
Student performance in year 1 undergraduate medical education during traditional, emergency online, online and HyFlex teaching strategy: a single center study*

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Abstract

Background The global pandemic caused by COVID-19, the subsequent improvement in health situation caused by anti- COVID-19 vaccination and the developments in digital technology prompted changes in undergraduate medical education as to content delivery and assessment. This study determined the difference in the performance of first year medical students in traditional face-to face, online and Hyflex teaching strategy.

Methods A non-concurrent cohort study was done to determine the performance of students in three annual subjects in Year 1 undergraduate medical education for school years 2018 to 2023. One-way ANOVA at $p=0.001$ determined significance of differences of variables.

Results There was no difference in the profile of students as to their sex, pre-medicine course and scores in the National Medical Admission Test (NMAT). The performance in the written examinations in Anatomy and Physiology showed significant difference ($p=0.001$) when the conduct of examinations was shifted online on an emergency basis. There was no difference ($p=0.001$) in performance in the laboratory conference sessions in Physiology, as compared to the focused group discussion sessions in Biochemistry and practical examinations in Anatomy.

Conclusion Significant difference in the performance of first year medical students was observed only during the emergency shift to online examinations, otherwise the performance was similar in traditional face-to face, online and Hyflex teaching strategy.

Key words: student performance, assessment, Year 1 undergraduate medical education, traditional face-to-face teaching, online teaching, Hyflex teaching

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The global pandemic caused by COVID-19 last 2020 forced educators to re-think their teaching-learning activities to ensure continuity of formal learning in educational institutions. Delivering content and performing student assessment online provided a viable alternative to ensure the health and safety of teachers and students alike according to study done on medical students.¹ While technology supported the rapid adaptation of educational institutions to shift to online methods of teaching and assessment, new challenges arose in undergraduate

medical institutions in the US and Spain.^{2,3} These include issues on integrity of online examinations even with visual proctoring according to a study on medical students.⁴

The improved health situation brought by population wide anti-COVID19 vaccinations and developments in technology as applied to teaching-learning activities encouraged medical educators to forge onwards with a hybrid flexible (HyFlex) teaching strategy. A HyFlex teaching model refers to an instructional approach that combines face-to-face instruction with online synchronous or asynchronous content delivery, thus providing multiple ways to deliver content and interact with students.^{5,6,7} There have been studies on the effectiveness of various strategies of teaching namely, traditional face to face, online, and HyFlex among medical students.^{7,8} Differences of opinions, however, were found among studies regarding student performance in assessment though there are studies which saw no significant difference between face to face and online teaching in undergraduate medical courses like Anatomy and Physiology among medical students in studies done abroad.^{3,9,10}

To date, there is paucity of local studies exploring the difference on student performance with traditional face to face, online and HyFlex teaching and their respective assessments. Hence, this study was conducted to determine the differences of first year students' performance in a medical school in the National Capital Region with regard to face to face, online and HyFlex or blended teaching and assessment. It was hypothesized that the performance of 1st year medical students was comparable whether the teaching strategy is traditional face-to-face, online and HyFlex. The aim of this study was to determine the difference in the performance of first year medical students in traditional face-to face, online and Hyflex or blended teaching strategy, with the following specific objectives:

1. to determine the profile of first year medical students in an academic medical institution in the NCR for the School Years 2018-19, 2019-20, 2020-21, 2021-22 and 2022-23, as to:
 - A. gender distribution
 - B. undergraduate/ pre -medicine course
 - C. scores in the National Medical Admission Test (NMAT)
2. to compare the scores (Mean, standard deviation) in the long examinations in the annual subjects

(Anatomy, Biochemistry, Physiology) and other assessment methods unique to the subject/ course in the second semester of Year 1 in the College of Medicine of the aforementioned school years.

Methods

A non-concurrent cohort study was done. This study was approved by the ethics committees of the academic medical center. The demographic profile of students was obtained as to gender, undergraduate course (health vs non health science), and scores in the National Medical Admission Test (NMAT).

