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ORIGINAL RESEARCH

Evaluating e-Learning in the Pathology Course During the COVID-19 Pandemic

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Purpose: Synchronous and asynchronous e-learning is a promising and effective educational method for the delivery of medical lessons. Due to the public health measures implemented during the COVID-19 pandemic, our Pathology Department faced the challenge of a total online transition of the lessons. Therefore, the aim is to evaluate the aspects of the applied e-learning method they received.

Materials and Methods: At the end of the semester when e-learning was applied, we designed a structured questionnaire consisting of 17 items via Google Forms, which took the students between 5 and 7 minutes to complete. Of the 257 students registered on the Pathology course in the fifth semester, 207 students (80.5%) returned completed valid questionnaires.

Results: Fifteen of the seventeen components of the e-learning Pathology questionnaire were evaluated highly by the vast majority of the students. The two remaining items, the HIPON platform and the Microlabs e-lessons, were evaluated highly by almost half the students. Approximately 93% of medical students answered that e-learning could be integrated with real class lessons in the medical curriculum: 62.8% (N = 130) of students answered to a great extent, and 30.4% (N = 63) answered to a small extent. Statistically significant differences were found between the demographic characteristics of the participants (gender, permanent residence, working status) and their evaluation of the e-learning items.

Conclusion: E-learning was successfully implemented for the delivery of the pathology lessons and was widely accepted by the students, providing evidence for its future integration into the medical curriculum. Our findings illuminate various aspects of the students' experience with e-learning, and we strongly recommend that the students' evaluation and perspective be taken into consideration by the faculty in the development of policies for higher-quality medical education.

Keywords: medical students, e-learning evaluation, pathology course

Introduction

The disruption in medical education worldwide due to the COVID-19 pandemic has had a significant impact on the delivery of lessons in all educational institutions.[1] During the winter semester of the academic year 2020–2021, e-classes replaced real classes in all universities in Greece due to government restrictions as well as laws mandating e-learning in response to the COVID-19 pandemic.[2] The closure of universities necessitated the implementation of innovative methods for delivering education to ensure students continue to receive adequate teaching while adapting to the new circumstances.[3] Lectures were developed to be delivered online as webinars utilizing various platforms through technologically enhanced approaches that have been proved to promote students' engagement.[4] No studies focusing on the use of virtual, synchronous learning accommodating large groups of students in medical school settings simultaneously have been found.[4] Therefore, since the pandemic necessitated online teaching regardless of the number of students, the nature of the course, and the faculty's readiness and flexibility to transition to remote learning in terms of the personnel's capability and technological efficacy, we believe it is vital to ask medical students to evaluate the education they received through the applied e-learning methods.

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After conducting a literature review, we identified a lack of studies on the evaluation of e-pathology courses. In general, this gap in the research field of e-learning pathology was mentioned before the global pandemic in terms of the cost-effectiveness of the e-learning technologies and the pre- and post-test scores of the participants.[5] Our research is novel, as it was conducted after a 6-month e-semester –from September 2020 to February 2021- with e-learning modalities as the exclusive method of delivering education. The objective of our research is e-learning at the Pathology course and its evaluation. We think the components of e-learning, both synchronous and asynchronous, should be investigated with consideration to the improvement of the educational practices in medical education.

Literature Review of Studies Evaluating e-Learning During the Pandemic

A recent study focused on the evaluation of an e-learning module offered in a pathology course in India;[6] however, in this study, e-learning is a priori considered a supplementary method to the traditional classroom-based teaching. Our research was conducted a year later when, due to the unprecedented challenges caused by the pandemic, e-learning was the main method of education delivery. It is not a temporary modality but an online learning transition, a lasting educational e-process. Nevertheless, even though this research was conducted in a pre-pandemic class, it provided evidence that e-learning was very useful to medical students and suggested that it should be integrated into medical education.[6]

Another recent study was conducted one year before the pandemic in a clinical pathology course for nursing students to explore the acceptance and impact of an e-classroom via Google in Taiwan.[7] Students were divided into two groups: the experimental group that attended both traditional and Google Classroom lessons, and the control group that attended exclusively traditional lessons. The study concluded that the experimental group demonstrated high acceptance of the Google Classroom lessons and that blended learning – the combination of this e-classroom and traditional learning – resulted in similar learning satisfaction and achievement compared to the traditional learning model of pathology. The study suggested that the Google Classroom platform should be integrated into traditional teaching.

Moreover, during the COVID-19 pandemic, three studies on the pathology course were conducted in the USA in the spring of 2020. The first was conducted at the University of California, San Francisco, and aimed to assess medical students' perceptions of learning in an advanced clinical elective pathology course offered in a remote learning environment.[8] The overall positive response of students provided evidence that many aspects of anatomic pathology were successfully transitioned in the e-learning environment.[8,9] The second study was conducted at the University of Iowa, and it compared pathology teaching before and during the pandemic according to the curriculum.[10] The student feedback was generally positive, and the end-of-course evaluations suggested a preference for live streaming teaching in small groups. The third study was conducted in the Department of Pathology at MD Anderson Cancer Center in Houston, Texas.[11] Its training program, which includes clinical and educational operations, was shifted to a hybrid on-site and remote training model. The responses of the clinical fellows, faculty members and research fellows showed that the latter model can maximize anatomic pathology learning opportunities while maintaining the safety of everyone involved.

The "pandemic edition" of a forensic medicine and pathology course[12] from the Institute of Forensic Medicine at Cardiff University School of Medicine, Wales, UK, also included both synchronous and asynchronous e-learning resources for the students. A comparative study based on three time periods (2015–2019, 2019, 2020) was conducted. Based on students' feedback, this online "pandemic edition" of the course was well received and compared favorably with the feedback from previous years. This study also demonstrates the relevance to undergraduate medical students of the application of forensic medicine and pathology to the safeguarding of patients.

