percentage distribution of participants by gender, academic department, and type of accommodation

Factor analysis results

Exploratory factor analysis (EFA) was conducted to assess the structural validity of the survey instrument and identify the underlying dimensions shaping students' perceptions of distance anatomy education. The analysis identified five factors with eigenvalues exceeding 1, Collectively explaining 59.23% of the total variance. The percentage of variance explained by each factor is detailed in Table 4, demonstrating their individual and cumulative contributions to the model.

Factor contributions

- Importance of Anatomy and Suggestions emerged as the dominant factor, accounting for 25.00% of the variance. This factor includes items evaluating the perceived importance of anatomy education in clinical and professional contexts, such as its relevance to students' academic programs and applicability to their future careers.
- The second factor, Effectiveness of Distance Education, explained 18.73% of the variance. Items within this factor assessed students' evaluations of the overall quality and effectiveness of anatomy education delivered through distance learning, including the adequacy of teaching materials and comparisons with face-to-face instruction.
- Motivation and Engagement, the third factor, Contributed 5.60% to the total variance. This dimension encompasses students' enthusiasm, willingness to participate in classes, and sense of progress throughout the course.
- The fourth factor, Accessibility in Distance Education, accounted for 5.35% of the variance. This factor highlights the ease of accessing course materials, live lectures, and recorded sessions, emphasizing the role of technological infrastructure in supporting student learning.
- The final factor, Sufficiency of Course Content, explained 4.53% of the variance. This dimension reflects students' perceptions of the adequacy of the course content in meeting their academic and professional needs.

Factor loadings and interpretations

The factor loadings provided a detailed view of the structure and meaning of the five dimensions that emerged from the exploratory factor analysis. Each factor was defined by items with high loadings, which consistently reflected students' perceptions of distance anatomy education and its role in vocational health training.

The *Importance of Anatomy and Suggestions factor, which explained the largest proportion of variance, was primarily defined by items indicati*ng that students regarded anatomy as an indispensable subject within

Table 3 Reliability analysis of scales and items related to students' perceptions of anatomy education

Scales and Items	Cronbach's Alpha	Cronbach's Alpha if Item Deleted
Motivation and Engagement	0.791	
I attended anatomy classes enthusiastically and willingly throughout the semester.		0.764
At the end of the semester, I believe I have general knowledge about human anatomy.		0.737
At the end of the semester, my perspective on anatomy has positively changed.		0.737
I leave the class having understood the subject.		0.757
Seeing the cadaver helped in understanding and comprehending the anatomy topics covered so far.		0.778
I would choose this course even if anatomy were offered as an elective in the curriculum.		0.781
The videos on the YouTube channel motivated me to learn anatomy and increased my interest in the subject.		0.775
Importance of Anatomy and Suggestions	0.878	
Anatomy is a necessary course for my department.		0.866
The clinical information taught in the anatomy course is important for my profession.		0.876
Practical sessions (laboratory classes) for anatomy should also be included in the course schedule.		0.854
I would like to see theoretical anatomy education through medical models.		0.850
I would like to see theoretical anatomy education through cadavers.		0.856
I would like to process anatomy lessons using patient examples.		0.860
I believe the anatomy knowledge I have gained will be useful in my professional life.		0.870
Regular attendance is necessary for success in anatomy courses.		0.869
I think the information learned from the videos on the YouTube channel is useful for anatomy applications.		0.872
Sufficiency of Course Content	0.646	
I think the duration of anatomy classes in the curriculum is sufficient.		0.642
I think the content of the anatomy course we have covered is sufficient.		0.372
I find the anatomy education I have received sufficient for now and for the future.		0.625
I believe that the content provided in the videos on the YouTube channel is sufficient for practical anatomy education.		0.645
Accessibility in Distance Education	0.718	
I did not have any issues following live anatomy lessons in distance education.		0.695
I watched live class recordings to learn anatomy during distance education.		0.676
I did not encounter any problems accessing live class recordings of anatomy lessons during distance education.		0.610
Watching live class recordings of anatomy lessons during distance education positively affected my learning.		0.640
I did not encounter any issues accessing the videos on the YouTube channel.		0.678
Effectiveness of Distance Education	0.869	
Having anatomy lessons delivered online increased my motivation to learn.		0.850
I think the duration of anatomy lessons in distance education is sufficient.		0.852
The teaching materials used in anatomy lessons during distance education were well-prepared.		0.871
I think the anatomy lessons delivered in distance education were effective.		0.847
The anatomy lessons provided through distance education facilitated effective learning.		0.839
I think anatomy lessons delivered via distance education are equivalent to face-to-face education.		0.842
I would prefer anatomy lessons to always be delivered online instead of face-to-face.		0.850
I believe that the videos on the YouTube channel have improved my practical anatomy knowledge.		0.843

Table 4 Factor analysis results showing variance explained by each scale

Scale	Initial Eigenvalues: Total	Percentage of Variance (%)	Cumulative Percentage (%)
Importance of Anatomy and Suggestions	7.001	25.002	25.002
Effectiveness of Distance Education	5.247	18.739	43.741
Motivation and Engagement	1.570	5.608	49.350
Accessibility in Distance Education	1.499	5.354	54.703
Sufficiency of Course Content	1.268	4.530	59.233

their academic programs. High-loading items reflected strong agreement that the knowledge acquired in anatomy would be useful in future professional practice and that clinical knowledge provided in the course was directly relevant to their vocational training. This dimension demonstrated that students perceived anatomy not merely as a theoretical requirement but as essential knowledge forming the foundation of professional competence.

The *Effectiveness of Distance Education* factor was characterized by items emphasizing the adequacy and quality of teaching materials and instructional methods

used during online delivery. Items with high factor loadings included statements regarding the preparedness of materials and the contribution of the YouTube channel to practical understanding. At the same time, responses highlighted skepticism regarding whether distance education could reach the same standard as face-to-face learning, indicating that although digital tools were considered supportive, they were not perceived as fully equivalent to traditional instruction.

