Interdisciplinary Research in Medical Sciences Specialty
ISSN: 3062-4401
2025, Volume 5, Issue 2, Page No: 102-112

Available online at: www.galaxypub.co/page/journals

Galaxy Publication

Recorded Lectures as Supplementary Learning Resources in Clinical Training: An Evaluation Study

Hamidou Diallo[1], Mamadou Barry[1], Ibrahima Camara[1]*

[1]Department of Biomedical Research, Faculty of Medicine, University of Conakry, Conakry, Guinea.

***E-mail** ✉ ibrahima.camara.bio@yahoo.com
Received: 03 September 2025; **Revised:** 01 December 2025; **Accepted:** 05 December 2025

ABSTRACT

Technology provides new opportunities for learning, including the use of recorded lectures (RLs). This study aimed to assess how effective online RLs are for learning within clinical courses at a School of Medicine. The research was conducted in four phases: (i) a pre–post uncontrolled study to measure knowledge acquisition from RLs, (ii) a non-randomised crossover study comparing learning when RLs were viewed before or after a face-to-face lecture (FL), (iii) focus groups to explore students' perceptions of RLs, and (iv) a randomised controlled trial examining whether embedding questions every 10 minutes and adding a summary page to RLs enhances learning. Findings indicated that RLs produced measurable knowledge gains comparable to those from FLs. Additionally, whether students viewed an RL before or after attending an FL, the overall incremental learning was similar. Students expressed positive attitudes toward RLs, though they did not view them as a full substitute for FLs. Finally, incorporating periodic questions and a summary page into RLs did not result in improved learning outcomes. In summary, RLs can effectively support learning in clinical courses; however, students' continued preference for FLs supports the implementation of a blended learning approach.

Keywords: Undergraduate medical education, Online systems, ELearning, Recorded lectures

How to Cite This Article: Diallo H, Barry M, Camara I. Recorded Lectures as Supplementary Learning Resources in Clinical Training: An Evaluation Study. Interdiscip Res Med Sci Spec. 2025;5(2):102-12. https://doi.org/10.51847/HWm2uHCPjG

Introduction

Information and communication technologies have found numerous applications in education, including the broad concept of e-learning, which involves using electronic systems—primarily Internet-based—to enhance knowledge and performance [1, 2]. The widespread availability of affordable mobile devices has further facilitated students' access to information, making these tools increasingly integral to learning [3]. Medical students, in particular, are familiar with such innovations and are likely to use advanced technology for diagnosis, treatment, and decision-making in their future practice.

Students today tend to be more technologically inclined [4, 5], and their patterns of technology use are shaping new approaches to learning [6]. Traditional methods like face-to-face lectures (FLs) no longer fully satisfy undergraduate students' needs [7]. Information technology holds the potential to transform medical education, with students often adapting to it more readily than other groups [8]. The rapid access to information allows educators to innovate and address the evolving demands of the curriculum.

One approach that accommodates students' schedules is online recorded lectures (RLs), accessible via the Internet or local networks. RLs enable self-paced learning, allowing students to pause, rewind, or fast-forward to review challenging material and take detailed notes [9]. Some continuing medical education programs provide RLs to mitigate challenges related to commuting and work schedules [10, 11].

Research on RLs in undergraduate medical education has shown mixed but generally positive outcomes. In preclinical courses, RLs have produced comparable or superior performance in subjects like biochemistry [12], embryology [13, 14], and anatomy [15, 16]. High usage rates are reported when RLs are available [17–19], though one study noted limited use, which was inversely associated with grades in basic science courses [20]. At Harvard Medical School, 20.2% of first- and second-year students cited scheduling flexibility as the main reason for preferring RLs over live lectures [21]. Some evidence suggests slightly improved Step 1 scores with easier RL access [22], while other studies found no correlation between RL use and final grades [23]. Zureick *et al*. observed that students consistently attending FLs or viewing RLs in histology performed better than those with a mixed approach, while interruptions negatively affected performance in both formats [24].

Clinical course studies show varied results. A before-and-after study in pediatric emergency medicine found higher post-test scores for students and residents who watched RLs, although no direct comparison with FLs was made [25]. Maher *et al*. reported similar learning outcomes for RLs and FLs in substance use disorder courses, with slightly higher satisfaction in the FL group [26]. A crossover randomized trial in rheumatology found equivalent scores but a preference for FLs [27]. Brockfeld *et al*. showed no difference in clinical exam performance between RLs and FLs in Germany, though nearly half of students preferred FLs [28]. Similarly, Alnabelsi *et al*. reported comparable improvements in knowledge with RLs and FLs [29].

At the Alberto Hurtado School of Medicine (AHSM) at Cayetano Heredia Peruvian University (UPCH), some clinical courses had RLs available since 2014. However, the effectiveness of RLs during clinical training in Latin American medical schools has not been formally evaluated. Changes in lecture delivery should be assessed to ensure they meet educational goals, and students' perceptions of benefits and drawbacks should be understood before broader implementation.

This study's primary aim was to evaluate the effectiveness of online RLs for clinical course learning in the Undergraduate Medicine Program by comparing knowledge gains through objective assessments. Secondary aims included: 1) comparing RLs versus FLs; 2) assessing whether the sequence of RLs and FLs affects learning; 3) comparing RLs with supplemental content to standard RLs; and 4) examining students' perceptions of RLs as a learning tool.