During the pandemic, a research study in telepathology was conducted in Turkey during the spring semester of the academic year 2019–2020.[13] After three online microscopy e-lectures, students' feedback was obtained through an online questionnaire. The study concluded, as did the previous studies, that the integration of online learning into both theoretical and practical areas of medical education as part of an interdisciplinary project, with the collaboration of health, computer and education professionals, is crucial for high-quality education, as was strikingly seen during the COVID-19 crisis.

Our research gave medical students the opportunity to provide their perspective and evaluate the online pathology course they attended. It was the first time that all the lessons in the semester were taught exclusively via e-learning

methods, both synchronous and asynchronous, and therefore we asked students to evaluate the teaching they received through the applied e-learning modalities. The research was conducted after the autumn/winter semester was completed, about 6 months after all the above studies in the academic year 2020–2021. Unlike the majority of medical studies that utilized questionnaires for students to evaluate either asynchronous e-learning[14,15] or blended learning that includes real class lessons and asynchronous e-learning,[16–19] our research focuses on e-learning methods and resources that totally replaced teaching in traditional classroom setups and laboratories.

Materials and Methods

Applied e-Learning Pathology

The faculty had chosen the Skype for Business platform for the delivery of synchronous e-learning in all courses of the Medical School. In the pathology course, registered students first received an e-tutorial on the use of the selected platform and a hyperlink to access the e-lesson via e-mail.[20] All the pathology live streaming lessons of the semester were divided in four types: theory, macroscopic, microscopic, and clinical. This division was the same as in the pre-pandemic real class. The duration of each e-lesson, regardless of the type, was 3 hours on a weekly basis.[21] In all the live streaming e-lessons, the professor was present while teaching with the use of PowerPoint presentations, screen sharing software, e-microscope slides, and virtual patient clinical descriptions.[22] Engaging discussions took place between professor and students to clarify any doubts, articulate thoughts on the course's content, and process its material.[20] All the e-lessons during the semester were recorded and uploaded to the e-class platform of the course on the university's website.

In 2013, the faculty launched the asynchronous, interactive e-learning platform HIPON for its students with the aim of supplementing and enriching their learning experience.[23] Other asynchronous e-learning modules offered for the pathology course were Massive Open Online Courses (MOOCs), video-recorded lectures from lecture theaters, and other legible pathology e-resources including previous asynchronous e-lessons.[21]

Questionnaire Design

The present study was conducted after obtaining the approval of the Institutional Ethics Committee, protocol number 429, in January 2021. The approval included the structured questionnaire for medical students (in February of the same year) to be completed on a voluntary basis. The questionnaire's demographic questions included the participants' gender, permanent residence, and working status –for the latter, we evaluated this aspect as it is common in Greece for students to work in parallel with their studies and also, because the e-learning method applied could possibly serve any working person. Based on the types of live streaming lessons students received, the first questions focused on the evaluation of theory e-lessons, macroscopic e-lessons, microscopic e-lessons, and clinical e-lessons. For the synchronous e-learning, we also asked students about the e-teaching they received with the use of histological slides via a digital microscope and asked for their opinion on the effectiveness of the method. Moreover, they were asked to evaluate the interactivity between them and the professor, the choice of the latter being present while teaching, and the adopted teaching methodology. The last question related to synchronous e-learning concerned the students' perspective of the practice of recording the e-lessons.

The questions associated with asynchronous e-learning in the pathology course evaluated the educational resources available for students in their e-portfolio: the HIPON platform, MOOCs, the recorded e-lessons, and other digital links with pathology educational content. Students were asked to comment on their satisfaction with the above asynchronous e-learning methods and the flexibility that asynchronous e-learning offers in terms of personal space and organization of study time.

Data Collection and Analysis

The structured questionnaire was prepared at the end of the semester and sent via Google Forms to all e-mail addresses of the students registered on the pathology course in the fifth semester. Participation in the research was voluntary, and anonymity was ensured.[24] The questionnaire required between 5 and 7 minutes to complete. Of the 257 students that

were registered on the pathology course in the fifth semester, 207 students (80.5%) returned completed valid questionnaires.

The data analysis was performed with the open source program Statistical Processing PSPP v.1.5.1. Tables and figures were created in LibreOffice Calc 7.3.0. To validate each questionnaire instrument used in the study, exploratory factor analysis was performed in all cases using Principal Component Analysis (PCA) extraction and Varimax rotation. PCA better explains the variance that can exist between factors where factoring axis analysis fails.[25,26] Factor analysis for E-Class evaluation in pathology items was conducted with principal components in a correlation table with Varimax rotation. It was more appropriate to use the correlation matrix. Varimax rotation was used to maximize the total variance in each factor.[27] There was sample adequacy – KMO = 0.920 > 0.600 – and the data were suitable for analysis without zero divisions – $X^2(91) = 1971.89$, $p < 0.05$. All extractions were > 0.40. The overall explanation was ~65%, which is showing borderline validity for this scale. Our factor analysis of the pathology items produced two scales: Pathology E-Class Learning and Pathology E-Class Material. Both scales included 13 items, and some items were common to both scales due to medium–high loadings in both scales with a border accepted validity. Both scales included the four types of e-lessons: Theory, Macrolabs, Microlabs, and Clinical. Pathology E-Class Learning also included items of the applied synchronous e-learning: histological slides, practice of recording e-lessons, interactivity, professor's presence, and the effectiveness of synchronous e-learning. The Pathology E-Class Material included teaching style, HIPON platform links, MOOC links, links to e-lessons' recordings, and links to digital asynchronous educational resources.

We used reliability analysis with Cronbach's alpha to measure each scale's reliability. All the values were > 0.65, indicating good internal consistency. To apply the appropriate analysis test, since some require the existence of normal distribution of values (parametric tests), we performed normality analysis with the Kolmogorov–Smirnov test. In the normality analysis, all the p values were < 0.05, showing a non-normal sample distribution, and therefore non-parametric tests were used.

The non-parametric Kruskal–Wallis test[28] was used and revealed the significant differences among the scales and the items of the study. Mean analysis followed and supported the findings of the applied statistics.

Results

The demographics are presented in detail in Table 1.