The *Motivation and Engagement* factor reflected students' enthusiasm for attending anatomy classes and their perception of progress over the semester. High-loading items demonstrated that students reported attending classes willingly and experienced a positive shift in their perspective toward anatomy. These results emphasize that motivation and engagement were sustained when students perceived the learning process as structured and meaningful, even in a distance education context.

The *Accessibility in Distance Education* factor was defined by items related to the ease of following live lessons and accessing recorded sessions. Students who reported no technical difficulties consistently rated their learning experiences more positively, whereas those who encountered access problems expressed reduced satisfaction. This dimension underscored the direct link between accessibility of online platforms and the perceived effectiveness of distance anatomy education.

Finally, the *Sufficiency of Course Content* factor was characterized by items assessing the adequacy of the course duration, content coverage, and its capacity to meet professional requirements. Responses reflected general satisfaction with the sufficiency of anatomy education when supported by digital resources such as videos, but also indicated that certain students perceived gaps, particularly in relation to practical training components.

In summary, the factor loadings confirmed the validity of the five identified dimensions and demonstrated that students' perceptions of distance anatomy education were shaped by the combined influence of content adequacy, accessibility, motivation, effectiveness of delivery, and above all, the acknowledged importance of anatomy for professional development.

Descriptive statistics and response distributions

This section presents the descriptive statistics and response distributions of the survey items, offering an overview of students' perceptions of anatomy education. Response distributions for all survey items are presented in Table 5, while response options are visually represented in Fig. 3. These statistics illustrate the central tendencies and variability of student responses across key dimensions such as motivation, importance of anatomy and suggestions, course sufficiency, accessibility, and effectiveness of distance education.

Within the Importance of Anatomy and Suggestions dimension, the majority of students agreed that anatomy is an essential subject in their programs and emphasized its relevance for their future professional roles. This indicates that, regardless of delivery format, anatomy retained its status as a core discipline in vocational health education.

Responses related to Motivation and Engagement demonstrated strong support for the inclusion of practical sessions in the curriculum. Many students emphasized that applied components would reinforce theoretical knowledge and sustain their interest in the subject, pointing to the continued importance of experiential learning opportunities.

In terms of the Effectiveness of Distance Education, the results were more heterogeneous. Students acknowledged the benefits of prepared materials and online resources; however, agreement with the view that distance education could fully replace face-to-face instruction was limited. Only a minority indicated a preference for anatomy courses to be conducted exclusively online, suggesting that distance education was generally perceived as complementary rather than substitutive.

Perceptions of the Sufficiency of Course Content were also varied. While many respondents considered the scope and duration of the course to be adequate, a considerable proportion either remained neutral or expressed reservations. This variation suggests that expectations regarding the comprehensiveness of anatomy instruction were not uniformly met.

Items addressing multimedia resources received consistently positive evaluations. The YouTube channel, which provided video-based demonstrations of anatomical structures and models, was regarded by most students as a motivating and helpful supplement to formal instruction. It was also frequently described as sufficient for supporting aspects of practical learning, especially under conditions where laboratory access was not possible.

Comparative tests: analysis of group differences

The Comparative analyses of student responses across demographic variables are presented in Tables 6, 7 and 8. Group differences were examined using Mann-Whitney U and Kruskal-Wallis tests, and only statistically significant findings are described below.

Departmental comparisons

Significant differences were identified in the Motivation and Engagement dimension ($\chi^2 = 21.132$, $p < 0.001$). Students enrolled in the Home Patient Care (day program) reported higher levels of motivation compared with those in the Emergency and First Aid program.

Table 5 Distribution of responses for all questions on anatomy education

Questions	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)
1. I attended anatomy classes enthusiastically and willingly throughout the semester.	6.8	6.8	17	48.3	21
2. The videos on the YouTube channel motivated me to learn anatomy and increased my interest in the subject.	2.3	8.7	16.7	41.6	30.7
3. I think the information learned from the videos on the YouTube channel is useful for anatomy laboratory.	1.9	9.5	4.4	45.6	38.6
4. I believe that the content provided in the videos on the YouTube channel is sufficient for practical anatomy education.	1.6	16.6	8.4	42.3	31.1
5. Anatomy is a necessary course for my department.	6.8	1.1	5.7	36.9	49.4
6. I think anatomy is a challenging course.	6.8	11.9	16.5	36.4	28.4
7. I think the duration of anatomy lessons in the curriculum is sufficient.	17	15.9	17.6	27.8	21.6
8. I think the content covered in the anatomy course is sufficient.	6.8	6.8	16.5	45.5	24.4
9. The clinical information taught in the anatomy course is important for my profession.	5.7	2.8	6.3	43.8	41.5
10. I did not encounter any issues accessing the videos on the YouTube channel.	1.9	11.7	1.2	48.7	36.5
11. Practical sessions (laboratory classes) for anatomy should be included in the course schedule.	4.5	4	6.8	23.9	60.8
12. I would like to see theoretical anatomy education through medical models.	2.3	1.7	6.3	25.6	64.2
13. I would like to see theoretical anatomy education through cadavers.	2.3	4	6.8	25	61.9
14. I would like to process anatomy lessons using patient examples.	1.7	3.4	8	26.1	60.8
15. At the end of the semester, I believe I have general knowledge about human anatomy.	5.1	11.9	30.7	38.1	14.2
16. I believe the anatomy knowledge I have gained will be useful in my professional life.	3.4	2.8	9.1	41.5	43.2
17. At the end of the semester, my perspective on anatomy has positively changed.	2.8	6.8	16.5	44.9	29
18. Regular attendance is necessary for success in anatomy courses.	4	1.7	8.5	40.9	44.9
19. I leave the class having understood the subject.	4.5	6.3	32.4	38.1	18.8
20. Seeing the cadaver helped in understanding and comprehending the anatomy topics covered so far.	3.4	4	21.6	37.5	33.5
21. I find the anatomy education I have received sufficient for now and for the future.	8	10.8	25	39.2	17
22. I would choose this course even if anatomy were offered as an elective in the curriculum.	7.4	7.4	22.2	34.7	28.4
23. Having anatomy lessons delivered online increased my motivation to learn.	37.5	20.5	17.6	14.8	9.7
24. I think the duration of anatomy lessons in distance education is sufficient.	26.1	12.5	21.6	25	14.8
25. The teaching materials used in anatomy lessons during distance education were well-prepared.	12.5	6.8	23.3	36.9	20.5
26. I did not have any issues following live anatomy lessons in distance education.	21	18.8	18.8	23.9	17.6
27. I watched live class recordings to learn anatomy during distance education.	5.1	10.2	17.6	40.3	26.1
28. I did not encounter any problems accessing live class recordings of anatomy lessons during distance education.	12.5	14.8	17.6	29.5	25.6
29. Watching live class recordings of anatomy lessons during distance education positively affected my learning.	7.4	6.8	15.3	40.9	29.5
30. I think the anatomy lessons delivered in distance education were effective.	22.2	13.1	17.6	31.3	15.9
31. The anatomy lessons provided through distance education facilitated effective learning.	21	16.5	20.5	27.8	14.2
32. I think anatomy lessons delivered via distance education are equivalent to face-to-face education.	35.2	17	16.5	13.6	17.6
33. I would prefer anatomy lessons to always be delivered online instead of face-to-face.	44.9	16.5	10.8	13.1	14.8
34. I believe that the videos on the YouTube channel have improved my practical anatomy knowledge.	6.8	7.4	15.4	40.9	29.5

