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Original Article

Education Section

Media Matter: The Effect of Medium of Presentation on Student's Recognition of Histopathology

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ABSTRACT

Introduction: Pathology teaching has undergone transformation with the introduction of virtual microscopy as a teaching and learning tool.

Aim: To assess if dental students can identify histopathology irrespective of the media of presentation and if the media affect student's oral pathology case based learning scores. The perception of students towards "hybrid" approach in teaching and learning histopathology in oral pathology was also assessed.

Materials and Methods: A controlled experiment was conducted on year 4 and year 5 dental student groups using a performance test and a questionnaire survey.

Results: A response rate of 81% was noted for the performance test as well as the questionnaire survey. Results show a significant effect of media on performance of students with virtual microscopy bringing out the best performance across all student groups in case based learning scenarios. The order of preference for media was found to be virtual microscopy followed by photomicrographs and light microscopy. However, 94% of students still prefer the present hybrid system for teaching and learning of oral pathology.

Conclusion: The study shows that identification of histopathology by students is dependent on media and the type of media has a significant effect on the performance. Virtual microscopy is strongly perceived as a useful tool for learning which thus brings out the best performance, however; the hybrid approach still remains the most preferred approach for histopathology learning.

Keywords: Case based learning, Oral pathology, Virtual microscopy

INTRODUCTION

Oral pathology at the undergraduate level is a predominantly didactic and teacher-led course in a large group environment [1]. The traditional ways of teaching and learning pathology have been individual study, lectures, practical classes, demonstrations and small group tutorials [2], which differ greatly in format and content between institutions. Despite the variation, light microscopy still remains the most important tool for practical teaching and printed microscope images or photomicrographs remain the main stay of self-study material [2]. In the last decade, virtual microscopy, which has been described as the most significant innovation since the invention of the light microscope [3] has emerged as a powerful tool for teaching and learning microscopic anatomy [4], histology [5-8] and pathology [6,8-11].

At Penang International Dental College (PIDC), oral pathology is taught and assessed in year three of the five-year Bachelor of Dental Surgery program. Previously, practical teaching involved identification of histopathologic features using light microscopy to diagnose, which was supported by photomicrographs in standard textbooks or histopathology atlases. The students observed each tissue slide using light microscope, drew a histopathology diagram and wrote down features helpful in identification. Based on experience, this method of teaching was found to be primarily working on the principle of rote learning and did not help the student in understanding clinicopathologic correlation. To improve this, and encourage deep and meaningful learning, Case-Based Learning (CBL) was introduced in 2012 [12,13]. Case-Based Learning is defined as a teaching and learning approach that aims to prepare students for clinical practice, through the use of authentic clinical cases [14]. These cases link theory to practice, and are theoretically based on adult and Inquiry-Based Learning (IBL) approaches which promotes deep learning [2]. In the same year, virtual microscopy was implemented in PIDC using an Intranet Service or Local Area Network (LAN) to improve classroom histopathology teaching along with the existing use of light microscope and photomicrographs. This "hybrid" approach of teaching and learning histopathology in CBL is based on the principles of cognitive theory of multimedia learning [15].

There is convincing evidence of student satisfaction with the use of virtual microscopy [5,6,9-11]. However, its influence on academic performance is still not clear; with a few studies reporting no significant change [7,8] and few reporting significant improvement [4,16]. Experienced microscopists have little trouble interpreting material presented in any of the usual media including printed pictures in published atlases, static digital photomicrographs, projection slides or the standard of the discipline, microscopes, and glass slides. They also do not have trouble transposing or interpolating among the media [17,18]. But for learners, transfer among these media may not always be easy [17] although no controlled experimental studies were found to establish this empirically.

The aim of this study was to determine if students can identify histopathology irrespective of the media of presentation and if the media affect students' scores in CBL. Also assessed was the perception of students towards a "hybrid" approach in teaching and learning histopathology in oral pathology.

MATERIALS AND METHODS

The study was approved by the research and ethics committee of Penang International Dental College (Protocol No. PIDC/RES/RC/L006/14). Its design was based on the PIDC guidelines of research involving human subjects. The study was conducted only on undergraduate students who had passed their university examinations in oral pathology as they are competent and trained for exactly the same duration in the CBL environment using the hybrid approach.