Table 1 Demographics

		Freq. N	Freq. %
Gender	Female	116	56.0%
	Male	91	44.0%
	Total	207	
Region	Athens/suburbs	115	59.0%
	City outside Attica	44	22.6%
	Rural area	36	18.5%
	Other	12	
	Total	207	
Working Status	Non-working students	178	86.0%
	Working students	21	10.1%
	Freelancer working students	8	3.9%
	Total	207	

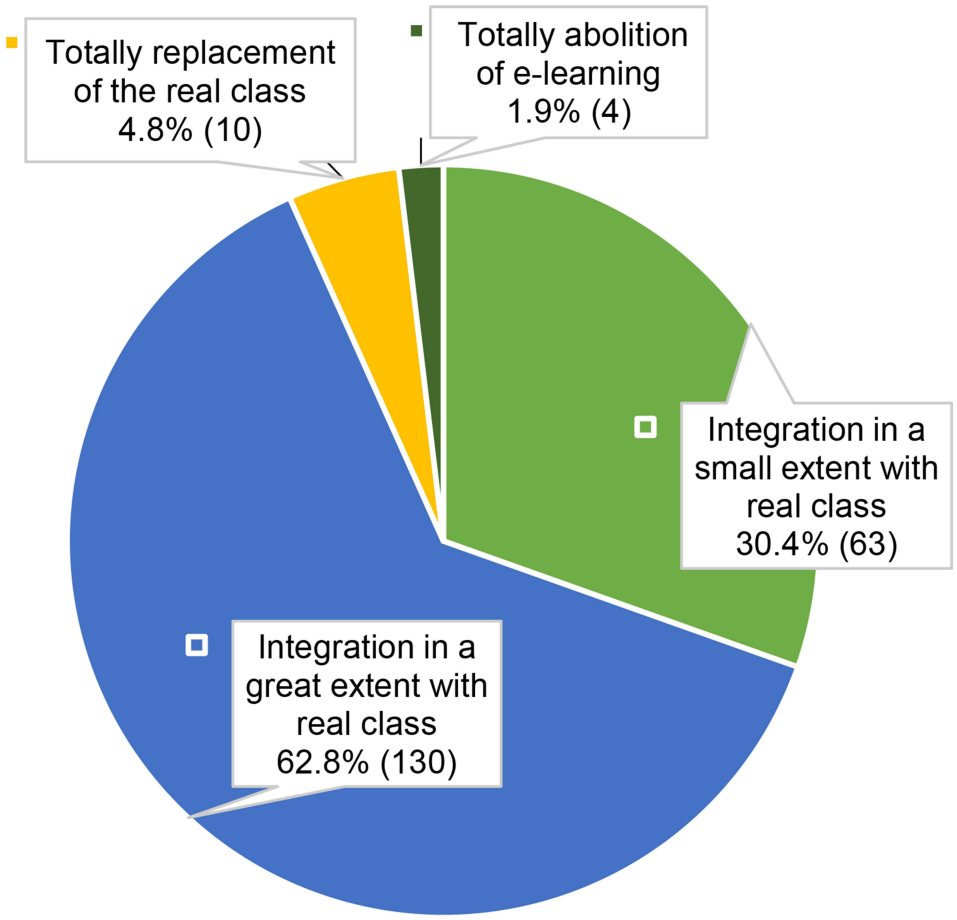

Figure 1 Integration of e-learning pathology into real class.

Evaluation of the e-Learning Pathology Components

Among the four types of e-lessons in live streaming (Table 2) the ePA Clinical lessons were the most frequently highly rated (86.5%), whereas the ePA Microlabs lessons were the least frequently highly rated (59.9%). Specific aspects of the applied synchronous e-learning method, such as the use of histological slides in digital microscopy, the professor's constant presence during e-teaching, and the approval of the teaching methodology during live streaming lessons were all evaluated highly by the majority of students (ie, > 80% of students). It is noteworthy that the practice of recording the live streaming e-lessons and later uploading them as video archives to the e-class portfolio of the students was evaluated at a remarkably high rate by 92.7% of the students.

Some asynchronous e-learning items of the pathology course were also evaluated highly by the majority of students: MOOCs (79.2%), recorded live streamed e-lessons (88.4%), and pathology online links (73.5%). The HIPON platform, which is an additional digital resource for studying, received a high rating from 59.4% of the students and an average rating from 36.6%.

Finally, students were asked to evaluate asynchronous e-learning in terms of overall satisfaction, flexibility, and personal study time. The students evaluated these aspects highly, indicating high acceptance of the applied e-learning method.

All the results we obtained from the questionnaires show that Pathology items (Table 2) of the e-learning method had a high positive rate (from > 70% of students) except the Links HIPON (59.4%) and the MicroLabs e-lessons (59.9%).

Of the 17 components of the e-learning Pathology questionnaire including synchronous and asynchronous items, 15 were evaluated highly by the vast majority of the students. The two remaining items were evaluated highly by more than half the students.

Table 2 Evaluation of the e-Learning Pathology (ePA) Items

Pathology Items	Frequency			Frequency %		
	Low (0–2)	Medium (4–7)	High (8–10)	Low (0–2)	Medium (4–7)	High (8–10)
ePA Theory e-lessons	4	54	149	1.9	26.1	72.0
ePA MacroLabs e-lessons	3	37	167	1.4	17.9	80.7
ePA MicroLabs e-lessons	58	32	124	28.0	15.4	59.9
ePA Clinical e-lessons	3	25	179	1.4	12.0	86.5
ePA Histological Slides presentation at e-lessons	1	35	171	0.5	16.8	82.6
ePA Effectiveness	2	47	158	1.0	22.7	76.3
ePA Live Course Interactivity	7	51	149	3.3	24.6	71.9
ePA Live Course Professor's presence	2	38	167	1.0	18.4	80.7
ePA Practice of recording the live e-lessons	0	15	192	0.0	7.2	92.7
ePA Live Teaching	3	37	167	1.5	17.8	80.6
ePA Links HIPON	8	76	123	3.9	36.6	59.4
ePA Links MOOC	1	42	164	0.5	20.3	79.2
ePA Links Recorded live e-lessons	4	20	183	1.9	9.6	88.4
ePA Links Asynchronous e-learning	3	52	152	1.4	25.1	73.5
ePa Overall Satisfaction with Asynchronous e-learning	1	42	164	0.5	20.3	79.3
ePA Personal Flexibility in Asynchronous e-learning	1	35	171	0.5	16.9	82.6
ePA Personal Study Time in Asynchronous e-learning	4	30	173	1.9	14.5	83.6

Integration of e-Learning Pathology

Concerning students' experience with e-learning for the whole semester, they were asked for their opinion on e-learning in the future in pathology. Approximately 93% of medical students answered that e-learning could be integrated with real class lessons in the medical curriculum: 62.8% (N = 130) of students answered to a great extent, and 30.4% (N = 63) to a small extent (Figure 1).

