ORIGINAL RESEARCH

Medical students' experience towards learning anatomy and relations to the anatomy learning environment during the Pre-clinical phase of the MBBS program in Sri Lanka - Preliminary Study (Phase I)

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Abstract

Objectives: To explore the anatomy learning experiences of medical students in Sri Lanka by assessing their learning approaches, the impact of the anatomy learning environment, the role of cadaveric dissection and modern technological tools, the challenges they face in learning anatomy, and the perceived relevance of anatomical knowledge to clinical practice.

Methods: A descriptive cross-sectional study was conducted among KDU medical students and recent graduates using the Anatomy Learning Experience (ALE) tool, a validated 39-item questionnaire. Convenience sampling was applied, and responses were collected via Google Forms. Data were analyzed using SPSS v27. Ethical clearance was obtained from KDU, and confidentiality was maintained.

Results: Most students preferred clinician-led teaching and online tools. Deep learning was dominant (87%), with minimal surface approach use. Cadaveric learning was valued, but clinical application confidence was moderate. Academic year, cadaver experience, and resource use significantly predicted clinical application perceptions. Significant differences emerged across ALE clusters by learning approach, academic year, and anatomy performance, highlighting the importance of active, contextual learning.

Conclusion: Interactive teaching, deep learning, and clinical integration enhance anatomy education. This validated framework informs national reforms, aiming to standardize and improve anatomical competency across Sri Lankan medical faculties.

Keywords: anatomy education, medical students, learning approaches, cadaveric dissection, clinical integration, learning environment, medical curriculum

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Introduction

Anatomy education had played a fundamental role in the preclinical phase of medical training, laying the groundwork for understanding human structure and function. At the Faculty of Medicine, General Sir John Kotelawala Defense University (KDU), Sri Lanka, the anatomy curriculum had included a combination of traditional methods such as cadaveric dissection and modern innovations such as 3D models and virtual tools. The anatomy learning environment and students' perceptions of it had been recognized as significant factors influencing both educational outcomes and future clinical competence (1).

Students had been observed to adopt different approaches to learning anatomy: a deep approach, which focused on understanding and integrating concepts; a strategic approach, which emphasized effective study techniques aimed at achieving high grades; and a surface approach, characterized by rote memorization with minimal understanding. These approaches had been shaped by the educational context, teaching quality, emotional responses, and the availability of learning resources (2).

Cadaveric dissection had remained a core part of anatomy education, valued for its ability to provide hands-on experience and spatial understanding of anatomical structures. However, it has also presented emotional and psychological challenges for some students, which may have influenced their learning engagement (3,4). In addition, modern technologies such as virtual dissection tools and 3D visualizations have been increasingly used to supplement traditional methods, enhancing comprehension and retention of complex content (1,5).

The curriculum in Sri Lankan medical schools had been designed to provide a balanced exposure to theory and practice, integrating lectures, tutorials, dissection, and assessments. Regular revision and competency checks had supported knowledge retention, ensuring readiness for clinical application (5).

The quality of the anatomy learning environment defined by teaching methods, emotional safety, availability of cadavers, and access to educational tools had a direct impact on students' motivation and learning strategies. Supportive environments had encouraged deep and strategic learning, while poorly equipped or overwhelming settings had contributed to surface-level approaches (3,2). Moreover, retention of anatomical knowledge had remained essential for clinical confidence and long-term medical competence (6).

This preliminary study had been conducted at KDU with the objective of evaluating how students' experiences and perceptions of learning anatomy are related to the anatomy learning environment during their preclinical education. The Anatomy Learning Experience (ALE) tool, developed by C.F. Smith (2017) (6), has been utilized to measure various domains, including students' study approaches, learning experiences, and perceived challenges. The insights gained from this study were intended to inform curriculum development and improve clinical preparedness among Sri Lankan medical students.