The performance of first year medical students in the different assessment methods (written examinations) in the three annual subjects namely Anatomy, Physiology and Biochemistry, practical examinations in Anatomy, laboratory conference sessions in Physiology and focused group discussion sessions in Biochemistry were compared during the same period (2nd semester) when traditional on campus teaching methods were utilized pre-pandemic, during the shift to online teaching, and utilizing HyFlex teaching methods (Table 1).

Results

Table 2 shows the profile of the students enrolled to the College of Medicine program. Through the school years included in this study, the National Medical Admission Test (NMAT) mean scores which ranged from 82-89th percentile did not differ significantly between males and females. Females (average=66%) numbered more than the males consistently.

Table 3 shows that majority (92%) of students enrolled to the College of Medicine Program were students with science pre-medicine programs.

Table 4 shows the performance of students in the long examinations in the three annual subjects for the school years 2018-2022. It shows a significant difference in the mean scores for the school year 2019-2020 when the examinations were shifted on emergency remote examination platforms instead of face-to-face conduct of exams. The scores were significantly higher compared to the other school years. The subsequent school years 2020 and 2021 were still conducted online but had visual proctoring by Zoom which is a video conferencing platform that allows users to conduct virtual meetings, webinars, and online events.

Table 1. Teaching and assessment methods, 2nd semester, school years (SY) 2018 – 2022.

School Year	Teaching Methods	Assessment Methods
2018-2019	Face to face, on campus	Face to face, on campus
2019- 2020	Face to face, on campus (1st half of semester) then shifted to online (2nd half of semester)	Face-to face, on campus Online, no visual proctoring
2020-2021	Online (synchronous and asynchronous)	Online, with visual proctoring
2021- 2022	Online (synchronous and asynchronous)	Online, with visual proctoring
2022- 2023	Online (synchronous and asynchronous) and face-to- face	Online, with visual proctoring and face- to- face

Table 2. Demographic profile of year 1 medical students, school years (SY) 2018- 2022.

School Year	Male Number (%)	Female Number (%)	NMAT Mean± sd Male	NMAT Mean± sd Male	p value
2018-2019	174 (35)	326 (65)	88.39 ± 6.98	87.85 ± 7.08	0.888
2019-2020	151 (32)	317 (68)	89.59 ± 7.77	88.72 ± 6.81	0.022
2020-2021	145 (35)	270 (65)	84.84 ± 12.19	84.83 ± 10.85	0.311
2021-2022	88 (33)	175 (67)	85.74 ± 9.07	82.03 ± 10.74	0.843
2022-2023	155 (35)	291 (65)	82.1 ± 8.20	80.71 ± 8.09	0.68

Table 3. Demographic profile of Year 1 medical students according to pre-medicine courses categorized as science and non-science courses for school years (SY) 2018- 2022.

School Year	Pre-Med Course	
	Science Number of students (%)	Non-Science Number of students (%)
2018-2019	470 (92)	40 (8)
2019-2020	433 (93)	35 (7)
2020-2021	376 (91)	39 (9)
2021-2022	240 (91)	23 (9)
2022-2023	410 (92)	36 (8)

Table 4. Student performance in the long examinations, 2nd semester, school years (SY) 2018 – 2022.

School Year	Anatomy (Mean+sd)	Biochemistry (Mean ±sd)	Physiology (Mean ±sd)
2018-2019	76.43 ± 8.00	77.76 ± 9.28	78.25 ± 9.81
2019-2020	85.55 ± 8.56	78.01 ± 4.66	86.55 ± 5.00
2020-2021	77.8 ± 9.38	74.18 ± 5.77	80.76 ± 6.95
2021-2022	74.72 ± 8.77	74.08 ± 4.92	79.83 ± 6.22
2022-2023	76.11 ± 8.67	76.61 ± 5.60	77.62 ± 6.42

One- way ANOVA P value <.001

Table 5 shows the performance of students in the final examinations in the three annual subjects for the school years 2018-2022. Similar to table 4, it shows a significant difference in the mean scores for the school year 2019 when the examinations were shifted to emergency remote examination platforms instead of face-to-face conduct of examinations. The students obtained higher scores than in the other school years. The subsequent school years 2020 and 2021 were still conducted online but had visual proctoring by Zoom.

