ORIGINAL ARTICLE

Beyond Academic Achievement: The Impact of a Multi-Platform Flipped Classroom on Student Engagement and Satisfaction in Practical Microbiology

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Background: The integration of digital technologies into medical education has necessitated a shift toward student-centered pedagogical models. This study aimed to evaluate the impact of a multi-platform flipped classroom (FC) model on academic achievement, student engagement, and satisfaction within a practical microbiology course.

Method: A retrospective cohort study was conducted involving 70 medical laboratory students at Mashhad University of Medical Sciences. The cohorts were divided into a traditional group (n = 35; year 2024) and an FC group (n = 35; year 2025). The FC group engaged in asynchronous pre-class preparation via instructional videos and digital resources, reinforced by mandatory introductory quizzes, while synchronous lab time was dedicated to interactive manual techniques. Data were collected using final academic grades and a validated 6-item Likert scale questionnaire. Statistical analysis was performed using independent t-tests.

Results: Although the FC group achieved a slightly higher mean grade (17.06 ± 2.66) compared to the traditional group (16.89 ± 1.95), the difference was not statistically significant (P = 0.76). However, the FC model yielded a substantial increase in student satisfaction (4.86 ± 0.4) compared to the traditional group (3.70 ± 0.90) ($p < 0.001$) and active engagement (4.67 ± 0.52) compared to the traditional group (3.25 ± 0.88) ($p < 0.001$). Notably, class participation scores increased by 87% in the flipped cohort.

Conclusion: While the flipped classroom model did not significantly alter raw academic scores, it fundamentally enhanced the educational environment by fostering superior student engagement and satisfaction. This model represents a robust alternative for practical laboratory instruction in the digital era.

Keywords: Flipped Classroom, Microbiology, Medical Education, Student Engagement, Active Learning

ماوراء التحصيل الأكاديمي: أثر الفصل الدراسي المعكوس متعدد المنصات على مشاركة الطلاب ورضاهم في علم الأحياء الدقيقة العملي

الخلفية: استلزم دمج التقنيات الرقمية في التعليم الطبي تحولاً نحو نماذج تربوية تركز على الطالب. هدفت هذه الدراسة إلى تقييم أثر نموذج الفصل الدراسي المعكوس متعدد المنصات على التحصيل الأكاديمي، ومشاركة الطلاب، ورضاهم في مقرر عملي في علم الأحياء الدقيقة.

الطريقة: أجريت دراسة أترابية استرجاعية شملت ٧٠ طالبًا في مختبرات الطب بجامعة مشهد للعلوم الطبية. قُسّمت الأتراب إلى مجموعتين: مجموعة تقليدية (ن = ٣٥؛ دفعة ٢٠٢٤) ومجموعة الفصل الدراسي المعكوس (ن = ٣٥؛ دفعة ٢٠٢٥). شاركت مجموعة الفصل الدراسي المعكوس في تحضير غير متزامن قبل الحصة عبر مقاطع فيديو تعليمية وموارد رقمية، مدعومة باختبارات تمهيدية إلزامية، بينما خُصص وقت المختبر المتزامن للتقنيات اليدوية التفاعلية. جُمعت البيانات باستخدام الدرجات الأكاديمية النهائية واستبيان مُعتمد من ستة بنود بمقياس ليكرت. أُجري التحليل الإحصائي باستخدام اختبارات t المستقلة.

النتائج: على الرغم من أن مجموعة الفصل الدراسي المقلوب حققت متوسط درجات أعلى قليلاً (١٧,٠٦ ± ٢,٦٦) مقارنةً بالمجموعة التقليدية (١٦,٨٩ ± ١,٩٥)، إلا أن هذا الفرق لم يكن ذا دلالة إحصائية (P = 0.76). مع ذلك، أدى نموذج الفصل الدراسي المقلوب إلى زيادة ملحوظة في رضا الطلاب (٤,٨٦ ± ٠,٤) مقارنةً بالمجموعة التقليدية (٣,٧٠ ± ٠,٩٠) (P < 0.001)، وفي مشاركتهم الفعّالة (٤,٦٧ ± ٠,٥٢) مقارنةً بالمجموعة التقليدية (٣,٢٥ ± ٠,٨٨) (P < 0.001). والجدير بالذكر أن درجات المشاركة الصفية ارتفعت بنسبة ٨٧٪ في مجموعة الفصل الدراسي المقلوب.

