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RESEARCH

# Enhancing Short-Term Recall of Anatomical Terminology Through Instructor-Led Cumulative Repetition: A Quasi-Experimental Study Among Medical Students

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## Abstract

**Background** Medical students are often faced to with the challenge of memorizing the large volume of anatomical terms, leading to reliance on monotonous memorization. Thus, this study aims to examine the comparative association between instructor-led cumulative repetition (ILCR) and traditional instruction with respect to short-term recall.

**Methods** A quasi-experimental within-subject design was chosen employed to control for inter-individual differences. 140 s-year medical students participated in course module where female genital system, external structures were taught using the ILCR method, while internal structures were taught with the traditional single-exposure method serving as an internal control. Retention was evaluated through immediate schematic labeling trials for short-term and later through a laboratory practical examination with 286 students, allowing comparison of performance between participating and non-participating students.

**Results** There was an instructional method difference in recall rates that was statistically significant within the same cohort. In the immediate recall trial, the correct response rate for structures taught with ILCR was 69.23%, compared to only 17.64% for the traditional method ($P < 0.001$). Moreover, students who participated in the ILCR trials achieved a median score of 90/100 in the final laboratory examination, whereas non-participants score was significantly lower (50/100) ($P < 0.001$).

**Conclusion** Instructor-led cumulative repetition appears to provide a meaningful pedagogical advantage over classical didactic teaching methods in supporting the retention of anatomical terminology. The marked difference observed between the experimental and internal control conditions suggests that integrating this approach into standard lectures may represent an effective and time-efficient strategy for enhancing learning outcomes in medical education.

**Keywords** Anatomy education · Cumulative repetition · Short-term recall · Within-subject design · Medical students

## 1 Introduction

Anatomy is the foundation of all the fields of education related to the human body, especially the medical field. Medical students need to learn the location, structure, relationships, and functions of organs in the body. This information provides a fundamental understanding that is essential for clinical applications such as medical diagnosis, treatment planning, and surgical interventions. Also, to ensure linguistic consistency in the medical field, students need to learn the Latin terms for all anatomical structures and simultaneously grasp their intricate grammatical and orthographic rules (including declensions, genders, and cases) [1–3]. However, the Terminologia Anatomica second edition (TA2), accepted by the International Federation of Anatomical Associations (IFAA), contains 7,113 terms [4] and the Terminologia Neuroanatomica (TNA) contains 4,399 terms [5], resulting in a complex learning process. Moreover, as Latin is no longer a spoken language, opportunities to practice are limited, complicating the development of language skills.

The combination of a new subject and new language can be stressful for students when learning extensive vocabulary related to anatomical structures within a limited time, thus making anatomy education a difficult, unmemorable,

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and tedious process [6, 7]. Additionally, this approach leads to rote memorization of seemingly unrelated lists of terms [8]. Therefore, it is necessary to teach anatomical logic by explaining the origins (etymology) and meanings (semantics) of the terms during lessons rather than focusing on rote memorization. Otherwise, presenting too much information in a short period makes the lesson boring, causes distraction, and reduces student participation [9]. On the other hand, students are asked to review the lessons to achieve successful examination results as repetitive learning improves memory performance and allows for longer retention [10, 11]. Nevertheless, when students repeat words that they do not comprehend during a lesson, this can result in a challenging memorization process. Consequently, studying unknown materials may result in failure to pass the examination. Conversely, in a practical laboratory examination of the names of anatomical structures learned in a short time, students are expected to correctly write the Latin version. This, in turn, becomes a source of stress for students rather than a means of acquiring knowledge [12, 13].

Enhancing memory and recall skills through instruction is essential for improving student achievement in education. Cumulative repetition and short-term recall are important strategies for knowledge retention and for overcoming learning obstacles. Various tasks within the central nervous system are responsible for retention and recall processes [14, 15]; however, to retain the new information, it must be repeated cumulatively. This process allows the hippocampus to be involved, reinforcing this information [16, 17]. It is recommended that the most basic and prominent anatomical structures be taught initially, followed by the other structures in a cumulative manner. Furthermore, the regular use of expressions, such as "*what-where-when*", during courses facilitates the formation of a circuit between the hippocampus and the prefrontal cortex, thereby enhancing the retention of information [16–19]. Otherwise, information that is not repeated over time will inevitably be forgotten [20, 21]. Regardless of the type of repetition, applying or building upon previously acquired knowledge, repetition is highly beneficial for students [22, 23]. In light of the aforementioned considerations, it becomes evident that a more efficacious approach would be to conduct these repetitions in with instructor-led cumulative repetition (ILCR) within the confines of the classroom rather than requiring students to engage in individual study repetitions.

While spaced repetition is widely advocated for self-study, the specific impact of ILCR within the active classroom environment remains underexplored The current study aimed to introduce a quasi-experimental within-subject design to assess the impact of ILCR during class on short-term recall, with reinforcing previously learned terminology before introducing new terms to prepare medical students for the clinical phase. Thereby providing a pedagogically grounded and neurocognitively supported model for enhancing anatomy education outcomes could converting short-term recall into stable encoded memory traces.