Table 6 shows the performance of students in the practical examinations in Anatomy for the school years 2018-2022. It shows a significant difference in the mean scores for the school year 2020-2021 when these examinations were conducted online with visual proctoring by Zoom. The scores were higher compared to the other school years.

Table 7 shows the performance of students in the focused group discussion sessions in Biochemistry

for the school years 2018-2022. It shows a significant difference in the mean scores for the school years 2019 and 2020 and 2022 when the learning activity was conducted online. Interestingly, in school year 2021, the mean scores remained significantly different from the other school years (2019, 2020, and 2022) even if the venue remained online.

Table 8 shows the performance of students in the Laboratory Conference sessions in Physiology for the school years 2018-2022. It shows a significant difference in the mean of scores for the school year 2019 when the sessions were shifted to an emergency online venue. The students got higher grades compared to the other school years. The subsequent school years 2020 and 2021 were still conducted online using discussion board of the learning management system of the university (Canvas) or via Zoom.

Table 5. Student performance in final examinations, 2nd semester, school years (SY) 2018 – 2022.

School Year	Anatomy (Mean+sd)	Biochemistry (Mean ±sd)	Physiology (Mean ±sd)
2018-2019	77.31 ± 6.19	74.03 ± 5.41	78.25 ± 9.81
2019-2020	82.37 ± 5.61	80.49 ± 5.63	86.55 ± 5.00
2020-2021	75.54 ± 8.22	74.52 ± 5.02	80.76 ± 6.95
2021-2022	75.42 ± 7.27	76.29 ± 5.20	9.83 ± 6.22
2022-2023	76.15 ± 7.00	76.53 ± 5.07	81.07 ± 6.42

One- way ANOVA p value <.001

Table 6. Student performance in anatomy practical examinations, 2nd semester, school years (SY) 2018 – 2022.

School Year	Number	Mean ± sd
2018-2019	490	78.37 ± 8.18
2019-2020	446	76.46 ± 9.66
2020-2021	376	88.25 ± 6.33
2021-2022	235	79.67 ± 11.94
2022-2023	382	78.34 ± 8.70
Total	1929	80.01 ± 9.80

One way anova p value <.001

Table 7. Student performance in biochemistry focused group discussions (FGD), 2nd semester, school years (SY) 2018 – 2022.

School Year	Number	Mean \pm SD
2018-2019	448	76.29 \pm 12.34
2019-2020	446	97.73 \pm 2.63
2020-2021	371	96.73 \pm 3.27
2021-2022	188	86.29 \pm 6.17
2022-2023	379	96.54 \pm 1.54
Total	1832	90.86 \pm 11.16

One way anova p value <.001

Table 8. Student performance in physiology laboratory conference, 2nd semester, school years (SY) 2018 – 2022.

Physiology, Lab conference, 2nd Semester, SY 2018-22		
School Year	Number	Mean \pm sd
2018-2019	320	71.81 \pm 3.86
2019-2020	442	82.39 \pm 6.50
2020-2021	395	76.79 \pm 9.78
2021-2022	199	70.12 \pm 11.71
2022-2023	435	74.03 \pm 12.47
Total	1791	75.87 \pm 10.25

One way anova p value <.001

Discussion

To manage the far-reaching restrictions on social and professional life brought upon us by the COVID-19 pandemic that affected societies globally, medical schools had to restructure their curriculum by switching to online learning.¹ Online learning meant that content delivery, student interaction and assessment have changed, therefore, the recognition that not only content but student engagement and supportive environment for both students and teachers are essential requirements in the context of an online undergraduate medicine teaching program as seen in previous studies.^{5,7} While the challenges were

multifaceted and have been identified, they have to be addressed appropriately. In a study among college students in Northern India, there were six major factors identified, namely, instructors, institution, students, infrastructure, content factors, and motivational factors.¹¹ Only the performance of students was discussed in the current study. Relevant issues beyond the scope of this paper were challenges related to students such as readiness, technical skills to learn online, network and speed issues, identity, interaction, and participation.¹¹ Concerns on student performance may be connected to student engagement during online classes. A study involving college

students observed that higher educational institutions' (HEI) support and faculty support significantly affected university students' academic and social concerns. Furthermore, resource availability was found to affect the academic concerns of students but not their social concerns. Further, these were the recommended strategies for HEIs and faculty to promote faculty-student interaction using both synchronous and asynchronous modes to reduce student concerns and to motivate them to engage in online classes.¹²

