


Comparisons of the Academic Performance of Medical and Health-Sciences Students Related to Three Learning Methods: A Cross-Sectional Study

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Introduction: The learning methods employed in medical education have substantially transformed from traditional face-to-face (FTF) instruction to online learning modalities. This study sought to quantitatively compare the impact of three learning methods on the academic performance of first-year medical and health sciences students enrolled in a Medical Terminology (MT) course. The learning methods examined include the FTF method, the online-synchronized method, and a blended learning method that combines elements of both. The scope of the analysis encompasses the academic years 2019, 2020, and 2023.

Methods: Academic performance was measured using overall scores and scores derived from the letter grades of 2446 first-year students assigned to the three learning methods that were compared.

Results: A significant improvement in 2023 was observed in the blended learning method, which consisted of 30% FTF and 70% online synchronized lectures for overall scores ($p < 0.0$) and the scores based on the A grades ($p < 0.0$) of students in the MT course, compared to the FTF learning method in 2019 or the online synchronized learning method in 2020.

Conclusion: The blended learning method, which combines FTF with online synchronized learning, appears to be a more effective method for enhancing the academic performance of first-year students compared to either the traditional FTF method or the solely online synchronized method.

Keywords: academic outcomes, blended learning, e-learning, health sciences, medical education, traditional learning

Introduction

Radical changes in educational methods during the COVID-19 pandemic (2020) spread rapidly worldwide along with social distancing, which prompted a transition from the traditional classroom face-to-face (FTF) learning towards more electronic learning (e-learning).^{1,2} Electronic learning (E-learning) adheres to the principles of Connectivism Learning Theory, a proposed learning theory for e-learning environments, where some medical schools adopted the use of technology and electronic media knowledge acquisition, such as virtual lectures.³⁻⁶ It aligns well with the Connectivism Learning Theory, which emphasises learning through a network of interconnected resources. This dynamic, real-time access enriches the online learning experience, making it more collaborative and engaging compared to traditional FTF methods.³⁻⁶ Online learning is a common e-learning instructional design. Yet, studies have reported challenges in the rapid shift from traditional to remote online delivery methods of medical curricula, such as students' engagement and satisfaction levels.⁵ This shift in education also has implications for students' knowledge acquisition, satisfaction, dropout rates, and examination scores.² In a recent study, Turnbull et al reviewed the most significant challenges associated with the transition to online learning, including users' competencies and access to the technology, as well as plagiarism and confidentiality. In the review, a transition to blended learning in which FTF is combined with e-learning was recommended.¹ That review recommended the use of blended learning, which combines FTF with e-learning.¹ In contrast, other online learning studies integrated various learning methods aligned with Connectivism Learning Theory were also used, such as blended learning, in higher education.^{4,7}

Graham (2006)⁸ defined blended learning as “combining the two different education models: traditional FTF learning and distance learning”. Binks et al⁵ referred to blended learning as a solution to overcome the limitations of online lectures where students’ engagement and satisfaction do not reach the level needed for deep learning to occur. Garrison and Vaughan (2008)⁹ described blended learning as combining FTF and computer-mediated components, using different instructional methods, including lectures and discussion groups led by educators who facilitated the learning process.^{8,9} A meta-analysis involving medical students and those in health education reported more significant knowledge gain, highlighting the advantage of incorporating blended learning.² Medical students have accepted blended learning and found it a practical learning approach.^{10,11} Previous studies have found that integrating it in the first years of undergraduate courses in higher education settings contributed to better academic performance, lower dropout rates, and higher exam scores.¹² Blended learning has been reported to be positively associated with accounting students’ academic performance (overall scores) compared to the FTF learning method.¹³

A recent study found that online and blended learning effectively improved second-year male medical students’ grammar skills, with significantly more significant progress among those in a blended learning group, which combined classroom and online learning compared with online learning alone.¹⁴ Although the authors reported the benefits of using blended learning, we were specifically interested in comparing the academic performance from traditional FTF, online synchronized, and blended learning methods in first-year students of method in medical and other health-sciences colleges. Therefore, this study aimed to quantitatively compare the effects of three learning methods (FTF, online synchronized, and blended learning) on the academic performance of first-year medical and health-sciences students in three academic years.

