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Medical Students' Engagement and Academic Performance in Radiology through Blended and Online Learning

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ABSTRACT

The COVID-19 pandemic necessitated a shift from traditional face-to-face (F2F) learning to online and blended learning modalities in medical education. This study evaluates engagement and academic performance in radiology among medical students in online versus blended learning. A cross-sectional study was conducted among the medical students who completed a two-week radiology posting at Universiti Malaysia Sarawak (UNIMAS) from 2020 to 2023. Data were collected through questionnaires assessing student enjoyment, preferences, perceived helpfulness of learning methods, and learning outcomes, followed by tests on knowledge retention and interpretation skills. A total of 433 students participated: 179 in the online group and 254 in the blended group. The mean age was 23.5 years, with 70.7% being female. In the online group, 57% enjoyed virtual learning, and 65.4% found asynchronous sessions helpful. In the blended group, 76.8% enjoyed F2F learning, and 82.7% found F2F sessions beneficial. Both groups reported satisfactory knowledge acquisition and adequate clinical skills. The E-learning Enrichment and Advancement Platform (eLEAP) was positively perceived. Both groups achieved comparable test performance with a median score of 4; however, the online group had a slightly higher mean score ($p = 0.006$). Both online and blended learning approaches were well received, with high satisfaction and positive perceptions of the learning experiences. Both methods have their own merits: online learning offers greater flexibility, while blended learning is preferred for interactions and practical components. The positive feedback and comparable performance suggest both methods are effective in radiology education. Future research should explore optimising the online and F2F components to enhance learning outcomes further.

Keywords: Radiology, Online, Blended, Medical student, Engagement

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INTRODUCTION

Learning institutions have been driven to embrace technology and shift to online platforms for teaching following the advent of COVID-19 in 2020. The pandemic had far-reaching consequences for global healthcare systems, undergraduate schooling (in general), and medical schooling, which includes radiology (in particular).

Radiology, which links basic medical sciences to clinical practice, is crucial for medical students to perform accurate diagnoses. Fundamentally, they are required to learn about radiation safety, various imaging modalities such as radiography, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), fluoroscopy, angiography, and mammography, as well as topics in chest, abdomen, paediatrics, head, and neck. Students learn to analyse clinical problems in daily practice, select appropriate imaging modalities, justify the indication for each, and understand their rationale and limitations throughout their posting. They also develop the ability to interpret common radiological conditions and identify cases that require urgent therapeutic intervention.

The radiology posting for Universiti Malaysia Sarawak (UNIMAS) medical students was entirely face-to-face (F2F) before 2020, lasting two weeks during the third or fourth year of the medical programme. Nonetheless, the rapid spread of COVID-19 between 2020 and 2021 led to a shift from in-person to digital instruction. A blended learning mode, which combines F2F classes with online resources, was introduced in radiology in 2022.

E-learning is broadly defined as the use of any electronic media (the internet) to acquire and improve knowledge in teaching and learning (1, 2). On-campus computer-assisted learning and (synchronous or asynchronous) online remote learning constitute two forms of e-learning (3). Students engaged in synchronous learning are present in a virtual classroom, wherein the instructor and students communicate in real time. Meanwhile, asynchronous learning accommodates the lessons delivered by educators using recorded material. No live interactive sessions occur with the educator. As a mixed form of synchronous or asynchronous e-learning and F2F learning, blended learning describes a learning environment that integrates multiple delivery methods designed to complement one another (4).

Zafar and colleagues highlighted the use of blended learning in radiology education for undergraduate students (2). A meta-analysis found that blended learning was more effective than traditional, non-blended learning. This learning mode can be most suitably implemented in radiology among all the specialties (5). Following Alamer, online learning significantly improves knowledge acquisition, interaction with tutors, as well as focus and engagement compared to F2F learning (6). Nonetheless, Chung and colleagues (7) claimed that students engaged in online learning had to allocate more time for self-study.

Blended learning is currently adopted in the radiology programme at UNIMAS medical school. Despite continuous efforts to improve radiology education, both student and lecturer feedback have highlighted room for improvement, specifically in making more engaging lessons. Some students in this programme prefer online learning for its convenience and self-paced learning. While online learning offers flexibility and certain advantages, its effectiveness in producing competent medical professionals remains less examined. This study aimed to explore engagement and academic performance in online and blended learning in radiology education among undergraduate medical students. These issues call for assessing different teaching approaches to guide future improvements in radiology education.