Regarding the teachers' skills needed for online classes, a study done on the faculty of the College of Medicine in Karachi, Pakistan, the teachers' digital competencies and technology use in teaching and learning in the time of the COVID-19 were reviewed since these skills would play a significant role in the integration of technology in the post-pandemic time in higher education.⁶

The issue of assessment in online classes needed to be addressed as well. Assessment in medical education is considered most essential as assessment would usually give the evidence that learning was carried out and the learning objectives were achieved.⁴ The assessment program is a measurement tool which evaluates the progress in knowledge, skills, behaviors, and the attitude of students. It determines the extent of instruction and intended learning outcomes achieved by students; thus it is considered an integral part of the instruction process.⁶ One study specified that electronic exams were conducted remotely and remained a primary mode of assessment for students' academic progress during the pandemic.¹³ Examination related factors such as efforts/time needed for preparation were found to be significantly associated with student's electronic exam dishonesty according to a study done on medical students in Jordan.¹⁴ According to a study on medical students in the US, the integrity of assessment was a vital and challenging issue, especially as testing becomes more commonly distant from the usual classroom setting.² Data from medical students in Spain suggested that students were searching for information about ways to cheat in examinations, including how to create cheat sheets. Most strikingly, the results showed a significant increase in searches for information on cheating on online exams during the COVID-19 timeframe and the Spanish lockdown period. Thus, their recommendation was that academic institutions

should be wary about the opportunities that the students may have to commit exam fraud.³

In this current study, the scores of students in the written examinations in all three subjects were significantly higher during the emergency shift to online learning when there was no remote visual proctoring compared to the scores obtained pre-pandemic, when there was remote visual proctoring during online examinations and when HyFlex teaching methods were utilized as face to face examinations conducted on campus were resumed. Despite reporting serious concerns about their overall experience with e-proctoring tools (e.g., privacy, environmental, and psychological concerns), the majority of students scored above average on their online examinations. Academic integrity also seemed to matter to students.² The issue of academic integrity was the major concern why remote visual proctoring utilizing Zoom was done for school years 2020-2021 and 2021-2022. A US study on medical students stated that there were three critical facts about the e-proctoring tool raised. First, e-proctoring could not fully replace the traditional, in-person proctoring experience. As such, these online systems can be used as a supplementary, short-term option for schools during sudden, critical situations. The second issue raised was that the COVID-19 pandemic forced universities to modify their assessments and communication tools to counter the crisis.² When health restrictions were eased for school year 2022-2023, the written examinations were once more conducted utilizing the traditional, face to face proctoring using paper and pen method. The third issue was that universities should exploit the capabilities gained during this technological transition to transform to new skylines of learning and education.² Advances in technology to support teaching and learning activities to include assessment utilizing web-based applications for examinations with face to face proctoring on campus was done. Indeed, online examinations can be proctored in different ways including in-person testing by requiring students to be physically present at a testing session, which could be at the institution or administered by an approved proctor situated remotely from the institution, or by utilizing online real-time proctor services.²

Another challenge presented by online classes was the unaddressed gap in psychomotor skills of students in online classes.⁴ Among the annual subjects included in this study, Anatomy would be the subject