Materials and Methods

Study design

The study was conducted in four distinct phases: (A) an uncontrolled pre–post design, (B) a non-randomized crossover study, (C) a focus group (FG) investigation, and (D) a parallel-group randomized controlled trial.

Description of the medical curriculum at AHSM

The medical program at AHSM spans seven years and is organized into four consecutive stages: basic sciences (year one), preclinical training (years two and three), clinical training (years four and five), externship (year six), and internship (year seven). During the clinical phase, students spend their mornings (8 a.m. to 12 p.m.) completing clinical rotations in various hospitals, followed by attendance at face-to-face lectures in the afternoon, typically consisting of two one-hour sessions.

Participants

The study population consisted of fifth-year medical students at AHSM who were enrolled in clinical courses during 2014. Eligibility criteria varied by phase: students registered in Medical Clinics II were included in phase A; those enrolled in Pediatric Clinics II were included in phase B; students who had taken part in either phase A or B were eligible for phase C; and students registered in Neurology Clinics were included in phase D. Individuals repeating a course or those transferring from other universities were excluded.

Table 1 presents the baseline characteristics for participants in phases A, B, and D. Across all phases, age and gender distributions were similar between groups. Participants ranged from 20 to 27 years of age, with an approximately equal representation of male and female students. In phase C, 25 students took part, with a mean age of 23 years **(Table 1)**

Table 1. Characteristics of participants in phases A, B and D.

		Group 1	Group 2	p
Phase A	n	19	22	
	Female, n (%)	9 (47.37%)	15 (68.18%)	0.216[a]
	Age, mean (range)	22.37 (20–25)	21.95 (20–24)	0.492[b]
Phase B	n	22	19	

	Female, n (%)	8 (36.36%)	13 (68.42%)	0.062[a]
	Age, mean (range)	22.05 (19–25)	22.58 (20–27)	0.347[b]
Phase D	n	62	62	
	Female, n (%)	29 (46.77%)	33 (53.23%)	0.590[a]
	Age, mean (range)	22.76 (20–27)	22.42 (20–26)	0.320[b]

a Fisher's exact test.
b Mann-Whitney U test.

Table 2. Age and VARK questionnaire results in FGs.

FG	Number of participants	Age		VARK			
		Mean	Range	Visual	Auditory	R/W	Kinesthetic
1	5	23	22–26	1	1	1	2
2	6	23	21–25	0	2	2	2
3	7	22	21–24	1	0	2	4
4	7	22	21–23	1	0	4	2

Procedures and techniques

Phase A

This phase focused on assessing knowledge acquisition from RLs. Students were randomly allocated to view one of two edited recorded lectures derived from actual class sessions previously delivered to another cohort. The assigned topics were liver function tests (group 1) and enteric viral hepatitis (group 2). Of the 54 students randomised, 41 (75.93%) accessed the online platform and completed the phase within one week of enrollment. The RLs were accessible for a one-week period via the virtual classroom. Each student first completed a pre-test, then viewed the assigned RL, and subsequently completed a post-test.

Phase B

This phase sought to compare knowledge acquisition from FLs versus RLs using a crossover design. Of the 60 eligible students, 41 (68.33%) completed all required activities (see SM2). Group 1 students completed a pre-test and then attended an FL on eating disorders, which was simultaneously recorded. Immediately afterward, they completed a mid-test. The following day, these students met in a designated room equipped with laptops, accessed the virtual classroom, viewed the RL, and subsequently completed a post-test.

Group 2 followed the reverse sequence. They first assembled in the same room to take a pre-test, view the RL, and complete a mid-test. Six days later, they attended the FL and then completed the post-test.

At the conclusion of the course, both groups completed a survey assessing their perceptions of online RLs as an alternative to traditional FLs. Responses were recorded using 5-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree).

Phase C

This phase involved a qualitative study using focus groups (FGs) and was guided by grounded theory. Reporting followed the Consolidated Criteria for Reporting Qualitative Research (COREQ) [30].

Four FGs were conducted to explore students' learning practices and their views on RLs. The objectives were: FG1 – understanding students' perceptions of RLs and their impact on learning; FG2 – investigating why some students did not watch RLs; FG3 – capturing experiences of students who first attended an FL and then watched the corresponding RL; FG4 – capturing experiences of students who first watched an RL and then attended the FL.

Participants were selected based on previous study involvement: FG1 included a random sample from phase A, FG2 included students who had not accessed any RLs in phase A, and FG3 and FG4 included random samples from groups 1 and 2 of phase B, respectively (see SM3). Invitations were sent via email after the completion of phases A and B. Non-participation reasons were not explored.

FGs were facilitated by trained moderators—an independent female anthropologist (FG1 and FG3) and a male sociology student (FG2 and FG4)—with the principal investigator assisting. Moderators had no prior assumptions

about the study topic, and participants had no personal relationship with them; the only known fact was the assistant's role as a medical professor. Each session began with introductions and a brief overview of the study.
Sessions were held in August 2014 in AHSM administrative rooms, with only moderators, participants, and the assistant present. Moderators encouraged open discussion, maintained neutrality, and probed for detailed responses, while the assistant helped clarify course content or medical terminology.
Before the discussions, participants completed the Spanish version of the VARK questionnaire [31] to identify their preferred learning styles.