METHODS

A total of 559 medical students (280 from year 2020 and 2021; 279 from year 2022 and 2023) who underwent a two-week radiology posting in the medicine programme at UNIMAS between 2020 and 2023 were selected for this cross-sectional study via census sampling.

Students from 2020 to 2021 engaged in online learning, with all radiology topics delivered online (including synchronous and asynchronous classes). An official learning management platform used at UNIMAS, known as the E-Learning Enrichment and Advancement Platform (eLEAP), complemented F2F teaching with online tools such as discussions, presentations, assessments, video demonstrations, quizzes, forums, seminars, and examinations. Students with access to interactive digital content and collaborative features are able to improve their learning experience. Counterparts from 2022 to 2023 underwent blended learning, encompassing F2F lectures, forums, seminars, and examinations, as well as eLEAP for video demonstrations and quizzes. Notably, the course learning outcomes and assessment tools remained constant in both cohorts throughout the years.

Questionnaires and self-administered assessments via Google Forms were employed in this study to gather quantitative data. The questionnaires were structured based on relevant works and modified to complement the study (8, 9). Radiologists and educational specialists were invited to review the questionnaire items for clarity and to eliminate bias. To capture the use of technological tools in the learning method, students' satisfaction with content delivery, and learning outcomes, a 5-point Likert scale (ranging from strongly disagree to strongly agree) was employed. Four clinical cases, as well as four radiographic and computed tomographic images, were included in the self-administered assessment to test medical students' knowledge retention and radiographic interpretation skills. Student representatives from each academic year distributed the survey to their classmates, with informed consent obtained, and the responses were subsequently gathered.

The questionnaire data were analysed using R Statistical Software (version 4.3.1; R Core Team 2024). While categorical data were described as percentages, continuous data were described as mean, median, and standard deviation (\pm SD). Independent t-tests were used to compare the means between the groups.

RESULTS

Demographic Characteristics

The survey questionnaire was distributed to 559 medical students between January 2024 and April 2024, yielding 433 responses (see Table 1). The participants were divided into two groups: 179 in online learning and 254 engaged in blended learning. The former primarily consisted of Year 4 students in 2019/2020 (21.8%) and Year 3 students in 2020/2021 (78.2%), while the latter encompassed Year 3 students in 2021/2022 (59.8%) and 2022/23 (40.2%). The participants' mean age was 23.5 years, and the majority were female (70.7%).

Table 1: Demographic characteristics of students

Demographic characteristics	Online learning (N = 179)	Blended learning (N = 254)	Overall (N = 433)
Age			
Mean (SD)	24.3 (1.05)	23.0 (0.80)	23.5 (1.10)
Median (Min, Max)	24.0 (21.0, 27.0)	23.0 (21.0, 26.0)	23.0 (21.0, 27.0)
	n (%)		
Gender			
Female	125 (69.8)	181 (71.3)	306 (70.7)
Male	54 (30.2)	73 (28.7)	127 (29.3)
Year			
2019/20 (Year 4)	39 (21.8)	0 (0.0)	39 (21.8)
2020/21 (Year 3)	140 (78.2)	0 (0.0)	140 (78.2)
2021/22 (Year 3)	0 (0.0)	152 (59.8)	152 (59.8)
2022/23 (Year 3)	0 (0.0)	102 (40.2)	102 (40.2)

Students' Experience on Online and Blended Learning

Table 2 presents a generally positive perception among 179 students enrolled in online learning, with a significant proportion (57%) either agreeing or strongly agreeing about online class enjoyment. With 29.6% favouring online learning and 34.1% not doing so, the preference for online learning was more varied. Approximately 57% of them found online synchronous lectures more helpful in their studies, while 65.4% favoured pre-recorded asynchronous lectures.

Of the 254 students engaged in blended learning, 76.8% reported enjoying the F2F classes. Most of them (70%) preferred F2F classes to online classes. About 82.7% of the participants considered F2F sessions helpful in their studies, with 58.7% deeming pre-recorded asynchronous lectures beneficial. The results imply a strong preference and positive perception regarding F2F learning.