most affected by this gap. There were a couple of studies which looked into assessment in Anatomy class. Among undergraduate medical students, the results indicated that online assessment of theoretical and practical anatomical knowledge was comparable to that of face-to-face assessment. But proper planning and preparedness were mandatory to achieve the desired outcomes.^{7,8} In this current study, although students scored higher on practical examinations conducted purely online, the skills acquired through face-to-face dissection and assessment were invaluable. Similarly, in a study conducted in Greece involving medical and dental students, traditional anatomy teaching was found to be the most preferred and effective teaching modality. Students ranked online anatomy lectures and pre-recorded anatomy lectures second in terms of effectiveness and preference. While the development of remote learning methods has increased students' active participation in anatomy lessons, it has significantly negatively affected their performance in examinations. Although remote learning cannot replace traditional anatomy teaching method, online lectures could be incorporated into anatomy curricula as an additional tool.¹⁴ On the other hand, content-heavy subjects like Physiology and Biochemistry presented with different concerns. A study conducted in Beijing on medical students concluded that there was no evidence that offline learning was more effective. Compared to offline learning, online learning has advantages in enhancing undergraduates' knowledge and skills, and could therefore, be considered a potential method for teaching undergraduate medical students.¹⁵ Another study done in Beijing on medical students expressed that synchronous distance education was not significantly different from traditional education in effectiveness and had even higher satisfaction ratings. Their findings seemed to provide indications for the adoption of online remote education in health science education centers.¹⁶ In a study done among medical students in the US, it was observed that changes made to the pre-clerkship Physiology curriculum during the COVID-19 pandemic were met with overall satisfaction from the students and resulted to an increase in the National Board of Medical Examiners (NBME) subject examination scores. Another study proposed that more attention to student connectedness be improved so that remote learning can be best optimized into future curricula development.¹⁷ Similarly, among college teachers in the UK, student satisfaction of their online

courses and their summative exam scores were compared to previous academic years. The overall satisfaction with the courses was similar to previous academic years; however, student performance in the summative examination of the first virtually delivered cohort was lower than the previous year's cohorts. The difference in year 1 and year 2 medical students' perceptions of virtual and blended instruction highlighted the importance of face-to-face learning during the first year.¹⁸

Regarding student performance in the focused group discussion sessions in Biochemistry, significant differences in scores across the school years indicated that the activity was a less reliable source of means of assessment regardless of the mode of teaching and conduct of the assessment. Admittedly, this assessment was fraught with issues. In a study done in Sweden involving college teachers, it was observed that unreliability in grading students was well-documented. However, studies investigating teachers' detailed use of assessment criteria are lacking.¹⁹ A similar study done in UK involving college teachers stated that in assessing students, it revealed several sources of inconsistency, such as teachers' own constructs, their interpretations and expectations about students' ability to manage academic work.²⁰ Limitations aside, there remains a need for student assessment. In UK, college teachers have pointed that assessment was fundamental to student learning and achievement. However, while research consistently emphasizes the role of assessment in supporting student development, the reality of assessment processes and practices in higher education often falls short.²¹ Moreover, to minimize grade variability, a study done in a college in China involving its faculty stated that tacit criteria and the different sources that form the tacit criteria needed to be identified, perceived, and communicated to the faculty to reduce grade variability and achieve a shared understanding of grading.²² The use of a rubric agreed upon by the faculty as to its content and utilization did not guarantee the reliability of the learning activity as a means to assess students' performance. A revisit of the whole activity focusing on the use of rubrics is warranted to emphasize the good practices as categorized into: 1) standardization of evaluation method, 2) objectiveness of evaluation, 3) guidelines for students' work, and 4) transparency of evaluation and the bad practices in the use of rubrics: 5) vague

descriptions in marking rubrics, and 6) failure to provide the ranges of marks for each grade.²³ Utilizing rubrics for assessment may be challenging but is widely believed to be a source of authentic assessment. In Australia, a study concluded that although there have been multiple definitions and operationalizations of authentic assessment, contemporary methods or approaches often emphasize replicating or imitating real-world job-related tasks. This suggests a focus on practical, hands-on activities that closely resemble what the students will encounter in actual work environments. The aim is to prepare these students by providing realistic, applicable experiences rather than purely theoretical or abstract learning. Authenticity cannot be completely unmoored from the reality of workplaces, the demands of the discipline, and the overall intended learning outcomes, however, a restricted view of how these aspects are represented in assessment can limit the sector's ability to prepare graduates who can engage with and shape the changing world.²⁴ To summarize and emphasize the prime importance of reliable assessment, a study done in Australia stated that summative assessment is often considered a motivator that drives students' learning. Higher education has a responsibility in promoting lifelong learning and assessment plays an important role in supporting students' capability to make evaluative judgements about their work and that of others.²⁵

