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Original Research Article

Improved Student Performance and Satisfaction after Implementing A Retrieval Practice Strategy in Anatomy Practical

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ABSTRACT

Reduction of curricular hours in integrated, organ system-based preclinical education resulted in fewer hours for cadaveric dissection, making learning from dissection challenging. Though students performed satisfactorily on written examinations, cadaver-based practical examination performance fell below an acceptable level. In these examinations, students successfully identified tagged structures on cadavers they dissected, but could not identify structures on other cadavers. Anatomists hypothesized that practical examination performance would improve if students as a group answered questions by using retrieval practice to review structures in all cadavers used for the examination.

Improving student recognition of structures across all cadavers presented an opportunity to change instructional practice. Anatomists developed and implemented a laboratory review based on the strategy of 'retrieval practice' (RP). The students rotated in teams through all dissected cadavers, identified several structures from a list provided at each cadaver, and answered questions about those structures. They engaged in peer-to-peer teaching that led to a deeper understanding of the content and outcome of RP.

Failures in the anatomy practical decreased after the implementation of this strategy, and scores improved significantly (pre-RP mean (SD) = 77.5 (12.4), post-RP mean (SD) = 85.9 (5.72). In addition, students evaluated RP highly. Two themes stood out: students appreciated the "ability to see all the cadavers used in the practical examination and answer higher-order questions" and that RP "allowed peer teaching, trust, and collegiality," allowing students to ask simple questions for better understanding without judgment.

Formative RP feedback allowed students to address knowledge deficits before practical examinations. A surface approach to learning anatomy resulted in lower achievement levels; a strategic approach resulted in higher attainment levels, and the RP provided this strategic approach.

KEYWORDS: Anatomy testing, Laboratory review, retrieval practice, Improved performance, student satisfaction, medical education.

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INTRODUCTION

The drawback of two years of basic science and two years of clinical training is that students may not recognize the importance of the basic biomedical sciences to clinical practice [1]. Although the integrated curriculum appears to be a solution, it has significantly shortened the time available to teach anatomy and embryology [2]. In recent years, concerns have been raised about medical students' knowledge of anatomy, their preparedness for clinical practice, and the impact on the quality and safety of the healthcare they provide [3].

The use of problem-based learning (PBL) [4], case-based learning (CBL) [5], or other small-group active learning, such as TBL [6], combined with exposure to patients through ambulatory clinic attendance, integrated clinical practice into the preclinical years. These diverse approaches further contributed to the development of curriculum integration in the preclinical years, both horizontally and vertically. At the end of each course or module, assessments included a written multiple-choice question (MCQ) exam and a relevant laboratory practical exam.

Cooper Medical School of Rowan University (CMSRU) enrolled its first class of 50 students in 2012. The school was approved to admit more students, increasing the class size to 100. As a result, the faculty size was also expanded.

Preclinical courses engaged students in active, case-based, participatory learning in small groups; the cases incorporated clinical inquiries and fostered the habit of self-regulated, self-directed learning. The preclinical curriculum encompassed horizontally and vertically integrated organ system-based courses/modules. Classes were short, especially in anatomy, and students needed to assimilate the required knowledge and understanding in fewer dissection hours. The integrated curriculum was touted as a cornerstone of modern medical education and practice; the information students were expected to learn and master also expanded rapidly.

In CMSRU's curriculum, assessment consisted of MCQ written examinations with clinical vignettes, while practical examinations used short-answer questions. After the spring 2013 course delivery, anatomy instructors in the Skin and Musculoskeletal (SMS) course noted a challenge: first-year medical students performed poorly on practical examinations. The practical examination required students to identify a tagged structure and answer a primary, secondary, or tertiary question about it.

Faculty realized that students correctly identified structures on the cadavers they dissected, but could not identify them on the others because they spent very little time reviewing cadavers they had not dissected and lacked familiarity with those structures. Faculty accepted the challenge of enhancing students' ability to recognize structures across all cadavers by implementing pedagogical changes, including the use of the Retrieval Practice Laboratory Review (RPLR) or Retrieval Review (RR).

