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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 the engagement and academic performance in online versus blended learning in radiology among medical students. A cross-sectional study was conducted among the medical students who completed 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. Total 433 students participated: 179 in online group and 254 in blended group. The mean age was 23.5 years, with 70.7% being female. In online group, 57% enjoyed virtual learning, and 65.4% found asynchronous sessions helpful. In blended group, 76.8% enjoyed F2F learning, and 82.7% found F2F sessions beneficial. Both groups reported satisfactory knowledge acquisition and clinical skills adequacy. 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 learning experiences. Both methods have own merits, with online learning provided greater flexibility, while blended learning was preferred for interactions and practical components. The positive feedback and comparable performance suggest both methods are effective in radiology education. Future research should explore on optimizing the online and F2F components to further enhance learning outcomes.

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

## 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 on 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 diagnosis. 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 pertaining to chest, abdomen, paediatrics, head, and neck. Students learn to analyse clinical problems in daily practice, select appropriate imaging modalities, justify the indication for each, as well as 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 UNIMAS medical students was completely face-to-face (F2F) before 2020, encompassing a two-week duration during the 3<sup>rd</sup> or 4<sup>th</sup> year of the medical programme. Nonetheless, the rapid spread of COVID-19 between 2020 and 2021 led to a transition from physical classes to digital platforms. A blended learning mode, which combines F2F classes with online resources, was incorporated into radiology from 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). Based on a meta-analysis study, blended learning proved 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 claimed that students engaged in online learning had to allocate more time for self-study (7).

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 has highlighted room for improvement, specifically in making more engaging lessons. Some of the students in this programme prefer online learning due to its convenience and self-paced study. While online learning offers flexibility and certain advantages, its effectiveness in producing competent medical professionals remains less examined. This study aimed to explore the engagement and academic performance in online and blended learning in radiology education in the context of 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. Approval to conduct this study was obtained from the Research Medical Ethics Committee, UNIMAS (Reference number: FME/24/89), and Ministry of Health Malaysia (NMRR ID-23-03413-DAU [IIR]).

Students from year 2020 to 2021 engaged in online learning, whereby all the radiology topics were conducted online (including online synchronous and asynchronous classes). An official learning management platform used in UNIMAS, known as the E-Learning Enrichment and Advancement Platform (eLEAP), was used to complement F2F teaching with online tools: discussions, presentations, assessments, videos demonstrations, quizzes, forums, seminars, and examination. Students with access to interactive digital content and collaborative features are able to improve their learning experience. Counterparts from the year 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 level toward content delivery, and learning outcome, a 5-point Likert scale (ranging from strongly disagree to strongly agree) was employed. Four clinical cases, as well as four radiographical images and cross-sectional images of computed radiography, were included in the self-administered assessment to test the medical students' knowledge retention and radiographic interpretation skills. Student representatives of each academic year distributed the survey to their classmates, with informed consent obtained and the responses subsequently gathered.

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

## RESULTS

**Table 1:** Demographic characteristics of students (n = 433)

	Online (N = 179)	Blended (N = 254)	Overall (N = 433)
<b>Age</b>			
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)
<b>Gender</b>			
Female	125	181 (71.3%)	306 (70.7%)
Male	54 (30.2%)	73 (28.7%)	127 (29.3%)
<b>Year</b>			
2019/20 (Year 4)	39 (21.8%)	0 (0%)	39 (21.8%)
2020/21 (Year 3)	140 (78.2%)	0 (0%)	140 (78.2%)
2021/22 (Year 3)	0 (0%)	152 (59.8%)	152 (59.8%)

2022/23 (Year 3)	0 (0%)	102 (40.2%)	102 (40.2%)
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**Table 2:** Students' experience on online learning and blended learning

	Online (N = 179)	Blended (N = 254)
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%)
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%)

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

	Online Mean (SD)	Blended Mean (SD)	p-value
<b>Learning outcome</b>			
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
<b>Content delivery</b>			
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
<b>Ease of accessing technology tools</b>			
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)	4.08 (0.9)	0.29

Note: Likert scores are shown as mean.