Methods

A descriptive cross-sectional study was conducted among current medical students and recent graduates from the Faculty of Medicine, KDU, as part of a preliminary investigation for the future study involving all the medical faculties in Sri Lanka. Data were collected using the ALE tool, a validated, self-administered questionnaire developed by C.F. Smith (2017) (6) to assess perceptions of the anatomy learning environment. The questionnaire consisted of 39 items rated on a 5-point Likert scale (1 - Strongly disagree to 5 - Strongly agree) and was structured into six clusters covering learning methods, cadaveric exposure, learning difficulties, clinical application of anatomy, overall perceptions, and year-specific issues. The composite sum thus ranged from 39 (all items = 1) to 195 (all items = 5), the composite mean ranged from 1.00 to 5.00. Additionally, socio-demographic data were also gathered. The ALE questionnaire was distributed via Google Forms, with participants providing electronic informed consent before participation. Responses were automatically collected and exported from Google Forms into Microsoft Excel for preliminary organization, then analyzed using IBM SPSS version 25.

Participants included medical students currently enrolled in an MBBS program (Bachelor or Medicine, Bachelor of Surgery) and graduates within five years of completing their degree, selected through convenience sampling. Students who had not completed their anatomy module or had withdrawn from the program were excluded. The required sample size was calculated to be 113, based on a population of 600 undergraduate medical students, using Cochran's formula with a 95% confidence level and 5% margin of error.

Ethical clearance for the study was obtained from the Ethics Review Committee of the Faculty of Medicine, General Sir John Kotelawala Defense University. Participation was voluntary, and confidentiality and anonymity of the data were strictly maintained throughout the research process.

Results

Participant Demographics

A total of 159 KDU MBBS students completed the survey, yielding a response rate of 97%. The sample included 112 females (70.4%) and 47 males (29.6%). Most respondents were from Year 1 (43.4%) and Year 2 (40.3%), while smaller proportions represented Years 3–5. The majority of students were day scholars (90.6%), with only a few being cadets (6.3%), international/local foreign students (Sri Lankan students with dual citizenship) (3.1%) (Table 1).

Descriptive Statistics of Anatomy Learning Experience (ALE Clusters)

The descriptive statistics for each of the six ALE clusters are summarized in Table 2, and the item-level means and standard deviations for all 39 questions are presented in detail in Table 3.

Table 1. Sociodemographic and Academic Characteristics.

Sociodemographic	n (%)
Gender	
• Male	47 (28.7)
• Female	112 (68.3)
Current year at the program	
• Year 1	69 (42.1)
• Year 2	64 (39)
• Year 3	6 (3.7)
• Year 4	14 (8.5)
• Year 5	6 (3.7)
Enrollment type	
• Cadet	10 (6.1)
• Day scholar	144 (87.8)
• Local	5 (3)
Anatomy/Pre-clinical result for 2nd MBBS	
• Distinction	-
• 2nd Class upper	2 (1.2)
• 2nd Class lower	4 (2.4)
• Pass (1st attempt)	14 (8.5)
• Pass (2nd attempt)	2 (1.2)
• Pass (3rd attempt)	3 (1.8)
• Not applicable (current preclinical students)	132 (80.5)

Table 2. Means and Standard Deviations of ALE Clusters.

Cluster	No in ALE tools	Mean (SD)
Cluster 1: Learning Resources	1-7	4.30(0.80)
Cluster 2: Cadaver-Based Learning	8-12	3.94(0.99)
Cluster 3: Learning Challenges	13-20	2.60(1.13)
Cluster 4: Use of Anatomy in Clinical Contexts	21-27	3.73(0.87)
Cluster 5: Perceptions of Anatomy's Importance	28-32	4.57(0.75)
Cluster 6: Transitional Year Perspectives	33-39	2.40(0.70)

<u>*Cluster 1: Learning Resources*</u>

Students rated clinician-based teaching (M = 4.30, (SD = 0.8) and online materials (M = 4.19, (SD = 0.75) as the most effective learning tools. Prosected specimens (M = 4.17, SD = 0.91) and mock exams (M = 4.06, (SD = 0.95) also received high ratings. Traditional lecture materials were less preferred (M = 3.05, (SD = 1.15), suggesting a student preference for interactive and applied learning strategies. (Table 3)

<u>*Cluster 2: Cadaver-Based Learning*</u>

Students reported a positive cadaveric experience. Working with cadaveric specimens (Mean = 3.94, (SD = 0.99) and within dissection groups (M = 3.68, (SD = 1.06) was seen as beneficial. The use of cadavers helped students understand death (M = 3.61, (SD = 1.07) and appreciate anatomical variation (M = 3.48, (SD = 0.91). The dissection environment was viewed as moderately daunting (M = 3.41, (SD = 1.14), but respect for cadavers was extremely high (M = 4.60, (SD = 0.84). (Table 3)