The RR sessions provided students with formative feedback and peer-to-peer teaching, helping them address knowledge gaps before exams. This study examines how retrieval practice, through peer-to-peer teaching with the content, improves students' knowledge of anatomy, resulting in better performance and enhanced learning.

MATERIALS AND METHODS

The Rowan University Institutional Review Board approved the protocol for this study as an 'exempt' study (ID: Pro2018002430).

The amount of time dedicated to teaching anatomy varied for each subject module in CMSRU's integrated organ system-based courses curriculum, and the laboratory dissection time changed accordingly. The anatomy laboratory was open 24/7 for additional study hours. Each dissecting group consisted of five randomly selected students; four full-time faculty members taught the lab. In addition to cadavers, the school provided anatomical models and bones, which were also used in the practical exam. The traditional "tag or spotter" test was criticized for testing

rudimentary levels of knowledge [7]. Hence, pure identification of a tagged structure was minimized in favor of higher cognitive level testing involving function and clinical application types of questions [8].

Our anatomy practical required to 1) name the tagged structure (remembering); 2) know the surrounding anatomy to recognize the structure (understanding) and its function (comprehension); and 3) understand the function of the structure (application) or what functional deficit occurs if the structure is damaged (analyzing) and, finally, identify which clinical condition is associated with that deficit (evaluating). Parallel to the integrated curriculum, the practical examination of anatomy followed Bloom's Taxonomy [9].

What is a Retrieval Practice Laboratory Review (RR)?

The RR is an inquiry-oriented approach in which faculty-generated review materials guide students through an organized exploration of dissected cadavers, anatomical models, bones, and skeletons. Students became comfortable with all the dissected cadavers used in the practical examination and familiar with the structures they were expected to learn about in preparation for the assessment. RR is an active-learning, group-oriented process; each group member serves as both a consultant and a learner, much like in team-based learning [6].

Faculty developed and implemented the RR during the SMS course. A monitored activity, it requires attendance. Students rotated in dissection teams through all the cadavers. They had to identify several structures from a provided list at each cadaver, answer follow-up questions about them, and engage in peer-to-peer teaching. The RR enhanced students' ability to correctly identify structures in all cadavers, answer related questions, and achieve a deeper understanding, rather than just superficial knowledge.

Design of RR

RR sessions were scheduled three days before each practical examination, allowing students to address any knowledge gaps before the exam. The faculty compiled a list of structures to be identified and, for each structure, developed a subset of questions (primary, secondary, and/or tertiary). The question list was divided among the dissected cadavers, so each cadaver had 2-4 structures with related questions. Secondary and tertiary questions covered embryology, congenital anomalies, or clinical deficits. The faculty ensured that each structure was repeated two or three times so that a student could identify the same structure in different cadavers. Students engaged in peer-to-peer teaching by working with their dissection teams to identify structures and answer questions.

The RR required that the dissection group begin with the cadaver they had dissected. At each cadaver or model/bone, students received a sheet listing the three or four structures they were to 1) identify and 2) describe, including function, nerve/vascular supply, and resulting deficits if the structure is affected. A buzzer sounded at regular intervals; groups then moved to the next cadaver to identify different structures and answer a new subset of questions. The faculty could confirm an identified structure and clarify information as needed. Students were not allowed to remove or copy the review sheets. The RR conducted an organized, mandatory review session that allowed students to identify various structures across all cadavers and collectively discuss their findings. Furthermore, the RR also served as a formative knowledge assessment, helping students review and consult colleagues to solidify their knowledge.

Anatomy Summative Examination

Each module included a practical anatomy examination and a written MCQ test. The cadaver-oriented tag test accounted for 30%-35% of the total course grade; the remainder was assigned to a written MCQ examination that followed the NBME question style [7]. The minimum passing grade on the practical examination was 70%. Failure to achieve a passing grade required remediation during the summer remediation period. The written MCQ examination included anatomy questions with clinical vignettes (vertical integration) and other basic sciences (horizontal integration). The anatomy questions were all associated

with clinical vignettes to assess comprehension and analytical ability.