## 2 Methods

### 2.1 Study Design

This study was conducted with second year medical student at the Kocaeli University Faculty of Medicine. Ethical approval was obtained from the Kocaeli University Non-invasive Ethics Committee (GOKAEK-2021/23.06) From a methodological perspective, the quasi-experimental within-subject design adopted in this study was chosen related to common ethical and curricular constraints inherent in medical education research. This design allowed each participant to serve as their own control, thereby minimizing confounding variables such as inter-individual differences in baseline academic ability or motivation. Recent medical education literature focusing on quasi-experimental study designs has highlighted the need to balance methodological rigor with field-based realism when assessing specific learning outcomes in authentic teaching settings [24]. Hence, the present study design exemplifies a pragmatic balance between experimental control and educational feasibility, allowing meaningful interpretation of short-term recall outcomes while preserving the integrity of the curriculum. As a total of 4 h of theoretical course time was insufficient to form both control and study group and this was also performed to ensure equal education opportunities for all participating students. In this context, the main objective of this study was to evaluate and analyze how medical students self-assess their competence with ILCR in remembering anatomical terminology and successfully reproducing it without errors in written laboratory examinations.

#### 2.1.1 Educational System

The medical faculty at our university adhere to a committee-based educational system. The curriculum comprises 3 years of preclinical studies, 2 years of clinical training, and 1 year of internship. Anatomy education is included in the final two committees of the first year and continues through the first four committees of the second year. Course content is distributed in accordance with the National Core Curriculum, and the learning objectives are determined accordingly. The Urogenital and Endocrine System Committee comprises 17 h of theoretical and 12 h of practical anatomy classes, with the Anatomy of the Female Genital System covered in 4 h of theoretical and 2 h of practical classes. All anatomic structures are described using Latin terminology. Upon completion of the committee, both board and practical

examinations are administered. The real challenge for students in the anatomy laboratory examination, is to write correctly the Latin terminology of the anatomical structure being pinned within a specified time using a buzzer system.

### 2.1.2 Participants

A poster including the study date and hour was hung in the classroom a few weeks before the lecture. Volunteer students who wanted to participate in the study were asked to be present in the lecture hall during class time. All trials were also performed with students who repeated the class, but their data were not included in the study. Also, anonymity enabled the students to feel comfortable in participating. No additional data were collected beyond sex, age, class repetition, or trial number. Furthermore, students were informed that these were just an essay, and their GPA would not be affected (Table 1).

### 2.1.3 Course Module

A total of 140 s-year medical students (60% females, 40% males) who studied the Anatomy of the Female Genital System for the first time (with a total enrollment of 292) participated voluntarily in the course module (Trial 1 and Trial 2). In accordance with the learning objectives related to external and internal part of the female genital system, schematic drawings were distributed to the students during lecture. These drawings were printed on both sides of the same sheet and contained the vulva (Schema 1 and Fig. 1) and internal organs (Schema 2 and Fig. 1). In Schema 1, 13 anatomical structures were indicated with arrows, while 17 are shown in Schema 2. Despite this difference, both schemas were designed in accordance with the predefined learning objectives. The same group of students was exposed to both schemas, and learning performance was calculated as the percentage of total correct responses rather than the absolute number of correctly identified structures. This approach was adopted to ensure comparability between schemas and to minimize the potential influence of unequal numbers of labeled structures.

### 2.1.4 Trial 1: (Immediate Recall- Experimental condition-ILCR)

The lesson began with the vulva; each vulvar structure was ILCR explained to the students and repeated five times. Starting with the peripheral structures, the first structure of the vulva was explained using two repetitions. The second structure of the vulva was then added with two repetitions. After explaining the second vulvar structure, additional repetitions were performed for the first structure. In this

**Table 2** Correct answer rates for Trial 3 in the laboratory module (%)

| | Only trial 3 participation (n = 74) Median (IQR) | All trial participation (n = 120) Median (IQR) | *P*-value | r |
|---|---|---|---|---|
| Schema 1 | 46.15 (38.46–53.85) | 92.31 (76.92–100) | **< 0.001*** | 0.82 |
| Schema 2 | 35.29 (29.41–47.06) | 82.35 (70.59–88.24) | **< 0.001*** | 0.80 |

Bold face *P*-values indicate statistically significant differences

IQR: interquartile range

r: Effect size

*Mann–Whitney U test

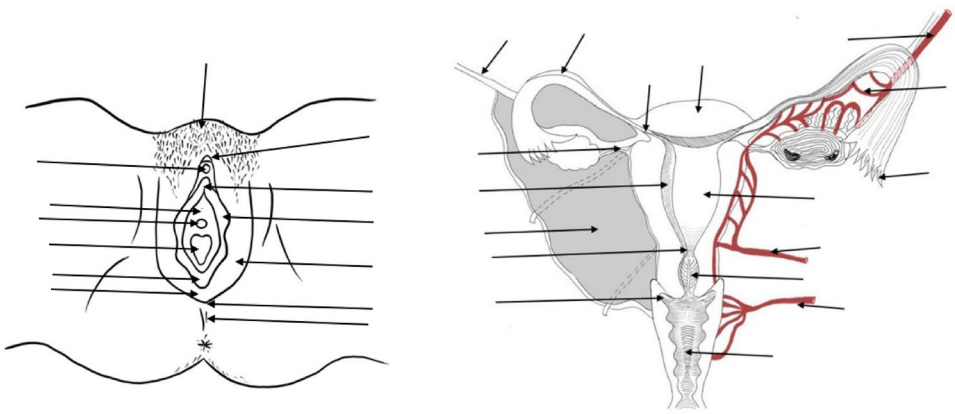


**Fig. 1** **a,b** Anatomical structures of the female genital system

a) Schema 1: External part (vulva)

b) Schema 2: Internal part

manner, each structure was repeatedly explained, and the previous structures were cumulatively explained until five repetitions were reached. During course, questions in the form of "what-where-when" were added to solicit interactive feedback from students, encouraging them to retain anatomical structures for a specific purpose.