Additional pairwise comparisons indicated that Elderly Care students also demonstrated higher motivation than Emergency and First Aid students, while Anesthesia students scored lower than their Home Patient Care (day program) peers. These results suggest that motivation toward anatomy may vary according to how directly students perceive the subject to be linked with their vocational practice.

Gender-based differences

A significant difference was observed in the Effectiveness of Distance Education scale ($Z = -2.006$, $p = 0.045$), where male students rated online anatomy instruction more favorably than female students. No statistically significant differences were identified between genders in the remaining dimensions, including Motivation and Engagement or Accessibility.

Fig. 3 Survey response distribution on distance anatomy education, covering effectiveness, content, and YouTube video support

Accommodation type

Accommodation type was associated with significant differences in both Effectiveness of Distance Education ($Z = -2.835$, $p = 0.005$) and Accessibility ($Z = -1.982$, $p = 0.048$). Students living in state dormitories reported lower levels of perceived effectiveness and accessibility compared with those living at home or with family. No significant differences were observed for the other scales.

In summary, departmental affiliation, gender, and accommodation type were found to influence specific perceptions of distance anatomy education. Motivation was highest among Home Patient Care students, male students expressed relatively greater confidence in the effectiveness of distance education, and dormitory residents experienced more difficulties with access and perceived effectiveness than students residing at home.

Correlation analysis

The Correlation analysis presented in Table 9 examined the relationships between the five key scales in anatomy education. The results are also illustrated as a heatmap in Fig. 4. Statistically significant correlations were observed between most scales, with varying strengths and directions.

A moderate positive correlation was found between Importance of Anatomy and Suggestions and Motivation and Engagement ($r = 0.405$, $p < 0.001$), suggesting that students who perceived anatomy as more relevant to their academic and professional development also demonstrated higher levels of motivation. In contrast, a weak negative correlation was observed between Importance of Anatomy and Effectiveness of Distance Education ($r = -0.197$, $p = 0.009$), indicating that students who strongly valued anatomy did not necessarily regard distance instruction as effective.

Table 6 Comparison of departments based on key factors in anatomy education

Scale	No	Department	*N*	x̄	SD	Mean Rank	X^2	df	*p*	MD
Importance of Anatomy and Suggestions	1	First Aid and Emergency	150	4.318	0.520	84.028	0.621	4	0.961	
	2	Home Patient Care (Evening)	146	4.286	0.798	90.429				
	3	Home Patient Care (Day)	146	4.144	1.098	90.000				
	4	Elderly Care	156	4.272	0.816	89.310				
	5	Anesthesia	150	4.356	0.585	91.474				
Effectiveness of Distance Education	1	First Aid and Emergency	150	2.811	1.060	87.962	4.759	4	0.313	
	2	Home Patient Care (Evening)	146	2.869	1.014	91.257				
	3	Home Patient Care (Day)	146	3.264	1.286	107.825				
	4	Elderly Care	156	2.581	0.979	76.293				
	5	Anesthesia	150	2.747	0.978	85.923				
Accessibility in Distance Education	1	First Aid and Emergency	150	3.377	0.941	82.915	3.256	4	0.516	
	2	Home Patient Care (Evening)	146	3.329	1.050	80.900				
	3	Home Patient Care (Day)	146	3.675	0.980	100.600				
	4	Elderly Care	156	3.632	0.808	95.552				
	5	Anesthesia	150	3.519	0.859	91.462				
Motivation and Engagement	1	First Aid and Emergency	150	3.484	0.584	69.236	21.132	4	*0.000*	1–3
	2	Home Patient Care (Evening)	146	3.895	0.724	99.300				1–4
	3	Home Patient Care (Day)	146	4.092	0.960	120.900				3–5
	4	Elderly Care	156	3.885	0.686	102.328				
	5	Anesthesia	150	3.538	0.724	78.090				
Sufficiency of Course Content	1	First Aid and Emergency	150	3.283	0.895	77.962	4.946	4	0.293	
	2	Home Patient Care (Evening)	146	3.495	0.998	92.786				
	3	Home Patient Care (Day)	146	3.750	1.075	104.500				
	4	Elderly Care	156	3.609	0.972	93.931				
	5	Anesthesia	150	3.462	0.808	86.731				