Kruskal–Wallis Tests' Results and Mean Analysis Results

Kruskal–Wallis tests were applied to the items (Table 3) and the scales (Table 4) of the study. Table 3 shows the differences and Table 5 the means of them among the e-Pathology total items and the three demographic parameters. Additionally, at Table 3 we can see the differences among the e-Pathology total items and e-learning integration.

Table 4 shows the two scales of the e-learning Pathology course, the e-Class e-learning and e-Class material, and their differences in terms of demographics and e-learning integration.

Statistically significant differences (Kruskal–Wallis) were found between demographics and E-Class total items of the e-learning Pathology course. In detail, the latter differences were observed between:

Table 3 Kruskal–Wallis Differences in e-Learning Pathology Total Items on demographics and e-Learning's Integration

	Gender		Region		Working Status		E-Learning Integration	
	χ^2	DF = 1	χ^2	DF = 2	χ^2	DF = 1	χ^2	DF = 1
ePA Theory e-lessons	0.30	0.584	0.76	0.685	1.49	0.222	4.41	0.036**
ePA MacroLabs e-lessons	3.49	0.062*	3.02	0.220	3.99	0.046**	11.85	0.001**
ePA MicroLabs e-lessons	0.02	0.895	0.21	0.898	2.07	0.151**	11.53	0.001**
ePA Clinical e-lessons	0.02	0.889	1.13	0.569	6.95	0.008**	12.32	0.000**
ePA Histological slides presentation in e-lessons	2.56	0.109	0.89	0.640	0.74	0.389	9.44	0.002**
ePA Effectiveness	0.02	0.892	1.29	0.526	2.43	0.119	26.06	0.000**
ePA Live Course Interactivity	2.18	0.140	0.17	0.917	5.17	0.023**	10.70	0.001**
ePA Live Course Professor's presence	2.03	0.154	1.50	0.473	10.59	0.001**	5.52	0.019**
ePA Practice of recording the live e-lessons	1.27	0.260	1.99	0.370	4.58	0.032**	5.91	0.015**
ePA Live Teaching	1.23	0.267	0.83	0.659	5.86	0.016**	6.40	0.011**
ePA Links HIPON	0.53	0.468	0.30	0.860	1.09	0.296	0.54	0.464
ePA Links MOOC	0.82	0.366	3.52	0.172	5.55	0.018**	1.26	0.262
ePA Links Recorded live e-lessons	0.81	0.367	7.92	0.019**	8.21	0.004**	4.14	0.042**
ePA Links Asynchronous e-learning	0.00	0.944	2.53	0.282	7.81	0.005**	4.82	0.028**
ePa Overall Satisfaction with Asynchronous e-learning	0.00	0.956	1.94	0.379	7.13	0.008**	15.62	0.000**
ePA Personal Flexibility in Asynchronous e-learning	0.26	0.609	1.17	0.558	9.36	0.002**	19.40	0.000**
ePA Personal Study Time in Asynchronous e-learning	0.73	0.393	6.91	0.032**	6.53	0.011**	24.58	0.000**

Note: **p ≤ 0.05, *p ≤ 0.10.
Abbreviatons: χ^2, chi-square distributions; DF, Degree of Freedom.

Table 4 Kruskal Wallis Differences in e-Learning Pathology e-Class Scales

	Gender		Region		Working Status		E-Learning Integration	
	χ^2	DF = 1	χ^2	DF = 2	χ^2	DF = 1	χ^2	DF = 1
ePA E-Class Learning	1.07	0.302	0.79	0.675	5.88	0.015**	16.66	0.000**
ePA E-Class Material	0.27	0.601	1.99	0.370	6.19	0.013**	13.73	0.000**
ePA E-Class Total	1.04	0.309	1.49	0.475	7.25	0.007**	16.59	0.000**

Note: **p ≤ 0.05.
Abbreviatons: χ^2, chi-square distributions; DF, Degree of Freedom.

- Gender and the specific type of MacroLabs e-lessons in particular. Females had higher means in almost all the e-learning Pathology items; however, mean scores of scales based on gender were very similar ($p < 0.20$).
- Region and the asynchronous module of Links Recorded live e-lessons, as well as the students' Personal Study Time and all Asynchronous e-learning tools; HIPON platform and MOOCs, recording of live lessons and all available digital resources in their portfolio. Students living in Athens had higher mean scores on e-learning Pathology (ePA) Links Recorded live e-lessons, ePA Links Asynchronous e-lessons, ePA Overall Satisfaction with Asynchronous e-lessons, ePA Personal Flexibility in Asynchronous e-lessons, ePA Personal Study Time and

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Table 5 Means of e-Learning Pathology's (ePA) Items per All Demographics