#### 2.1.5 Trial 1: (Immediate Recal-Internal Control-Traditional Instruction)

Subsequently, the internal genital organs were explained in a single traditional instruction with same students. Schema 2 served as the internal control condition, offering a direct comparison against the experimental method within the same student cohort. At the end of these sessions, students were asked to fill the anatomical structures in Schema 1 and 2 during Trial 1. Furthermore, while filling in the figure, students were asked which structures that they had learned during class were not included in the figure. This design enabled direct comparison between the two instructional strategies under identical conditions, minimizing confounding variables such as instructor bias, environmental variation, or time-on-task differences. The purpose was to evaluate how many anatomical structures could the students remember through ILCR during the lesson.

#### 2.1.6 Trial 2: (Reinforcement)

At this stage, the internal genital organs of women were taught with ILCR five times, and the structures of the vulva were reviewed again. This time, the students were asked to fill in the same figures, located on the back page.

#### 2.1.7 Trial 3: (Laboratory module)

A total of 194 students (52.6% females and 47.4% males) participated in Trial 3, which was conducted in the laboratory few days later. To spread out the repetitions, the anatomical structures learned in class were revisited a few days later in laboratory session with models, again using "what-where-when" to reinforce learning and long-term memory. The students were asked to complete the Fig. 1 again. Students who did not participate in the first two trials were asked to check the "first participation" box on the form.

#### 2.1.8 Final Assessment: (Laboratory trial examination module)

10 days later, a total of 286 students participated in the laboratory trial examination module. A practical laboratory examination was administered using a "buzzer system" where students identified pinned structures within a limited time (10 min for 10 questions). The students were required to write the Latin names of the anatomical structures indicated by the pin. Using the bell alert system, students rotated stations and submitted their final work anonymously in a closed box.

#### 2.1.9 Data collection

The correct and incorrect answers of the papers completed by the students for Trials 1, 2, and 3 were recorded, and the percentages of the total correct answers were calculated. Missing anatomical structures and incorrect Latin terms were also recorded. At the laboratory trial examination 10 points were awarded for each correct answer.

### 2.2 Statistical analysis

All statistical analyses were performed using IBM SPSS for Windows version 20.0 (IBM Corp., Armonk, NY, USA). Kolmogorov–Smirnov's test was used to assess the normality assumption. Continuous variables are presented as median and interquartile range (IQR), as the normality assumption was not satisfied. Categorical variables are summarized as counts and percentages. Comparisons between groups were carried out using the Mann–Whitney U test. Dependent-group comparisons were carried out using Wilcoxon signed rank test. All hypothesis tests were two-sided. A p-value $< 0.05$ was considered statistically significant.