The total number of students available at the time of the study were 110 from year IV semester 1 (Y4S1), year IV semester 2

(Y4S2) and year V semester 1 (Y5S1). Totally, 93 students gave consent for the study while 89 of them turned up on the day of the experiment. Students from Y4S1, Y4S2 and Y5S1 passed their oral pathology university exams three, nine and fifteen months ago, respectively. The total of 89 students were subjected to stratified randomization based on their previous oral pathology university practical examination scores in order to ensure equal characteristics in each study group [Table/Fig-1].

Study groups	Student groups			Total (n=89)
	Year 4[a] (Semester 1) (n=29)	Year 4[b] (Semester 2) (n=29)	Year 5[c] (Semester 2) (n=31)	
Light microscopy	09	10	09	28
Photomicrographs	10	11	11	32
Virtual microscopy	10	08	11	29

[Table/Fig-1]: Numbers of students in various study groups.
Year 4[a] semester 1- three months since passing oral pathology
Year 4[b] semester 2- nine months since passing oral pathology
Year 5[c] semester 1- fifteen months since passing oral pathology

A performance test consisting of five case based scenarios was developed and content was validated by two oral pathologist. The test addressed common oral lesions with clinical information, and supporting information such as clinical images/ radiographs. All student groups were exposed to the same case based scenarios but using only one media of histopathology presentation i.e., light microscopy or photomicrographs or virtual microscopy. They were given five minutes for each case at the end of which they had to give a final diagnosis. For every correct diagnosis one mark was awarded and for every wrong diagnosis no marks were given. The scores of the performance test were calculated for each student individually.

A written response questionnaire survey was also developed, based on a validated questionnaire by Farah and Maybury [6] which comprised of; demographic data including, age, gender and 16 questions with a 5–point Likert scale to assess the perception of students on light microscopy, photomicrographs and virtual microscopy in oral pathology. Permission was obtained from the authors and the final questionnaire developed included four questions (i.e., questions 9 to 12) from Farah and Maybury's questionnaire to help understand students' perception of the contribution of virtual microscopy on teaching and learning of oral pathology. The remaining questions were developed to stimulate student response towards CBL of oral pathology and the effects of histopathology media. Five open ended questions were included to collect rich data, addressing positive and negative aspects of media and ease of histopathology correlation. Overall, the questions were slightly inclined towards evaluating the perception of students towards virtual microscopy as it was the recent innovation implemented. The questionnaire was administered to the participants after they had completed the performance test.

The data collected using the performance test was tabulated and statistically analysed using the SPSS version 19.0 predictive analytic software. Cronbach's alpha was calculated to estimate the reliability of the performance test. It is a function of the number of items in a test, the average covariance between item-pairs, and the variance of the total score thus determining internal consistency. A two-way ANOVA was applied to help determine the influence of different categories of the independent variable i.e., light microscopy, photomicrography and virtual microscopy (study groups) on the dependent variable (CBL scores). A p-value of < 0.05 was considered the threshold value for significance.

Data obtained from the questionnaire was statistically analysed for descriptive analysis. The qualitative data from the open ended questions was analysed using the Hsieh and Shannon [19] description of conventional content analysis. This is done by first reading the open ended comments repeatedly. Thereafter, data was read word by word to derive codes to capture key thoughts or concepts. Next, codes are sorted into categories and into meaningful clusters [19].

RESULTS

The response rate for the performance test and the questionnaire was 81% including 61% (n=54) females. The age range was 21- 24 years. Levene's test for parametric data (CBL scores) verified the equality of variance in the samples (test of homogeneity, $p>0.05$) suggesting an approximately normal distribution of CBL scores.

The reliability test done for the five cases used in the performance test showed a Cronbach's alpha value of 0.48 which indicated low average internal consistency of the performance test. Across the three study groups i.e. light microscopy, photomicrography and virtual microscopy the CBL scores were highest for the virtual microscopy group (M=1.8, SD=0.9) while the lowest scores were with the group that went through the light microscopy media (M= 0.9, SD= 0.9) [Table/Fig-2].