N sample size, $\bar{x}$ Mean, *SD* standart deviation, X^2 Kruskall Wallis chi-square value, *df* degree of freedom, *MD* Meaningful Differences $p < 0.05$ is significant

Table 7 Comparison of scales between male and female participants in anatomy education

Scale	Gender	*N*	x̄	SD	Mean Rank	Mann-Whitney U	Wilcoxon W	Z	*p*
Importance of Anatomy and Suggestions	Female	507	4.315	0.677	89.560	3055.000	4381.000	−0.434	0.664
	Male	241	4.238	0.823	85.902				
Effectiveness of Distance Education	Female	507	2.717	1.005	83.584	2573.000	10448.000	−2.006	*0.045**
	Male*	241	3.081	1.130	100.540				
Accessibility in Distance Education	Female	507	3.445	0.915	86.496	2937.000	10812.000	−0.820	0.412
	Male	241	3.549	0.967	93.412				
Motivation and Engagement	Female	507	3.701	0.674	86.800	2975.000	10850.000	−0.695	0.487
	Male	241	3.742	0.878	92.667				
Sufficiency of Course Content	Female	507	3.413	1.008	86.720	2965.000	10840.000	−0.732	0.464
	Male	241	3.614	0.710	92.863				

N sample size, $\bar{x}$ Mean, *SD* standart deviation, *Z* Mann-Whitney U Z score $p < 0.05$ is significant

The strongest relationship was identified between Effectiveness of Distance Education and Accessibility ($r = 0.509$, $p < 0.001$). Students who reported fewer difficulties in accessing online content were more likely to evaluate distance anatomy education as effective. Additionally, Effectiveness was moderately correlated with Sufficiency of Course Content ($r = 0.370$, $p < 0.001$), suggesting that perceptions of well-structured content contributed to the perceived quality of distance learning.

Accessibility also showed moderate positive correlations with both Motivation and Engagement ($r = 0.447$, $p < 0.001$) and Sufficiency of Course Content ($r = 0.379$, $p < 0.001$). These results indicate that students who could reliably access materials were both more motivated and more satisfied with the adequacy of course content.

Finally, Motivation and Engagement correlated positively with Sufficiency of Course Content ($r = 0.346$, $p < 0.001$), highlighting that students who considered the course content sufficient were more likely to report sustained motivation throughout the semester.

Taken together, the correlation results demonstrate that students' perceptions of distance anatomy education were strongly influenced by the interplay between accessibility, content sufficiency, motivation, and effectiveness,

Table 8 Comparison of scales based on participants' accommodation type

Scale	Accommodation	*N*	x̄	SD	Mean Rank	Mann-Whitney U	Wilcoxon W	Z	*p*
Importance of Anatomy and Suggestions	Home	247	4.095	0.911	76.888	2748.500	4459.500	−1.894	0.058
	State Dormitory	501	4.392	0.591	92.100				
Effectiveness of Distance Education	Home	247	3.113	0.967	102.190	2454.000	9124.000	−2.835	*0.005**
	State Dormitory*	501	2.642	1.051	79.339				
Accessibility in Distance Education	Home	247	3.665	0.793	97.586	2721.000	9391.000	−1.982	*0.048**
	State Dormitory*	501	3.367	0.979	81.661				
Motivation and Engagement	Home	247	3.733	0.721	86.836	3325.500	5036.500	−0.031	0.976
	State Dormitory	501	3.704	0.757	87.083				
Sufficiency of Course Content	Home	247	3.397	0.901	82.052	3048.000	4759.000	−0.931	0.352
	State Dormitory	501	3.504	0.957	89.496				

N sample size, *x̄* Mean, *SD* standart deviation, *Z* Mann-Whitney U Z score $p < 0.05$ is significant

Table 9 Correlation coefficients (CC) and *p*-values (*p*) for relationships among scales in anatomy education

Scale	Importance of Anatomy and Suggestions		Effectiveness of Distance Education		Accessibility in Distance Education		Motivation and Engagement		Sufficiency of Course Content	
	CC	*p*	CC	*p*	CC	*p*	CC	*p*	CC	*p*
Importance of Anatomy and Suggestions	1.000		−0.197	*0.009*	0.128	0.090	0.405**	0.000	0.060	0.426
Effectiveness of Distance Education	−0.197	*0.009*	1.000		0.509**	0.000	0.350**	0.000	0.370**	0.000
Accessibility in Distance Education	0.128	0.090	0.509**	*0,000*	1.000		0.447**	0.000	0.379**	0.000
Motivation and Engagement	0.405**	*0.000*	0.350**	*0.000*	0.447**	0.000	1.000		0.346**	0.000
Sufficiency of Course Content	0.060	0.426	0.370**	*0.000*	0.379**	0.000	0.346**	0.000	1.000	

CC Correlation Coefficient (if it is negative, correlation is negative, if it is positive; correlation is positive)