	Gender		Region			Working Status	
	Females (N = 116)	Males (N = 91)	Athens/Suburbs (N = 115)	Urban Area (N = 44)	Rural Area (N = 36)	Students Do Not Work (N = 178)	Students Work (N = 29)
ePA Theory e-lessons	8.16	8.14	8.12	8.39	8.00	8.08	8.59
ePA MacroLabs e-lessons	8.50	8.18	8.45	8.41	8.08	8.27	8.90
ePA MicroLabs e-lessons	7.91	8.01	7.91	8.05	7.97	7.88	8.41
ePA Clinical e-lessons	8.98	8.84	8.91	9.05	8.78	8.81	9.59
ePA Histological slides presentation at e-lessons	8.74	8.49	8.62	8.80	8.44	8.60	8.83
ePA Effectiveness	8.42	8.34	8.43	8.57	8.08	8.31	8.83
ePA Live Course Interactivity	8.29	7.96	8.17	8.18	8.08	8.02	8.9
ePA Live Course Professor's presence	8.83	8.33	8.76	8.43	8.56	8.47	9.40
ePA Practice of recording the live e-lessons	9.58	9.34	9.52	9.39	9.39	9.41	9.86
ePA Live Teaching	8.66	8.34	8.47	8.61	8.72	8.41	9.17
ePA Links HIPON	7.59	7.49	7.60	7.30	7.53	7.49	7.93
ePA Links MOOC	8.60	8.44	8.7	8.32	8.33	8.44	9.07
ePA Links Recorded live e-lessons	9.19	8.91	9.28	9.07	8.56	8.96	9.72
ePA Links Asynchronous e-learning	8.28	8.37	8.47	8.23	8.11	8.21	9.00
ePa Overall Satisfaction with Asynchronous e-learning	8.48	8.52	8.63	8.52	8.19	8.40	9.07
ePA Personal Flexibility in Asynchronous e-learning	8.80	8.86	8.90	8.75	8.67	8.73	9.41
ePA Personal Study Time in Asynchronous e-learning	8.86	8.58	8.91	8.66	8.31	8.64	9.34

Table 6 Means of e-Learning Pathology's Total Items

Items	N = 207	
	Mean	SD
ePA Theory e-lessons	8.15	1.67
ePA MacroLabs e-lessons	8.36	1.62
ePA MicroLabs e-lessons	7.96	2.00
ePA Clinical e-lessons	8.92	1.60
ePA Histological slides presentation at e-lessons	8.63	1.64
ePA Effectiveness	8.39	1.69
ePA Live Course Interactivity	8.14	1.88
ePA Live Course Professor's presence	8.61	1.70
ePA Practice of recording the live e-lessons	9.47	1.14
ePA Live Teaching	8.52	1.64
ePA Links HIPON	7.55	2.06
ePA Links MOOC	8.53	1.62
ePA Links Recorded live e-lessons	9.07	1.57
ePA Links Asynchronous e-learning	8.32	1.83
ePa Overall Satisfaction with Asynchronous e-learning	8.50	1.55
ePA Personal Flexibility in Asynchronous e-learning	8.83	1.57
ePA Personal Study Time in Asynchronous e-learning	8.74	1.61

Asynchronous e-lessons, and ePA Links items compared to students living elsewhere, while on practical labs/courses, the former had lower mean scores than those living in other urban cities. Mean scores of scales based on Region were very similar with $p < 0.20$ difference.

- Students that work and almost all e-learning Pathology items. Students that work had higher mean scores on all ePA scales (~1 point) than students that do not work.

According to the applied mean analysis, the vast majority of the e-learning Pathology's items had high means. It is clear that Links of HIPON Platform and MicroLabs e-lessons had the lowest means in e-learning Pathology in total means (Table 6, Figure 2).

A statistically significant difference was found between integration of e-learning modalities into the pathology course in real classes and almost all e-learning Pathology items. It was found that the e-learning modalities which were highly supplementary to real classes had higher mean scores on all the ePA scales (~.50 point). The applied mean analysis of the item e-learning Pathology integration provided evidence that those who considered e-Class highly supplementary to real classes had much higher mean scores on e-learning Pathology items (Table 7, Figure 3).

Discussion

The unprecedented changes in the academic world brought by the COVID-19 pandemic led to the rapid evolution and domination of online teaching.[29] Regardless of how well-prepared they were, medical schools all over the world were recently thrown off balance when they were forced to shift to exclusive online teaching.[30] Since pathology teaching and assessment are fundamental components of the undergraduate medical curriculum,[31] our research focused on the

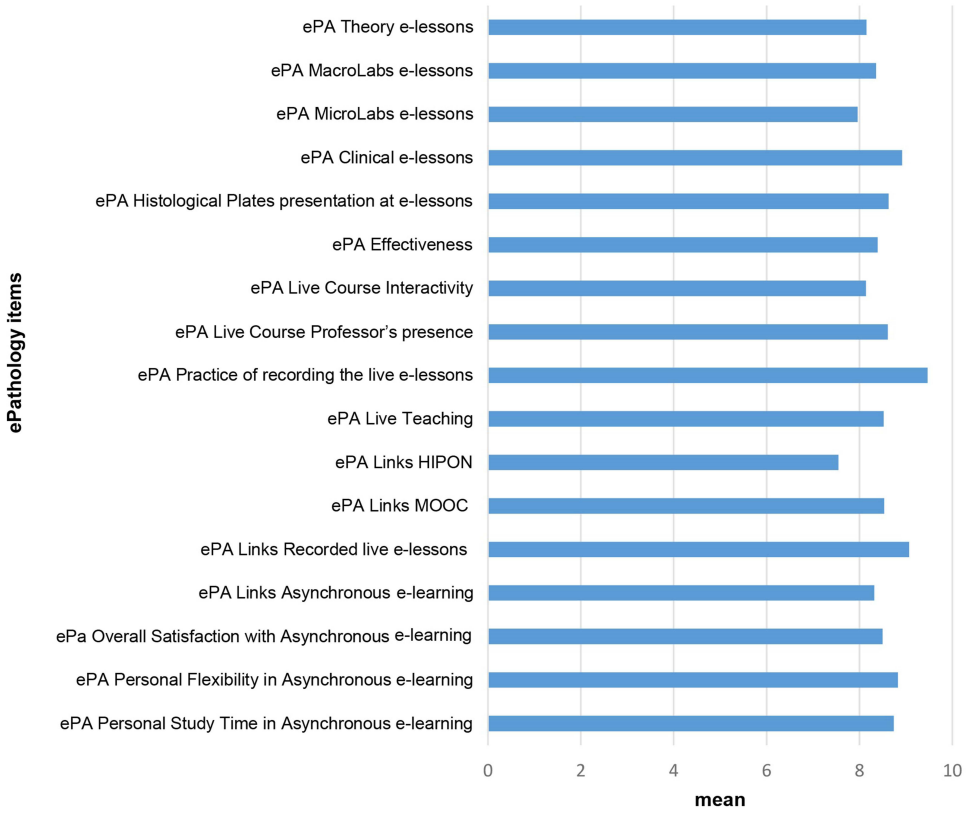

Figure 2 Means of e-learning pathology's total items.