الخلاصة: على الرغم من أن نموذج الفصل الدراسي المقلوب لم يُحدث تغييرًا ملحوظًا في الدرجات الأكاديمية الخام، إلا أنه حسّن البيئة التعليمية بشكلٍ جوهري من خلال تعزيز مشاركة الطلاب ورضاهم. يُمثل هذا النموذج بديلاً فعالاً للتدريس العملي في المختبرات في العصر الرقمي.

الكلمات المفتاحية: الصف المقلوب، علم الأحياء الدقيقة، التعليم الطبي، مشاركة الطلاب، التعلم النشط

تعلیمی کامیابی سے آگے: عملی مائکرو بایولوجی میں طلب علم کی مصروفیت اور اطمینان پر ایک کثیر پلیٹ فارم فلپ کلاس روم کا اثر

پس منظر: میڈیکل ایجوکیشن میں ڈیجیٹل ٹیکنالوجیز کے انضمام نے طلباء پر مبنی تعلیمی ماڈلز کی طرف تبدیلی کی ضرورت پیش کی ہے۔ اس مطالعہ کا مقصد ایک عملی مائکرو بایولوجی کورس کے اندر تعلیمی کامیابی، طالب علم کی مصروفیت، اور اطمینان پر ملٹی پلیٹ فارم فلپڈ کلاس روم (FC) ماڈل کے اثرات کا جائزہ لینا تھا۔

طریقہ: مشہد یونیورسٹی آف میڈیکل سائنسز میں میڈیکل لیبارٹری کے ۷۰ طلباء پر مشتمل ایک سابقہ مشترکہ مطالعہ کیا گیا۔ کوہورٹس کو ایک روایتی گروپ (n = 35؛ سال ۲۰۲۳) اور ایک FC گروپ (n = 35؛ سال ۲۰۲۵) میں تقسیم کیا گیا تھا۔ FC گروپ انسٹرکشنل ویڈیوز اور ڈیجیٹل وسائل کے ذریعے غیر مطابقت پذیر پری کلاس تیاری میں مصروف تھا، جسے لازمی تعارفی کوئزز کے ذریعے تقویت ملی، جبکہ ہم وقت ساز لیب کا وقت انٹرایکٹو دستی تکنیکوں کے لیے وقف تھا۔ حتمی تعلیمی درجات اور ایک توثیق شدہ ٦ آئٹم لیکرٹ اسکیل سوالنامے کا استعمال کرتے ہوئے ڈیٹا اکٹھا کیا گیا۔ شماریاتی تجزیہ آزاد ٹی ٹیسٹ کا استعمال کرتے ہوئے کیا گیا تھا۔

نتائج: اگرچہ FC گروپ نے روایتی گروپ (١٦,٨٩ ± ١,٩٥) کے مقابلے قدرے زیادہ اوسط درجے (١٧,٠٦ ± ٢,٦٦) حاصل کیے، لیکن فرق اعداد و شمار کے لحاظ سے اہم نہیں تھا (P = 0.76)۔ تاہم، FC ماڈل نے روایتی گروپ (٣,٧٠ ± ٠,٩٠) (P < 0.001) اور فعال مصروفیت (٣,٦٧ ± ٠,٥٢) روایتی گروپ (P 0.1 ± 3.25) (٣,٢٥ ± ٠,٨٠) کے مقابلے میں طلباء کے اطمینان (٣,٨٦ ± ٠,٣) میں خاطر خواہ اضافہ کیا۔ خاص طور پر، پلٹائے گئے گروہ میں کلاس میں شرکت کے اسکور میں ٨٧٪ اضافہ ہوا۔

نتیجہ: اگرچہ پلٹائے گئے کلاس روم ماڈل نے خام تعلیمی اسکورز کو نمایاں طور پر تبدیل نہیں کیا، اس نے بنیادی طور پر طالب علم کی مصروفیت اور اطمینان کو فروغ دے کر تعلیمی ماحول کو بہتر کیا۔ یہ ماڈل ڈیجیٹل دور میں لیبارٹری کی عملی ہدایات کے لیے ایک مضبوط متبادل کی نمائندگی کرتا ہے۔

کلیدی الفاظ: فلپڈ کلاس روم، مائکرو بایولوجی، میڈیکل ایجوکیشن، طالب علم کی مصروفیت، ایکٹو لرننگ

فراتر از پیشرفت تحصیلی: تأثیر مدل کلاس معکوس چندپلتفرمی بر مشارکت و رضایتمندی دانشجویان در درس میکروب‌شناسی عملی

زمینه و هدف: ادغام فناوری‌های دیجیتال در آموزش پزشکی، تغییر به سمت مدل‌های پداگوژیک دانشجومحور را ضروری کرده است. این مطالعه با هدف ارزیابی تأثیر مدل کلاس معکوس چندپلتفرمی بر پیشرفت تحصیلی، مشارکت و رضایتمندی دانشجویان در درس میکروب‌شناسی عملی انجام شد.