Materials and Methods

Study Design and Data Collection

This comparative study with a cross-sectional design was conducted to analyze data from three academic year cohorts to evaluate the academic performance (ie, scores) of students enrolled in their first year of medical school and those in health-sciences colleges at the Princess Nourah bint Abdulrahman University (PNU) in Saudi Arabia. The study retrieved student scores only from the mandatory course taught in the “two semesters” schedule system for the first year of the medical and health sciences colleges. An FTF learning method was employed before 2020 (before COVID-19), an online synchronized learning method was initiated in 2020 (during COVID-19), and the blended learning method began after the 2020 (after COVID-19) academic year for all students. Scores were retrieved only from students who had completed the scheduled course work within the expected time, attended at least 75% of the courses’ classes planned, and completed all course assessments and the final examination (with either a passing or failing grade in the course). No data from summer course results or second test results of students who failed the courses were included in this study to avoid distorting learning effects. Data were considered only for students who participated in previous studies on the FTF learning method in the two preceding academic years. Ethical approval was obtained from the Ethics Committee Review Board of PNU, Saudi Arabia (HAP-01-R-059), and it was exempt from the IRB review as it poses no more than minimal risk to the participants. Thus, consent was not required from the students to use their scores in this study, but permission was obtained from the responsible authority.

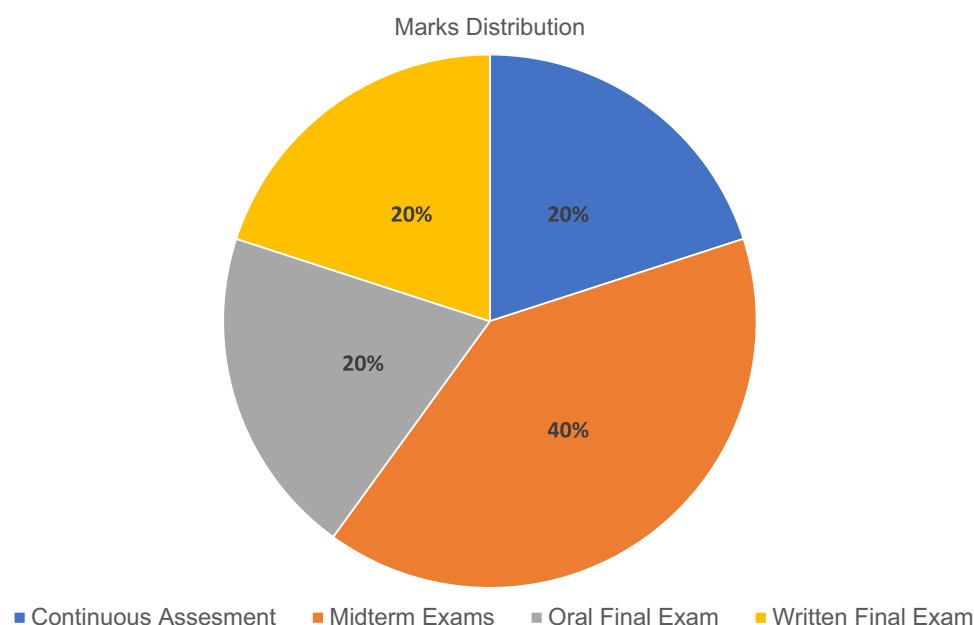
Based on the study’s inclusion criteria, only the Medical Terminology (MT) course was involved in this study. This course is mandatory for all first-year students in all medical and health-sciences programs, including medicine, dentistry, pharmacy, occupational therapy, physiotherapy, nutrition, radiology, respiratory therapy, health-sciences education, clinical psychology, and related undergraduate health and medical disciplines. The academic years included in this study were 2019, 2020, and 2023. The number of included students in the MT course during the three included academic years was 633 students in 2019, 832 in 2020, and 981 in 2023, for a total of 2,446 first-year students. The student’s university numbers, scores, and years of study were retrieved from records of the foundation year of medical and other health-sciences colleges at PNU. The MT course was first implemented as part of the study plan for the first-year curricula in 2019, and it continued to be taught during the 2019, 2020, and 2023 academic years, each year using different methods of learning (Table 1). The MT course had a fixed number of credit hours, content, and learning outcomes throughout this study. It consisted of two credit hours of lectures. The MT curriculum is designed to equip students and healthcare professionals with essential vocabulary in the medical field. It emphasizes the core components of medical terms (prefixes, suffixes, and roots) alongside key concepts in anatomy,