Histopathology media	Student group	Mean[#]	Std. Deviation	N
Light Microscopy	Y4S1[a]	1.00	1.22	9
	Y4S2[b]	1.20	0.92	10
	Y5S1[c]	0.44	0.53	9
	Total	0.89	0.96	28
Photomicrography	Y4S1	1.60	1.17	10
	Y4S2	1.82	1.17	11
	Y5S1	1.45	0.93	11
	Total	1.62	1.07	32
Virtual Microscopy	Y4S1	1.70	0.95	10
	Y4S2	2.12	1.12	8
	Y5S1	1.54	0.82	11
	Total	1.76	0.95	29
Total	Y4S1	1.45	1.12	29
	Y4S2	1.69	1.10	29
	Y5S1	1.19	0.91	31
	Total	1.44	1.05	89

[Table/Fig-2]: Mean Case Based Learning (CBL) scores for the performance test.
[#] Range= 0 to 5
Y4S1[a] = Year IV semester 1
Y4S2[b] = Year IV semester 2
Y5S1[c] = Year V semester 1

Effect of Media

A two-way analysis of variance (ANOVA) tested the effect of histopathology media (light microscopy, photomicrography and virtual microscopy) on CBL scores of the different student groups (Y4S1, Y4S2 and Y5S1). The change in histopathology media showed a significant effect on the CBL scores ($p<0.05$). There was no significant effect ($p=0.10$) on the CBL scores between the student groups (Y4S1, Y4S2 and Y5S1) despite the phase difference of 3 months, 9 months and 15 months since passing the oral pathology course. The interaction of the histopathology media and student groups also did not show a significant effect on the CBL score ($p=0.95$) [Table/Fig-3]. In other words, CBL scores were dependent on the histopathology media only and not on the year of study of the student.

Perceptions of Instructiveness of Media

CBL and Light microscopy, Photomicrographs and Virtual microscopy

The rating scale results for overall agreement were calculated by adding the responses received for "agree" and "strongly agree" for each question. The results showed that 85% (n=76) preferred virtual microscopy for CBL as compared to 45% (n=40) for photomicrographs and 33% (n=7) for light microscopy. This was also the trend for histopathology teaching preference with

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17.62[a]	8	2.20	2.195	.036
Intercept	180.54	1	180.54	179.896	.000
Histopathology media	13.29	2	6.64	6.621	.002*
Student group	4.74	2	2.37	2.363	.101
Histopathology media a Student group	0.70	4	0.17	.175	.951
Error	80.29	80	1.00		
Total	282.00	89			
Corrected Total	97.91	88			

[Table/Fig-3]: Two-way ANOVA Testing the effect of histopathology media[a] and student groups[b] on CBL score.
[a] R Squared = .180 (Adjusted R Squared = .098)
Histopathology Media[a] = Light microscopy, Photomicrography, Virtual Microscopy
Student group[b] = Y4S1, Y4S2, Y5S1
* = Significant variable

22% (n=19) preferring virtual microscopy, 10% (n=9) preferring photomicrographs and only 8% (n=9) opting for light microscopy. However, the majority (94%, n=84) still preferred the present hybrid system for CBL [Table/Fig-4].

Features of virtual microscopy

Ninety percent of the students (n=80) agreed that virtual microscopy has enhanced their learning of histopathology and 82% (n=73) felt that it has helped them understand case based scenarios better as compared to the use of light microscopy and photomicrographs. With respect to maneuverability and resolution of images, 95% of the students (n=84) felt that it allowed identification of required structures, tissues and cells. A 92% of the students (n=82) felt that navigation was easier than that of glass slides and the same number of students felt that the software technology used was effective for the oral pathology course. 73% (n=65) found the use of virtual microscopy more fun as compared to use of light microscopy and photomicrographs. 88% students (n=78) felt that the feature of image capture helped them to improve their understanding after scheduled class time. An 84% (n=75) were of the opinion that virtual microscopy allowed greater collaboration with fellow students, while 86% of the students (n=76) felt that virtual microscopy in CBL of oral pathology has helped them to understand the clinicopathologic correlation better [Table/Fig-4].

Open-ended responses on light microscopy.

The total number of positive comments about light microscopy was 87 while there were 124 negative comments. The most frequent positive comments were: “it is important to be exposed to light microscope”, “easy to set up where insufficient resources or technology” and “magnification is adjustable”. The most frequent negative comments received were: “time consuming, group based learning not possible….”, “ strain to the eye, difficult to see, images are not clear….” and “ only one can see at a time, time consuming and hampers collaborative learning” .

Open-ended responses on photomicrographs.

The total number of positive comments received for photomicrographs was 103 while 101 negative comments were received. The most frequent positive comments were: “easy accessibility….”, “easy to understand…” and “easy to handle, less bulky, not fragile”. The most frequent comments negative were: “unable to magnify images; they look different from light microscope and virtual microscope images…..difficult to correlate” and “area of interest are only printed….spoon fed”.