$p < 0.05$ is significant

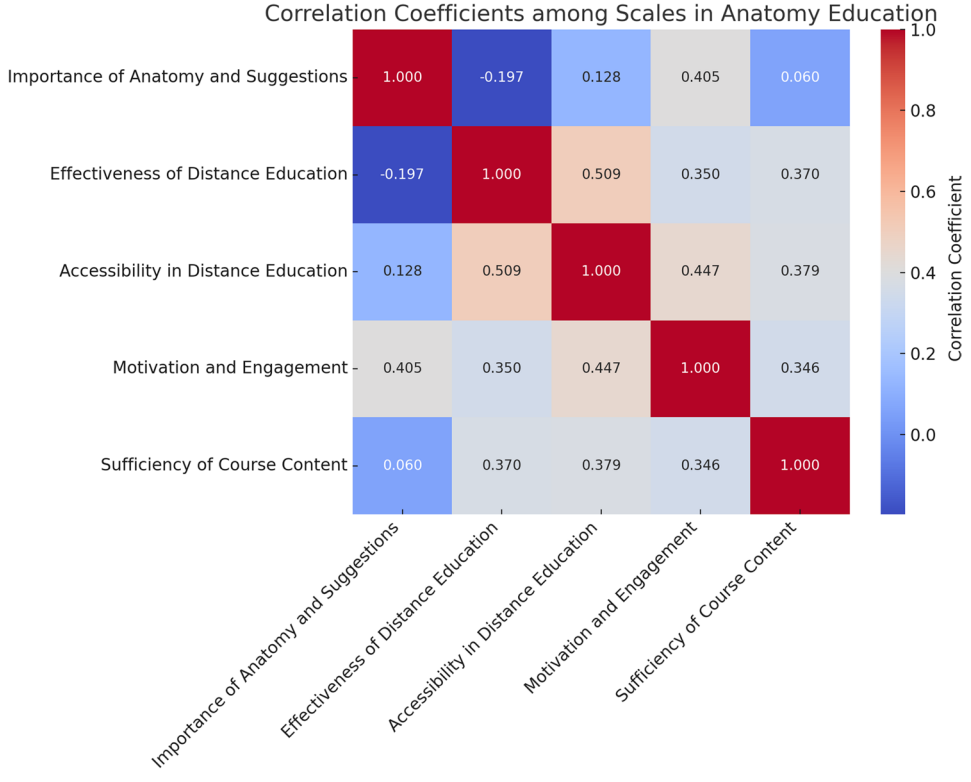

Fig. 4 Heatmap showing correlations among anatomy education scales: motivation, accessibility, effectiveness, sufficiency, and importance

with accessibility emerging as the most critical factor in shaping positive evaluations.

Discussion

This study provides a comprehensive analysis of the challenges and opportunities associated with distance anatomy education, highlighting the interconnected factors that influence its effectiveness. The findings reveal significant variations in motivation, perceived relevance, sufficiency of course content, and overall perceptions of anatomy education among health science students. These differences were influenced by factors such as department, gender, and accommodation type, as well as the critical role of accessibility in online education.

Differences in motivation and engagement across departments

The observed differences in motivation and engagement across departments highlight the importance of tailoring anatomy education to specific professional applications. Home Patient Care students demonstrated higher motivation and engagement, likely due to the program's direct emphasis on caregiving, where anatomy knowledge is essential for understanding age-related health conditions, mobility challenges, and chronic illnesses. This relevance fosters a sense of purpose and reinforces motivation, further supported by interpersonal aspects of caregiving that emphasize empathy and effective patient care. Practical approaches such as case-based learning and patient-centered scenarios also enhance engagement in this group [11, 12].

Conversely, First Aid and Emergency students reported lower motivation scores, reflecting a disconnect between the theoretical structure of anatomy education and the fast-paced, action-oriented demands of emergency care. For these students, rapid decision-making and procedural skills are prioritized, leading to a perception that certain theoretical components of anatomy are less critical. This underscores the importance of interactive and hands-on training, including simulated emergency scenarios, to meet the professional needs of this department [8, 13].

Similarly, Anesthesia students exhibited lower motivation, which may indicate insufficient integration of anatomy content with their specialization in the nervous, cardiovascular, and respiratory systems. Since anesthesia practice relies on detailed anatomical knowledge for procedures such as intubation, epidural anesthesia, and regional blocks, curricula should emphasize these areas through practical and scenario-based learning approaches, including clinical vignettes and procedural simulations [14, 15].

These findings are consistent with previous research demonstrating that contextualizing anatomy education within professional practice enhances student engagement and perceived relevance. Case-based learning, simulations, and augmented reality (AR) have been shown to improve motivation and performance by providing applied and interactive opportunities. For example, Ferrer-Torregrosa et al. (2016) found that AR enhanced both academic outcomes and motivation compared to traditional methods, while Sadeesh et al. (2021) emphasized the indispensability of cadaver-based learning for developing three-dimensional anatomical understanding [11, 16, 17].

The lack of significant differences in other scales, such as the Importance of Anatomy or the Effectiveness of Distance Education, suggests that while motivation and engagement vary by department, students generally recognize anatomy as relevant to their professional development and perceive distance education similarly in terms of overall effectiveness.

Gender-based differences in perceptions of distance education

The gender-based differences observed in the Effectiveness of Distance Education scale suggest that male students perceived online anatomy education as more effective than female students. This disparity may be related to factors such as technological adaptability, learning preferences, and external responsibilities. Male students often demonstrate greater familiarity and confidence with digital tools and online platforms, which may positively influence their experiences in distance learning environments. Previous studies have shown that men are more inclined to adopt and experiment with new technologies, contributing to higher confidence and satisfaction with online instruction [18, 19].

Similar patterns were reported by Alsoufi et al. (2020) [20] and Liem et al. (2024) [2], who noted that male students tended to rate online education more positively. Male students may also prefer the self-paced and autonomous nature of distance learning, whereas female students often favor collaborative and interactive approaches that are not fully replicated in online settings [21].

Female students may also face additional challenges in balancing online education with familial or caregiving responsibilities, particularly in cultural contexts where these roles are traditionally assigned to women. This aligns with previous studies documenting the difficulties female students encounter in managing competing demands during distance education [22, 23]. Such pressures may negatively affect their learning experiences and contribute to lower perceptions of effectiveness. Female students may also be more sensitive to the lack of interactive, hands-on elements in online anatomy education,

which could hinder engagement and perceived outcomes [24].