<u>*Cluster 3: Learning Challenges*</u>

Students highlighted anatomy as a memory-heavy subject (M = 2.60, (SD = 1.13) and challenges in retaining prior content (M = 2.39, SD = 1.11). Students were moderately affected by teaching styles (Mean = 3.08, (SD = 1.18) and the volume of content (M = 3.82, (SD = 1.01). There was a clear exam-oriented approach: "I learned mainly to pass exams" scored (M = 3.53, (SD = 1.00). (Table 3)

Table 3. Item-level Means and Standard Deviations (ALE Questionnaire Items)

Question number	Question	Mean	SD
Cluster 1	**Your learning Experience**		
1	I find/found reading textbooks an effective way of learning anatomy.	3.53	1.03
2	I find/found online material an effective way of learning anatomy.	4.19	0.748
3	I find/found material provided by the course an effective way of learning anatomy e.g., handbooks/lecture notes.	3.05	1.152
4	I find/found using imaging material, e.g., MRI an effective way of learning anatomy.	3.57	1.008
5	I find/found mock exams an effective way of learning anatomy.	4.06	0.946
6	I find/found Dissecting Room specimens an effective way of learning anatomy.	4.17	0.915
7	I find/found clinician-based teaching an effective way of learning anatomy.	4.30	0.796
Cluster 2	**Learning on cadavers**		
8	The most effective way I learn/t anatomy in the dissecting room is/was to get my hands in and feel for structures.	3.94	0.989
9	The most effective way I learn/t anatomy in the dissecting room is/was involving in group works.	3.68	1.063
10	I feel the dissecting room is a daunting environment to learn in.	3.41	1.137
11	I feel that I learned/am learning other things whilst in the dissecting room e.g. natural variation.	3.48	0.91
12	I feel that working with cadavers helped me to positively address the issue of death.	3.61	1.067
Cluster 3	**Learning problems**		
13	I find/found the amount of anatomy I need/ed to learn daunting.	3.82	1.012
14	I believe that the anatomy resources within the Faculty of Medicine are limited.	3.13	1.162
15	I have problems in learning anatomy because I don't see the point to it.	4.17	0.982
16	I have problems in learning anatomy because the teaching styles do not suit me.	3.08	1.18
17	I feel course assessments do not reflect the learning.	3.53	0.999
18	My main motivation for learning anatomy is to pass exams.	3.06	1.218
19	I find anatomy learning difficult because it is based on recall memory.	2.60	1.125
20	I struggle to build on my anatomy knowledge as I often forget what I learnt last semester/year/s	2.39	1.113
Cluster 4	**Using Anatomy**		
21	I believe the medicine course allows me to quickly use anatomy knowledge acquired by me.	3.49	0.906
22	I have problems using my anatomy knowledge because I am not confident in my knowledge base.	2.86	1.072
23	I find that my anatomy learning can benefit the other subject learning.	3.88	0.944
24	I believe cadaveric specimens should be handled with the utmost ethical care and respect.	4.60	0.842
25	I find I am using anatomical terms and language at most opportunities at the clinical settings.	3.73	0.869
26	I find I use my anatomy radiology knowledge frequently in clinical settings.	3.38	0.906
27	I find I use my surface anatomy knowledge frequently in clinical settings.	3.54	0.973
Cluster 5	**Overall Perceptions of Anatomy**		
28	I feel that I will become part of the medical profession once I can fully communicate in medical (anatomical) language.	3.84	0.993
29	I feel that understanding anatomy is a very important part of becoming a doctor.	4.57	0.750
30	I feel that working with cadaveric material is an important part of becoming a doctor.	4.26	0.944
31	My opinions on anatomy's relevance have increased as the course has progressed.	4.11	0.846
32	Because of the specialty I am interested in, I feel anatomy is not of importance to me.	4.06	1.027
Cluster 6	**Specific to Final Year**		
33	I am concerned that my knowledge of anatomy is not good enough to practice safely.	2.40	0.699
34	In hindsight, I would have preferred the anatomy teaching to be more spread out over the 5 years.	3.90	0.876
35	My chosen career path will mean I will need to learn more anatomy at postgraduate level.	3.90	0.994
36	In hindsight, I see very clearly the importance of anatomy, which I did not see in the first couple of years.	3.90	1.101
Cluster 6	**Specific to Years 1 and 2**		
37	I feel that there is so much to learn, and the only way to work is by trying to remember it all.	3.53	1.074
38	I feel confident about how I am supposed to be learning anatomy.	2.83	0.997
39	I am enjoying learning anatomy.	3.27	1.007