Open-ended responses on virtual microscopy.

The total numbers of positive comments received were 202 while 41 negative comments were received. The most frequent positive comments were: “I can focus in areas of preference while still getting an overview of the original image”, “easy to zoom and identify cells” and “fun to learn and labeling with different colors”. The most frequent negative comments were: “software dependent”, “need to find the area of interest in the large specimen” and “there is an image lag sometimes”.

Histopathology correlation

To the question “Do you think you can identify histopathology features in photomicrographs (book images) and relate it to a

	Questions	(%) Strongly disagree	(%) Disagree	(%) Neutral	(%) Agree	(%) Strongly agree	(%) Overall Agreement*
1.	I preferred light microscopy for case based learning of oral pathology.	3	28	36	22	10	33
2.	I preferred photomicrographs (book images) for case based learning of oral pathology	2	26	27	30	15	45
3.	I preferred virtual microscopy for case based learning of oral pathology.	0	1	13	45	40	85
4.	The present system of using light microscopy, photomicrographs and virtual microscopy for case based learning is good	0	1	4	46	48	94
5.	I would prefer using only light microscope for histopathology teaching	22	51	20	6	1	7
6.	I would prefer using only photomicrographs for histopathology teaching	29	45	16	8	2	10
7.	I would prefer using only virtual microscopy for histopathology teaching	9	40	28	15	8	22
8.	Using the virtual microscopy enhanced my learning of histopathology in Oral Pathology compared to light microscopy and photomicrographs.	0	0	10	46	44	90
9.	The maneuverable images studied with the virtual microscope were of sufficient resolution to allow identification of the required structures, tissues and cells	0	1	3	40	55	95
10.	Navigation of the images with the virtual microscope viewer was easier than that of the glass slides.	0	2	6	34	58	92
11.	The software viewing technology used in the virtual microscope was effective for the purposes of this course †	0	1	7	47	45	92
12.	Using the virtual microscope was more fun than using the light microscope and photomicrograph	0	3	24	39	34	73
13.	Using the virtual microscope during scheduled laboratory class time helped me understand the case based scenarios better than light microscope and photomicrograph	0	0	18	39	43	82
14.	The histopathologic pictures taken by virtual microscope helped me to improve my understanding of the material outside the scheduled laboratory class time	1	1	10	44	44	88
15.	The virtual microscopy software allowed for greater degree of collaboration with fellow students.	0	1	15	40	44	84
16.	The use of virtual microscopy in case based learning of oral pathology has helped me in better understanding of clinico-pathologic correlation	0	2	11	38	48	86

[Table/Fig-4]: Perception of students towards use of light microscopy, photomicrographs and virtual microscopy in case based learning (n=89).
%Overall agreement*= agree% + strongly agree%
† For Q11 n=88

light microscopic slide and virtual microscope slide of the same pathology case?" 52% of the students (n=46) answered "Yes", 27% (n=24): "No" and 21% (n= 19) was answered: "maybe". Other comments received were: "virtual microscopy is good but light microscopy should be continued as it gives a good exposure", and "please continue using all methods"

DISCUSSION

The aim of this study was to discover if students can identify histopathology irrespective of the media of presentation and if media of presentation affects students' scores in CBL. The controlled experiment, using the performance test indicates that learners cannot identify histopathology irrespective of the media of presentation in a case based learning scenario. This was similar to the findings of Scoville and Buskirk [17] who reported that medical students taught using only virtual microscopy were unable to identify tissue on glass slide. The present study also showed that CBL scores depended significantly on the medium of presentation. In other words, if the medium of presentation is changed it affects the CBL score. A number of retrospective studies in various settings found that the introduction of virtual microscopy did not have a significant effect on academic performance [10,13,14,20]. On the other hand, Raja reported a significant improvement in performance of students in a pre-test post-test experiment [16], while Anyawu et al., reported significant effect on scores in a test conducted using same set of histology slides for light and virtual microscopy on the same cohort [4]. In contrast to Anyawu et al. in our study the student groups had a phase difference since completion of the oral pathology course and they were tested for effect of histopathology media on CBL scores. In most studies the academic performance testing was done based on spot identification for either dental histology [13] or general histology [14-16]. The present study tested the performance of students using case based scenarios with different histopathology media, which can be seen as incremental value to the studies done with similar previous academic scores [13,14,20]. The results of this study suggest that students in a CBL performance setting did better when virtual microscopy is used, as compared to light microscopy or photomicrographs.