Phase D
This phase investigated whether the addition of supplementary resources to RLs enhances knowledge acquisition. During the second semester, fifth-year students enrolled in the Neurology Clinics course were provided with a lecture on meningitis exclusively as an RL in a virtual classroom. A total of 124 students participated in this phase (see SM4), with a mean age of 22.59 years. They were randomly assigned into two groups: group 1 viewed the standard RL, while group 2 accessed a modified version designed to reinforce learning.
Modifications for group 2 incorporated suggestions gathered from participants in phase C. The RL was structured into three sections and delivered as a lesson module, consisting of HTML pages with a guided progression based on student interactions. After each video section, students answered single-answer multiple-choice questions (five options), receiving immediate feedback regardless of their selection, and the lesson concluded with a summary page. Students could continue through the module even if they selected incorrect answers.
Both groups completed the activities in separate rooms equipped with laptops. Each student first took a pre-test, then engaged with the assigned RL or lesson module, and finally completed a post-test.

Usage of software for RLs
Lectures were recorded using Camtasia Studio 8.3 (TechSmith, Okemos, MI), which enables screen capture along with audio recording. The software captured both the presentation slides and the instructor's narration. Recordings were then edited to remove idle time and other unnecessary segments, producing a smoother and more concise presentation.
For phases A, B, and D, virtual classrooms were hosted on an AHSM server and built using Moodle 2.6 (Moodle Pty Ltd, Perth, Australia), an open-source learning management system. Moodle facilitated test creation, answer collection, and other essential administrative functions. RLs for phases A and B were stored directly within Moodle, while phase D recordings were uploaded to Vimeo to prevent overloading the AHSM server. The "restricted access" feature in Moodle was enabled to ensure sequential completion of tasks, such as requiring students to finish the pre-test before accessing the RL.
In phase B, each laptop had Safe Exam Browser (SEB) 2.0 (ETH Zurich, Zurich, Switzerland) installed to deliver assessments securely. Moodle was configured to restrict test access exclusively through SEB, and students had to log in with their usernames and passwords on a main page. Once activated, SEB prevented students from using their laptops for any purpose other than completing the test. In phase D, SEB was not used since the RLs were hosted externally, but question and answer randomization features in Moodle were still enabled.

Data collection
In phases A, B, and D, online assessments consisted of 10 multiple-choice, single-answer questions, administered according to the procedures described for each phase to evaluate knowledge gain. Students were given a maximum of five minutes to complete each test. The order of both questions and answer options was randomized to minimize the potential for cheating. Review of answers was disabled after submission, and only the first response to each question was accepted. All questions were created by the study investigator and reviewed by either the course instructor or content specialists.
For phase C, the investigators developed a semi-structured interview guide for each FG, with shared content outlined in SM5. All sessions were conducted in Spanish and audio-recorded with participant consent using two recorders. Moderators also took field notes during the discussions. Each FG lasted approximately one hour. The number of FGs conducted was considered sufficient to achieve data saturation. Audio recordings were transcribed verbatim for analysis, and transcripts were not returned to participants for review or correction.

Ethical considerations

All participants provided written informed consent prior to enrollment. They were assured that non-participation would have no negative impact on their academic standing. Measures were taken to ensure the confidentiality of the data collected. As the study consisted of educational interventions, it was classified as minimal-risk research. Students' test results were not incorporated into course grades. Study records were anonymized and will be securely stored until the results are published. Additionally, participants were informed of the study's objectives and familiarized with its procedures. The study protocol received approval from the Institutional Review Board at UPCH (IRB #62655).

Data analysis

For numerical variables, means and ranges were reported, while categorical variables were summarized using frequencies and percentages. Comparisons of categorical variables were performed with Fisher's exact test. The Kolmogorov-Smirnov test indicated that scores and changes in scores were not normally distributed, so nonparametric methods were applied. Differences between two independent groups were assessed using the Mann-Whitney U test, and paired score comparisons were conducted with the Wilcoxon signed-rank test. A p-value below 0.05 was considered statistically significant.

In phase C, each moderator independently coded the data from their assigned FG. The information was then organized into a coding framework with three primary themes: (1) perceptions of FLs, (2) perceptions of RLs, and (3) expectations regarding RLs. Subthemes were derived using the constant comparative method from grounded theory, following the steps of open, axial, and selective coding [32]. The data were carefully reviewed to create descriptive and interpretive summaries aligned with a coding table, after which the results were compared and subthemes finalized. Data management was performed using a word processing program rather than specialized qualitative analysis software. Participants were not asked to provide feedback on the findings.

Sample size and power

The number of participants in this study was determined by their academic group assignments, so no formal sample size calculation was conducted beforehand. Nevertheless, for phases A, B, and D, the minimum difference in score changes that could be reliably detected with the available participants was estimated. Calculations assumed a standard deviation of 2, a significance level of 0.05, and 80% statistical power. The outcome measure was the change in test scores, defined as post-test minus pre-test (or mid-test versus pre-test and post-test versus mid-test in phase B).

In phase A, with 19 students per group, the study could detect a mean score change of at least 1.36 points. For phase B, with 19 and 22 students per group, the detectable change was 1.799 points. In phase D, which included 62 students in each group, the minimum detectable difference in mean score was 1.014 points.

Results and Discussion

Phase A

Knowledge improvements were significant across all groups **(Figure 1)**, indicating that learning can be achieved through the use of RLs.

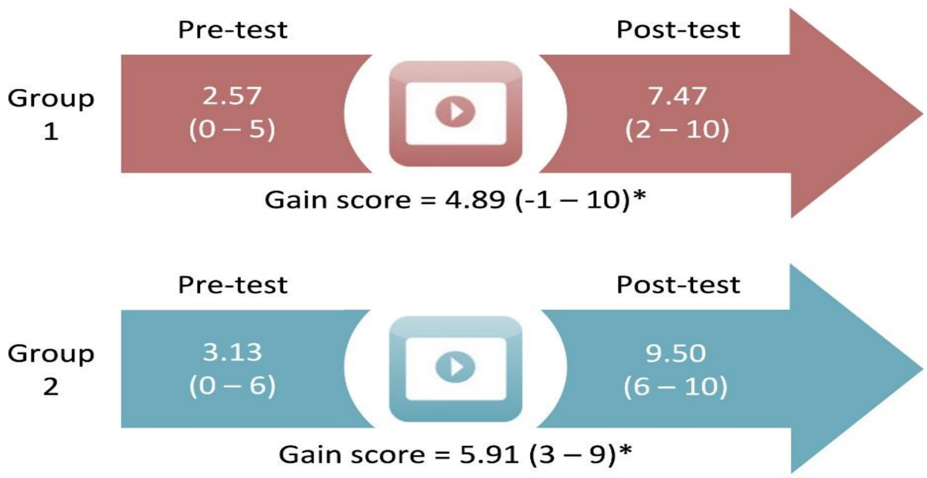

Figure 1. Test results in phase A. $*p \leq 0.001$ (Wilcoxon signed-rank test).

Phase B

No significant differences in baseline knowledge were observed between the two groups (Mann-Whitney U test, p = 0.800). Both groups experienced a significant increase in scores from pre- to mid-test ($p \leq 0.001$) **(Figure 2)**, with similar improvements whether students viewed the RL or attended the FL (p = 0.915). Gains from mid- to post-test were smaller but remained statistically significant (p = 0.021 for group 1 and p = 0.022 for group 2) and showed no meaningful difference between the groups (p = 0.417). These results indicate that revisiting the same lecture in a different format contributes additional knowledge, independent of the order in which the lecture formats are presented.

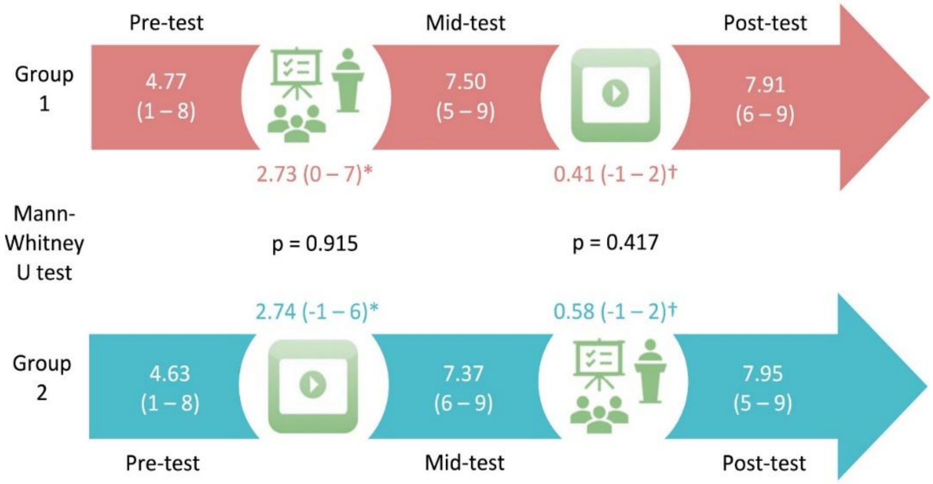

Figure 2. Test outcomes in phase B. ∗$p \leq 0.001$ (Wilcoxon signed-rank test); †p = 0.021 for Group 1 and p = 0.022 for Group 2 (Wilcoxon signed-rank test).

Survey results on student perceptions of RLs showed general agreement with their use, with a mean rating of 4.07 (see SM6).

Phase C

The VARK questionnaire revealed that kinesthetic (10 participants, 40%) and reading/writing (9 participants, 36%) were the most frequently reported learning styles. No students demonstrated a multimodal preference. Learning style did not appear to correspond with RL use, as neither the group that viewed the RL (FG1) nor the group that did not (FG2) showed a predominant style. **Table 3** provides a summary of the subthemes identified under the three main themes, which are discussed in greater detail below. Relevant participant quotations (Q) can be found in SM7.

Table 3. Themes and subthemes of FGs.

Theme	Subthemes
Perceptions of FLs	Value of interactive teaching methods; Role of the instructor; Note-taking practices; Integration of theory and practical application
Perceptions of RLs	RLs as a time-efficient learning tool; RLs as reinforcement for understanding; Teacher–student interaction; Factors discouraging RL usage
Expectations for RLs	Importance of audiovisual elements; Guidance and support from the teacher; Diversity of topics and ease of access

Perceptions about FLs

Importance of a dynamic methodology. Students emphasized that lectures should go beyond simply displaying and reading slides. Monotonous presentations were seen as ineffective, especially when the same material could be reviewed independently at home. They valued teaching approaches that encourage active participation and promote a horizontal, rather than hierarchical, relationship between teacher and student, fostering a more interactive exchange of knowledge (Q1). Conversely, poorly structured lectures led to disengagement, boredom, and even drowsiness among students (Q2).

Importance of the teacher. Participants viewed medical instructors as guides or mentors whose role extends beyond delivering information. They appreciated when teachers shared practical experience and clinical judgment, including recommendations for readings or research topics (Q3–5). Students noted that not all instructors fulfill this role, with some merely reading slides without meaningful interaction (FG4). Professors who are actively engaged in research, maintain up-to-date knowledge, and are recognized in their fields were particularly valued, as this encouraged attendance and reinforced the students' sense of being part of a prestigious institution (Q6–7). Additionally, students paid attention to the teacher as a role model, observing professional behavior, communication style, and appearance (Q8).

Taking notes. Many students reported using mobile devices, such as tablets or smartphones, to take notes and create diagrams. They also downloaded presentation slides to annotate directly. However, they acknowledged that note-taking sometimes divided their attention and made it difficult to follow the lecture, prompting some to record the lecture for later review (Q9).

Balance between theory and practice. Students stressed the importance of integrating theoretical knowledge with practical clinical experience. They valued when teachers illustrated concepts with real patient cases, connecting new material to professional practice and enhancing comprehension (Q10–11).

Classroom environment. Although not part of the original discussion guide, participants spontaneously highlighted the role of the physical classroom environment. Poor infrastructure or uncomfortable conditions were seen as detrimental to attention and learning (Q12–13).

Perceptions about RLs

RLs and time management. Students highlighted that one of the main advantages of RLs is the flexibility to organize their own study schedules, which they associated with the autonomy and responsibility of being university students. This flexibility contrasted with FLs, which they perceived as more rigid and time-consuming due to fixed schedules (Q14). Travel to clinical rotations or distant lecture halls was seen as a significant drawback of FLs, whereas online RLs allowed students to better allocate their time, reduce commuting, and optimize their study routines (Q15–16). The ability to pause, replay, or adjust playback speed also enabled them to study at their own pace and in comfortable settings, such as while having coffee or lying in bed (Q17–18).

RLs as learning reinforcement. Participants viewed RLs as an effective tool for reinforcing knowledge, particularly when tailored to students' needs. They noted two key benefits: first, RLs reduce distractions commonly experienced in FLs, such as drowsiness, poor classroom conditions, or divided attention due to note-taking (Q19); second, RLs can be reviewed collaboratively with peers, enhancing understanding through discussion (Q20). Nonetheless, some students felt that FLs helped maintain focus because the presence of the instructor created a structured environment (Q21). Several students suggested that RLs should be made available prior to clinical rotations, allowing them to engage with the material in advance and contribute more meaningfully during FLs (Q22). They also emphasized that RLs alone are insufficient for effective learning; dynamic and interactive elements are necessary to maintain engagement and accommodate different learning preferences (Q23–25).

Teacher–student relationship. Some participants expressed concern that relying solely on RLs could undermine the development of critical thinking, professional skills, and human interaction, which are cultivated through direct engagement with instructors (Q26–27).

Reasons for not watching RLs. Among the six students in FG2 who were invited to watch an RL but did not, reasons included technical difficulties (two students; Q28–29), perceived lack of value in watching the lecture (two students; Q30–31), and time constraints due to other commitments (two students; Q32–33).

Expectations regarding RLs

Importance of audiovisual elements. Students emphasized that incorporating audiovisual techniques in RLs could enhance learning. They suggested alternating between slides and brief shots of the teacher to reduce monotony (Q34). The addition of visual cues, such as arrows, images, videos, closed captions, or sound effects, was seen as a way to reinforce key points and improve comprehension (Q35–36). At the same time, students noted that focusing on the teacher's face can help convey emphasis through gestures or body language, highlighting important content (Q37). High-quality audio was also considered essential; one participant reported that in a previous RL, the instructor's voice was too low, underlining the need to check audiovisual quality before release.

Teacher support. Students highlighted that RLs lack the immediate interaction available in FLs, which allows questions to be addressed in real time. Some proposed integrating a chat feature to enable questions during the lecture. However, this would require scheduling the RLs when the teacher is available, potentially limiting the flexibility and autonomy that RLs offer (Q38).

Variety of topics and accessibility. Participants expressed a desire for a broader range of RLs covering more topics to encourage their use. They recommended maintaining a video library where RLs are fully accessible and downloadable at any time, rather than being restricted by the official platform (Q39). Students also suggested incorporating periodic reinforcement questions and pre- and post-tests to support learning (Q40–41), but they opposed restricting access to subsequent RL sections until questions were answered correctly, as this could interfere with individual learning pace and cognitive preferences.

Phase D

At baseline, both groups demonstrated comparable levels of knowledge (p = 0.609, Mann-Whitney U test). Consistent with the findings from phases A and B, both groups showed a significant increase in knowledge after viewing the RLs **(Figure 3)** (SM8). However, the inclusion of supplementary materials in the RL for group 2 did not lead to additional knowledge gains (p = 0.767).

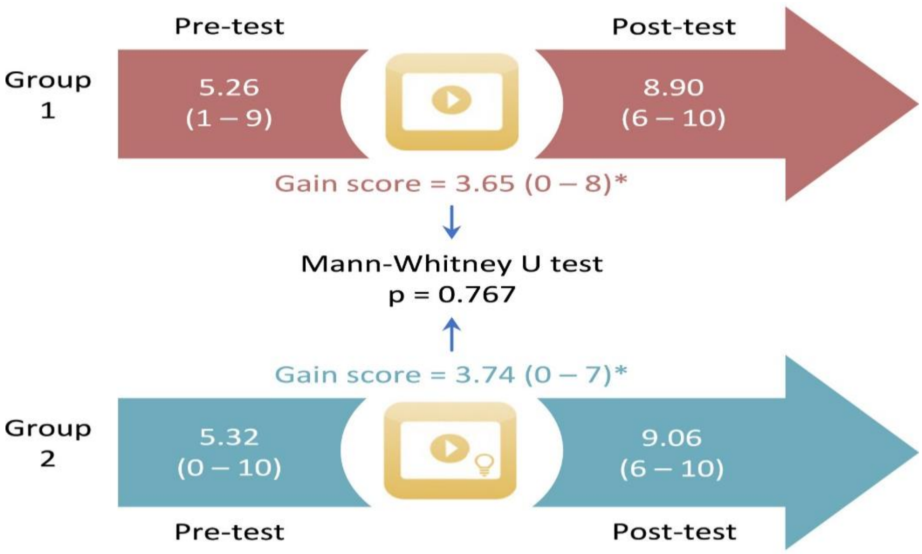

Figure 3. Test results in phase D. ∗p ≤ 0.001 (Wilcoxon signed-rank test).

This study demonstrates that recorded lectures (RLs) produce comparable knowledge gains to traditional face-to-face lectures (FLs), supporting their use in clinical courses. In phase A, RLs were effective in increasing students' knowledge, consistent with findings from previous studies in areas such as cataract surgery [33], dermatology [34], and management of violent patients [35].

Phase B showed that knowledge acquisition was similar regardless of whether content was delivered via RL or FL. Comparable results have been reported in studies on cardiac ultrasound [36] and sleep medicine [37]. Furthermore, viewing an RL before or after the corresponding FL led to similar learning gains, indicating that RLs can serve as a valuable complement to FLs. However, student proficiency with technology can influence outcomes. For instance, Backhaus *et al*. reported that "digital natives" scored lower than "traditional learners" on a goitre lecture delivered face-to-face, whereas both groups achieved similar results with RLs [38]. While students are generally comfortable with technology, not all may engage with all available RLs, but this should not preclude the inclusion of RLs as supplementary material.

Phase C highlighted the importance of a dynamic teaching methodology. Students emphasized that interactive and participatory lectures enhance engagement and learning, a finding echoed in research at Robert Wood Johnson Medical School, where students preferred FLs with strong visual and interactive components [9]. Conversely, monotonous FLs, characterized by passive slide reading without active participation, were criticized. Students cautioned that RLs adopting such methods would lose their advantages, underscoring the need for thoughtful design. Similar observations were made at the University of Queensland, where content quality, structure, and format of RLs emerged as key determinants of student satisfaction [39].

Students valued RLs for the flexibility they provide, allowing independent management of study time, control over playback, and the ability to pause or rewind content (Q14–18). Studies by Jordan *et al*. [40] and Chapman *et al*. [41] reported similar findings, highlighting the appeal of flexible access in acute care and advanced therapeutics courses. These preferences align with the characteristics of students born in the 1990s, who are accustomed to digital environments and have developed study habits shaped by technology [42].
Although RLs were appreciated, students emphasized that they should not replace FLs. The role of medical teachers—sharing experience, providing guidance, and offering human interaction—remains critical to professional development. Students value instructors as mentors, whose presence supports learning and decision-making in clinical contexts. This finding aligns with studies at the University of Massachusetts Medical School [43] and Charité – Universitätsmedizin Berlin [44], where RLs were regarded as a complementary tool rather than a substitute for FLs.
The VARK questionnaire applied in phase C indicated that kinesthetic and reading/writing were the predominant learning styles. Students' preference for interactive case discussions aligns with kinesthetic learning, while valuing slide-based note-taking aligns with reading/writing learning styles. Graphical summaries, relevant for visual learners, did not enhance knowledge gain in phase D, and the ability to replay RL segments suggested lower reliance on auditory learning.
In phase D, adding periodic questions and summary slides to the RL did not improve knowledge gains, likely because students in advanced clinical years were already adept at extracting key information, and some reached maximum post-test scores. Future studies could increase the number of assessment items to detect subtle differences. In contrast, a study at Harvard University found that embedding questions within RLs helped students maintain attention, enhance annotations, and reduce cognitive load [45].
This study has several limitations. Due to academic constraints, a fully randomized, parallel-group comparison of RLs versus FLs could not be conducted. Not all students in phase A viewed the RL, and phase B group assignments were predetermined by the Undergraduate Direction, limiting randomization. The small sample size in phase B restricted detection of minor differences. Additionally, focus group participation was predominantly female, introducing potential bias and preventing analysis of cross-gender differences in learning preferences. Future research should examine gender-related differences in learning styles and outcomes.
Considering students' appreciation of FLs and the advantages of RLs, we recommend implementing a flipped classroom or blended learning model [46]. In this approach, RLs and supplementary materials are accessed online, while in-person sessions focus on case discussions, problem-based learning, and addressing questions that arise during self-directed study. Recent meta-analyses and scoping reviews support the effectiveness of flipped classrooms in improving learning outcomes in both preclinical and clinical years of undergraduate medical education [47, 48].

Acknowledgments: We are grateful to the students for their participation in this study.

Conflict of Interest: None

Financial Support: This work was supported by the Fogarty International Center, United States National Institutes of Health (D43TW008438-0109).

Ethics Statement: None

References

1. Vaona A, Banzi R, Kwag KH, Rigon G, Cereda D, Pecoraro V. E-learning for health professionals. Cochrane Database Syst Rev. 2018.
2. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of e-learning in medical education. Acad Med. 2006;81(3):207-12.
3. Boruff JT, Storie D, Smith A, Brown T, Clark R, Lee J. Mobile devices in medicine: a survey of how medical students, residents, and faculty use smartphones and other mobile devices to find information. J Med Libr Assoc. 2014;102(1):22-30.
4. Gurpinar E, Bati H, Tetik C, Yilmaz S, Demir A, Kaya F. Learning styles of medical students change in relation to time. Adv Physiol Educ. 2011;35(3):307-11.

5. Judd T, Kennedy G, Smith A, Brown T, Clark R, Lee J. A five-year study of on-campus internet use by undergraduate biomedical students. Comput Educ. 2010;55(4):1564-71.
6. Han H, Nelson E, Wetter N, Smith A, Brown T, Clark R. Medical students' online learning technology needs. Clin Teach. 2014;11(1):15-9.
7. Shi C, Wang L, Li X, Chai S, Niu W, Kong Y. Virtual classroom helps medical education for both Chinese and foreign students. Eur J Dent Educ. 2015;19(4):217-21.
8. Mooney GA, Bligh JG, Smith A, Brown T, Clark R, Lee J. Information technology in medical education: current and future applications. Postgrad Med J. 1997;73(865):701-4.
9. Gupta A, Saks NS, Smith A, Brown T, Clark R, Lee J. Exploring medical student decisions regarding attending live lectures and using recorded lectures. Med Teach. 2013;35(9):767-71.
10. Harden RM, Smith A, Brown T, Clark R, Lee J, Wilson K. A new vision for distance learning and continuing medical education. J Contin Educ Health Prof. 2005;25(1):43-51.
11. Davis N, Davis D, Bloch R, Smith A, Brown T, Clark R. Continuing medical education: AMEE education guide No 35. Med Teach. 2008;30(7):652-66.
12. Prakash SS, Muthuraman N, Anand R, Smith A, Brown T, Clark R. Short-duration podcasts as a supplementary learning tool: perceptions of medical students and impact on assessment performance. BMC Med Educ. 2017;17(1):16.
13. Beale EG, Tarwater PM, Lee VH, Smith A, Brown T, Clark R. A retrospective look at replacing face-to-face embryology instruction with online lectures in a human anatomy course. Anat Sci Educ. 2014;7(3):234-41.
14. Evans DJR, Smith A, Brown T, Clark R, Lee J, Wilson K. Using embryology screencasts: a useful addition to the student learning experience? Anat Sci Educ. 2011;4(2):57-63.
15. Singh A, Min AKK, Kim J, Lee S, Park H, Choi Y. Digital lectures for learning gross anatomy: a study of their efficacy. Korean J Med Educ. 2017;29(1):27-32.
16. White LJ, McGowan HW, McDonald AC, Smith A, Brown T, Clark R. The effect of content delivery style on student performance in anatomy. Anat Sci Educ. 2019;12(1):43-51.
17. Clarkson CW, Franklin DS, Gibson JW, Samuel JC, Teeter WA, Smith A. Use of lecture recordings in medical education. JIAMSE. 2011;21(1):21-8.
18. Pilarski PP, Johnstone DA, Pettepher CC, Osheroff N, Smith A, Brown T. From music to macromolecules: using rich media/podcast lecture recordings to enhance the preclinical educational experience. Med Teach. 2008;30(6):630-2.
19. Topale L, Smith A, Brown T, Clark R, Lee J, Wilson K. The strategic use of lecture recordings to facilitate an active and self-directed learning approach. BMC Med Educ. 2016;16(1):201.
20. McNulty JA, Hoyt A, Gruener G, Chandrasekhar A, Espiritu B, Price R. An analysis of lecture video utilization in undergraduate medical education: associations with performance in the courses. BMC Med Educ. 2009;9:6.
21. Cardall S, Krupat E, Ulrich M, Smith A, Brown T, Clark R. Live lecture versus video-recorded lecture: are students voting with their feet? Acad Med. 2008;83(12):1174-8.
22. Bridge PD, Jackson M, Robinson L, Smith A, Brown T, Clark R. The effectiveness of streaming video on medical student learning: a case study. Med Educ Online. 2009;14:11.
23. Bacro TRH, Gebregziabher M, Fitzharris TP, Smith A, Brown T, Clark R. Evaluation of a lecture recording system in a medical curriculum. Anat Sci Educ. 2010;3(6):300-8.
24. Zureick AH, Burk-Rafel J, Purkiss JA, Hortsch M, Smith A, Brown T. The interrupted learner: how distractions during live and video lectures influence learning outcomes. Anat Sci Educ. 2018;11(4):366-76.
25. Burnette K, Ramundo M, Stevenson M, Beeson MS, Smith A, Brown T. Evaluation of a web-based asynchronous pediatric emergency medicine learning tool for residents and medical students. Acad Emerg Med. 2009;16(Suppl 2):S46-50.
26. Karam-Hage M, Maher KH, Brower KJ, Mullan PB, Gay T, Gruppen LD. Web-streamed didactic instruction on substance use disorders compares favorably with live lecture format. Acad Psychiatry. 2013;37(3):165-70.
27. Schreiber BE, Fukuta J, Gordon F, Smith A, Brown T, Clark R. Live lecture versus video podcast in undergraduate medical education: a randomised controlled trial. BMC Med Educ. 2010;10:68.
28. Brockfeld T, Muller B, de Laffolie J, Smith A, Brown T, Clark R. Video versus live lecture courses: a comparative evaluation of lecture types and results. Med Educ Online. 2018;23(1):1555434.

29. Alnabelsi T, Al-Hussaini A, Owens D, Smith A, Brown T, Clark R. Comparison of traditional face-to-face teaching with synchronous e-learning in otolaryngology emergencies teaching to medical undergraduates: a randomised controlled trial. Eur Arch Otorhinolaryngol. 2015;272(3):759-63.
30. Tong A, Sainsbury P, Craig J, Smith A, Brown T, Clark R. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007;19(6):349-57.
31. Samano R, Preciado E, Fleming N, Smith A, Brown T, Clark R. Cuestionario VARK. 2007.
32. Merriam SB, Tisdell EJ. Qualitative research: a guide to design and implementation. 4th ed. San Francisco: Jossey-Bass; 2016.
33. Malik U, Kirkby E, Tah V, Bunce C, Okhravi N, Smith A. Effectiveness and acceptability of a cataract surgery teaching video for medical students. Med Teach. 2012;34(2):178.
34. Cipriano SD, Dybbro E, Boscardin CK, Shinkai K, Berger TG, Smith A. Online learning in a dermatology clerkship: piloting the new American Academy of Dermatology medical student core curriculum. J Am Acad Dermatol. 2013;69(2):267-72.
35. Ball CA, Kurtz AM, Reed T, Smith A, Brown T, Clark R. Evaluating violent person management training for medical students in an emergency medicine clerkship. South Med J. 2015;108(9):520-3.
36. Cawthorn TR, Nickel C, O'Reilly M, Kafka H, Tam JW, Jackson LC. Development and evaluation of methodologies for teaching focused cardiac ultrasound skills to medical students. J Am Soc Echocardiogr. 2014;27(3):302-9.
37. Bandla H, Franco RA, Simpson D, Brennan K, McKanry J, Bragg D. Assessing learning outcomes and cost effectiveness of an online sleep curriculum for medical students. J Clin Sleep Med. 2012;8(4):439-43.
38. Backhaus J, Huth K, Entwistle A, Homayounfar K, Koenig S, Smith A. Digital affinity in medical students influences learning outcome: a cluster analytical design comparing vodcast with traditional lecture. J Surg Educ. 2019;76(3):711-9.
39. Sturman N, Mitchell B, Mitchell A, Smith A, Brown T, Clark R. Nice to watch? Students evaluate online lectures. Clin Teach. 2018;15(1):19-23.
40. Jordan J, Jalali A, Clarke S, Dyne P, Spector T, Coates W. Asynchronous vs didactic education: it's too early to throw in the towel on tradition. BMC Med Educ. 2013;13:105.
41. Chapman C, White CB, Engleberg C, Fantone JC, Cinti SK, Smith A. Developing a fully online course for senior medical students. Med Educ Online. 2011;16.
42. Vie S, Smith A, Brown T, Clark R, Lee J, Wilson K. Digital divide 2.0: "generation M" and online social networking sites in the composition classroom. Comput Compos. 2008;25(1):9-23.
43. Billings-Gagliardi S, Mazor KM, Smith A, Brown T, Clark R, Lee J. Student decisions about lecture attendance: do electronic course materials matter? Acad Med. 2007;82(10 Suppl):S73-6.
44. Nast A, Schafer-Hesterberg G, Zielke H, Sterry W, Rzany B, Smith A. Online lectures for students in dermatology: a replacement for traditional teaching or a valuable addition? J Eur Acad Dermatol Venereol. 2009;23(9):1039-43.
45. Szpunar KK, Khan NY, Schacter DL, Smith A, Brown T, Clark R. Interpolated memory tests reduce mind wandering and improve learning of online lectures. Proc Natl Acad Sci U S A. 2013;110(16):6313-7.
46. Staker H, Horn MB. Classifying K-12 blended learning. Innosight Institute; 2012.
47. Hew KF, Lo CK. Flipped classroom improves student learning in health professions education: a meta-analysis. BMC Med Educ. 2018;18(1):38.
48. Tang B, Coret A, Qureshi A, Barron H, Ayala AP, Law M. Online lectures in undergraduate medical education: scoping review. JMIR Med Educ. 2018;4(1):e11.