Table 2: Students' experience with online learning (N = 179) and blended learning (N = 254)

Students' experience	Online learning n (%)	Blended learning n (%)
Enjoy online / F2F		
Strongly disagree	10 (5.6)	4 (1.6)
Disagree	20 (11.2)	6 (2.4)
Neutral	47 (26.3)	49 (19.3)
Agree	63 (35.2)	103 (40.6)
Strongly agree	39 (21.8)	92 (36.2)
Prefer online / F2F		
Strongly disagree	24 (13.4)	5 (2.0)
Disagree	37 (20.7)	11 (4.3)
Neutral	65 (36.3)	60 (23.6)
Agree	24 (13.4)	88 (34.6)
Strongly agree	29 (16.2)	90 (35.4)

(Continued on next page)

Table 2: (Continued)

Students' experience	Online learning n (%)	Blended learning n (%)
Synchronous lecture / F2F is helpful		
Strongly disagree	6 (3.4)	3 (1.2)
Disagree	21 (11.7)	5 (2.0)
Neutral	50 (27.9)	36 (14.2)
Agree	65 (36.3)	107 (42.1)
Strongly agree	37 (20.7)	103 (40.6)
Asynchronous lecture is helpful		
Strongly disagree	8 (4.5)	7 (2.8)
Disagree	13 (7.3)	35 (13.8)
Neutral	41 (22.9)	63 (24.8)
Agree	51 (28.5)	64 (25.2)
Strongly agree	66 (36.9)	85 (33.5)

Students' Perception and Engagement on Radiology Education

Students' perceptions of their radiology education experience (see Table 3) are related to learning outcomes, content delivery, and ease of access to technology in blended and online learning. The participants ranked their experience using a Likert scale, with 1 = strongly disagree and 5 = strongly agree. Overall, both student groups found that radiology teaching improved their knowledge of medical imaging and prepared them to face real clinical scenarios. Online learning students were more satisfied with content delivery compared to their counterparts in blended learning ($p = 0.006$). Overall, radiology education proved adequate for clinical application.

The students positively perceived the use of virtual learning tools (eLEAP), and the ease of internet access for coursework. In addition, participants from both learning modes agreed that navigating online platforms (Microsoft Teams and Webex) and accessing electronic devices (computers, laptops, tablets, or mobile phones) were convenient for their learning.

Table 3: Students' perception of their experience of radiology education ranked on a Likert scale from 1 to 5 (1 = strongly disagree and 5 = strongly agree)

Students' perception	Online learning Mean (SD)	Blended learning Mean (SD)	p-value
Learning outcome			
The radiology posting improves my knowledge on medical imaging.	4.3 (0.81)	4.36 (0.72)	0.38
The radiology posting prepares me to face the actual clinical scenarios in the hospital setting.	4.0 (0.94)	3.9 (0.89)	0.27
Content delivery			
The content delivery of radiology posting is fulfilled.	4.2 (0.76)	4.02 (0.78)	0.02
The content of radiology posting is adequate to cover the important clinical applications in clinical postings.	4.03 (0.84)	3.87 (0.86)	0.06

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Table 3: (Continued)

Students' perception	Online learning Mean (SD)	Blended learning Mean (SD)	p-value
Ease of accessing technology tools			
The use of virtual learning tools (eLEAP) is helpful in my learning.	4.02 (0.91)	3.87 (0.98)	0.10
It is easy for me to use the platforms (Microsoft Team, Webex etc).	4.2 (0.95)	4.16 (0.9)	0.63
It is easy to access electronic device (computer, laptop, tablet, mobile phone, etc.) for learning purpose.	4.31 (0.83)	4.36 (0.79)	0.49
It is easy for me to connect to the internet to access coursework learning.	3.98 (1.0)	4.08 (0.9)	0.29

Note: Likert scores are shown as mean.

Students' Performance on Assessment

The students' assessment performance, encompassing four case scenarios and four image interpretations, is presented in Table 4. The scores ranged from 0 to 8. Most of the blended learning participants were in the mid-range, with 28% scoring 4 and 31% scoring 5. Only 5.5% managed to score 6. Very few students reached the higher end, with just 0.8% scoring 7 or 8. The majority of online learning students scored between 4 and 5, with 32% scoring 4 and 23% scoring 5. Intriguingly, the higher percentage of students scoring 6 (13%), 7 (2.8%), and the highest score of 8 (1.7%) set the online group apart. These participants significantly outperformed the blended group in these categories. While both groups achieved a median score of 4, the online students performed slightly better with higher mean scores of 4.3 than their blended counterparts which scored 4 ($p < 0.05$).