Moving forward, recognizing the advantages and limitations of both online and in-person or face to face modes of teaching, a study done in Hong Kong declared that with the gradual containment of the pandemic, there is no need for school lockdown. As a result, the teaching format has changed to HyFlex mode integrating both face-to-face and online modes.²⁶ Even as the pros and cons have been considered, the shift to online education has significantly impacted medical students in Egypt. Medical students reported various limitations and challenges of online medical education, which must be addressed considering the potential benefits of online platforms over traditional face to face learning.²⁷ A study done among medical students in Saudi Arabia described the improved HyFlex course that utilized live online courses and on-demand courses where on-demand video was uploaded via the online conference system, such as Zoom or Webex, and during class schedule students only asked

questions and the teacher quickly responded to these questions.²⁸ In a study done in Australia involving college students stated that online learning, should be allowed in combination with conventional learning (Hyflex) but students should be prepared for it.²⁹ A study done in Ohio, US stated that students liked face-to-face learning because it enabled them to acquire motor skills and develop interpersonal relations.³⁰ Another study done in the US concluded that modified HyFlex instructional model had no negative impact on student performance in the class, both in overall learning and on individual grades. Furthermore, students greatly enjoyed the educational choices and overwhelmingly reported that the incorporation of technology increased their participation in class and comprehension of course content.³¹ Since a HyFlex teaching mode allowed teaching-learning activities to be conducted either face-to-face or online, providing multiple methods to deliver content and interact with students, this teaching mode would ensure minimal disruption of learning due to concerns on health and safety and societal concerns as well.^{32,33,34,35} A study done in the US reported that while online teaching could not replace traditional teaching, there was no preference for one type of modality over the other. Therefore, a multi-modal learning approach combining online with face-to-face educational modalities for medical students could be efficient and successful.³⁶

Conclusion and Recommendation

There was significant difference in student performance in the written examinations in the three annual subjects in Year 1 of the College of Medicine program during the emergency shift to online examinations when there was no visual proctoring, otherwise, student performance remained similar all through the school years included in this study spanning different modes of teaching and conduct of examinations from traditional face to face, online and HyFlex mode of teaching. Likewise, there was no difference in student performance in laboratory conference sessions of Physiology across the different modes of teaching.

It is recommended that online examinations (through web-based applications or through the center's learning management system) with face to face proctoring be utilized in written examinations.