Cluster 4: Use of Anatomy in Clinical Contexts

Students acknowledged the clinical relevance of anatomy. They recognized the value of using anatomical terms in patient care (M = 3.73, (SD = 0.87), understanding radiological images (M = 3.38, (SD = 0.91), and applying surface anatomy (M = 3.54, (SD = 0.97). However, confidence in their knowledge base was moderate (M = 2.86, (SD = 1.07), reflecting a gap between theoretical learning and clinical readiness. (Table 3)

Cluster 5: Perceptions of Anatomy's Importance

There was a strong consensus on the importance of anatomy in medical practice (M = 4.57, (SD = 0.75). Cadaveric dissection was viewed as essential to professional development (M = 4.26, (SD = 0.94). Students generally felt that their understanding of anatomy improved over time (M = 4.11, (SD = 0.85). (Table 3)

Cluster 6: Transitional Year Perspectives

Final-year students (Year 5) indicated a lack of preparedness for clinical practice due to limited anatomy exposure (M = 2.40, (SD = 0.70), and strongly supported anatomy being taught throughout the curriculum (M = 3.90, (SD = 0.87). Early-year students described anatomy as overwhelming (M = 3.53, (SD = 1.07), but still enjoyable (M = 3.27, (SD = 1.01). (Table 3)

Inferential Analysis

The independent samples t-test showed no statistically significant differences between male and female students across the ALE clusters ($p > 0.05$), suggesting that gender was not a defining factor in their perceptions of the anatomy learning environment.

Differences by Academic Year

A one-way ANOVA tested the effect of academic year on all cluster scores. Cluster 4 showed a statistically significant difference. $F(4,154) = 5.716$, ($p < 0.001$). Post Hoc Games-Howell tests indicated that Year 5 students scored significantly higher than Year 1 ($p = 0.001$) and Year 2 students ($p = 0.040$). Confidence in applying anatomy clinically increases significantly with academic progression, supporting the need for vertical integration of anatomy in the curriculum. (Table 4)

Pre-clinical Performance

A one-way ANOVA test explored whether performance in preclinical anatomy (first/second/third attempt) affected perceptions. Significant difference found in Cluster 4 ($F(5,151) = 3.504$, ($p = 0.005$). Post Hoc analysis showed that students who passed on the first attempt scored significantly higher in Cluster 4 than those who passed on the second ($p = 0.042$) or third attempt ($p = 0.027$). Better preclinical performance correlates with greater clinical confidence in using anatomical knowledge. (Table 4)

Batch Differences

Batch-wise analysis also revealed a significant difference in Cluster 5. $F(4,154) = 1.882$, ($p =0.042$). Batch 42 scored significantly higher than Batch 39 ($p = 0.005$). This could reflect curriculum evolution, improved teaching resources, or faculty changes over time. (Table 4)

Predictors of key anatomy learning outcomes - Multiple Linear Regression Analysis

Model 1: Predicting Clinical Application (Cluster 4)

The dependent variable was Cluster 4. The model was statistically significant, $F(5, 153) = 5.259$, ($p < 0.001$ with an Adjusted R^2 of = 0.118), indicating that approximately 11.8% of the variance in clinical application was explained by the predictors. Three variables significantly contributed to the model: use of learning resources (Cluster 1; : $\beta = 0.226$, ($p = 0.005$), cadaver-based learning experiences (Cluster 2; : $\beta = 0.227$, ($p = 0.015$), and academic year ($\beta = 0.221$, ($p = 0.004$). Students who actively utilize learning resources, gain hands-on cadaveric experience, and are at later stages of their medical program demonstrate greater confidence in applying anatomical knowledge in clinical settings.

Model 2: Predicting Perception of Importance (Cluster 5)

The dependent variable was Cluster 5 ($F(5,153) = 4.075$, ($p = 0.002$, Adjusted $R^2 = 0.089$). Significant Predictor was Cluster 2 (Cadaver-Based Learning): $\beta = 0.312$, ($p < 0.001$. A strong cadaveric experience is the most influential factor predicting students' recognition of anatomy's importance.