These findings emphasize the importance of creating inclusive and adaptive online learning environments that address gender-specific barriers. Incorporating more interactive and collaborative components, such as virtual group discussions and live Q&A sessions, may enhance female students' learning experiences. Targeted interventions, such as digital literacy workshops, can help bridge confidence gaps in technology use [5, 25]. Offering flexible scheduling or recorded lectures may further reduce barriers for students with caregiving responsibilities. As noted by Yoo et al. (2021), blended learning models can improve academic outcomes, but additional measures are needed to ensure equitable participation and engagement across genders [1].

The impact of accommodation type on learning experiences

Students residing in state dormitories reported significantly lower scores for both Effectiveness of Distance Education and Accessibility compared to those living at home. This finding suggests that dormitory conditions create barriers that negatively affect students' online learning experiences. Factors such as limited private study space, shared internet connections, and frequent interruptions may contribute to reduced engagement. Prior studies have emphasized that the quality of the learning environment directly influences participation and outcomes in distance education [22, 23]. Infrastructure limitations, including slower internet speeds and connectivity problems in dormitories, further hinder effective access to educational resources [19, 24].

In contrast, students living at home reported higher levels of accessibility and perceived effectiveness, consistent with previous research indicating that home environments typically provide better connectivity and fewer distractions, which facilitate greater engagement and improved outcomes [26]. Conversely, the challenges associated with shared spaces and unreliable internet in dormitories highlight the need for targeted institutional interventions to support equity in access to online education [3, 16].

Addressing these disparities requires investments in dormitory infrastructure, such as reliable high-speed internet and designated study areas. Such improvements would not only enhance academic performance but also promote fairness in access to distance learning opportunities [27]. Yoo et al. (2021) [1] also emphasized that technical support and improved internet infrastructure are critical for student engagement and success. Ensuring these conditions is essential to providing equitable and supportive educational experiences for all students, regardless of living arrangements.

Correlations among key factors

The positive correlations observed in this study emphasize the interrelated nature of the factors shaping anatomy education. The association between Motivation and Engagement and Importance of Anatomy and Suggestions ($r = 0.405$, $p < 0.001$) indicates that students are more motivated when they perceive anatomy as directly relevant to their professional future. This finding highlights the importance of designing curricula that clearly connect anatomical knowledge to vocational applications [12, 28].

The strong correlation between Accessibility and Effectiveness of Distance Education ($r = 0.509$, $p < 0.001$) underscores the role of digital infrastructure in determining the quality of learning experiences. Previous studies have consistently shown that difficulties in accessing live and recorded lectures significantly reduce students' satisfaction and engagement in distance learning [3, 13]. Enhancing technical infrastructure and ensuring reliable access are therefore essential to improving the overall effectiveness of online anatomy education.

In addition, the YouTube channel used in this study played a notable role in strengthening student engagement. A large proportion of participants reported that the videos motivated them to learn anatomy, increased their interest in the subject, and supported laboratory-related applications. These results are consistent with prior research demonstrating the benefits of multimedia resources in both theoretical and practical anatomy education [12, 20, 29].

Contribution of the YouTube channel to distance anatomy education

The YouTube channel significantly contributed to students' learning experiences by providing accessible and flexible content. Most participants reported no difficulties in accessing the videos, which allowed them to revisit lessons and reinforce understanding through asynchronous learning. This flexibility was particularly valuable in regions with infrastructural challenges and during crises such as the COVID-19 pandemic and the 2023 Kahramanmaraş earthquakes [13, 29]. Previous studies have similarly emphasized the advantages of video platforms in supporting self-paced learning and improving comprehension of complex topics [29].

The videos' inclusion of practical demonstrations and detailed explanations appeared to compensate for the absence of hands-on sessions. A substantial proportion of students reported that the channel provided sufficient support for practical anatomy education and improved their practical knowledge. These findings align with evidence that multimedia tools can complement traditional methods and provide scalable solutions for anatomy education [3, 8, 29]. Videos have also been shown to enhance

spatial understanding of anatomical structures when cadaver-based training is limited [29].

The channel also demonstrated a positive impact on motivation and engagement, as indicated by the high internal consistency (Cronbach's Alpha = 0.775) of related survey items. Students perceived the channel as a motivating and integral part of their learning, which supports prior findings that structured digital resources can foster interest and improve academic performance [11, 29, 30].

Nevertheless, reliance on digital platforms also highlights the importance of addressing access and digital literacy disparities. While most students accessed the channel without difficulty, future efforts should focus on enhancing inclusivity and supporting learners with limited technological resources or varying levels of digital competence. Providing training in digital tools and improving accessibility can reduce barriers and ensure equal opportunities for all students [29].

Broader implications of crisis-driven education models

The COVID-19 pandemic and the 2023 Kahramanmaraş earthquakes demonstrated that online education can ensure continuity during crises, but they also revealed limitations, particularly in disciplines such as anatomy that require hands-on practice. Given Turkey's earthquake-prone geography, future disruptions to in-person education are likely, underscoring the need for sustainable distance education models that can adapt to emergency conditions. Investments in digital infrastructure, interactive learning tools, and flexible academic policies are essential to maintain educational quality under such circumstances. Blended learning, which integrates online and face-to-face components, has been identified as a promising model for balancing flexibility with practical engagement [8, 31].