Typically, the tag tests included student-dissected cadavers, skeletons, and anatomical models. The number of practical examination questions usually ranged from 25 to 35, depending on the area studied and the allotted dissecting time. Students received 60 seconds to answer each question and, after the buzzer, moved to the next. Students could start with any question and, after the buzzer, move to the next; the student who started on the last question would return to the first. Sixty seconds per question was sufficient, as more time allowed students to change their answers too many times, perhaps from the correct answer to the wrong one.

DATA ANALYSIS AND RESULTS

An Independent Samples t-test was conducted to assess differences in practical examination performance in the Skin and Musculoskeletal (SMS) course before and after the implementation of RR sessions (Table 1). The analysis revealed that medical students' practical examination scores before RR implementation {Mean (SD) = 77.5 (12.4)} were significantly lower than post-RR scores {Mean (SD) = 85.19 (5.72)}; $t(438) = -3.25$, $p < .001$.

To further examine the impact of RR across cohorts, a one-way between-subjects ANOVA was conducted to compare practical examination scores across six undergraduate medical education class years. The analysis showed asignificant effect of RR on student performance at $p < .001$ [$F(5,434) = 5.20$, $p = .000$].

Post hoc Tukey HSD comparisons indicated that the 2013 course delivery, which did not experience RR, had a significantly lower mean score (77.50) than the courses delivered in 2014 (85.19), 2015 (86.77), 2016 (84.59), 2017 (85.75), and 2018 (85.90). However, although the 2014 cohort did not have access to RR, their performance was not significantly different from that of post-RR cohorts. This raises questions about what additional factors might have contributed to student performance beyond the introduction of RR. It may be that the 2014 class was better prepared, given that medical school requires a higher level of knowledge. It is also possible that the second class performed well without RR due to the overall quality of the class and other factors, such as well-prepared students.

The number of students who did not pass the practical examination before and after RR implementation is illustrated in Figure 1. Notably, no students failed the 2015 or 2018 practical examinations. This trend suggests that, while RR may have played a role in improving overall performance, other factors, such as curricular adjustments, student preparation habits, and faculty support, may have also contributed.

Table 1: Student Performance Records for the SMS Course.

Course Delivery	N	Exam Average	Median	Standard Deviation	Range		Exam Average Below Passing*
2013	49	77.5	79.5	12.4	44.4	97.8	13
2014	62	85.9	84.62	5.72	51	100	3
2015	69	86.77	87.39	5.36	73.33	96.37	0
2016	80	84.59	85.23	6.12	65.66	94.88	2
2017	86	85.75	86.22	6.64	66.82	97.28	3
2018	94	85.9	86.35	5.67	72.08	96.77	0

Note: In 2013 and 2014, no RR was provided.

* Indicates average practical examination performance below 70.00

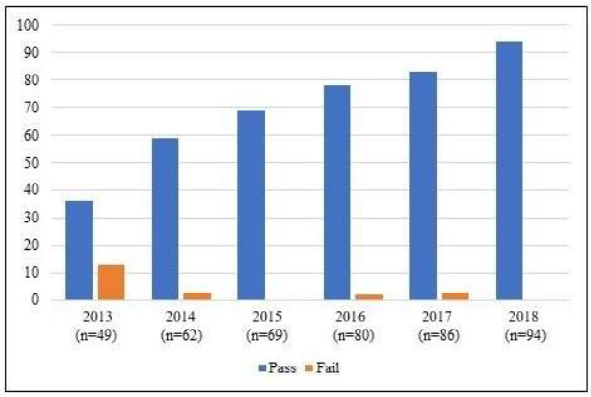

Fig. 1: Anatomy Practical Pass Rates Pre- and Post-RR Implementation. The figure displays the number of passes and failures on the SMS assessments by student year.

The figure shows the number of passes and failures on the SMS assessments by student year. Anatomy Practical Pass Rates Before and After RR Implementation.

