Satisfaction of Medical Students in Studying Histology Using Virtual and Light Microscopy: A Cross-sectional Study

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ABSTRACT

Background. Medical education has changed as a result of the COVID-19 pandemic. There has been a shift from face to face learning to virtual classes using online learning platforms such as Canvas. These virtual and online alternative methods to medical education brought up concerns about the preparedness of medical students in studying Histology. This study addresses the student's preference and attitude on the learning of histology using light microscopy vs virtual microscopy.

Objectives. The specific objectives of the study are to determine students' preference, attitudes, and overall satisfaction on the use of light microscopy vs virtual microscopy using a Likert scale.

Methods. An enhancement program was conducted by the Department of Anatomy, UP College of Medicine from June 13 to June 17, 2022 among first year medical students. The students were exposed to prosected cadavers, models, specimens, histologic glass slides, and electronic images. During the activity, the second and third floor of Calderon Hall was divided into several stations, each with its own learning outcomes.

This is a descriptive cross-sectional study. In all the learning stations, both virtual and light microscopy learning modalities were made available to the students. The student was at liberty to select virtual microscopy, light microscopy or both. In one of the stations, allocated to OS 205 (The study of the anatomy and histology of the thorax), students were randomized to one learning modality (light vs virtual microscopy) and made to identify one predetermined structure. Students answered a short questionnaire that allowed them to express their preference for the modality that was assigned. The questionnaire survey included questions on students' preference for either light microscopy (LM) or virtual microscopy (VM), ease of use, and satisfaction. A total of five statements were included in the survey questionnaire. All questions in the survey were scored on a 5-point Likert scale (5: strongly disagree, 4: disagree, 3: neutral, 2: agree, and 1: strongly agree). A comments section was also included in the survey to explore students' experiences of the two learning methods.

Results. A total of 160 students participated in the study. Seventy-nine (79) students were randomized to the light microscopy group and 81 one students were randomized to the virtual microscopy group. There were no differences in the demographic characteristics between those randomized to virtual vs light microscopy.

There were no differences in the net ratings between those randomised to virtual vs light microscopy in the following domains: 1) ease in looking for structures, 2) ability to identify the structure correctly, 3) method enhancing learning, and 4) overall satisfaction. There was a difference in the net rating between those randomized to virtual vs light microscopy in the domain on quality of the image being easily adjusted (58% vs 97.5%).

Conclusion. Medical students who used light microscopes demonstrated a more positive attitude towards its ability to enhance learning and showed greater satisfaction in using this method. Ease in manipulating image quality was better in the light microscopy group. However, the accuracy of identification of histological structures using either platform did not differ. Both virtual and light microscopy are effective learning methods.

Keywords: light microscopy, virtual microscopy, medical education, histology, teaching

eISSN 2094-9278 (Online)
Published: October 26, 2023
https://doi.org/10.47895/amp.v57i10.7180

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INTRODUCTION

Medical education has changed as a result of the COVID-19 pandemic. There has been a shift from face to face to virtual classes using online learning platforms such as Canvas. Recorded lectures were made available to the students for asynchronous viewing. The Zoom™ platform allowed synchronous lectures to be delivered while students remained in the confines of their homes.

For learning theory and pedagogy, the use of virtual learning platforms and synchronous lectures were acceptable. These platforms, however, are perceived not to be as effective in learning practical skills that would have been provided by laboratory classes. In Histology, these include searching and identifying cells, tissues or organs using the light microscope. During the pandemic, the study of actual histologic slides using the light microscope had to be replaced with online laboratory videos and virtual histologic images.

Virtual microscopy, which uses information technology to view digital microscope images, has gradually been used by universities across the world in the teaching of histology and pathology in various health related subjects. In 2017, in the study of oral pathology, Fernandes et al.[1] showed that the use of virtual microscopy was preferred by dental students over light microscopes. This was evident in the performance during examinations of the students who performed better using virtual slides compared to conventional slides.

In a meta-analysis by Wilson et al. on the efficiency of learning and learner preference using virtual microscopy versus light microscopy, results showed that virtual microscopy was preferred over light microscopy in the study of histology and pathology based on learner preference, evaluation surveys, and examination results.[2] These findings were consistent with the results of several other studies.[3-8]

Krippendorf B and Lough J in 2005[9], reported good results from students and faculty when there was a switch from light microscope to virtual microscope in the teaching of histology.