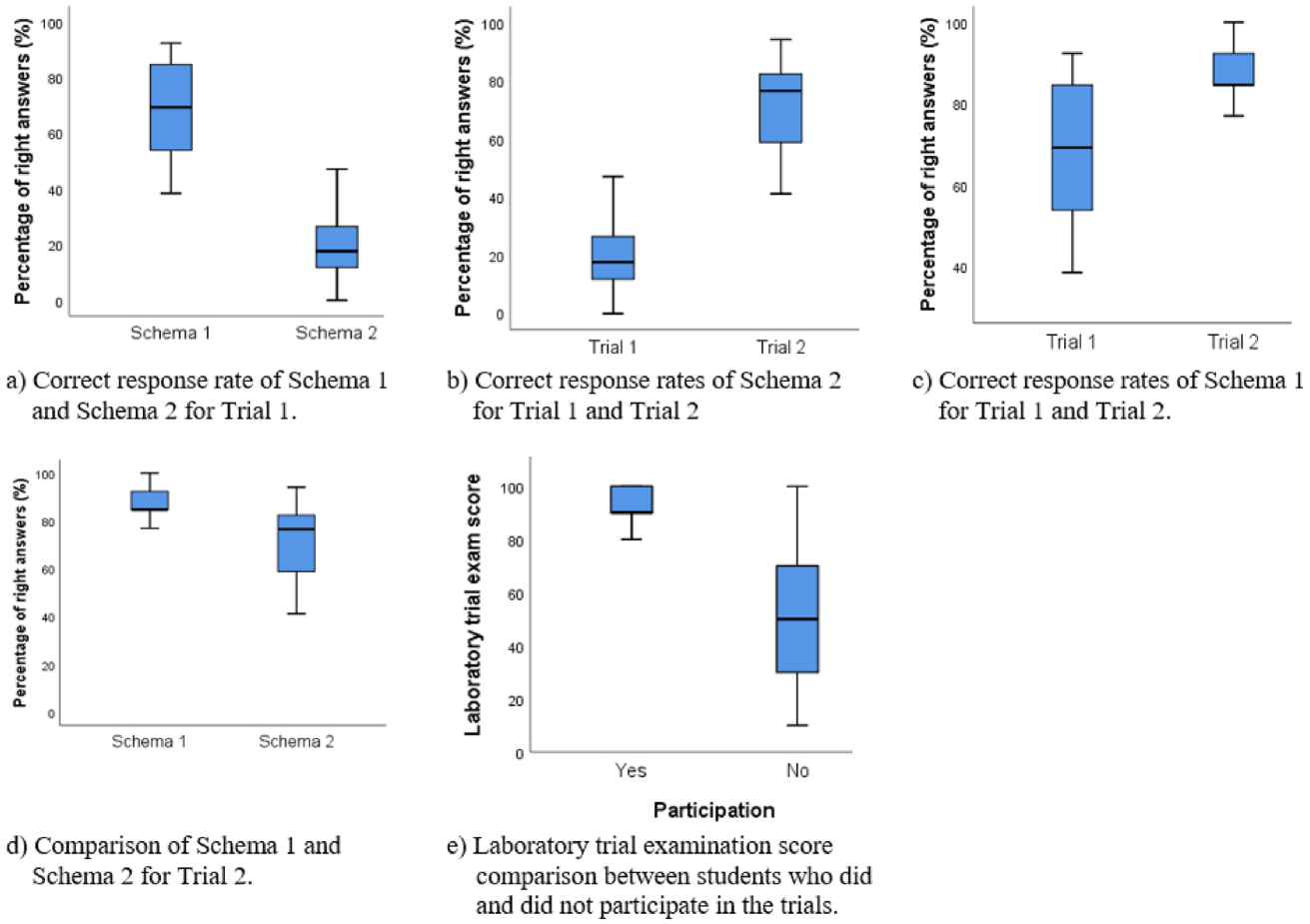
## 3 Results

In the course module, Trial 1 was completed by 140 volunteer students (60% females and 40% males) during class and the mean age of the students was 19.31 ($\pm 0.61$).

Primary Outcome: In the within-subject analysis of Trial 1, recall performance was higher for anatomical structures taught using ILCR (Schema 1) compared with those taught using the traditional single-session method (Schema 2-Internal Control). The median correct response rate was 69.23% (IQR: 53.84–84.61) for Schema 1 and 17.64% (IQR: 11.76–27.94) for Schema 2, indicating a strong association between instructional approach and immediate recall performance within the same student cohort ($P < 0.001$) (Fig. 1).

Secondary Outcome: Reinforcement and Retention (Trial 2).

When the structures initially taught using the traditional method were subsequently reintroduced using ILCR in Trial 2, a marked increase in recall performance was observed. The median correct response rate for Schema 2 increased from 17.64% in Trial 1 to 76.47% (IQR: 58.82–82.35) in Trial 2, demonstrating an association between ILCR and improved recall performance ($P < 0.001$, $r = 0.87$) (Fig. 2a, 2b).




a) Correct response rate of Schema 1 and Schema 2 for Trial 1.

b) Correct response rates of Schema 2 for Trial 1 and Trial 2

c) Correct response rates of Schema 1 for Trial 1 and Trial 2.

d) Comparison of Schema 1 and Schema 2 for Trial 2.

e) Laboratory trial examination score comparison between students who did and did not participate in the trials.

**Fig. 2** Box plots related to trials and laboratory examination scores

A total of 194 students (52.6% female; 47.4% male) with a mean age of 19.28 (±0.65) years participated in Trial 3 and 74 students filled in the figure for the first time (Table 2). The average number of correct answers for Schema 1 and 2 was lower for students who participated in the laboratory module for the first time than for those who had participated in the first two trials. In other words, the correct response rates of students who had previously participated in the course module were statistically significantly higher ($P < 0.005$) with a large effect size (r = 0.82; r = 0.80).

A total of 286 students participated in the laboratory trial examination module; 144 were female (50.3%) and 142 were male (49.7%). Students who had participated in the ILCR trials (n = 194) showed higher performance compared with those who had not participated (n = 74). The median examination score was 90 (IQR: 90–100) among participating students and 50 (IQR: 30–70; r = 0.78) among non-participating

**Table 3** Average score for 10 questions asked in the laboratory examination

| | Students who did not participate in any trials (n = 92) Median (IQR) | Students participating in the trials (n = 194) Median (IQR) | *P*-value | r |
|---|---|---|---|---|
| Laboratory examination score (Max. 100 point) | 50 (30–70) | 90 (90–100) | < 0.001* | 0.78 |

Bold face p-values indicate statistically significant differences

IQR: interquartile range

r: Effect size

*Mann–Whitney U test

students, suggesting an association between prior exposure to ILCR-based instruction and examination performance ($P < 0.001$) (Table 3).

### 3.1 Most Common Mistakes

The most common mistakes were to confuse two structures, including the ostium vaginae and vestibulum vaginae, the frenulum clitoridis and preputium clitoridis, and the plica palmatae and carina urethralis vaginae.

The most common orthographic errors were in the use of the term "externum" instead of "externa", and "labia" instead of "labium" or "laborium" in "labium majus vulvae" and "commissura anterior labiorum", respectively.

## 4 Discussion

The critical challenge in medical education lies in the transfer of foundational anatomical knowledge from the preclinical setting to competence in clinical practice [25–27]. Deficiencies in retention directly impair essential clinical skills, including diagnostic and therapeutic procedures, accurate physical examination, and radiographic interpretation [28]. Findings align with neurocognitive principles asserting that effective long-term retention necessitates revisiting information at optimal retrieval intervals [29]. Starting with a limited general overview and gradual elaboration, rather than simultaneously providing detailed and complex information at the same time, seems to be the most important feature of effective teaching [8, 30, 31]. Consequently, when students observe that they gain permanent knowledge from each repetition, their motivation increases, and they become more focused in class and eager to acquire new information (as demonstrated in Tables 1 and 2). As reported by Altalhab et al. [32], using simple schematic drawings to reinforce visual memory can help to retain the long-term memory of words that were only verbally repeated. Consequently, most students were encouraged to think that "I think what I am learning in this class will be useful for me to know", showing a similar positive response to that obtained in the study by Fives et al. [33]. Otherwise, repetitions not performed during class, especially for students who do not enjoy studying anatomy [34], may lead to distress and cause them to drift away from the course, ultimately leading to memorization [8]. Therefore, the present study employed a quasi-experimental within-subject design to rigorously evaluate the pedagogical efficacy of ILCR versus a traditional single-exposure method in retaining anatomical terminology and provided a robust evidence that integrating systematic, guided repetition within the lecture environment dramatically improves short-term retention.