Table 4: Students' performance on assessment

Total score (n)	Online learning n (%)	Blended learning n (%)	p-value
0	0 (0.0)	1 (0.4)	
1	0 (0.0)	6 (2.4)	
2	12 (6.7)	27 (11.0)	
3	35 (20.0)	51 (20.0)	
4	58 (32.0)	71 (28.0)	
5	42 (23.0)	80 (31.0)	
6	24 (13.0)	14 (5.5)	
7	5 (2.8)	2 (0.8)	
8	3 (1.7)	2 (0.8)	
Mean score (SD)	4.3 (1.3)	4 (1.3)	0.006

Note: Online learning (N = 179); blended learning (N = 254)

DISCUSSIONS

This study analysed gaps between online and blended learning from students' perspectives and performance in radiology. Although their feedback proved positive for both approaches, the assessment results indicate that the online learning group performed slightly better than the blended learning group. This result suggests the potential benefits of cognitive learning in an online setting. As past research indicates, online learning is effective for acquiring theoretical knowledge (10).

Nguyen (11) examination on the effectiveness of online learning highlighted its effectiveness, which sometimes exceeds that of traditional F2F lessons when the content fits the delivery method. This is particularly important in radiology education, where most of the teaching and learning materials rely on visual and imaging aids. Despite participating in radiology education for an average of 36 to 48 months pre-assessment, students who engaged in online learning achieved higher scores than their counterparts in blended learning, who participated about 12 to 24 months prior. They learned at their own pace (early morning, late night, or afternoon), as online learning provides greater flexibility in time. Furthermore, the participants were able to access and revisit the recorded lectures via eLEAP at any time. The online students had fewer distractions and better concentration in studying during the pandemic and lockdown periods than in a traditional lecture hall setting with classmates and a noisy background. As the online group students are currently practising more clinical work in hospitals, they can relate to radiological interpretation more easily than blended learning students, who are still in medical school. These individuals are more digitally savvy and can adapt more effectively to virtual tools, leading to more effective online learning than in-person learning.

The majority of students preferred blended learning, with 82.7% reporting that F2F sessions were helpful for their learning. Much emphasis is placed on the practical use of the theory. While online learning may be useful in knowledge-based assessments, students continue to prefer the practical learning format and exposure to traditional F2F instruction in the radiology programme. Blended students' trend towards F2F classes corroborates past research (12), specifically in areas involving a lot of visual interpretation (radiology). This finding also aligns with meta-analyses, which show that e-learning is preferable, with better learning outcomes and student satisfaction, compared to F2F instruction (2, 13).

Both groups perceived the convenience of using digital resources and web-based platforms for learning radiology. Students who are more receptive to online learning platforms can effectively navigate online learning as technology advances and its incorporated into learning systems. Although Chung et al. (7) highlighted the challenges of online learning during the pandemic, technological advances have addressed these issues over time. The participants in this study highlighted the ease with which they could use electronic devices to access the internet. The smooth transition from the paradigm of in-person learning to online learning has been assisted by eLEAP, a platform that includes and encourages active learning models (flipped classroom and active-teaching models) rather than a full didactic learning style that entails listening and watching.

Clinically, the elicited outcomes were more aligned with the online group regarding content delivery in radiology education. Online learning can be as effective as blended learning when properly designed and integrated into the curriculum. This contradicts the opinion that using technologies to deliver medical programmes is less effective than traditional methods in medical training, particularly in radiology, where image interpretation is best performed

online. McRoy et al. (14) and Li et al. (15) highlighted the effectiveness of online methods in radiology teaching, with better education outcomes yielded in image interpretation and case studies.

Online learning is as efficient as blended learning in delivering theoretical and knowledge-oriented content in radiology. The majority of students favoured the blended learning approach, which is more suitable for developing clinical competencies and enhancing medical students' overall learning experience. In analysing overall performance and preferences, incorporating elements from both online and blended learning approaches can further enhance learning outcomes in radiology education.

This study is not without its limitations. For example, some medical students in the online learning group were not contactable. This led to disproportionate responses from the students in each representative year. As the online learning group completed radiology posting with an average of 36 to 48 months before participating in this study, this time gap might cause recall bias compared to the blended group. Single-institution sampling also restricted the generalisability of the outcomes. Hence, a multi-centre approach should be considered to ensure a broader presentation of radiology education in undergraduates.

CONCLUSION

This study evaluated students' engagement and academic performance across two teaching formats (online and blended) for radiology education. In line with the current findings, both methods have distinct advantages. Students preferred online learning, which offers greater flexibility and allows them to learn at their own pace. Blended learning incorporates the most favourable attributes of online and F2F methods to address student needs by promoting the flexibility of e-learning and the practical, hands-on training required for competent practice. Given the shift in medical education trends, particularly after COVID-19, this study calls for more flexibility in learning approaches that include both online and F2F learning.

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ETHICAL APPROVAL

Approval was obtained from Research Medical Ethics Committee, UNIMAS (Reference number: FME/24/89) and the Ministry of Health Malaysia (NMRR ID-23-03413-DAU (IIR)). Clinical trial number: not applicable. The study was performed in accordance with the ethical standards of the research committee and the Declaration of Helsinki and its later amendments.

REFERENCES

1. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of e-learning in medical education. *Acad Med.* 2006;81(3):207–12. <https://doi.org/10.1097/00001888-200603000-00002>
2. Zafar S, Safdar S, Zafar AN. Evaluation of use of e-learning in undergraduate radiology education: a review. *Eur J Radiol.* 2014;83(12):2277–87. <https://doi.org/10.1016/j.ejrad.2014.08.017>
3. Ward JPT, Gordon J, Field MJ, Lehmann HP. Communication and information technology in medical education. *Lancet.* 2001;357(9258):792–6. [https://doi.org/10.1016/S0140-6736\(00\)04173-8](https://doi.org/10.1016/S0140-6736(00)04173-8)
4. Vavasseur A, Muscari F, Meyrignac O, Nodot M, Dedouit F, Revel-Mouroz P, et al. Blended learning of radiology improves medical students' performance, satisfaction, and engagement. *Insights Imaging.* 2020;11(1):61. <https://doi.org/10.1186/s13244-020-00865-8>
5. Liu Q, Peng W, Zhang F, Hu R, Li Y, Yan W. The effectiveness of blended learning in health professions: Systematic review and meta-analysis. *J Med Internet Res.* 2016;18(1):e2. <https://doi.org/10.2196/jmir.4807>
6. Alamer A, Alharbi F. Synchronous distance teaching of radiology clerkship promotes medical students' learning and engagement. *Insights Imaging.* 2021;12(1):41. <https://doi.org/10.1186/s13244-021-00984-w>
7. Chung E, Subramaniam G, Dass LC. Online learning readiness among university students in Malaysia amidst COVID-19. *Asian J Univ Educ.* 2020;16(2):45–58. <https://doi.org/10.24191/ajue.v16i2.10294>
8. Prezzia C, Vorona G, Greenspan R. Fourth-year medical student opinions and basic knowledge regarding the field of radiology. *Acad Radiol.* 2013;20(3):272–83. <https://doi.org/10.1016/j.acra.2012.10.004>
9. Nyhsen CM, Steinberg LJ, O'Connell JE. Undergraduate radiology teaching from the student's perspective. *Insights Imaging.* 2013;4(1):103–9. <https://doi.org/10.1007/s13244-012-0206-8>
10. Dost S, Hossain A, Shehab M, Abdelwahed A, Al-Nusair L. Perceptions of medical students towards online teaching during the COVID-19 pandemic: a national cross-sectional survey of 2721 UK medical students. *BMJ Open.* 2020;10(11):e042378. <https://doi.org/10.1136/bmjopen-2020-042378>
11. Nguyen, T. The effectiveness of online learning: beyond no significant difference and future horizons. *MERLOT J Online Learn Teach.* 2015;11(2):309–19.
12. O'Doherty D, Dromey M, Loughheed J, Hannigan A, Last J, McGrath D. Barriers and solutions to online learning in medical education – an integrative review. *BMC Med Educ.* 2018;18(1):130. <http://doi.org/10.1186/s12909-018-1240-0>
13. Bernard RM, Borokhovski E, Schmid RF, Tamim RM, Abrami PC. A meta-analysis of blended learning and technology use in higher education: from the general to the applied. *J Comput High Educ.* 2014;26(1):87–122. <https://doi.org/10.1007/s12528-013-9077-3>
14. McRoy C, Patel L, Gaddam DS, Rothenberg S, Herring A, Hamm J, et al. Radiology education in the time of COVID-19: a novel distance learning workstation experience for residents. *Acad Radiol.* 2020;27(10):1467–74. <https://doi.org/10.1016/j.acra.2020.08.001>
15. Li CH, Rajamohan AG, Acharya PT, Liu C-SJ, Patel V, Go JL, et al. Virtual read-out: radiology education for the 21st century during the COVID-19 pandemic. *Acad Radiol.* 2020;27(6):872–81. <https://doi.org/10.1016/j.acra.2020.04.028>