روش: این مطالعه کوهورت گذشته نگر بر روی ۷۰ دانشجوی علوم آزمایشگاهی دانشگاه علوم پزشکی مشهد انجام شد. شرکت کنندگان به دو گروه سنتی (۳۵ نفر؛ سال تحصیلی ۱۴۰۳) و کلاس معکوس (۳۵ نفر؛ سال تحصیلی ۱۴۰۴) تقسیم شدند. از یک هفته قبل، ویدئوهای آموزشی و منابع دیجیتل در اختیار گروه کلاس معکوس قرار گرفت و سپس کل زمان آزمایشگاه به تکنیک‌های عملی تعاملی اختصاص یافت. داده‌ها از طریق نمرات نهایی و پرسشنامه استاندارد ۶ گویه‌ای لیکرت جمع‌آوری و با آزمون t مستقل تحلیل شدند.

یافته‌ها: اگرچه گروه کلاس معکوس میانگین نمره بالاتری (۲/۶۶ ± ۱۷۰۶) نسبت به گروه سنتی (۱/۹۵ ± ۱۶۸۹) کسب کرد اما این تفاوت از نظر آماری معنادار نبود ($p = 0.76$). با این حال، مدل معکوس منجر به افزایش چشمگیری در رضایتمندی دانشجویان (۰/۴ ± ۴/۸۶) در مقابل مدل سنتی (۰/۹ ± ۳/۷۰) ($p < 0.001$) و افزایش مشارکت فعال (۰/۵۲ ± ۴/۶۷) در مقابل مدل سنتی (۰/۸۸ ± ۳/۲۵) ($p < 0.001$) شد. نمرات مشارکت در کلاس در گروه معکوس ۸۷ درصد رشد داشت.

نتیجه گیری: اگرچه مدل کلاس معکوس نمرات خام تحصیلی را به طور معناداری تغییر نداد، اما با ایجاد مشارکت و رضایتمندی بیشتر، محیط آموزشی را به طور بنیادین ارتقا بخشید این مدل یک جایگزین قدرتمند برای آموزش‌های عملی آزمایشگاهی در عصر دیجیتال محسوب می‌شود.

واژه های کلیدی: کلاس معکوس، میکروب‌شناسی، آموزش پزشکی، مشارکت دانشجویی، یادگیری فعال

INTRODUCTION

Medical education, particularly in skill-based and laboratory-oriented disciplines such as clinical microbiology, plays a central role in training competent medical laboratory professionals (1, 2). Traditional pedagogical approaches typically combine centralized lectures with supervised laboratory practice, but they often face major constraints, including limited time for repeated hands-on practice and insufficient engagement with complex microbiological concepts (3). In recent years, global medical education has shifted from teacher-centered models toward student-centered, active-learning approaches that prioritize higher-order cognitive skills (4, 5).

One of the main innovative models in this transition is the Flipped Classroom (FC). In this model, instructors move the delivery of foundational theoretical knowledge to the asynchronous environment, or pre-class phase, allowing synchronous class time to focus on problem-solving, practical skill acquisition, and higher-level interaction (6). Given the complex nature of microbiology laboratory sessions, which require precise manual dexterity in techniques such as Gram staining, bacterial culture, and microscopic identification, digital platforms for pre-class instruction can reduce students' cognitive load before they enter the laboratory environment (7, 8). Despite the growing adoption of the FC model, evidence regarding its effectiveness in paramedical laboratory settings remains mixed. Some studies report clear improvements in academic performance, whereas others note challenges related to student self-regulation and digital literacy (9-11).

Accordingly, this study aimed to compare the effectiveness of a multi-platform FC model, using Aparat, Telegram, and the "Navid" learning management system (LMS), with that of traditional teaching methods.

METHODS

Study Design and Participants

This retrospective cohort study took place at the Faculty of Paramedical Sciences, Mashhad University of Medical Sciences. The study population consisted of undergraduate medical laboratory students enrolled in the practical microbiology course. After applying the inclusion and exclusion criteria, which excluded students with excessive absences and those who withdrew from the course, the final analysis included 70 students. The participants were divided into two distinct cohorts: the control group (n = 35), representing the 2024 academic year and receiving traditional instruction; and the intervention (FC group) (n = 35), representing the 2025 academic year and receiving instruction through the FC model.

Homogeneity and Group Comparison

To limit potential confounding variables associated with historical cohorts, the study evaluated the baseline characteristics of both groups. Both cohorts entered the program through the national entrance examination under identical academic requirements and followed the same standardized curriculum. The course instructors, educational objectives, and assessment methods also remained constant across both years. The study used a sample size of 35 students per group, consistent with the Central Limit Theorem, to support an approximately normal distribution of data for statistical inference.

Educational Intervention

In the FC (intervention, group), the pedagogical focus shifted to asynchronous pre-class preparation. Students received educational materials, including customized instructional videos hosted on Aparat, digital slides, and detailed handouts, one week before each session through the "Navid" LMS and a dedicated Telegram channel. Figure 1 summarizes the complete structure of this multi-platform FC model and the student learning trajectory. The instructors monitored student compliance with pre-class video viewing through platform-specific metrics, including view counts on Aparat and read receipts on Telegram. To support self-regulated learning and ensure pre-class preparation, instructors administered a short, mandatory quiz at the start of each session. Consequently, synchronous laboratory time focused on hands-on techniques, including Gram staining, bacterial culture interpretation, microscopic examination, and group discussions.

In contrast, the traditional (control) group followed a conventional teacher-centered model. Each session began with a 45-minute theoretical lecture, followed by students spending the remaining time on practical laboratory tasks.

Data Collection Instruments

Two primary instruments were used for data collection:

1. Academic Achievement: The study assessed student performance using a final composite score comprising a theoretical written examination and an Objective Structured Practical Examination (OSPE).
2. Satisfaction and Engagement Questionnaire: The researchers developed a 6-item questionnaire based on a review of existing literature on flipped learning. The instrument used a 5-point Likert scale, ranging from 1, "strongly disagree," to 5, "strongly agree," to assess two domains: "Satisfaction with Teaching Method" (3 items) and "Active Participation/Engagement" (3 items). A panel of educational experts confirmed the questionnaire's content validity.

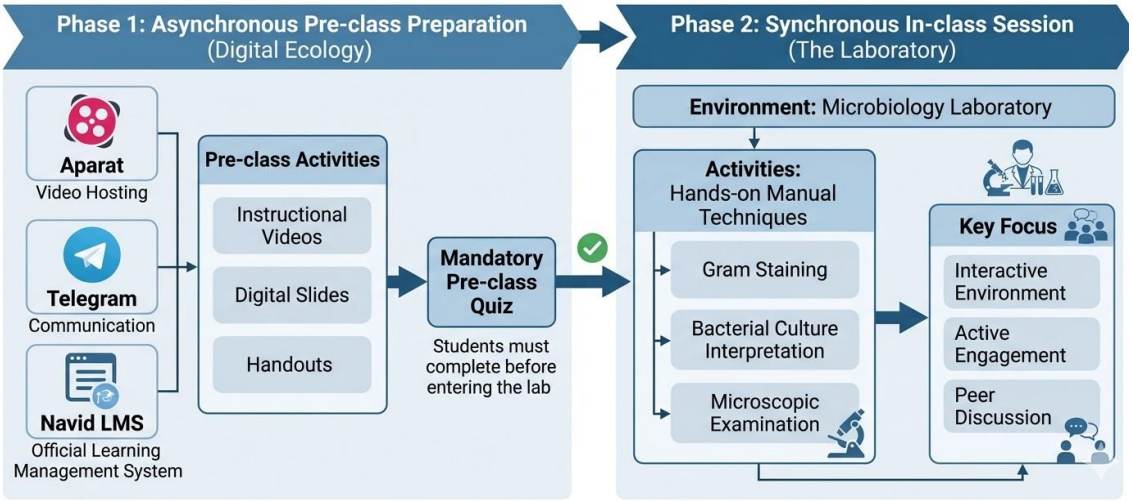

Figure 1. Conceptual Framework of the Multi-Platform Flipped Classroom Model. This flowchart illustrates the student learning trajectory across two distinct phases. Phase 1 (Asynchronous Pre-class Preparation) displays the integration of multiple digital platforms (Aparat, Telegram, Navid LMS) to deliver instructional videos, slides, and handouts, culminating in a mandatory pre-class quiz. Phase 2 (Synchronous In-class Sessions) delineates the practical laboratory activities (e.g., Gram staining, bacterial culture interpretation, microscopic examination) and the subsequent key focus on an interactive, active learning environment through peer discussion