Table 1 Three Types of Learning Methods for First-Year Students in Medical and Health Sciences Within the MT Course Across the Academic Years 2019, 2020, and 2023

	FTF- 2019	Online-2020	Blended-2023
Year	In 2019	In 2020	In 2023
Method	100% of traditional classroom FTF learning method	100% of online Synchronized learning method	Blended method: 30% of FTF learning method and 70% of online synchronized learning method
Delivery	100% of lectures delivered FTF in classrooms	100% of lectures delivered online in real-time	30% of lectures delivered FTF in classrooms and 70% of lectures delivered online in real-time

Abbreviations: MT, medical terminology; FTF, face-to-face.

physiology, and disease processes to enhance understanding and communication in healthcare. The content of this course covered the following topics: building medical terms for disease, terms related to the human body system, medical diagnoses, and treatment. The material is presented through 11 lectures, with each lecture lasting two hours. The MT course had six learning outcomes. Three knowledge outcomes included recognizing, defining, and describing medical terms related to the body systems in health and disease. Two skills outcomes covered pronunciation and spelling abilities, and one competence-learning outcome involved demonstrating autonomous learning skills by completing online assignments. A group of medical educational staff with PhD degrees and experience in course design constructed the MT course de novo to be delivered in 2019 as one with a 100% FTF learning method. In 2020, during COVID-19, the course was revised to be delivered via a remote online-synchronized learning method. After 2020, the blended learning method was used for this course. It consisted of a 30% FTF learning method to cover the skills and competence outcomes and a 70% online-synchronized learning method to cover the learning of knowledge outcomes. A team of qualified English and medical educators from the previous designer group redesigned the learning method for the course after 2020. The qualified educational designers from the electronic learning administration at PNU were charged with effectively integrating FTF and online components. The institutional support for this study included technical support, tools, and professional designers during all periods. The marking scheme, which was followed during the years covered by this study, was consistent. The MT course assessments were conducted throughout the semester and included 20% of the marks for the continuous evaluation (submitted via Blackboard) and 40% for two midterm formal exams. The final assessments were conducted at the end of the semester after the course was completed, and they consisted of oral and written final exams, which were formal exams with a total of 40% of the marks. (Figure 1).

**Figure 1** MT course marks distributions for first-year students in medical and health sciences.

The questions on the formal examinations were randomly selected from a questions bank, composed of items written and updated annually by course instructors and the examination committee of Quality Assurance. The questions of the final written exams were constructed to test the course's learning outcomes, with a difficulty level ranging from low to medium to high, and with consideration for the expected time needed by students to answer each question. The exams consisted of the following items: multiple choice, matching, short answer, and fill the gap. All formal exams were conducted FTF in classrooms, except for the online learning methods in 2020, when they were performed live online. The total overall achievement score for each course was 100, which was calculated by summing the 60 scores of the semester assessments and 40 scores of the final evaluations. The time dedicated to all the formal assessments and the instructors selected from a group of medical and other health sciences educators were the same throughout the study period. This consistency strengthens the construct validity of the student's academic performance measures. Their overall scores are the outcomes that represent their academic performance.