evaluation of the applied e-learning Pathology by asking the students registered on the course about their e-learning experience during one semester. They attended a full-time program pre-pandemic, with their natural presence in real classes according to the curriculum of the medical school. The pandemic changed the educational procedure, transformed the real audience to an e-audience, and incorporated e-learning as an equal method to teaching in real classes. Medical students were compelled to adjust quickly to learning entirely from home,[32] and we believe it is crucial to learn from their experience.

The vast majority of the e-learning Pathology items had very high mean scores. Among the four types of pathology e-lessons, the ePA Clinical e-lessons were the most frequently highly evaluated. This could be linked to the modern trends of teaching in medical education that are more focused on practical and interactive learning than theory-driven learning. It is indisputable that simulation with everyday practice of medicine assisted by the professor's guidance is a promising pedagogical tool in medicine.[33] Our view is that medical education teaching methodologies should follow the steps of scientific methods, namely, starting with observation (patients' symptoms, laboratory data [biochemical, imaging macroscopic and microscopic tissue lesions]), which should guide the steps to conceptualization (ie, pathological evaluation), differential diagnosis, and final diagnosis leading to the application of the appropriate concept in clinical practice (ie, patients' prognosis and management).[34] Therefore, the study of theory should follow clinical practice and not vice versa. Our department's education philosophy is for the students to develop practical observation skills, as these are considered fundamental for clinical thinking and essential for becoming competent clinicians.

The faculty delivered e-lessons in pathology with the presentation of histological slides through a digital/virtual microscope, and the relevant students' evaluation was very positive. Teaching pathology via digital, screen share microscopy serves as a valuable tool of e-learning and, in parallel, as an effective practice to overcome the increasing number of students, the shortage of pathology academics in regional medical schools, and the challenges of teaching students who permanently live in rural areas.[35]

Table 7 Means of e-Learning Pathology Items per e-Learning Integration

	E-Learning 's Low Integration into Real Class			E-Learning 's High Integration into Real Class			Significant test	
	Mean	N	SD	Mean	N	SD	χ^2	DF=1
ePA Theory e-lessons	7.76	67	1.94	8.34	140	1.50	4.41	0.036**
ePA MacroLabs e-lessons	7.69	67	2.10	8.68	140	1.22	11.85	0.001**
ePA MicroLabs e-lessons	7.27	67	2.30	8.29	140	1.76	11.53	0.001**
ePA Clinical e-lessons	8.25	67	2.17	9.24	140	1.12	12.32	0.000**
ePA Histological slides presentation at e-lessons	8.04	67	2.04	8.91	140	1.33	9.44	0.002**
ePA Effectiveness	7.48	67	2.05	8.82	140	1.29	26.06	0.000**
ePA Live Course Interactivity	7.43	67	2.32	8.49	140	1.53	10.70	0.001**
ePA Live Course Professor's presence	8.15	67	2.09	8.83	140	1.44	5.52	0.019**
ePA Practice of recording the live e-lessons	9.33	67	1.06	9.54	140	1.18	5.91	0.015**
ePA Live Teaching	7.93	67	2.22	8.80	140	1.18	6.40	0.011**
ePA Links HIPON	7.21	67	2.56	7.71	140	1.76	0.54	0.464
ePA Links MOOC	8.31	67	1.83	8.64	140	1.51	1.26	0.262
ePA Links Recorded live e-lessons	8.67	67	2.07	9.26	140	1.23	4.14	0.042**
ePA Links Asynchronous e-learning	7.84	67	2.22	8.55	140	1.56	4.82	0.028**
ePa Overall Satisfaction with Asynchronous e-learning	7.87	67	1.81	8.80	140	1.32	15.62	0.000**
ePA Personal Flexibility in Asynchronous e-learning	8.13	67	1.80	9.16	140	1.33	19.40	0.000**
ePA Personal Study Time in Asynchronous e-learning	7.85	67	2.11	9.16	140	1.08	24.58	0.000**

Note: **$p \leq 0.05$.
Abbreviatons: χ^2, chi-square distributions; DF, Degree of Freedom.

Despite the above, of the 17 evaluated items, 3 had the lowest mean scores in total means. Among them, the ePa Microlabs e-lessons based on conventional glass slides photos on PowerPoint presentations were least frequently evaluated with high marks by the students even though the relevant technology was utilized efficiently through high-resolution images. This could indicate the students' need to engage in the real-life operation of the microscope through conventional or virtual glass slides and their need for guidance from the professor in acquiring this practical skill. Even though the effectiveness of virtual microscopy as an educational tool has already been proven,[36,37] real life experience seems to be crucial pedagogically to teach students the skill to evaluate microscopic diagnostic features in patients' tissues to establish a diagnosis. The professor's guidance in the procedure[23] is necessary in both the virtual and the conventional slides, and therefore we conclude that the active role of the professor is irreplaceable in both e-learning and traditional face-to-face learning.

The HIPON platform is another item that had one of the lowest mean scores in e-learning Pathology in total means. It was evaluated as 7.55 out of 10, which is considered a medium score. "ICT e-modules on HistoPathology: a valuable online tool for students, researchers and professionals – HIPON" was a 3-year project supported and co-funded by the Lifelong Learning Program of the Education, Audiovisual and Culture Executive Agency (EACEA), The Commission of the European Union. It concerns general and systematic pathology, provides navigation to virtual slides, and includes case studies, educational videos, pathology's image archives, and self-assessment tests. HIPON's purpose is not to provide just another pathology website atlas, but to pass on professional experience and thinking in pathology. HIPON

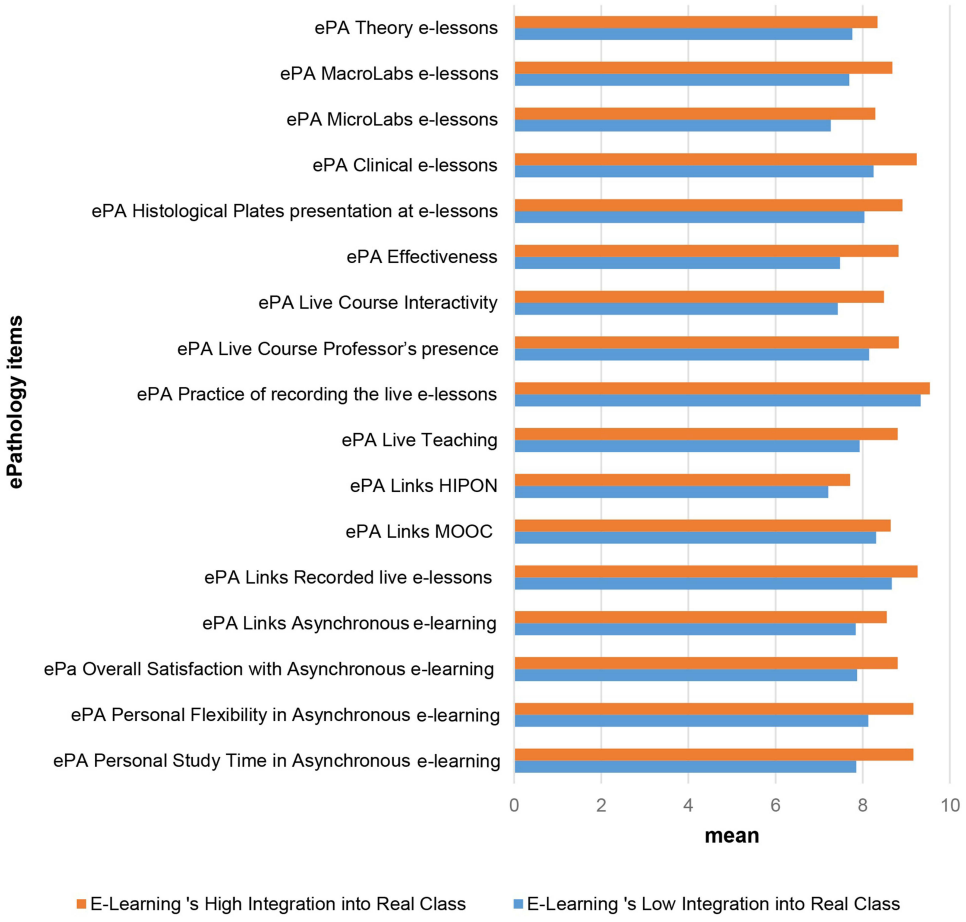

Figure 3 Means of e-learning pathology items per e-learning integration.

implements the strategy of case-based learning and decision-making in pathology.[38] The HIPON platform was selected to be used by the faculty after its development and positive evaluation by the EACEA experts.[38,39] There is a possibility that students that did not access this platform rated it with a medium or low evaluation score. We observed that when the students were asked to utilize the platform without guidance, they seemed reluctant to adopt this learning style, as they are used to a more theory-based approach via traditional textbooks. One major issue in medical education is the uncertainty and anxiety the students feel concerning their abilities and the latter's implementation in solving practical issues of everyday medical practice. They seem to feel underprepared to cope with the everyday decision-making and challenges of the professional. Therefore, it is vital for academic professors to take into consideration the students' perspectives and needs, personally reassure them about their skills, and empower them to make decisions, promote clinical thinking, and exercise practical skills.

The two highest scores in our research were recorded for the practice of video-recording the live streaming e-lessons and the asynchronous links to other video-recorded e-lessons, with the rate in mean scores of 9.47 and 9.07, respectively, in total means; both provide evidence that the practice of recording and sharing the e-lessons should be continued in the future. Recent research with the same students related to the timing of the uploading of a video-recorded e-lesson concluded that the most difficult e-lessons with complex learning points should be video-recorded and uploaded at the beginning of the semester. Additionally, as expected, students tend to watch a greater number of e-lessons when the examination period is approaching.[22]

The remaining mean of items of e-learning pathology is between 8 and 9 out of 10, which indicates that both synchronous and asynchronous e-learning Pathology were successfully organized, applied, and delivered to the registered pathology students.

Students also evaluated the effectiveness of e-learning Pathology. Identifying effectiveness as the ability to achieve the improvement of a learners' knowledge[6] and knowing that all students registered on the course achieved a passing

grade in the exams,[21] we conclude that the faculty has organized the e-learning procedure successfully. Effectiveness, efficacy, usage and quality are the four keys for the evaluation of e-learning.[40] The implementation of effective and successful online learning and the inclusion of digital resources can yield a range of positive outcomes, such as developing a learning environment that caters for students with different learning needs and applying multiple learning channel methodologies to promote an interest in the instructional materials and foster the students' knowledge of pathology.[41]

The teaching methodology of the professor, including their choice to be constantly present in a separate column during the live streaming e-lesson, and the interaction between the professor and the students have been rated positively by the students. It has been stated that the instructor's teaching style and visual presence are instrumental in engaging students with the content.[42] Traditionally, pathologists' teaching roles are focused on tumor boards, medicine autopsy conferences, and directly at the microscope with visiting clinical teams.[43] However, within a synchronous e-learning field, the professor has additional roles as an educator, namely, to make this sudden transition from real classes to e-classes easier and effective, to e-deliver the pathology knowledge in a compelling way, to promote conversations between the professor and the audience, and to enable all participants to have an enjoyable and active e-learning procedure. It is also necessary to mention the work on the digital contents of the course that the professor has to prepare and the technical knowledge that is required.