The University of the Philippines does not have its own virtual microscopy platform. Although the University has its own bank of virtual histologic images, it does not have the infrastructure to provide these resources to students. Instead, the University has arranged for the use of the virtual microscopy resources of other universities such as the University of Minnesota.

Prior to investing in its own virtual histology platform, there is a need to determine the perceptions of students on the effectiveness of this teaching modality.

The objective of this study is to determine the students' preference, attitude, and satisfaction on the use of virtual microscopy versus light microscopy in identifying histological structures. The specific objectives are 1) To determine students' preference on the use of virtual microscopy versus light microscopy in the study of histological structures using a Likert scale to rate the following parameters: a) ease of identification of histologic structures, b) accuracy in identifying histological structures, c) ability to manipulate and enhance image characteristics (i.e., contrast, brightness, resolution) and d) ability of the alternative teaching modalities to enhance learning. The second objective is to rate the overall students' satisfaction on the use of either teaching modality, also using a Likert scale.

METHODS

Study design and participants

We conducted a descriptive cross-sectional study to determine the student's preferences, attitudes, and overall satisfaction on the use of light microscopy (LM) versus virtual microscopy (VM) in identifying histological structures. The study was done at the UP College of Medicine from June 13 to June 17, 2022.

Study Setting

A face to face learning activity was organized by the Department of Anatomy on June 13-17, 2022 called Learning Enhancement in Anatomy Program (LEAP). This is to provide hands-on experience in identifying gross and microscopic structures to supplement the students' virtual learning. The activity was designed to enhance the learning in Anatomy by exposing students to prosected cadavers, models, specimens, histologic glass slides, and electronic images. During the activity, the classrooms and laboratories were divided into several stations, each with its own learning outcomes.

Study Procedure

In all the learning stations, both virtual microscopy and light microscopy learning modalities were made available to students. The students were allowed to select virtual microscopy, light microscopy or both. In one station on the study of the anatomy and histology of the thorax, students were randomized to one learning modality and were asked to identify one predetermined structure.

Randomization

Students were instructed to pick the assigned learning method from an opaque envelope (Figure 1).

Data collection

After being asked to identify the histologic structure, the students were given access to the answer key. We provided the students with a short questionnaire that evaluated their preference for the modality that was assigned. A total of five statements were included in the questionnaire. Students rated their preference using a 5-point Likert scale as follows: 5: strongly disagree, 4: disagree, 3: neutral, 2: agree, and 1: strongly agree. The students were also allowed to provide comments to explore students' experiences of the two learning

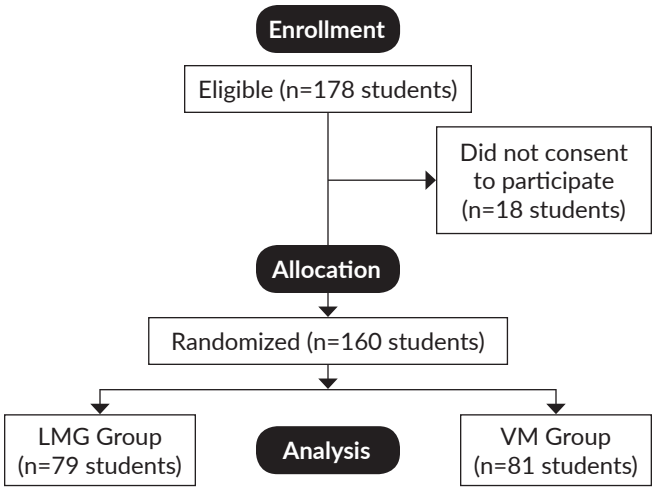

Figure 1. Randomization and assessment protocol for virtual microscopy/light microscopy groups.

methods (Appendix). We provided all the students with a course feedback form for the purpose of evaluating the program for further improvement. The students' perceptions and attitudes were triangulated with their feedback. We performed a secondary analysis of these scores and feedback.

Variables

Satisfaction was operationally defined as a rating of 1 or 2 in a 5-point Likert scale. Ease of identification of the structure, ability to identify the structure correctly, easier adjustment of the image quality, and enhancement of learning were also operationally defined as a rating of 1 to 2 in a 5-point Likert scale.