The questionnaire study suggests that the majority of the students prefer virtual microscopy for CBL in oral pathology. This supports the findings reported by Farah & Maybury where 97% of the cohort of students (n=108) preferred virtual microscopy as compared to only 12% of students who preferred light microscopy for oral pathology [6]. McCready & Jham also reported a very high (92%) preference for virtual microscpy as compared to light microscopy for oral pathology teaching [11]. The agreement for the use of virtual microscopy has also been reported to be high in dental histology [9] and other fields of medicine that use microscopy as a method of teaching such as general histology [17], cellular physiology [16] and pathology [6,10].

Preference for virtual microscopy is explained by the reasons of end-user satisfaction such as: effective software, ease of navigation, maneuverability & resolution of images, image capture feature that helped to improve understanding after scheduled class time and the thought that virtual microscopy was more fun as compared to light microscopy and photomicrographs. These findings were similar to previous reported studies conducted on dental students for oral pathology teaching [9,12].

This study was different as it also assessed photomicrographs over light microscopy and virtual microscopy, which has not been reported previously. Photomicrographs were found to be the second choice after virtual microscopy for CBL. The responses highlight the advantages perceived by students as it is reported to be less cumbersome, more user-friendly and can be referred to more easily. But when compared to virtual microscopy photomicrographs lack the advantages of maneuverability, image clarity and inter-action capability.

The least preference for light microscopy is explained by the large volume of negative comments. Most comments on drawbacks of light microscopy explain the reason for its low preference which was similar to findings reported in other reported studies [6,9,16]. The response to the question on using only one medium i.e., light microscopy, photomicrographs or virtual microscopy also received low agreement. However, the response to the 'hybrid' system of using light microscopy, photomicrography and virtual microscopy for CBL was rated very high with most students in favor of continuing the present system of teaching and learning. This was strongly supported by the open ended comments. This finding in our study as well as other reported studies [9,10,16] suggests an underlying deeper perception among the global student community about the enthusiasm in embracing new virtual technology while still expressing anxiety about eradication of the traditional light microscopy teaching. Upon reflection, the cause for student anxiety may be the shift from light microscopy to virtual microscopy which is similar to the shift from literacy to electracy, which probably is representative of students' apprehensions to a shift from teacher–centered learning to a more self-directed, student centered learning method [21].

Collaborative learning in virtual microscopy received positive responses similar to many previous published reports [6,8,9,12,13,22]. An explanation for this is our observation of students actively working on case based scenarios and interacting in groups, which also helps in sharing the work load and probably relates to the reported fun experience. Collaborative learning will enhance the ability of future professionals to successfully collaborate with peers [12] and help sustain interest in microscopic pathology [10].

The majority of the students agreed that virtual microscopy helped understand case based scenarios better as well as improved their understanding of clinic-pathologic correlation compared to light microscopy and photomicrographs. In this study most students felt that they can correlate between the same images given through different histopathology media which is not reflected through the overall mean scores (across all study groups) of the performance test. This is in contrast to the common belief among content experts, who consider it difficult for students to interpret and correlate microscopic material presented in any of the media [17]. This perception among students needs further research to improve our understanding of the factors influencing long term learning of histopathology.

The present study was conducted on dental students who have successfully completed their oral pathology course in year 3 of their dental curriculum. The principal investigator has no role in any of the future summative assessments. However, involvement in general administration and curriculum implementation may be one of the influences leading to high response rate. Considering that the study was conducted on adults, who have the right to form their own opinion and express it freely the influence of the investigator on the participants in the study is believed to be minimal.

LIMITATION

As a model, the limitation of the present study is the low internal consistency of the performance test due to the limited number of cases. This however, could not be overcome due to the availability of limited resources.

CONCLUSION

The findings of the present study suggest that histopathology media has a significant effect on performance, which is directly related to its positive perception and acceptance among the student community. In this study all student groups scored better

with virtual microscopy which suggests that the present system of case based learning does have a positive impact among learners. In the years to come the students who will join health professional courses globally will all be digital natives because of the ubiquitous presence of digital technologies in all aspects of our lives. It is thus important to be prepared for this shift in paradigm from literacy to electracy and assess their impact on teaching and learning, in order to stay adept and constantly adapt ourselves to fulfill student learning needs of the future.

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