In the field of asynchronous e-learning on the pathology course, students evaluated the relevant aspects with scores between 8 and 10 in total means, with the exception of recorded e-lessons, which were graded between 9 and 10, as mentioned above. MOOCs and different digital resources such as articles, publications and hyperlinks were well accepted by the students. All the asynchronous tools were considered optional but not of less importance, as their core purpose was to enrich students' knowledge in the field of pathology. The available online material that was suggested as asynchronous e-learning by the faculty provided knowledge acquisition, revision, or feedback.[15]

The satisfaction with the e-learning of the course that students received was also given a high positive score, as was the flexibility it offers and the advantage in the organization of their study time. The comparative advantage of e-learning is that it does not require live appointments and thus provides personal freedom regarding the time and place for choosing their online educational method. When students choose asynchronous e-learning, they use personalized learning methods, reorganize their time to improve productivity, and set individualized priorities.[44] Since the faculty offers the recorded live streaming lessons as video archives, it is necessary to investigate whether this practice affects the number of students attending the live streaming lessons (in real time). In our previous research,[45] we observed that during each 3-hour live e-lesson, the dropout rate was statistically significant, but there was no statistically significant difference in the dropout rate during the e-lessons. The findings of this current research may be consistent with some of the conclusions of this earlier research.[45] But in this present study, students were given the opportunity to provide their perspective on the way e-learning was structured and applied. Moreover, students were asked to evaluate the asynchronous e-learning methods provided by the faculty.

Our findings revealed that students' evaluation of the e-learning they received on the pathology course for the whole period of the autumn/winter semester and during the pandemic was highly positive. Regarding the subject of integration of e-learning modules into real classes, students strongly support that they could be highly supplementary to real classes, while giving their high evaluation on almost all the e-learning Pathology items and scales of the research. The high level of acceptance of both the synchronous and the asynchronous e-learning modalities indicates that e-learning should be integrated into the medical curriculum, a finding that aligns with the existing literature. A recent study revealed that student satisfaction was high in relation to curricular modification and students strongly supported the implementation of such a teaching approach in upcoming modules.[46] Based on our research, as well as other pre-pandemic studies[47] in the field of pathology education, it is evident that e-learning has been incorporated successfully and evaluated positively.

In terms of demographics, it is interesting to note the statistically significant preference of female participants for the ePA Macrolabs e-lessons compared to the male participants. As the Macrolabs' content consists of studying organs and surgical specimens, this preference could indicate the rising interest of women in surgery. We also found the predictable statistically significant preference of working students for asynchronous e-learning, as it suits their schedule and time needs, as well as the statistically significant higher evaluation of every aspect of e-learning by the students who consider

e-learning highly supplementary to the teaching procedure. Finally, the statistically significant preference of students living in the capital city for asynchronous e-learning compared to the students living in other regions could be attributed to the capital city's more intense pace of life.

Moreover, a new modality in asynchronous e-learning pathology is game-based learning such as "Kahoot!", a mobile game-based online digital formative assessment tool[48] that has recently been evaluated by medical students.[49] Since gaming technologies are considered eligible for opportunistic learning and offer advantageous learning strategies that facilitate continued educational outcomes in moments of down time,[50] we propose that the department should consider its addition to the students' portfolio.

One limitation of our study is that it has been conducted in one pathology course at one specific university. Nevertheless, the long duration of e-learning and the fact that over 80% of students (N = 207) registered on the course participated voluntarily in our research strengthen our results and reduce the risk of a false generalization of our findings in other undergraduate medical classes that share similar characteristics. Moreover, we could have asked the students for their e-examinations experience in the pathology course at the end of the e-semester. Evaluating the e-examination procedure could enrich our research findings regarding the efficacy of e-learning. It would also offer valuable insights into the novel approach of medical school e-examinations during the COVID-19 pandemic.[32]

We believe this study is unique and inclusive of every aspect of the e-learning procedure, both synchronous and asynchronous, that was implemented in the pathology course during the COVID-19 pandemic. We believe our findings and conclusions are vital for illuminating the perspective of students on online medical education and are important in the consideration of future practices for higher-quality teaching and the development of the educational procedure. Moreover, it is essential that medical educators reflect and evaluate their professors' teaching ability to meet their students' learning needs.[51] Additionally, our conclusions could serve the faculty's preparations in subsequent emergency situations that disrupt traditional teaching.[24]

Conclusions

Although the COVID-19 pandemic accelerated the development of online medical education and numerous researchers have explored the topic, few studies have focused on online teaching.[52] The popularity of e-learning as an educational tool has grown rapidly, but more efforts have been concentrated on advancing technology than on attempting to understand the needs and learning styles of e-learners,[6] including evaluating reports on the field of synchronous and asynchronous e-learning.

Students' feedback showed that the e-learning program they received during the pandemic for the whole autumn/winter semester was conducted successfully. The integration of e-learning into medical education should be considered seriously in the future. In general, under the lockdown circumstances due to the pandemic, students welcomed e-learning on the pathology course. Medical educators should continue to engage with e-learning even after the COVID-19 pandemic[20] in an effort to develop innovative approaches to train medical students. Interactive teaching methodologies have greater potential to promote student engagement than traditional didacticism[53] in a population that is now considered a digital generation.

We also believe that further studies in the field of e-learning pathology should be conducted in the future to enhance our knowledge of the online teaching procedure and the improvement of its quality. Additionally, further research should adopt qualitative analysis techniques, which promote deeper analysis of the students' perspective, and future studies should be focused on learners' outcomes in terms of achievement in e-examinations.

Ethics Approval and Informed Consent

Ethical approval for the research and the questionnaire was obtained from the Ethics Committee of the National and Kapodistrian University of Athens, protocol number 429, and the research was conducted following the guidelines of the Declaration of Helsinki. Students were informed about the purpose of the study, and consent was obtained from them. Confidentiality and privacy were ensured during the whole period of the study.

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Disclosure

The authors declare that they have no conflicts of interest in this work.

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