One of the main challenges is the Latin-derived medical terms, which present students with the difficulty of learning a new language. Similar to learning a new language, to enhance the retention of anatomical terms, both oral and written repetitions were used during class, emphasizing the etymological and semantic aspects of the words, which have been observed to be effective in memory recall [20, 32, 35]. Even of Schema 1 and Schema 2 were not fully equivalent, as they differed in anatomical region, number of structures, potential difficulty and cognitive load, their allocation followed the standard curricular sequence rather than assumptions of relative difficulty. Accordingly, differences in recall performance were interpreted as a comparative association between instructional approach within same student. Therefore, as a result, a statistically significant difference was observed between the correct answer rates obtained for Schema 1, with ILCR in Trial 1 (69.20%, ranging from 53.80 to 84.61%) and Schema 2, with a traditional single-session model (17.64%, ranging from 11.76 to 27.94%) ($P < 0.001$). Without structured, instructor-guided reinforcement during class, students are more likely to rely on individual self-study, which may lead to feelings of inadequacy and uncertainty, particularly when learning complex anatomical terminology within limited timeframes. This perception can reduce engagement and increase confusion [8]. One study reported that a general gynecologist must know 86 structures to practice safely and competently [36]. Here, the aim was to transfer as many basic anatomical structures (n = 30) as possible to the clinical period. Later in the clinical period, with the addition of new information, the number of structures should increase and easily correlate with clinical knowledge. To make verbal repetition more effective,

**Table 1** Correct answer rates for Trial 1 and Trial 2 in the course module (%)

| | Trial 1 (n = 140) Median (IQR) | Trial 2 (n = 140) Median (IQR) | *P*-value | r |
|---|---|---|---|---|
| Schema 1 | 69.23 (53.84–84.61) | 84.68 (84.61–92.30) | **< 0.001*** | 0.76 |
| Schema 2 | 17.64 (11.76–27.94) | 76.47 (58.82–82.35) | **< 0.001*** | 0.87 |
| *P* value | **< 0.001*** | **< 0.001*** | | |

Bold face p-values indicate statistically significant differences

IQR: interquartile range

r: Effect size

*Wilcoxon signed-rank test

"what-where-when" elements were incorporated into the class to reinforce recall of structures that were interactively repeated with students [16, 37, 38]. For example, which ligament suspends the ovary to the pelvic wall, where does the obturator nerve pass through, and when does a woman struggle to cross her legs; what the origin of the round ligament of the uterus is called, where does the round ligament of the uterus terminate, and when does the function of the round ligament of the uterus become active; what is the function of the Bartholin's gland, where is the Bartholin's gland anatomically located, and when does the function of the Bartholin's gland become active. Thus, newly learned and recalled information contributes to the consolidation of memories in the hippocampus for long-term retention [14, 16, 19].

Some studies have reported that hippocampal neurons exhibit activity against both newly learned and recalled information by encountering item-specific episodic memory signals [17, 39]. Based on this information, and to avoid uniform repetitions that resemble superficial similarities, different numbers of repetitions were used to induce deeper sensory engagement and facilitate reasoning, leading to more comprehensive learning. Extended repetitions over time demonstrated that, particularly for Schema 1 with a higher number of repetitions, students participating in all trials achieved a correct answer rate of 92.31% (76.92–100%) in Trial 3, whereas students who only participated in Trial 3 obtained a correct answer rate of 46.15% (38.48–53.85%), showing a significant difference between the two groups ($P < 0.001$) (Table 2). For Schema 2, the obtained rates were as follows: for participating students, 82.35% (70.59–88.24%), and for students participating for the first time, 35.61% (29.41–47.06%). Similarly, a significant difference was observed based on the participation status for Schema 2 ($P < 0.001$) (Table 2). Otherwise, the repetitions will become monotonous, and students' desire to learn will decrease. Additionally, in routine laboratory classes, the spontaneous recall of previously studied elements boosts students' confidence and engagement in the lesson [40]. However, first-time participants tended to be more reserved and preoccupied while avoiding eye contact. Briefly, exposure to similar principles through various ILCR methods [41] has an impact on the degree of information retention, leading to increased correct response rates (Table 2 and Fig. 2). Furthermore, in the Laboratory examination module, the lower frequency of errors in writing Latin terms for anatomical structures indicated the effectiveness of ILCR, which facilitated the encoding of information into memory with increased reinforcement. Therefore, it is necessary to utilize multiple teaching materials to ensure the retention of anatomical structures [42]. As suggested by Zhan et al. [11], multiple repetition studies are likely to strengthen the connection between the hippocampus and neocortical regions during memory recall. Educators should encourage students to actively participate in class and play a key role in implementing learning strategies that contribute to student success [43]. In addition, regular assessment of whether the intended learning goals have been achieved is essential because the goal of educators should not be to merely present the subject matter but to "teach" it.

A critical strength of the present study is the utilization of a within-subject design, where the same cohort of students served as their own controls for different anatomical structures (external vs. internal genital organs). This approach effectively controlled for major confounding variables that plague educational research, such as baseline knowledge, motivation, and inherent student aptitude [44]. In addition, working with classmates provides support and motivation. For example, through the efficient use of class time, approximately 80% of the material should be taught during class [25], and ILCR during class provide a deeper understanding of the material, ensuring students' long-term retention. The literature suggests that approximately one-third of medical students transfer a sufficient level of anatomical knowledge to the clinical phase [41, 45]. In this study, it is indicated that students who accurately filled out the provided diagram twice during the class and then repeated it during the laboratory session were enthusiastic to study and were more likely to transfer anatomical knowledge to the clinical phase easily. The fact that non-participating students in the laboratory trial examinations module scored an average of 50 (30–70) points, while participating students scored an average of 90 (90–100) points, indicates that recalls were associated with ILCR and that the learning objectives could be achieved as shown in Fig. 3. Furthermore, the observed differences between participants and non-participants underscore the importance of integrating ILCR into the core curriculum rather than offering it as an optional activity enhancing memory through different methods expect alone at home [10, 46] and having students work together on the same diagram to achieve the same goal should be among the objectives of educators to increase knowledge retention among students.

### 4.1 Limitations

While this study presents an educational value of ILCR, several limitations merit consideration. Although the within-subject design reduced inter-individual variability, participation in the ILCR sessions was voluntary, raising the possibility of self-selection bias, as more motivated students may have been more likely to participate. In addition, the instructional sequence was fixed and counterbalancing was not implemented. Although this was considered during the study design phase, the rigid structure of the medical anatomy curriculum with tightly scheduled committees and predefined topic sequences left little flexibility to alter

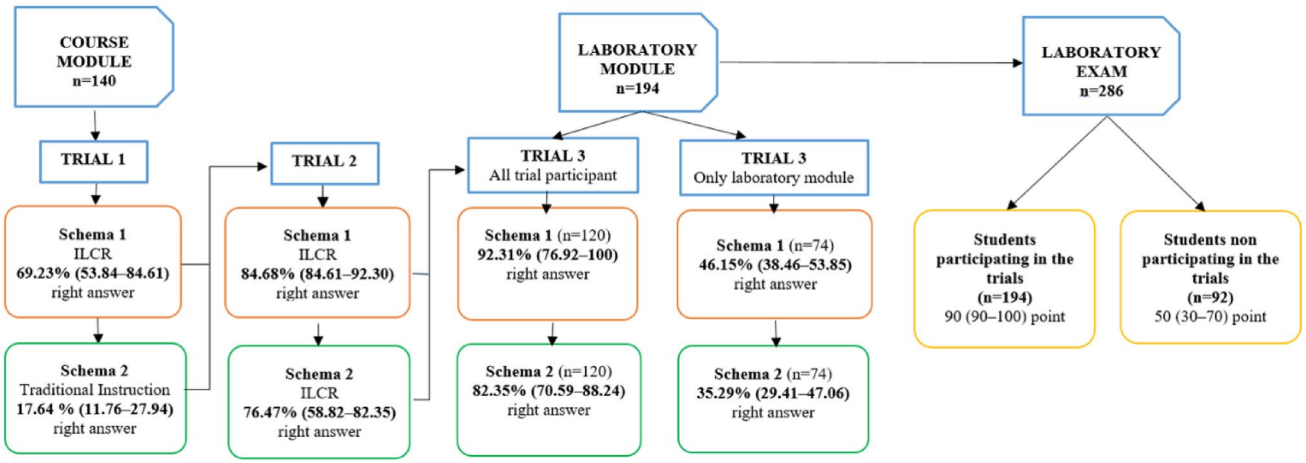



**Fig. 3** Flow chart showing the relationship between ILCR and examination success

instructional order without disrupting routine teaching or creating inequities among student groups. Finally, the study was conducted at a single institution, limiting the generalizability of the absolute scores. Furthermore, in future studies, similar experiments could be repeated with student identifiers, and students could be asked to fill out the same form just before the start of the Obstetrics and Gynecology clinical rotation to recall the anatomy of the female genital system.

### 4.2 Implications for Anatomy Education

The findings suggest that ILCR can be seamlessly integrated into existing anatomy curricula without additional technological or temporal demands. By embedding cumulative repetition into lectures or lab sessions, educators may enhance the durability of memory traces and reduce forgetting rates. Such approaches can bridge the gap between traditional didactics and evidence-based learning theories, fostering a more neuroaligned pedagogy for medical students.

## 5 Conclusions

Memorization can be challenging in anatomy courses due to the extensive number of structures and specialized terminology involved. Integrating instructor-led cumulative repetition into course formats may enhance the effectiveness of the anatomy curriculum by supporting knowledge consolidation and deeper conceptual understanding While reviewing material remains an essential component of learning, relying solely on independent study may be insufficient; structured guidance provided by the instructor during class appears particularly important within limited instructional time. Accordingly, anatomy teaching approaches should aim to optimize class time by incorporating in-class review activities and reinforcing fundamental concepts to foster student engagement and confidence. In addition, combining face-to-face instruction with online review opportunities in hybrid learning environments may further support knowledge consolidation. To reduce the effects of visual familiarity and promote transferable understanding, repetitions using varied schematic representations and three-dimensional models should also be considered.

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**Authors' Contributions** A.T conceived and designed research; analyzed data; interpreted results; prepared figures; drafted manuscript; edited and revised manuscript.

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**Availability of Data and Materials** The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Declarations

**Ethics Approval** The project was approved by the Kocaeli University Non-invasive Ethics Committee (GOKAEK-2021/23.06), and informed consent was obtained from all study participants. No identifying information was collected to protect participant anonymity.

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

**Conflict of interest** The authors declare no competing interest.

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## References

1. Bowen JL, ten Cate O. Prerequisites for Learning Clinical Reasoning. In: ten Cate O, Custers EJFM, Durning SJ, editors. Principles and Practice of Case-based Clinical Reasoning Education: A Method for Preclinical Students 2017. Chapter 4. https://doi.org/10.1007/978-3-319-64828-6_4
2. Lysanets YV, Bieliaieva OM. The use of Latin terminology in medical case reports: quantitative, structural, and thematic analysis. J Med Case Rep. 2018;12:45. https://doi.org/10.1186/s13256-018-1562-x.
3. Mareckova E, Simon F, Cerveny L. Latin as the language of medical terminology: some remarks on its role and prospects. Swiss Med Wkly. 2002;132:581–7. https://doi.org/10.4414/smw.2002.10027.
4. FIPAT. Terminologia Anatomica. 2nd ed. FIPAT.library.dal.ca. Federative International Programme for Anatomical Terminology; 2019
5. FIPAT. Terminologia Neuroanatomica. FIPAT.library.dal.ca. Federative International Programme for Anatomical Terminology; 2017. https://libraries.dal.ca/Fipat/tna.html
6. Cheung CC, Bridges SM, Tipoe GL. Why is anatomy difficult to learn? The implications for undergraduate medical curricula. Anat Sci Educ. 2021;14:752–63. https://doi.org/10.1002/ase.2071.
7. Hall S, Stephens J, Parton W, et al. Identifying medical student perceptions on the difficulty of learning different topics of the undergraduate anatomy curriculum. Med Sci Educ. 2018;28:469–72. https://doi.org/10.1007/s40670-018-0572-z.
8. Wilhelmsson N, Dahlgren LO, Hult H, Scheja M, Lonka K, Josephson A. The anatomy of learning anatomy. Adv Health Sci Educ Theory Pract. 2010;15(2):153–65. https://doi.org/10.1007/s10459-009-9171-5.
9. Ghosh SK, Chakraborty S. Enhancing learning in anatomy lectures. Educ Health (Abingdon). 2015;28:216–7. https://doi.org/10.4103/1357-6283.178603.
10. Çan MA, Toraman Ç. The effect of repetition- and scenario-based repetition strategies on anatomy course achievement, classroom engagement and online learning attitude. BMC Med Educ. 2022;22:491. https://doi.org/10.1186/s12909-022-03564-8.
11. Zhan L, Guo D, Chen G, Yang J. Effects of repetition learning on associative recognition over time: role of the hippocampus and prefrontal cortex. Front Hum Neurosci. 2018;2:277. https://doi.org/10.3389/fnhum.2018.00277.
12. Chandavarkar U, Azzam A, Mathews CA. Anxiety symptoms and perceived performance in medical students. Depress Anxiety. 2007;24:103–11. https://doi.org/10.1002/da.20185.
13. Zill SN. Rethinking gross anatomy in a compressed time frame: clinical symptoms, not case studies, as the basis for introductory instruction. Clin Anat. 2021;34:57–70. https://doi.org/10.1002/ca.23645.
14. Amin H, Malik AS. Human memory retention and recall processes: a review of EEG and fMRI studies. Neurosciences. 2013;18:330–44.
15. Kim J, Ghim JW, Lee JH, Jung MW. Neural correlates of interval timing in rodent prefrontal cortex. J Neurosci. 2013;33:13834–47.
16. Chao OY, Silva MADS, Yang YM, et al. The medial prefrontal cortex–hippocampus circuit that integrates information of object, place and time to construct episodic memory in rodents: behavioral, anatomical and neurochemical properties. Neurosci Biobehav Rev. 2020;113:373–407. https://doi.org/10.1016/j.neubiorev.2020.04.007.
17. Urgolites ZJ, Wixted JT, Goldinger SD, et al. Two kinds of memory signals in neurons of the human hippocampus. Proc Natl Acad Sci U S A. 2022;119:e2115128119. https://doi.org/10.1073/pnas.2115128119.
18. Eichenbaum H. On the integration of space, time, and memory. Neuron. 2017;95:1007–18. https://doi.org/10.1016/j.neuron.2017.06.036.
19. Rolls ET. Hippocampal spatial view cells for memory and navigation, and their underlying connectivity in humans. Hippocampus. 2023;33:533–72. https://doi.org/10.1002/hipo.23467.
20. Atoofi S. Reconsidering repetition in language education: an edusemiotic approach. Soc Semiot. 2022;29:670–83. https://doi.org/10.1080/10350330.2018.1514777.
21. Vredeveldt A, Hildebrandt A, Van Koppen PJ. Acknowledge, repeat, rephrase, elaborate: witnesses can help each other remember more. Memory. 2016;24:669–82. https://doi.org/10.1080/09658211.2015.1042884.
22. Kooloos JGM, Bergman EM, Scheffers M, et al. The effect of passive and active education methods applied in repetition activities on the retention of anatomical knowledge. Anat Sci Educ. 2020;13:458–66. https://doi.org/10.1002/ase.1924.
23. Fendos J. Anatomy terminology performance is improved by combining jigsaws, retrieval practice, and cumulative quizzing. Anat Sci Educ. 2021;14:641–57. https://doi.org/10.1002/ase.2018.
24. Agostino S, Cherasco GM, Papotti G, Milan A, Abate Daga F, Abate Daga M, et al. Impact of simulation-based and flipped classroom learning on self-perceived clinical skills compared to traditional training. Educ Sci. 2025;15(1):31. https://doi.org/10.3390/educsci15010031.
25. Koppes DM, Triepels CPR, Notten KJB, et al. The level of anatomical knowledge, hard to establish: a systematic narrative review. Med Sci Educ. 2022;32:569–81. https://doi.org/10.1007/s40670-022-01509-w.
26. Sinclair D. The two anatomies. Lancet. 1975;1:875–8.
27. Prince KJ, Scherpbier AJ, Van Mameren H, et al. Do students have sufficient knowledge of clinical anatomy? Med Educ. 2005;39:326–32. https://doi.org/10.1111/j.1365-2929.2005.02096.x.
28. Arráez-Aybar LA, Sánchez-Montesinos I, Mirapeix RM, et al. Relevance of human anatomy in daily clinical practice. Ann Anat - Anat Anz. 2010;192:341–8. https://doi.org/10.1016/j.aanat.2010.05.002.
29. Ebbinghaus H. Memory: a contribution to experimental psychology. Ann Neurosci. 2013;20:155–6. https://doi.org/10.5214/ans.0972.7531.200408.
30. Sözmen EY, Karaca O, Batı AH. The effectiveness of interactive training and microlearning approaches on motivation and independent learning of medical students during the COVID-19 pandemic. Innov Educ Teach Int. 2023;60:70–9. https://doi.org/10.1080/14703297.2021.1966488.
31. Jurjus RA, Lee J, Ahle S, et al. Anatomical knowledge retention in third-year medical students prior to obstetrics and gynecology