Data analysis

Demographic characteristics of students in the light microscopy and virtual microscopy groups were summarized as counts and percentages. Distribution of students in the two groups were compared using Fisher's exact test for sex and previous experience, and Chi-square test for pre-medical courses. Non-responses were not included in the comparisons.

A horizontal percentage stacked bar chart was used to present the distribution of the students' response in the evaluation of the program. Bar charts were generated using the ggplot R package for student's preference, attitude, and satisfaction. Preference, attitude, and satisfaction scores measured using Likert scales were expressed as percentages. *P*-values < 0.05 were considered statistically significant. Statistical analyses were performed using Statistical Package for Social Sciences or SPSS version 29.

We computed net ratings by subtracting negative ratings (disagree or strongly disagree) from positive ratings (strongly agree and agree).

The study was reviewed and exempted from further ethics evaluation by the UP Manila Ethics Review Board.

RESULTS

A total of 160 students participated in the study. Seventy-nine (79) students were randomized to the light microscopy group and 81 one students were randomized to the virtual microscopy group. Eighteen (18) students did not consent to participate in the study.

The demographic characteristics of the participants were similar between the two modalities as seen in Table 1. The number of female and male participants were almost equal in both groups. INTARMED (at least 20%) and Biology

Table 1. Demographic Characteristics of Students who Used Light Microscopy and Virtual Microscopy Modalities in the Study

Demographic Variables		Light Microscopy (n=79)		Virtual Microscope (n=81)	
		Counts	%	Counts	%
Sex	Female	39	49.4	40	49.4
	Male	40	50.6	40	49.4
	No response	0	0	1	1.2
Pre-medical course	INTARMED	16	20.3	18	22.2
	Biology	12	15.2	18	22.2
	Psychology	10	12.7	6	7.4
	Public Health	6	7.6	6	7.4
	Others	34	43.0	31	38.3
	No response	1	1.3	2	2.5
Previous experience	Both Compound Light Microscope and Virtual Microscope	62	78.5	71	87.7
	Either Compound Light Microscope or Virtual Microscope	15	19.0	8	9.9
	Compound Light Microscope	13	16.5	1	1.2
	Virtual Microscope	2	2.5	7	8.6
	No response	2	2.5	2	2.5

Table 2. Net ratings: Light Microscope vs Virtual Microscope

Question	Virtual microscope (n=81)						Light Microscope (n=79)					
	Strongly Agree n (%)	Agree n (%)	Neutral n (%)	Disagree n (%)	Strongly disagree n (%)	Net rating (%)	Strongly agree n (%)	Agree n (%)	Neutral n (%)	Disagree n (%)	Strongly disagree n (%)	Net rating (%)
1. It was easy to look for the structure	46 (56.8)	24 (29.6)	8 (9.9)	3 (3.7)	0 (0)	82.7	37 (46.8)	31 (39.2)	9 (11.4)	2 (2.5)	0 (0)	83.6
2. I was able to identify the structure correctly	56 (69.1)	13 (16.0)	3 (3.7)	6 (7.4)	3 (3.7)	74.1	42 (53.2)	26 (32.9)	1 (1.3)	8 (10.1)	2 (2.5)	73.4
3. The quality of the image could be easily adjusted	29 (35.8)	31 (38.3)	8 (9.9)	12 (14.8)	1 (1.2)	58.0	55 (69.6)	22 (27.8)	2 (2.5)	0 (0)	0 (0)	97.5
4. This method may enhance my learning	51 (63.0)	27 (33.3)	3 (3.7)	0 (0)	0 (0)	96.3	66 (83.5)	12 (15.2)	1 (1.3)	0 (0)	0 (0)	98.7
5. Overall I am satisfied with the use of this method	49 (60.5)	27 (33.3)	4 (4.9)	1 (1.2)	0 (0)	92.6	60 (75.9)	17 (21.5)	2 (2.5)	0 (0)	0 (0)	97.5