Statistical Analysis

The study analyzed the data using Microsoft Excel. Independent t-tests compared the mean scores and questionnaire ratings between the two groups. Descriptive statistics, including the mean and standard deviation (SD), were reported, and the level of statistical significance was set at $p < 0.05$.

Study Outcomes and Hypothesis

This study defined three primary outcomes: (1) academic achievement, assessed through final composite grades consisting of a theoretical written examination and an Objective Structured Practical Examination (OSPE); (2) student engagement, evaluated through the active participation subscale of the questionnaire; and (3) student satisfaction, measured through the satisfaction subscale of the same instrument. The study hypothesized that the FC model, supported by mandatory pre-class quizzes, would create a more interactive learning environment, produce significantly higher levels of student engagement and satisfaction than the traditional instructional method, and potentially improve academic achievement.

RESULTS

A total of 70 medical laboratory students participated in this study, divided equally into two cohorts of 35 students. The results are presented in two main sections: academic achievement, based on final grades, and student perceptions, based on satisfaction and engagement.

Academic Achievement

The comparison of final composite grades, which comprised theoretical and OSPE assessments, showed that the FC group achieved a higher mean score (17.06 ± 2.66) than the traditional group (16.89 ± 1.95), excluding pre-class quiz scores. However, this difference was not statistically significant ($p = 0.76$). Although the groups showed no significant difference in performance, the FC cohort had greater score dispersion, as indicated by the standard deviation (SD). Table 1 summarizes the detailed grade comparisons.

Table 1. Comparison of Final Grades between Traditional and Flipped Groups

Group	N	Mean Grade (SD)	P-value
Traditional (2024)	35	16.89 (1.95)	0.76
Flipped (2025)	35	17.06 (2.66)	-

Student Satisfaction and Engagement

In contrast to academic performance, questionnaire data showed highly significant differences in all evaluated items in favor of the FC model ($p < 0.001$).

In the satisfaction domain, the FC group reported significantly higher agreement across all items, with the overall satisfaction mean of 4.86 ± 0.40 compared with 3.70 ± 0.90 in the traditional group. Notably, the FC group showed strong agreement regarding their desire to use this method in future courses (4.85 ± 0.429).

In the engagement domain, class participation (Item P1) showed the largest improvement, increasing from 2.51 ± 1.039 in the traditional group to 4.71 ± 0.458 in the FC group. In addition, the FC group, representing the 2025 academic year, showed a consistent reduction in SD across all questionnaire items, indicating a more homogeneous, consistently positive learning experience than the traditional

cohort. Table 2 presents the detailed item-by-item analysis.

Table 2. Comparison of Satisfaction and Engagement Scores (5-point Likert Scale)

Domain / Item	Traditional Mean (SD)	Flipped Mean (SD)	P-value
Satisfaction Domain	3.70 (0.90)	4.86 (0.40)	< 0.001
R1: Satisfaction with delivery method	4.00 (0.76)	4.80 (0.405)	< 0.001
R2: Contribution to concept clarity	4.11 (0.83)	4.91 (0.373)	< 0.001
R3: Preference for future use	3.00 (1.11)	4.85 (0.42)	< 0.001
Engagement Domain	3.25 (0.88)	4.67 (0.52)	< 0.001
P1: Level of participation/questions	2.51 (1.03)	4.71 (0.45)	< 0.001
P2: Active presence vs other courses	3.51 (0.98)	4.51 (0.50)	< 0.001
P3: Perception of interactive environment	3.71 (0.62)	4.77 (0.59)	< 0.001

DISCUSSION

The transition from traditional, teacher-centered pedagogy to student-centered, technology-supported models has become a major feature of modern medical education (12). The present study compared the effectiveness of a multi-platform FC model with traditional teaching methods in a practical microbiology course. The findings show two distinct outcomes: the FC model did not significantly affect academic achievement, as reflected in final grades ($p = 0.76$), but it was associated with a substantial, statistically significant increase in student engagement and satisfaction ($p < 0.001$).