**Table 4:** Students' performance on assessment

	Online (N = 179)	Blended (N = 254)	<i>p</i> -value
Total score (n)			
0	0 (0%)	1 (0.4%)	
1	0 (0%)	6 (2.4%)	
2	12 (6.7%)	27 (11%)	
3	35 (20%)	51 (20%)	
4	58 (32%)	71 (28%)	
5	42 (23%)	80 (31%)	
6	24 (13%)	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

### *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 ones 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, with the majority of them being female (70.7%).

### *Students' experience on online and blended learning*

Table 2 presents a generally positive perception among 179 online learning students in radiology education, with a significant proportion (57%) either agreeing or strongly agreeing in terms of online class enjoyment. With 29.6% favouring online learning and 24.1% 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% expressed enjoyment of these 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.

### ***Students' perception and engagement on radiology education***

Students' perception of their experience of radiology education (see Table 3) is related to learning outcomes, content delivery, and ease of accessing technology among students in blended and online learning. The participants ranked their experience using a Likert scale, with 1 = strongly disagree and 5 = strongly agree. Overall, both the student groups discovered that radiology teaching improves their knowledge of medical imaging and prepares them to face actual 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 ease of internet access for coursework. In addition, participants from both the learning modes agreed that navigating online platforms (Microsoft Teams, and Webex) and access to electronic devices (computers, laptops, tablets, or mobile phones) was convenient for their learning.

### ***Students' performance on assessment***

The students' assessment performance, encompassing four case scenarios and four image interpretations, are 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 highest score of 8 (1.7%) set the online group apart. These participants significantly outperformed the blended group in these categories. While both the groups achieved a median score of 4, the online students performed slightly better with higher mean scores of 4.3 than their blended counterparts (4) ( $p < 0.05$ ).

## DISCUSSIONS

This study performed an analysis of the gaps between online and blended learning with regard to the students' viewpoint and performance in radiology. Although their feedback proved positive for both the approaches, the assessment results indicate that the online learning group performed slightly better than the blended learning group. This result suggests the potential benefits in achieving cognitive learning within an online setting. Following past research, online learning is effective for acquiring theoretical knowledge (10).

Nguyen and colleagues' 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 (11). 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, the students engaged in online learning achieved better 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 managed to access and revisit the recording lectures via eLEAP at any given 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 better to virtual tools, leading to more effective learning online than in-person.

The majority of students preferred blended learning with 82.7% reporting F2F sessions to be helpful in 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 instructions in the radiology programme. Blended students' trend toward F2F classes corroborates past research (12), specifically in areas involving a lot of visual interpretation (radiology). This finding also coincides with the meta-analyses, in which e-learning is preferable with better learning outcomes and student satisfaction compared to F2F instruction (2, 13).

Both the groups positively perceived the convenience of using digital resources and web-based online platforms for learning radiology. Students who are more receptive to online learning platforms can effectively navigate online learning following technology advancements and its incorporation into learning systems. Although Chung et al. (7) highlighted the challenges related to online learning during the pandemic, technology usage has 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 of paradigm to online learning has been assisted by eLEAP, a platform that includes and encourages active learning teaching models (flipped classroom and models of active teaching and passive learning), compared to a full didactic learning style that entails listening and watching.

Clinically, the elicited outcomes were more inclined to the online group with regard to 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 and Li et al. highlighted the effectiveness of online methods in radiology teaching, with better education outcomes yielded in image interpretation and case studies (14, 15).

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 the overall performance and preferences, incorporating the elements from both online and blended learning approaches can further enhance the learning outcomes in radiology education.

This study is not without its limitations. For example, some of the medical students from 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 which might cause recall bias compared to the blended group. Single institution sampling also restricted the outcome generalisability. 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 based on two (online and blended) teaching formats in delivering radiology education. In line with the current findings, both methods have distinct advantages. Students preferred online learning, which offers greater flexibility in

their learning 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 derived from 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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### **ETHICS APPROVAL**

Approval was obtained from Research Medical Ethics Committee, UNIMAS (Reference number: FME/24/89) and 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 amendment.

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