References

1. Stoeckl F, Müller L, Brady A, Trilla A, Mähringer-Kunz A, Hahn F, et al. How COVID-19 kick-started online learning in medical education-The DigiMed study. *PLoS One* 2021 Sep 21;16(9). doi: 10.1371/journal.pone.0257394.
2. Milone AS, Cortese AM, Balestrieri RL, Pittenger AL. The impact of proctored online exams on the educational experience. *Curr Pharm Teach Learn* 2017;9(1):108-14.
3. Comas-Forgas R, Lancaster T, Calvo-Sastre A, et al. Exam cheating and academic integrity breaches during the COVID-19 pandemic: An analysis of internet search activity in Spain. *Heliyon* 2021;7. doi: 10.1016/j.heliyon.2021.e08233.
4. Elshama SS. How to use and apply assessment tools in medical education? *Iberoam J Med* 2020;4:351-9.
5. Khan AM, Patra S, Gupta P, Sharma AK, Jain AKJ. Rapid transition to online teaching program during COVID-19 lockdown: Experience from a medical college of India. *Educ Health Promot* 2021 Mar 31;10:99. doi: 10.4103/jehp.jehp_606_20. eCollection 2021.
6. Akram H, Yingxiu Y, Al-Adwan AS, Alkhalifah A. Technology integration in higher education during COVID-19: an assessment of online teaching competencies through technological pedagogical content knowledge model. *Front Psychol* 2021 Aug 26;12:736522. doi: 10.3389/fpsyg.2021.736522. Epub 2021 Aug 26.
7. Albalushi H, Al Mushaiqri M, Sirasanagandla SR, Das S. Students' performance in face-to-face, online, and hybrid methods of teaching and assessment in anatomy. *Int J Environ Res Public Health* 2022 Oct;19(20):13318. Published online 2022 Oct 15. doi: 10.3390/ijerph192013318.
8. Memon I, Feroz Z, Alkushi A, Qamar N, Ismail F. Switching from face-to-face to an online teaching strategy: how anatomy and physiology teaching transformed post-COVID-19 for a university preprofessional program. *Adv Physiol Educ* 2021 Sep 1;45(3):606-11. doi: 10.1152/advan.00033.2021.
9. Liu XY, Lu C, Zhu H, Wang X, Jia S, Zhang Y, et al. Assessment of the effectiveness of BOPPPS-based hybrid teaching model in physiology education. *BMC Med Educ* 2022;22:217.
10. Guo J, Li L, Bu H, Feng M, Yang Y, Zhang Y, et al. Effect of hybrid teaching incorporating problem-based learning on student performance in pathophysiology. *J Int Med Res* 2020;48:300060520949402. Erratum in: *J Int Med Res* 2021;49:3000605211017393.
11. Siddiquei MI, Kathpal S. Challenges of online teaching during COVID-19: An exploratory factor analysis. *Hum Behav Emerg Technol* 2021;5:811-822.15 .
12. Al-Maskari A, Al-Riyami T, Kunjumammed SK. Students' academic and social concerns during COVID-19 pandemic. *Educ Inf Technol (Dordr)* 2022;27(1):1-21. doi: 10.1007/s10639-021-10592-2. Epub 2021 Jun 30.
13. Elsalem L, Al-Azzam N, Jum'ah AA, Obeidat N. Remote E-exams during COVID-19 pandemic: A cross-sectional study of students' preferences and academic dishonesty in faculties of medical sciences. *Ann Med Surg (Lond)* 2021 Feb;62:326-333. doi: 10.1016/j.amsu.2021.01.054.
14. Totlis T, Tishukov M, Piagkou M, Kostares M, Natsis K. Online educational methods vs. traditional teaching of anatomy during the COVID-19 pandemic. *Anat Cell Biol* 2021 Sep 30;54(3):332-9. doi: 10.5115/acb.21.006.
15. Pei L, Wu H. Does online learning work better than offline learning in undergraduate medical education? A systematic review and meta-analysis. *Med Educ Online* 2019;24:1666538.
16. He L, Yang N, Xu L, Ping F, Li W, Sun Q, et al. Synchronous distance education vs traditional education for health science students: A systematic review and meta-analysis. *Med Educ* 2020;54(12):1161-1171. doi: 10.1111/medu.14364.
17. Chang M, Cuyegkeng A, Breuer JA, et al. Medical student exam performance and perceptions of a COVID-19 pandemic-appropriate pre-clerkship medical physiology and pathophysiology curriculum. *BMC Med Educ* 2022 Dec 2;22(1):833. doi: 10.1186/s12909-022-03907-5.
18. Ayoubieh H, Alkhalili E, Nino D, Coue M, Herber-Valdez C, Pfarr CM. Analysis of Pre-clerkship Medical Students' Perceptions and Performance During the COVID-19 Pandemic. *Med Sci Educ* 2023 Jan 9;33(1):147-56. doi: 10.1007/s40670-022-01723-6.
19. Bloxham S, den-Outer B, Hudson J, Price M. Let's stop the pretence of consistent marking: exploring the multiple limitations of assessment criteria. *Assess Eval High Educ* 2016;41(3):466-81.
20. Rinne I. Same grade for different reasons, different grades for the same reason? *Assess Eval High Educ* 2024;49(2):220-232. Published online Apr 27, 2023. doi: 10.1080/02602938.2023.2203883.
21. Medland E. Assessment in higher education: drivers, barriers and directions for change in the UK. *Assess Eval High Educ*. 2016;41(1):81-96. Published online Nov 21, 2014. doi: 10.1080/02602938.2014.982072.
22. Liao L. Dancing with explicit criteria or marginalising them: the complexity of grading student work and the reconstruction of the meaning of criterion-referenced assessment. *Teach High Educ* 2022 Sep 6. doi: 10.1080/13562517.2022.2119076.
23. Chan Z, Ho S. Good and bad practices in rubrics: the perspectives of students and educators. *Assess Eval High Educ* 2019;44(4):533-45. doi: 10.1080/02602938.2018.1522528.
24. Ajjawi R, et al. 'From authentic assessment to authenticity in assessment: broadening perspectives. *Assessment & Evaluation in Higher Education* 2023; 49(4): 499–510. doi: 10.1080/02602938.2023.2271193.
25. Fischer J, Blomberg G, Deane T, Winberg S. How does assessment drive learning? A focus on students' development of evaluative judgement. *Assess Eval High Educ* 2023 May 4. doi: 10.1080/02602938.2023.2206986.