and surgery rotations. Anat Sci Educ. 2014;7:461–8. https://doi.org/10.1002/ase.1441.
32. Altalhab S. Short- and long-term effects of repetition strategies on vocabulary retention. Adv Lang Lit Stud. 2018;9:146–9. https://doi.org/10.7575/aiac.alls.v.9n.2p.146.
33. Fives C, Lone M, Nolan YM. Motivation and learning methods of anatomy: associations with mental well-being. Clin Anat. 2022;35:26–39. https://doi.org/10.1002/ca.23781.
34. Çetkin M, Turhan B, Bahşi İ, Kervancıoğlu P. The opinions of medicine faculty students about anatomy education. Eur J Ther. 2016;22:82–8. https://doi.org/10.5578/gmj.32156.
35. Büyükbay S, Azizollah V. The effectiveness of repetition as corrective feedback. J Lang Teach Res. 2010;1:181–93. https://doi.org/10.4304/jltr.1.3.181-193.
36. Koppes DM, Snoeren A, Notten KJB, et al. Anatomy (knowledge) in postgraduate obstetrics and gynaecology training: is it sufficient enough? Ann Anat. 2022;239:151826. https://doi.org/10.1016/j.aanat.2021.151826.
37. Smulders TV, Black-Dominique A, Choudhury TS, et al. A real-world what-where-when memory test. J Vis Exp. 2017;123:55646.
38. Sugar J, Moser MB. Episodic memory: neuronal codes for what, where, and when. Hippocampus. 2019;29:1190–205. https://doi.org/10.1002/hipo.23132.
39. Nakamura NH, Sauvage MM. Encoding and reactivation patterns predictive of successful memory performance are topographically organized along the longitudinal axis of the hippocampus. Hippocampus. 2016;26:67–75. https://doi.org/10.1002/hipo.22491.
40. Rudoler JH, Herweg NA, Kahana MJ. Hippocampal theta and episodic memory. J Neurosci. 2023;43:613–20. https://doi.org/10.1523/JNEUROSCI.1045-22.2022.
41. Jurjus RA, Brown K, Goldman E, et al. Curricular response to increase recall and transfer of anatomical knowledge into the obstetrics/gynecology clerkship. Anat Sci Educ. 2016;9:337–43. https://doi.org/10.1002/ase.1587.
42. Seker M, Yuzbasioglu N. A different approach to anatomy education: "Sami ZAN, professor of anatomy, MD." Balk Med J. 2015;33:6–7. https://doi.org/10.5152/balkanmedj.2015.15923.
43. Rutenberg I, Ainscough L, Colthorpe K, Langfield T. The anatomy of agency: improving academic performance in first-year university students. Anat Sci Educ. 2022;15(6):1018–31. https://doi.org/10.1002/ase.2137.
44. Kotil G, Barut C. A vulvar anatomy description comparison between the anatomy and gynecological textbooks. Bratisl Med J. 2025;126:1362–70. https://doi.org/10.1007/s44411-025-00229-y.
45. Bhangu A, Boutefnouchet T, Yong X, et al. A three-year prospective longitudinal cohort study of medical students' attitudes toward anatomy teaching and their career aspirations. Anat Sci Educ. 2010;3:184–90. https://doi.org/10.1002/ase.165.
46. Albert FA, Seidu AA, Mason HM, et al. A systematic review of medical practitioners' retention and application of basic sciences to clinical practice. BMC Med Educ. 2024;24:997. https://doi.org/10.1186/s12909-024-05952-8.

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