In this study, synchronous learning refers to live-streaming lectures and learning activities where instructors and students interacted online in "real-time", and students' attendance was mandatory for at least 85% of the lectures. In all three learning methods in all three cohorts (Table 1), video- and audio-recording method of all course lectures was incorporated, where all students were allowed to access them via Blackboard at their own pace at any time during the academic semester. These video podcasts consisted of slides designed using Microsoft PowerPoint™ and identical to the FTF slides. Native English instructors experienced in lecturing and podcasting set up and recorded the lectures at the beginning of the semester. The content and duration of the lectures were the same as those presented in FTF learning. The video-recorded lectures were available for students all the time until the end of the semester. All cohorts can access video-recorded lectures through Blackboard.

Dependent Variables

We compared the students' performance across various learning methods using their overall scores and scores stratified by the letter grading system in the MT course. Academic performance was objectively measured using the students' attained scores, including their assessment components during the semester (60 scores) and final assessments (40 scores). The primary dependent variable in this study was students' academic performance, as measured by their overall scores (0–100). The secondary outcome variable was students' academic performance stratified by the letter grading system as follows: A score (90–100), B score (80–89), C score (70–79), D score (60–69), and F, which was a failing score (less than 60).

Independent Variables

The independent variables of the three learning methods used in this study were as follows:

1. FTF - 2019, where 100% of the lectures were delivered using the traditional classroom FTF learning method;
2. Online - 2020, where 100% of the lectures were delivered online using a synchronized learning method, and;
3. Blended - 2023, where 30% of the lectures were delivered using the FTF learning method and 70% using the synchronized learning method.

Among the undergraduate applicants, PNU accepts those who are the highest score achievers on a cognitive test to be registered annually in the first year of medical school and the health-sciences colleges. Cognitive scoring consisted of students' high school grade average, national aptitude, and national achievement test scores. The two latter tests measure students' analytical and deductive skills and their comprehension, application, and inferences in biology, chemistry, physics, mathematics, and English. The students in all three learning methods had similar supporting technology, including learning management systems, such as Blackboard and support provided by the university, IT support, free internet, and an electronic library, which was available for students to access by computers using the internet, and it included all lectures recorded in video and audio. All FTF lectures were delivered in the classrooms in the same building throughout the three years of the study period. All synchronized online lectures were conducted remotely via an online Microsoft team™, and students used computers and the internet to access online lectures. All educational strategies were similar, where the lectures included PowerPoint

presentations, group work, and group discussion. All the students were provided with the same reading material for the lectures and copies of the lecture slides. No substantial changes were made in the curricula of any courses during the three-year cohort. All learning objectives and outcomes of each course were identical for all learning methods. Instructors were selected annually from the same pool of medical college faculty to teach courses based on the college selections. An identical method for course evaluation was applied to both courses for all delivery methods throughout the three years of the study. All of the teaching sessions included the same information and used similar teaching methods in all learning methods. All faculty and students received appropriate training and continuous support via an e-learning unit.

Statistical Analysis

Descriptive statistics, including percentages, medians, means, and standard deviations, were calculated using Microsoft Excel™ for the outcome variables. All of the outcome variables in this study were continuous, and the overall scores were not normally distributed. Thus, students' performance (overall score distribution) over the three years with the three learning methods was analyzed using the Kruskal Wallis Test for score comparisons. The scores based on the letter grading system, "A score (90–100), B score (80–89), C score (70–79), D score (60–69), and F, which indicates a failing score (less than 60)", were analyzed using the Kruskal Wallis Test. The Two-Sample *T*-test was used for further confirmation since scores were normally distributed. Statistics Kingdom (which analyses online statistical tests in the public domain: <https://www.statskingdom.com>) was used to conduct the Kruskal Wallis statistical tests, and Microsoft Excel™ was used to conduct the Two-Sample *T*-Test for the comparisons. The confidence interval (CI) was 95%, and $p < 0.05$ was considered statistically significant.

Results

As measured by overall scores, academic performance was derived from the 2,446 students enrolled in the first year of medical school and health-sciences colleges in 2019, 2020, and 2023. The scores retrieved from the students showed consistent characteristics throughout the study. Students' ages, genders, and stages of medical education were similar. All the students were females because PNU is a female university, and their ages ranged from 18 to 19 years old. The descriptive statistics included the number of students, as well as the mean, standard deviation, and median of their total scores and letter grading system scores, indicating their academic performance in each learning method for three years (Table 2).