Model 3: Predicting Final Year Experiences (Cluster 6)

The dependent variable was Cluster 6, $F(5,153) = 1.711$, ($p = 0.137$), indicating no statistical significance. Final-year transitional experiences (e.g., feeling unprepared) are likely contextual or emotional, and not fully explained by the predictors in this model.

Sociodemographic - Regression Analysis

The academic year was a consistent positive predictor across both Cluster 4: ($\beta = 0.221$, ($p = 0.004$) as well as Cluster 5: ($\beta = 0.204$, ($p = 0.014$). Senior students are more confident in using anatomy clinically and value its role in medicine more highly. (Table 5)

Effect of Learning Approach on ALE Clusters

Using computed mean scores across various questionnaire items, the questions were clustered into 3 learning approaches: Deep, Strategic and Surface. This categorization is based on validated methodology in educational psychology and aligns with the original Approaches and Study Skills Inventory for Students (ASSIST) structure (7). Deep learning approach was identified when students had the highest mean in Deep strategy-related items (e.g., engagement, conceptual understanding). The Strategic learning approach is indicated when performance and goal-oriented items scored highest. Surface learning approach was noted when rote memorization and minimal effort responses predominated (8). The application of this framework in the context of anatomy education is well-established (6). A frequency analysis was conducted to determine how many students fell into each category (values not shown here but should be included if available for clarity).

Table 4. Summary of Significant ANOVA Results for ALE Questionnaire Clusters vs Sociodemographic Groups.

Dependent Variable (Cluster)	Independent Variable	*F*-value	*p*-value
Cluster 4: Use of Anatomy	Academic Year	5.716	< 0.001
Cluster 4: Use of Anatomy	Preclinical Performance	3.504	0.005
Cluster 5: Perceptions of Importance	Batch	1.882	0.042

Table 5. Significant Predictors from Regression Models for ALE Clusters.

Dependent Variable	Significant Predictor	Beta Coefficient (β)	*p*-value
Cluster 4	Cluster 1: Learning Resources	0.226	0.005
Cluster 4	Cluster 2: Cadaver-Based Learning	0.227	0.015
Cluster 4	Academic Year	0.221	0.004
Cluster 5	Cluster 2: Cadaver-Based Learning	0.312	< 0.001
Cluster 5	Academic Year	0.204	0.014

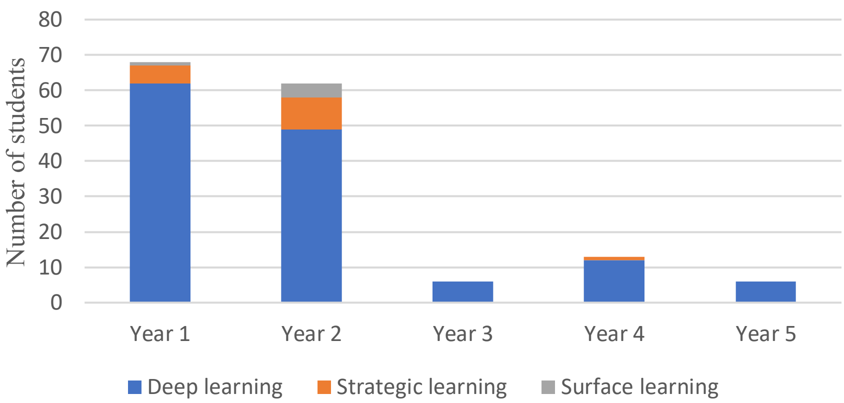

Figure 1. Learning Approaches by the Current Year in the MBBS Program

Table 6. ANOVA Results for Learning Approaches by Sociodemographic

Learning Approach	Factor	*F*	*p*-value
Surface	Anatomy Result	3.165	0.010
Surface	Gender, Year, Enrollment	NS	> 0.05
Strategic	Anatomy Result	3.156	0.010
Strategic	Gender, Year, Enrollment	NS	> 0.05
Deep	Anatomy Result	3.124	0.011
Deep	Gender, Year, Enrollment	NS	> 0.05

The Deep learning approach was by far the most dominant, with 135 students (87.1%) identifying with this style. (Figure 1). This suggests a very high prevalence of students who engage meaningfully with anatomical concepts, aiming for true understanding over rote memorization. Only 15 students (9.7%) followed a Strategic approach, indicating a much smaller group of goal-oriented learners focused on exam performance and organization. The Surface approach was the least common, with 5 students (3.2%), showing minimal reliance on rote learning or low-engagement strategies.