DISCUSSION

The present study's results demonstrate that the RR introduction at CMSRU had a positive outcome: student performance improved after implementing this innovative approach, despite the reduced anatomy teaching time. These findings are significant. Such reductions in anatomy curricular time were not unique to medical schools in the United States [2]; they also occurred in North and South American countries [11, 12], as well as the United Kingdom and the Republic of Ireland [13]. By utilizing different strategies, the challenge became an opportunity. Other approaches to improving the learning outcomes supported the assertion that 'where there is a will, there is a way' [14, 15]. Conceptually, the RR is a different approach, but Hofer found that using checklists in a gross anatomy laboratory improved learning outcomes and dissection quality [14]. Rao Bhagavathula utilized a pre-laboratory assignment to improve academic performance and student engagement in a neuroanatomy course [15].

The anatomy practical examinations are much different from all other exam types; students are expected to be familiar with many anatomical structures in different student-dissected cadavers. Additionally, 1) students are expected to know the clinical significance of most of these structures and 2), where applicable, the embryological origin of and congenital disabilities related to some of the structures. In the last two decades, the NBME licensing examination questions have evolved to become based on a horizontally and vertically integrated curriculum. In addition to developing a curriculum for 21st-century medical students, assessments should incorporate other subjects that connect to knowledge, comprehension, and integration [16]. Since the beginning of the CMSRU in 2012, the faculty have written new questions that are discussed and modified as necessary to conform to the USMLE style. For the cadaver-oriented practical exams, the faculty consistently created new questions that were reviewed and approved by the anatomy faculty.

The use of RR sessions was an innovative method for addressing the problem of student failures on the SMS anatomy practical examinations, which was attributed to poor learning and a lack of diligent preparation for the type of testing. Participation in RR resulted in students becoming comfortable with all the cadavers used in the practical examination and gaining familiarity with the structures that they were expected to focus on in both learning and preparation for the assessment, while engaging in peer-to-peer teaching, all of which led to a deeper understanding of the content. Studying the effect of active and passive repetitive learning activities in the retention of anatomy knowledge, Kooloos concluded that the repetition of anatomical knowledge in any form is beneficial for students and will likely improve student outcomes in a curriculum that builds on prior knowledge [17]. Minhas noted that, during initial learning, active learning methods outperform passive ones because of improved student engagement and attitude [18].

Constructivist teaching and theory are grounded in the belief that learning occurs when learners actively engage in the process of constructing meaning and knowledge, rather than passively receiving information. Learners create their own meaning and understanding. Constructivism as a theory can be effective in teaching and educational contexts because

students learn through experience rather than solely from textbooks. They are encouraged to apply their critical thinking, deductive reasoning, and analytical abilities to articulate their thoughts and develop solutions.

The RR allowed students to engage in peer-to-peer teaching and simultaneously observe and learn how other students approached structure identification by looking at the surrounding structures and differentiating similar structures, such as nerves and blood vessels. This peer-to-peer teaching is identical to "developing medical students as teachers." In addition, RR required the students to review all the cadavers systematically. It is essential to highlight that each dissection group rapidly became a cohesive and productive team, going through the cycle of forming, norming, storming, and performing [19]. This is crucial for successful team interactions, development of trust, professionalism, and communication [6, 20].

The RR sessions also provided the students with formative feedback, allowing them to address any deficits in knowledge before the examinations. According to Rowland, practical examinations are more suitable for testing anatomical knowledge than written ones [21]. As described by Smith, basic factual understanding is a key component of learning; when applied to core concepts, the basic building blocks, which can be classed as "identity," are essential in learning anatomy [22].

The end goal of medical school is, of course, clinical practice, which requires strong clinical reasoning skills. A surface approach to anatomy is significantly related to a low achievement level and little development of clinical reasoning skills; a deep or strategic approach is associated with a high attainment level. Students enjoy the RR and find it helpful in developing their understanding of anatomy and relationships between structures.

ABBREVIATIONS

CMSRU: Cooper Medical School of Rowan University
SMS: Skin-Musculoskeletal Course
MCQ: Multiple Choice Questions.

Author Contributions All of the authors were involved in the research, preparation, and final approval of the manuscript.

Conflicts of Interests: All of the authors declare that there are no competing interests.

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