The overall academic performance of the students in the MT course in 2023 using blended learning (30% of FTF learning and 70% of online synchronized learning) exhibited a statistically significant improvement compared with the traditional classroom FTF learning in 2019 and the online synchronized learning in 2020 using Kruskal Wallis Test (Table 3). The latter in 2020 showed an increase in the overall scores compared with the 100% FTF learning method in 2019.

Academic performance based on the letter grading system showed a similar pattern for grade A. The other letter grades (B, C, D, and F) showed no statistically significant differences using the Kruskal Wallis Test (Table 3 and Figure 2). The Two-Sample *T*-Test, showed similar results, but grade C students achieved significantly more C scores in the blended learning method in 2023 than in the FTF method in 2019 using Two Sample *T*-Test ($p < 0.0$).

Discussion

The blended learning method, which incorporated a 30% FTF learning method and a 70% online synchronized method, was associated positively with academic performance among first-year medical and health sciences students in PNU, compared with a sole 100% FTF learning method or a 100% lecture using a sole online-synchronized method in the MT course. The students in the online 2020 group showed better overall scores after the traditional FTF 2019 learning method was revised to use online-synchronized learning, and their scores continued to improve with the 2023 blended learning method.

The observed improvement in the student's scores following the blended learning method, as compared to the FTF and synchronized online methods, may suggest that the blended learning method contributed to enhanced knowledge and skills among the students. The blended method in this study combined online-synchronized lectures, designed to achieve

Table 2 Descriptive of First-Year Students' Academic Performance for 2019, 2020, and 2023 Academic Years in MT Course Students in Medical and Health Sciences

Scores		FTF- 2019	Online-2020	Blended-2023
Overall scores 100–0	n Mean±SD median	633 89.59±8.27 92	833 90.073±9.85 93	981 91.89±9.07 95
A scores 100–90	n % Mean±SD median	388 61% 94.8±2.8 95	553 66% 95.8±2.9 96	713 73% 96.5±2.9 97
B scores 89–80	n % Mean±SD median	167 26% 85.4±2.6 86	168 20% 84.8±3.1 85	164 17% 85.1±2.7 85
C scores 79–70	n % Mean±SD median	60 9% 75.6±2.8 76	61 7% 75.4±2.9 76	66 7% 75.6±3.0 76
D scores 69–60	n % Mean±SD median	16 3% 64.5±3.4 63.5	44 5% 64.9±3.5 66	34 3% 64.6±3.2 65.5
F scores 60–0	n Mean±SD% Median	2 50.5±1.50% 50.5	7 52.5±51% 54	4 50.8±3.90% 50.5

Abbreviations: MT, medical terminology; FTF- 2019, 100% of traditional classroom face-to-face learning method in 2019; Online-2020, 100% of online synchronized learning method in 2020; Blended-2023, Blended method composed of 30% of FTF and 70% of online synchronized learning method in 2023; n, total number of students; SD, standard deviation; %, percentage.

Table 3 Comparisons of the First-Year Students' Academic Performance Between Three Learning Methods for 2019, 2020, and 2023 Academic Years in MT Course in Medical and Health Sciences

Scores	FTF- 2019 vs Online-2020	Online-2020 vs Blended-2023	FTF- 2019 Vs Blended-2023
Total scores 100–0	(p<0.00)	(p<0.0)	(p<0.0)
A scores 100–90	(p<0.00)	(p<0.0)	(p<0.0)
B scores 89–80	(P= 0.07)	(P= 0.22)	(P= 0.24)
C scores 79–70	(P= 0.35)	(P= 0.35)	(p= 0.49)
D scores 69–60	(P= 0.38)	(P= 0.33)	(P= 0.48)
F scores <60	(P=0.24)	(P= 0.47)	(P= 0.47)

Note: Significant at p<0.05 using the Kruskal Wallis Test.