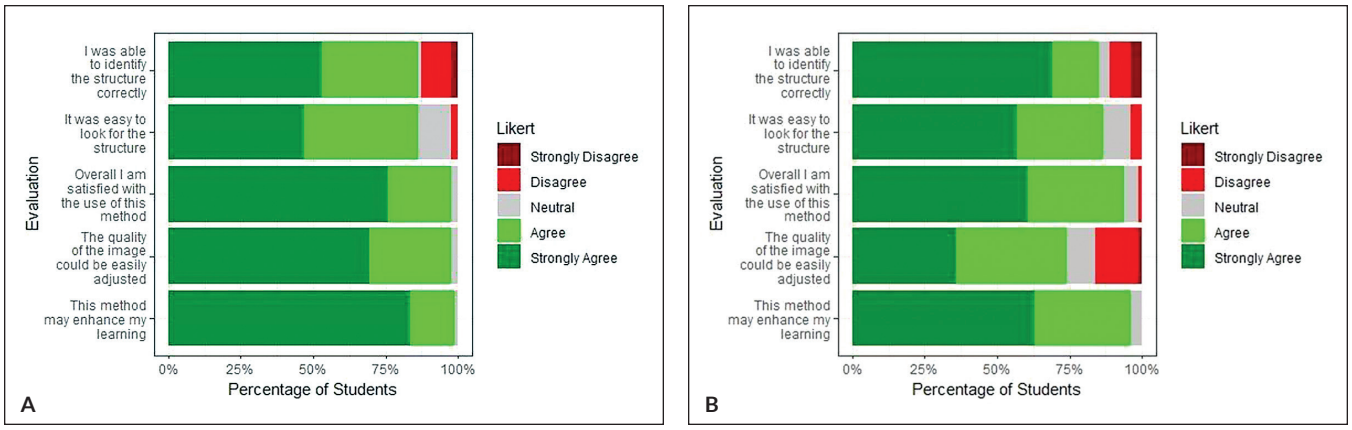

Figure 2. Distribution of attitude, overall satisfaction, and preference scores in students who used light microscopy **(A)** and virtual microscopy **(B)** modalities.

(at least 15%) were the most frequent pre-medical courses in the participants. These were followed by Psychology and Public Health majors. More than 75% of the students had prior use of both compound light microscope and virtual microscope, while a few students had previous experience of using either modality. The distribution of the students with previous experience of both modalities and at least one modality was similar in the light microscopy and virtual microscopy groups.

The distribution of attitude, overall satisfaction, and preference scores of students in the light microscopy and virtual microscopy groups are shown in Figure 2.

In the virtual microscopy group (Table 2), 86.4% gave positive ratings for question 1 (ease of identifying structure) while 3.7% gave negative ratings making the net rating 82.7%. For question 2 (identifying structure correctly), 85.2% gave a positive rating and 11.1 % gave a negative rating with a net rating of 74.1%. For question 3 (adjustment of image quality), 74.1 % gave a positive rating and 16.1% gave a negative rating with a net rating of 58%. For question 4 (method may enhance learning), 96.3% gave a positive rating and no one gave a negative rating giving a net rating of 96.3%. However, only 51 students (63%) strongly agreed that virtual microscopy enhances learning.

In the light microscopy group (Table 2), for question 1 (ease of identifying the structure), 86% of students who use a light microscope gave positive ratings while 2.5% gave negative ratings giving a net rating of 83.6%. For question 2 (identifying structure correctly), 86% gave positive ratings for light microscopy and 12.6% gave negative ratings with

Table 3. Number of Students who Correctly Identified Histologic Structure (Virtual vs Light Microscopy)

	Virtual Microscopy (n=81)	Light Microscopy (n=79)	P-value
Correctly identified structure	69 (85.2%)	68 (86.1%)	>0.9999

a net rating of 73.4%. For question 3 (adjustment of image quality), 97.5% gave a positive rating and 0 gave a negative rating with a net rating of 97.5%. For question 4 (method may enhance learning), 98.7% gave a positive rating and none gave a negative rating with a net rating of 98.7%. Sixty-six students (83.5%) strongly agreed that light microscopy enhanced their learning. For question 5 (overall satisfaction), 97.5% gave a positive rating and none gave a negative rating giving a net rating of 97.5%.

Although both virtual and light microscopy enhances learning there were more students in the light microscopy who strongly agreed that this modality enhances learning. For question 5 (overall satisfaction), 93.8% gave a positive rating and 1.2% gave a negative rating for a net rating of 92.6%.

In terms of accuracy in identifying histological structures, the number of students who identified the structure correctly in the light microscopy and virtual microscopy groups were similar. At least 85% of students correctly identified the assigned histological structure. Altogether, these results suggest that both microscopy modalities are at par in terms of an objective measure of accuracy, despite more favorable responses for light microscopy in subjective scales (Table 3).