Previous studies have emphasized both the strengths and shortcomings of online education in crisis contexts. Boulos (2022) [13] noted that online platforms were effective in maintaining continuity but often failed to replicate the engagement and skill development associated with in-person teaching. Similarly, Yoo et al. (2021) [1] found that while students valued the flexibility of online learning, they consistently emphasized the irreplaceable benefits of cadaver-based dissection. In line with these findings, digital approaches such as online lectures and multimedia resources should be considered supplementary, as they enhance theoretical understanding and accessibility but cannot replace the indispensable value of hands-on experiences, including cadaver dissection and laboratory-based training. These considerations highlight the need for hybrid approaches that combine digital tools with direct, hands-on experiences to optimize anatomy education in crisis and non-crisis settings alike.

Strengths and limitations

This study provides a comprehensive analysis of health sciences vocational school students' perceptions of distance anatomy education. The inclusion of a large and diverse sample enhances the reliability of the findings, while the participation of students from multiple departments allows for comparative analyses across different demographic and professional groups. Additionally, the timing of data collection, which coincided with challenging periods such as the COVID-19 pandemic and the 2023 Kahramanmaraş earthquakes, offers valuable insights into the impact of distance education under crisis conditions.

The study's focus on theoretical anatomy education addresses a notable gap in the literature, while the use of validated and reliable measurement tools ensures that the findings are statistically robust. Furthermore, the meticulous application of data collection methods and adherence to ethical procedures enhances the academic credibility of the study and supports meaningful implications for educational policies.

Despite its strengths, this study has several limitations that should be acknowledged:

First, the focus on theoretical anatomy education excludes practical components, such as cadaver dissection and hands-on laboratory experiences, which are critical for a comprehensive understanding of anatomy. The absence of data on these aspects limits the generalizability of the findings to the broader scope of anatomy education.

Second, the geographic scope of the study is restricted to a single region in Turkey, which may not reflect the experiences of students in other regions or countries with different educational infrastructures and cultural contexts. This limitation necessitates caution when applying the findings to a global context. Future research should aim to include more diverse geographic regions to enhance external validity.

Third, the reliance on self-reported data may introduce response bias, as participants might overestimate or underestimate their experiences and perceptions due to social desirability or recall issues. Additionally, the study does not account for individual differences in learning styles or technological proficiency, which could significantly influence students' experiences with distance education. Future research should incorporate objective performance measures and qualitative methodologies to mitigate this limitation.

Fourth, while the study utilized validated measurement tools, the sudden transition to distance education during crises, such as the COVID-19 pandemic and the 2023 Kahramanmaraş earthquakes, may have introduced unforeseen variables that were not fully captured in the survey. Psychological stress, accessibility issues,

and variations in institutional preparedness might have influenced students' experiences in ways that were not explicitly measured. Future research should examine the long-term impact of crisis-driven distance education on students' professional competencies and adaptation to hybrid learning models.

Finally, this study did not include a concurrent control group receiving traditional face-to-face anatomy instruction. Because teaching shifted fully online during the COVID-19 pandemic and remained predominantly distance-based after the February 6, 2023 earthquakes, establishing such a comparison group was not feasible within the study period. Future research incorporating parallel control groups or quasi-experimental designs would allow stronger inferences regarding the relative effectiveness of distance versus in-person anatomy education.

Conclusion

This study provides an in-depth examination of the multifaceted factors influencing the effectiveness of distance anatomy education, emphasizing the importance of tailored educational strategies. Addressing observed disparities through curriculum customization, technological support, and infrastructure improvements is essential to ensure equitable and effective learning experiences for all students.

Blended learning models stand out as a promising approach, combining the flexibility of online education with the depth and engagement of face-to-face learning. Moreover, investment in advanced technologies, such as augmented reality (AR) and virtual reality (VR), can further enhance learning outcomes while addressing the limitations exposed during crisis scenarios.

Future research should focus on incorporating practical anatomy components, evaluating these approaches across diverse student populations, and exploring their applicability in different geographic regions. Expanding the scope of studies to include comparative analyses of hybrid learning models and their long-term impact on students' professional competencies would provide valuable insights for shaping the future of anatomy education.

In conclusion, this study underscores the need for adaptable, inclusive, and technology-supported educational models that cater to the unique needs of various student groups, ensuring the resilience and effectiveness of anatomy education in both routine and crisis settings.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-07991-1.

Supplementary Material 1.

Acknowledgements

The author extend their sincere gratitude to all the students who participated in the survey, contributing valuable insights to this study. Their engagement and willingness to share their experiences were instrumental in shaping the findings of this research.Additionally, we would like to express our heartfelt appreciation to Assoc. Prof. Dr. Muhammed Yayla from the Department of Pharmacology, Faculty of Medicine, Kafkas University, and Prof. Dr. Binali Çatak from the Department of Public Health for their invaluable support and guidance throughout this study. Their expertise, constructive feedback, and unwavering encouragement greatly enriched the research process and enhanced the quality of our work.

Authors' contributions

ABK: Conceived and designed the study, developed the methodology, conducted the data analysis, prepared the figures, wrote the manuscript, and approved the final version for submission.

Funding

No funding was received for conducting this study.

Data availability

The datasets used in this report are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and was approved by the Research Ethics Committee of Kafkas University (Approval Number: 13). Human Ethics and Consent to Participate declarations are provided accordingly.
All participants provided written informed consent prior to their inclusion in this study.

Competing interests

The author declare no competing interests.