Abbreviations: MT, medical terminology; FTF- 2019, 100% of traditional classroom face-to-face learning method in 2019; Online-2020, 100% of online synchronized learning method in 2020; Blended-2023, Blended method composed of 30% of FTF and 70% of online synchronized learning method in 2023; n, total number of students; SD, standard deviation; %, percentage.

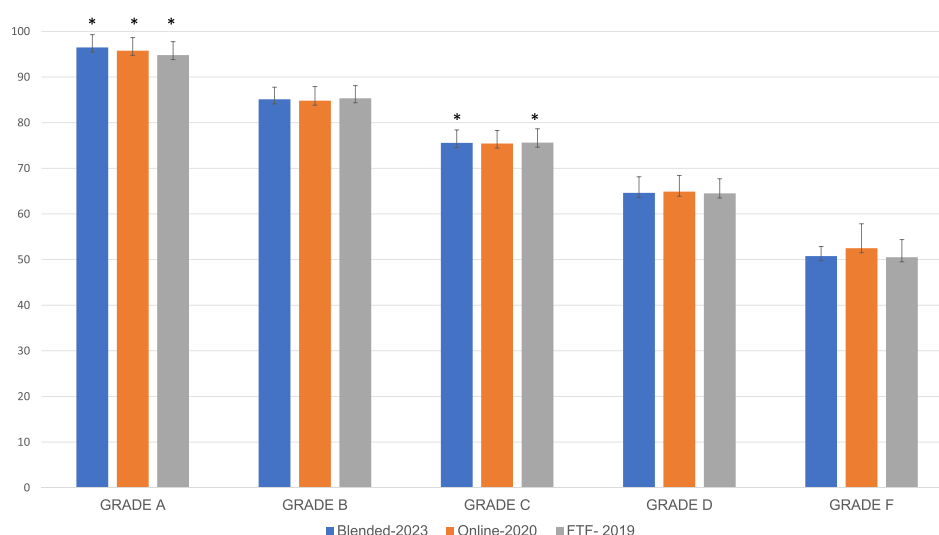


Figure 2 Impact of three learning methods on first-year students' academic performance in MT medical and health sciences courses. *, Significant at $p < 0.05$.

knowledge learning outcomes, and FTF lectures, designed to achieve the skills and competency learning outcomes of the course. Incorporating online elements into the traditional FTF method is considered a successful strategy for constructing blended learning methods.¹ Studies of health science college students have highlighted knowledge acquisition as an advantage of blended learning over traditional learning or learning that depends solely on online education.^{1,2} Consistent with our results, a recent study reported that medical students in their first year performed better on grammatical knowledge and skill acquisition tests when blended learning was used, compared with online learning.¹⁵ Although some studies have found that e-learning is an effective educational tool for undergraduate clinical medicine, other studies have reported that teaching new skills still requires direct observation that involves traditional learning. Students view e-learning as a complementary method rather than a replacement.¹⁵ Binks et al (2021)⁵ referred to blended learning as a solution to overcome the limitations of online lectures where students' engagement and satisfaction do not reach the level needed for deep learning to occur.⁵ Medical students accept blended learning, especially when incorporating educator-led activities.¹¹ The educators and students in our study received continuous proper training in e-learning and support provided by the university's e-learning administration since 2019, which is an essential component of the achievement of successful blended learning.¹

In the present study, the outcomes of the learning methods consisted of students' overall scores (total number of marks awarded) and the letter grading system. Many studies have used these outcomes as objective measures for various learning methods.^{12,16} López-Pérez et al (2011)¹² found that the exam scores of students in higher education have increased and that student dropout rates have decreased using blended learning methods. Moreover, they reported that subjective measures of students' perceptions of blended learning were related to their final marks based on the activities they engaged in during class and factors such as their age, background, and class attendance.