Effect of Learning Approach on ALE Clusters

A series of one-way ANOVA tests were performed to evaluate whether students with different learning approaches (Deep, Strategic, Surface) differed significantly in their experiences across the ALE clusters. Significant differences were observed in the following clusters (Table 6):

Cluster 1: Learning Resources

Post Hoc Games-Howell test showed that students with a Strategic learning approach reported significantly higher use of learning resources compared to those with a Surface approach (F-value = 5.487), (p = 0.005). Strategic learners are more proactive and utilize a wider range of learning tools (e.g., mock exams, clinical materials, online platforms) to achieve academic goals.

Cluster 2: Cadaver-Based Learning

Deep and Strategic learners showed more positive attitudes toward cadaver-based learning than Surface learners (F-value = 3.265, (p = 0.041). It indicated that deep learners value hands-on, conceptual learning, while Strategic learners recognize cadaveric work as a means to achieve professional competence. Surface learners may feel more discomfort or less engagement in the dissection lab.

Cluster 3: Learning Challenges

Surface learners scored significantly higher, indicating they perceive more difficulty, low retention, and exam-oriented stress (F-value = 3.787), (p = 0.025). It displayed that surface learners tend to struggle with high-volume memorization-based subjects like anatomy. This confirms prior findings that surface approaches are associated with less effective learning outcomes.

Cluster 4: Using Anatomy in Clinical Contexts

Deep and Strategic learners reported higher confidence in applying anatomy clinically than Surface learners. (F-value = 5.706, (p = 0.004). The Deep learners were shown to be internalizing and connecting anatomical knowledge, while Strategic learners applying it to perform well in practical settings. In contrast, Surface learners showed reduced confidence in applying knowledge beyond rote recall.

Cluster 5: Perception of Anatomy's Importance

Strategic learners showed more appreciation of anatomy's role in medicine than surface learners. (F-value = 3.091, (p = 0.048). Their academic goals aligned with recognizing anatomy's value for clinical excellence and assessments, prompting greater investment in understanding its relevance.

Cluster 6a and 6b: Transitional Experiences

Students with a Deep or Strategic approach reported fewer negative transitional experiences and higher adaptability when progressing from preclinical to clinical phases. Surface learners felt more overwhelmed and less prepared. It displayed that adaptive learning strategies equip students to cope better with curriculum changes, reinforcing the importance of fostering reflective, goal-oriented approaches early in medical education.

Discussion

This study provides a multi-dimensional analysis of Anatomy Learning Experiences (ALE) among MBBS students, revealing critical insights into pedagogical effectiveness, curricular design, and the psychological dimensions of anatomical education. Our findings both corroborate and extend existing literature while highlighting actionable areas for reform.

Pedagogical preferences and the shift toward active learning

The strong preference for clinician-led teaching, online resources, prosected specimens, and mock exams over traditional lectures underscores a paradigm shift in medical education. Students clearly favor applied, interactive methods that bridge theory and clinical practice. This aligns with global trends emphasizing active learning for complex, visually oriented subjects like anatomy (3,5). Traditional lectures received the lowest ratings (M = 3.05), suggesting passive delivery fails to address anatomy's spatial and functional complexities. These results reinforce calls for blended learning models integrating digital tools (e.g., virtual dissection platforms), early clinical exposure, and simulation-based assessments (9).

Cadaveric learning: ethical reverence and emotional challenges

Despite the dissection environment being perceived as daunting (M = 3.41), students demonstrated profound respect for donors (M = 4.60) and recognized the irreplaceable value of cadaveric work for understanding anatomical variation (M = 3.48) and professional development (M = 4.26). This support mirrors Smith's (2009) (2) findings that dissection cultivates empathy and professionalism. However, persistent moderate stress levels indicate a need for structured psychological support, such as mandatory reflection sessions or ethics modules, to mitigate emotional burdens (1).