The absence of a statistically significant difference in final grades, 17.06 ± 2.66 in the FC group compared with 16.89 ± 1.95 in the traditional group, requires a nuanced interpretation. This result is consistent with several key studies in medical education, including those by Hew and Lo (2018) and O'Flaherty and Phillips (2015), which suggest that the FC model does not always produce higher terminal scores than traditional lectures (3, 13). More recently, Shi et al. (2025) and Spaic et al. (2025), in large-scale meta-analyses, similarly reported that the effect of FC on academic performance varies across contexts, further supporting the present findings (9, 11).

Two primary factors may explain this nonsignificant outcome. First, the ceiling effect should be considered; the traditional group already achieved a relatively high mean score (16.89/20), leaving limited statistical power to detect a significant increase in the intervention group. Second, the increased standard deviation (SD = 2.66) in the FC group indicates a challenge with self-regulated learning (SRL). Although the FC model allows high-achieving students to benefit from asynchronous digital resources, it may also create challenges for students with lower self-discipline or limited digital literacy, leading to wider score dispersion (14, 15). This suggests that although the FC model can be effective, it may require additional scaffolding for students who struggle with autonomous learning.

The most notable finding of this study was the 87% increase in active class participation (Item P1, mean: 4.71 ± 0.45). This shift can be explained through the lens of inverted Bloom's taxonomy. In the traditional model, students often use class time for lower-order cognitive tasks, such as remembering and understanding through lectures. In the FC model, these tasks shifted to the pre-class phase through localized digital platforms, including Aparat, Telegram, and the Navid LMS. Consequently, synchronous laboratory time focused on higher-order cognitive activities, including the application, analysis, and synthesis of microbiological data. These findings are consistent with those of Algarni (2024) and Ridha et al. (2024), who reported significant improvements in student engagement and active participation after the implementation of flipped learning in biomedical and health science contexts (10, 14). Mandatory pre-class quizzes served as an important extrinsic motivator, helping ensure that students entered the laboratory with a sound theoretical foundation (16). This cognitive preparation likely reduced cognitive load during complex manual tasks, such as Gram staining and bacterial identification, thereby creating a more confident and interactive learning environment (7, 17).

Regarding student satisfaction, the overall mean score in the FC group (4.86 ± 0.40) was markedly higher than that in the traditional group (3.70 ± 0.90), with particular agreement on the desire to use this method in future courses (4.85 ± 0.43). This strong preference for the FC model indicates that the digital-native generation of medical students may respond more favorably to multimodal content delivery. By using accessible platforms such as Aparat and Telegram alongside the official Navid LMS, the model created a digital learning environment that aligned with students' learning habits. These results agree with those of Chen et al. (2025) and Martín-Alguacil and Avedillo (2024), who showed that student-centered, interactive learning environments consistently yield higher satisfaction ratings than conventional lecture-based approaches (4, 5). Furthermore, Phillips and Wiesbauer (2022) noted that the flexibility inherent in the FC model is a key driver of student satisfaction in medical education settings (6).

Despite its strengths, this study has several limitations. The historical cohort design, although practical, cannot fully account for potential generational differences between the two academic years. In addition, the researcher-made questionnaire, although reviewed by experts for content validity, requires further psychometric testing in larger populations.

CONCLUSION

The FC model, supported by multiple digital platforms, may offer a more effective pedagogical strategy for practical microbiology than traditional methods. Although it may not significantly increase raw examination scores in high-performing cohorts, it can promote student engagement and create a highly satisfactory learning environment. Medical universities aiming to train proactive laboratory professionals should consider integrating this model into practical curricula.

Ethical Considerations:

Ethical issues including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc. have been completely observed by the authors. This study was approved by the Ethics Committee of Mashhad University of Medical Sciences (Ethical Code: IR.MUMS.FHMPM.REC.1404.246). All participants provided informed consent, and the study was conducted in accordance with the Declaration of Helsinki (2008). The researchers analyzed the data anonymously to protect student privacy.

ACKNOWLEDGMENTS

This article is based on the General Medicine thesis of Alireza Moaddab (under the supervision of Dr. Alireza Neshani). The authors would like to express their gratitude to the "Research & Technology Chancellor" at Mashhad University of Medical Sciences for the financial support of this study (Grant No. 4041409). We also thank all the medical laboratory students who participated in this research.

Financial Support: Not applicable

Conflict of Interest: The authors declare that they have no competing interests.

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