In the present study, not only did overall scores increase significantly when the learning shifted from an FTF to an online method and an online to a blended method, but academic performance also improved as measured by the scores of the A grades. This finding can be explained by the advantages gained from 70% of the online learning components in the blended method of our study. Research conducted in Saudi Arabia at the College of Medicine found that high-achieving students with an A grade GPA in medical education showed a preference for online educational resources, compared with lower-achieving students with lower scores.¹⁶ Another study showed that medical students found online learning encouraging and suggested incorporating training for educators and students to achieve more effective student experiences.¹⁷ A mixed-methods study at PNU on students' and staff's experiences with distance education found that students in the different years of pharmacy college who were recruited for that study showed positive views and readiness to participate in distance learning with the medical and health-sciences students, which might have contributed to our results.¹⁰

Strengths and Weaknesses

We observed that a blended learning method, which included FTF and online synchronized lectures, seemed to lead to some improvements in our study. The large sample size, the multi-health professions design, and the statistical findings are valuable in demonstrating that blended learning is an acceptable alternative to the traditional FTF learning method used in many courses. However, this finding is confined to the academic performance of females because our sample was recruited from an all-female university. Nevertheless, a similar study conducted⁷ on male first-year Saudi medical students showed results that were consistent with our results. Previous findings in the literature on gender performance in learning are inconsistent. Some argue that female students perform better than their male counterparts on exams following hybrid learning methods¹³. In contrast, other studies that contradict this finding have shown no significant gender differences in online learning performance nor in online learning barriers between males and females.^{18,19} However, some studies have reported a negligible effect of gender on online learning.^{18,19} Future research on both genders should be conducted at more than one university on other essential variables, such as academic performance and learning methods. Further studies could incorporate more learning methods, such as hybrid learning, to test the efficacy of different types of blended learning among first-year medical and health-sciences students. The one-time measurement (of exposure and outcomes) makes it impossible to determine a causal relationship between academic performance and learning methods. Thus, a future longitudinal study design that follows students over time, beginning in their first year of studies, would strengthen the association between the two variables and reveal a broader range of interesting findings.

Conclusion

This study quantitatively investigated first-year medical and health-sciences students' academic performance across three years of FTF, online synchronized, and blended learning methods. The results yielded evidence related to the effect of the three learning methods on the academic performance (eg, scores) of the students. The data collected over three years showed that blended learning methods composed of 30% FTF lectures combined with 70% online synchronized lectures are at least as good, if not slightly better, than the two solo methods and most likely improved the academic performance of first-year students. Existing evidence suggests that the appropriate balance between FTF and online-synchronized education, based on course learning outcomes, might improve the academic performance of first-year students. Incorporating this type of blended learning method in higher education could be most useful in medical and health sciences education for the academic performance of first-year students.

The present study has important implications for first-year students majoring in the health profession, including medicine, dentistry, pharmacy, occupational therapy, physiotherapy, nutrition, radiology, respiratory therapy, health education, clinical psychology, and related undergraduate health and medical disciplines. The findings of this study highlight the value of using a blended learning method during the first year of higher education because it is associated with students' academic performance, compared with other learning methods, especially in the MT course. We recommend a blended learning method with a well-designed integration of traditional FTF and online synchronous learning methods. It is essential to consider the appropriate learning method for each course's learning outcome when developing the curriculum for blended learning. Educators and stakeholders could consider e-learning without abandoning their roles as guides and FTF observers for skill acquisition. Furthermore, higher education institutions and universities might find integrating blended learning into their curricula helpful. However, they must also provide sufficient technological and technical support, such as learning management systems and the Internet, and training for students and educators.

Disclosure

The author reports no conflicts of interest in this work.