The confidence gap in clinical application

While students acknowledged anatomy's clinical relevance (Cluster 4), their confidence in applying knowledge was notably low (M =

2.86), particularly among junior cohorts. Regression analysis revealed that clinical confidence grew significantly with academic progression ($\beta = 0.221$, ($p = 0.004$) and hands-on cadaveric experience ($\beta = 0.227$, ($p = 0.015$). Paradoxically, Year 5 students, though most confident in applying anatomy, reported feeling underprepared for clinical practice (M = 2.40). This suggests theoretical knowledge alone is insufficient; curricula must integrate deliberate practice in clinical skills (e.g., radiological interpretation, procedural anatomy) earlier and more frequently (5).

Deep learning dominance and its advantages

The overwhelming adoption of a deep learning approach (87.1%) is a standout finding. These students prioritized conceptual understanding over rote memorization, correlating with superior outcomes such as higher engagement with resources, greater cadaver lab confidence, and better clinical adaptability. This contrasts with studies reporting higher surface/strategic approaches in anatomy-heavy curricula (6), possibly reflecting institutional emphasis on critical thinking. Deep learners' resilience during the preclinical-to-clinical transition underscores the value of fostering intrinsic motivation through problem-based learning (PBL) and concept mapping. Conversely, surface learners (3.2%) reported significant struggles with retention, stress, and clinical readiness, highlighting a need for targeted academic interventions.

Curricular implications: vertical integration and spiral learning

Year 5 students' strong endorsement of continuous anatomy training (M = 3.90) and ANOVA results showing year-wise progression in clinical confidence ($p < 0.001$), validate the need for vertical integration through a 'spiral curriculum' where anatomy is revisited during clinical rotations, which could bridge the preparedness gap (1). Batch-wise differences in perceived importance (Cluster 5) further suggests that curriculum evolution (e.g., integrating cross-sectional anatomy or surgery modules) enhances students' appreciation of anatomy's relevance.

Sociodemographic and performance insights

The absence of gender differences across ALE clusters challenges assumptions about gender-based learning disparities in STEM. Additionally, students who passed anatomy on their first attempt exhibited higher clinical confidence, implying that early academic success reinforces self-efficacy. This underscores the importance of foundational support to prevent knowledge gaps from compounding.

Study Limitations and Future Expansion

As a preliminary study conducted exclusively at KDU, our findings offer a foundational but institution-specific perspective. The homogeneity of our cohort, predominantly early-year (83.7% Year 1–2) and day-scholar students (90.6%), limits generalizability across diverse medical education contexts in Sri Lanka. Nevertheless, this deliberately focused scope allowed us to rigorously validate our ALE framework and methodology. Critically, this work launches preliminary study of a larger national initiative, with the second part of the study planned to extend this investigation to all medical faculties in Sri

Lanka. A major limitation of this study is the small and unequal group size when comparing learning approaches. In particular, the 'surface learner' group comprised only of five participants (3.2% of the sample). The use of one-way ANOVA under these conditions may compromise the assumptions of normality and homogeneity of variance. Future studies with larger, more balanced samples are necessary to confirm these associations. Alternatively, non-parametric approaches such as the Kruskal–Wallis test could be considered, as they are less sensitive to small and unequal group sizes.

This further study will:

1. Compare curricular models (e.g., traditional vs. integrated systems) and resource disparities (e.g., cadaver access, digital infrastructure),
2. Identify systemic barriers to anatomy proficiency unique to the Sri Lankan context,
3. Develop evidence-based national guidelines for anatomy education reform.

By scaling this research nationally, we can discern whether the dominance of deep learning at KDU reflects exceptional pedagogy or broader cultural learning traits, and determine how socioeconomic factors (e.g., rural vs. urban campuses) impact anatomical competence.

Societal Impact and Future Directions

The planned nationwide study directly addresses Sri Lanka's need for equitable medical education. By benchmarking anatomy education across all faculties, we can advocate for resource standardization (e.g., shared digital repositories, cadaver ethics protocols) and policy reforms to ensure every future physician meets clinical anatomy competency standards, irrespective of the institution.

Conclusion

This KDU-based study establishes that interactive pedagogy, deep learning, and clinical integration are pivotal to anatomy mastery. While preliminary, its design provides a validated framework for the imminent national study. By scaling this investigation across Sri Lanka, we can catalyze data-driven, equitable reforms to transform anatomy education into a unifying foundation for the country's next generation of clinicians.

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