26. Shek DTL, Zhu X, Li X, Dou D. Satisfaction with HyFlex teaching and law-abiding leadership education in Hong Kong University students under COVID-19. *Appl Res Qual Life* 2022; 17: 2833-58.
27. Mortagy M, Abdelhameed A, Sexton P, Olken M, Hegazy MT, Gawad MA, Senna F, Mahmoud IA, Shah J. Egyptian Medical Education Collaborative Group (EGY MedEd); Aiash H. Online medical education in Egypt during the COVID-19 pandemic: a nationwide assessment of medical students' usage and perceptions. *BMC Med Educ* 2022 Mar 30;22(1):218. doi: 10.1186/s12909-022-03249-2.
28. Kakeshita T. Improved HyFlex course design utilizing live online and on-demand courses. In: Csapo B, Uhomoibhi J, editors. *Proceedings of the 13th International Conference on Computer Supported Education (CSEDU)*; 2021 Apr 23-25; Online Streaming. Setúbal, Portugal: SciTePress 2021; 2: 104-13.
29. Hanafy SM, Jumaa MI, Arafa MA. A comparative study of online learning in response to the coronavirus disease 2019 pandemic versus conventional learning. *Saudi Med J* 2021; 42: 324-31.
30. Arias JJ, Swinton J, Anderson K. Online vs. face-to-face: A comparison of student outcomes with random assignment. *E J Bus Educ Scholarsh Teach* 2018;12:1-23.33.
31. Miller J, Risser M, Griffiths R. Student choice, instructor flexibility: moving beyond the blended instructional model. *Issues Trends Educ Technol* 2013;1:8-24. doi: 10.2458/azu_itet_v1i1_16464.
32. Bergwerk M, Gonen T, Lustig Y, Amit S, Lipsitch M, Cohen C, et al. Resurgence of SARS-CoV-2 infection in a highly vaccinated health system workforce. *N Engl J Med* 2021;385:1330-2. doi: 10.1056/NEJMc2112981.
33. Philstar.com. SWS: 78% of Filipinos still worried about getting COVID-19. Philstar.com. March 20, 2023. Available from: <https://www.philstar.com/headlines/2023/03/20/2253124/sws-78-filipinos-still-worried-about-getting-covid-19>.
34. Department of Education (DepEd). On class suspensions and shifting to ADM due to high heat index, other calamities. [Internet] DepEd; 2024 April 4 [cited 2024 June 11]. Available from: <https://www.deped.gov.ph/2024/04/04/on-class-suspensions-and-shifting-to-adm-due-to-high-heat-index-other-calamities>
35. Philippine Information Agency (PIA). Metro Manila schools resort to online classes amid nationwide transport strike. [Internet] Manila: PIA; 2023 Mar 6 [cited 2024 Jun 11]. Available from: <https://pia.gov.ph/news/2023/03/06/metro-manila-schools-resort-to-online-classes-amid-nationwide-transport-strike>
36. Abualadas HM, Xu L. Achievement of learning outcomes in non-traditional (online) versus traditional (face-to-face) anatomy teaching in medical schools: A mixed method systematic review. *Clin Anat* 2023 Jan;36(1):50-76. doi: 10.1002/ca.23942. Epub 2022 Aug 25.