References

1. Turnbull D, Chugh R, Luck J. Transitioning to e-learning during the COVID-19 pandemic: how have higher education institutions responded to the challenge? *Educ Inf Technol*. 2021;26:6401–6419. doi:10.1007/s10639-021-10633-w
2. Vallée A, Blacher J, Cariou A, Sorbets E. Blended learning compared to traditional learning in medical education: systematic review and meta-analysis. *J Med Internet Res*. 2020;22:e16504. doi:10.2196/16504

3. Al-Balas M, Al-Balas HI, Jaber HM, et al. Distance learning in clinical medical education amid COVID-19 pandemic in Jordan: current situation, challenges, and perspectives. *BMC Med Educ.* 2020;20:341. doi:10.1186/s12909-020-02257-4
4. Alqahtani AY, Rajkhan AA. E-Learning critical success factors during the COVID-19 pandemic: a comprehensive analysis of e-learning managerial perspectives. *Educ Sci.* 2020;10:216. doi:10.3390/educsci10090216
5. Binks AP, LeClair RJ, Willey JM, et al. Changing medical education, overnight: the curricular response to COVID-19 of nine medical schools. *Teach Learn Med.* 2021;33:334–342. doi:10.1080/10401334.2021.1891543
6. Goldie JGS. Connectivism: a knowledge learning theory for the digital age? *Med Teach.* 2016;38(10):1064–1069. doi:10.3109/0142159X.2016.1173661
7. Vranes A, Marković L, Mariokov MJ. Connectivism as a learning theory from the prism of blended learning. In: 8th International Conference of Education, Research and Innovation; November 18–20, 2015; Seville, Spain. ICERI2015 Proceedings, IATED Digital Library.
8. Graham C. Blended learning systems: definition, current trends, and future directions. In: Bonk CJ, Graham CR, editors. *The Handbook of Blended Learning: Global Perspectives, Local Designs.* Pfeiffer; 2006:3–21.
9. Garrison DR, Vaughan ND. *Blended Learning in Higher Education: Framework, Principles, and Guidelines.* John Wiley & Sons; 2008.
10. Altwaijry N, Ibrahim A, Binsuwaidan R, Alnajjar LI, Alsouk BA, Almutairi R. Distance education during COVID-19 pandemic: a college of pharmacy experience. *Risk Manag Health Policy.* 2021;14:2099–2110. doi:10.2147/rmhp.s308998
11. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of e-learning in medical education. *Acad Med.* 2006;81:207–212. doi:10.1097/00001888-200603000-00002
12. López-Pérez MV, Pérez-López MC, Rodríguez-Ariza L. Blended learning in higher education: students' perceptions and their relation to outcomes. *Comput Educ.* 2011;56:818–826. doi:10.1016/j.compedu.2010.10.023
13. Dowling C, Godfrey J, Gyles N. Do hybrid flexible delivery teaching methods improve accounting students' learning outcomes? *Account Educ.* 2003;12:373–391. doi:10.1080/0963928032000154512
14. Ali A, Khan RMI, Alouraini A. A comparative study on the impact of online and blended learning. *SAGE Open.* 2023;13(1). doi:10.1177/21582440231154417
15. Rogers DA, Regehr G, Yeh KA, Howdieshell TR. Computer-assisted learning versus a lecture and feedback seminar for teaching a basic surgical technical skill. *Am J Surg.* 1998;175(6):508–510. doi:10.1016/S0002-9610(98)00087-7
16. Alabdulwahhab KM, Kazmi SY, Sami W, et al. Use of online resources by undergraduate medical students at the College of Medicine, Majmaah University, Kingdom of Saudi Arabia. *PLoS One.* 2021;16:e0255635. doi:10.1371/journal.pone.0255635
17. Salih KM, Elnour S, Mohammed N, et al. Climate of online E-Learning during COVID-19 pandemic in a Saudi medical school: students' perspective. *J Med Educ Curric Dev.* 2023;10:23821205231173492. doi:10.1177/23821205231173492
18. Akhter H, Rahman AAA, Jafrin N, Saif ANM, Esha BH, Mostafa R. Investigating the barriers that intensify undergraduates' unwillingness to online learning during COVID-19: a study on public universities in a developing country. *Cogent Education.* 2022;9:2028342. doi:10.1080/2331186X.2022.2028342
19. Yu Z. The effects of gender, educational level, and personality on online learning outcomes during the COVID-19 pandemic. *Int J Educ Technol High Educ.* 2021;18:14. doi:10.1186/s41239-021-00252-3

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