Received: 21 March 2025 / Accepted: 8 September 2025
Published online: 14 October 2025

References

1. Yoo H, Kim D, Lee YM, Rhyu IJ. Adaptations in Anatomy Education during COVID-19. J Korean Med Sci. 2021;36(1):e13. https://doi.org/10.3346/jkms.2021.36.e13.
2. Liem IK, Fatril AE, Husna FA. Satisfaction of lecturers and undergraduate students of medical faculties in Indonesia towards online anatomy learning during COVID-19 pandemic. BMC Med Educ. 2024;24:695.
3. 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 Biology. 2021;54:332–9.
4. Diaz CM, Linden K, Solyali V. Novel and innovative approaches to teaching human anatomy classes in an online environment during a pandemic. Med Sci Educ. 2021;31:1703–13.
5. Hisham SHA, Hadie SNH, Kasim F, Shamsuddin SA. From crisis to opportunity: enhancing anatomy education in a post-COVID world: the universiti sains Malaysia experience. Korean J Med Educ. 2024;36:435–43.
6. Ortadeveci A, Ermez MN, Oz S, Ozden H. A survey study on distance anatomy education: challenges unique to anatomy. Surg Radiol Anat. 2022;44:41–7.
7. Singal A, Bansal A, Chaudhary P, Singh H, Patra A. Anatomy education of medical and dental students during COVID-19 pandemic: a reality check. Surg Radiol Anat. 2021;43:515–21.
8. Singh K, Gaur U, Hall K, Mascoll K, Cohall D, Majumder MA. Teaching anatomy and dissection in an era of social distancing and remote learning. Adv Hum Biol. 2020;10:90.
9. Babacan S, Dogru Yuvarlakbas S. Digitalization in education during the COVID-19 pandemic: emergency distance anatomy education. Surg Radiol Anat. 2022;44:55–60.

10. Özen KE, Erdoğan K, Malas MA. Evaluation of views and perceptions of the medical faculty students about distance anatomy education during the COVID-19 pandemic. Surg Radiol Anat. 2022;44:61–71.
11. 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. 2021;43:531–5.
12. Sugand K, Abrahams P, Khurana A. The anatomy of anatomy: A review for its modernization. Anat Sci Educ. 2010;3:83–93.
13. Boulos AN. Evaluation of the effectiveness of online education in anatomy for medical students during the COVID-19 pandemic. Ann Anat - Anat Anzeiger. 2022;244:151973.
14. Harmon DJ, Attardi SM, Barremkala M, Bentley DC, Brown KM, Dennis JF, et al. An analysis of anatomy education before and during Covid-19: May–August 2020. Anat Sci Educ. 2021;14:132–47.
15. Chang M, Yeh C, Lue J, Liao M. Medical students' preferences for asynchronous online or face-to-face learning strategies in learning gross anatomy and neuroanatomy during the covid -19 pandemic. Clin Anat. 2024;37:791–807.
16. Nebot-Cegarra J, Nebot-Bergua C, Gascón-Bayarri J, Macarulla-Sanz E, Ricart S. B-learning in human anatomy: comparative analysis of academic achievement between face-to-face and e-learning modalities. Ann Anat - Anat Anzeiger. 2025;257:152339.
17. Ferrer-Torregrosa J, Jiménez-Rodríguez MÁ, Torralba-Estelles J, Garzón-Farinós F, Pérez-Bermejo M, Fernández-Ehrling N. Distance learning ECTS and flipped classroom in the anatomy learning: Comparative study of the use of augmented reality, video and notes. BMC Med Educ. 2016;16:230. https://doi.org/10.1186/s12909-016-0757-3.
18. Venkatesh V, Morris MG, Davis GB, Davis FD. User acceptance of information technology: toward a unified view. MIS Q. 2003;27:425–78.
19. Kay RH, LeSage A. Examining the benefits and challenges of using audience response systems: A review of the literature. Computers Educ. 2009;53:819–27.
20. Alsoufi A, Alsuyihili A, Msherghi A, Elhadi A, Atiyah H, Ashini A, et al. Impact of the COVID-19 pandemic on medical education: Medical students' knowledge, attitudes, and practices regarding electronic learning. PLoS ONE. 2020;15(11):e0242905. https://doi.org/10.1371/journal.pone.0242905.
21. Felder RM, Brent R. Understanding student differences. J Eng Educ. 2005;94:57–72.
22. OECD. Education at a Glance 2021. OECD; 2021.
23. Hodges CB, Moore S, Lockee BB, Trust T, Bond MA. The difference between emergency remote teaching and online learning. Educause Rev. 2020. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning.
24. Ardies J, De Maeyer S, Gijbels D, van Keulen H. Students attitudes towards technology. Int J Technol Des Educ. 2015;25:43–65.
25. Co M, Cheung KYC, Cheung WS, Fok HM, Fong KH, Kwok OY, et al. Distance education for anatomy and surgical training – A systematic review. Surg. 2022;20:e195–205.
26. Mortagy M, Abdelhameed A, Sexton P, Olken M, Hegazy MT, Gawad MA, et al. Online medical education in Egypt during the COVID-19 pandemic: a nationwide assessment of medical students' usage and perceptions. BMC Med Educ. 2022;22:218.
27. Chapupu T, Gatsi AB, Chibhabha F, Zilundu PLM. Self-regulated learning of anatomy during the COVID-19 lockdown period in a low-income setting. BMC Med Educ. 2024;24:548. https://doi.org/10.1186/s12909-024-05329-x.
28. Attardi SM, Harmon DJ, Barremkala M, Bentley DC, Brown KM, Dennis JF, et al. An analysis of anatomy education before and during Covid-19: August–December 2020. Anat Sci Educ. 2022;15:5–26.
29. Mustafa AG, Taha NR, Alshboul OA, Alsalem M, Malki MI. Using YouTube to learn anatomy: perspectives of Jordanian medical students. Biomed Res Int. 2020;2020:1–8.
30. Chaker R, Gallot M, Madi A, Collet C, Hoyek N. Teaching human anatomy before during and after COVID-19 pandemic: A longitudinal study on kinesiology students' performance, cognitive load, and congruent embodied learning. Anat Sci Educ. 2025;18:48–58.
31. Papa V, Varotto E, Galli M, Vaccarezza M, Galassi FM. One year of anatomy teaching and learning in the outbreak: has the Covid-19 pandemic marked the end of a century-old practice? A systematic review. Anat Sci Educ. 2022;15:261–80.

Publisher's Note