DISCUSSION

The use of virtual microscopy has emerged as an essential platform to continue the delivery of histology and pathology education during the COVID-19 lockdowns. Before the pandemic, virtual microscopy was already explored as an alternative to conventional microscopy. Several advantages of virtual microscopy include ease of maintenance, indefinite reproduction and preservation, and the possibility of scaling up to accommodate large classes.[9] Several studies have shown favorable ratings of virtual microscopy over light microscopy in medical, dental, veterinary, and undergraduate students.[1,2,3,6] Furthermore, some of these studies suggest that learning and academic performance improve using virtual microscopy.[2, 9]

In the current study, there was no difference in the overall satisfaction of medical students using the light microscope or virtual microscope. There was no difference in preference, perception of enhanced learning, and satisfaction with any of the modality. Students performed similarly in identifying a histological structure when using virtual microscopy or light microscopy. These are unexpected findings in light of previous reports highlighting the acceptability and favorability of virtual microscopy over conventional methods.

However, a closer look into the preference scores revealed that light microscopy was superior to virtual microscopy when considering the ease of adjusting the quality of the images. Around 98% of students strongly agreed or agreed that the quality of the image using light microscopy can be easily adjusted compared to the net rating of only 58% of students using the virtual microscopy platform. The adjustment of the quality of images used for virtual microscopy ultimately depends on the strength of the internet connection and the resolution of the user's viewing screen. This factor can vary across devices in different institutions and households, leading to variations in subjective evaluations of the experience. Further qualitative studies can investigate the specific attributes of light microscopy that resulted in positive perceptions from students in our setting.

A meta-analysis of 12 studies comparing virtual and optical microscopy reported a small but significant benefit of virtual microscopy on learner performance, measured as the difference between pretest and posttest scores (standardized mean difference between virtual and optical microscopy = 0.28; 95% CI = 0.09–0.47; P = 0.03).[2] However, significant heterogeneity among studies was observed (I^2 = 89%, P < 0.001), limiting the generalizability of this finding. Possible causes of this heterogeneity included differences in the quality of the virtual microscopy platform, study design, duration of intervention, and quality of assessment tools. Furthermore, this increase in learning when using virtual microscopy compared to optical microscopy was only seen in undergraduate participants (standardized mean difference = 0.25; 95% CI = 0.15–0.36; P < 0.00001) and was no longer significant for medical students (standardized mean difference = 0.29; 95% CI = 0.00–0.58; P = 0.05). Further evaluation of this possible improvement in learning is warranted using a better experimental design. A more robust evaluation tool should be used and can include questions asking students to identify structures across organ systems or spectra of disease.

The objective of the study was mainly exploratory to address the inability of performing light microscopy in the virtual setting that was adapted during the height of the COVID-19 pandemic. It is a purely descriptive, single centered, and there was no sampling frame. It relied purely on students volunteering and it did not take into consideration the students' background on computer literacy.

CONCLUSION

Medical students studying histology preferred light microscopy to virtual microscopy in terms of ease of manipulating image quality but not with regard to perceived ease and accuracy of identification of histologic structures. Students who used light microscopy demonstrated a more positive attitude toward its ability to enhance learning and showed greater satisfaction in using this method. The accuracy of identification of histological structures using either platform did not differ, suggesting that virtual and light microscopy

may be equally beneficial for learners. Histology educators, among other medical faculty members, can utilize these modalities complementarily to achieve learning outcomes in various settings for instruction.

Statement of Authorship

Both authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

Both authors declared no conflicts of interest.

Funding Source

None.

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APPENDIX

Questionnaire

OS205 Evaluation Sheet: Light Microscopy vs Virtual Microscopy Method
Student No.: _____ Sex: ____ M ____ F
Pre-medical Course: _____
Previously used (check all that applies): ____ Compound light microscope ____ Virtual Microscopy
Assigned method: ____ Compound light microscope ____ Virtual Microscopy

You are asked to find one structure. You will be randomized to the use of either a light microscope or virtual microscope. Pick from an envelope to determine which method will be assigned to you. Check the key after you have identified the structure.

	1 (Strongly agree)	2 (Agree)	3 (Neutral)	4 (Disagree)	5 (Strongly disagree)
1. It was easy to look for the structure					
2. I was able to identify the structure correctly					
3. The quality of the image could be easily adjusted					
4. This method may enhance my learning					
5. Overall I am satisfied with the use of this method					

Comments: