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Evaluation of multidisciplinary strategies and traditional approaches in teaching pathology in medical students

Running head: Evaluation of pathology teaching

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SUMMARY

This study aims to evaluate the impact on the implementation of multiple strategies to improve medical student's pathology learning experience. In two consecutive years, medical students after a whole year of enrolling in pathology teaching were invited to complete questionnaires rating and commenting on the personal learning experience of multiple teaching resources delivered in pathology. In both years, the overall score was high (mean score = 4.57 ± 0.63 /5) for the newly introduced sessions, namely histology lectures, clinical integrations and virtual microscopy pre-practical sessions. However, this was only marginally different from that of traditional practical (mean = 4.37 ± 0.68 /5) and pathology lecture sessions (mean = 4.42 ± 0.61 /5). In addition, 53% positive correlation was noted for the overall responses between virtual microscopy guided pathology modules and practical sessions indicating **the benefit of virtual microscopy in better preparing students for these sessions** ($p < 0.001$). Qualitative comments suggested that the virtual microscopy sessions along with clinical scenario based learning were extremely useful for students' learning in pathology. To conclude, a multidisciplinary approach by clinical integration and flexibility in the mode of delivery by the use of virtual microscopy has the potential to better engage students to the learning of pathology.

Keywords: Pathology; teaching; education; virtual microscopy; digital

INTRODUCTION

Pathology teaching integrates the scientific basis of disease processes into the clinical years, where the pathophysiology and pathogenesis will be applied within a practical clinical context.¹ Studies have suggested that junior doctors must understand the pathological basis of disease for them to recognize and use the language of medicine, as well as to comprehend evidence-based treatments and outcomes, describe the natural history of the disease and for better preparation for the genetic evolution of modern medicine.²

Pathology education generally utilizes a combination of traditional teaching methods such as lectures, tutorials and practical sessions¹. The traditional use of microscope provides more interactive and moving imprints of tissue pathologies compared to the static, close-up images from a textbook or online.³ In a conventional practical education setting, students will cover differences between normal and abnormal tissue changes, to scan the entire slide, find the area of pathology, then zoom in, and study it.² Histopathology education has undergone substantial changes in recent years with the advancement of new technologies and teaching tools.⁴⁻⁷ These include the introduction of virtual microscopy, digital image /audio modules and podcasts for gross pathology pots were also introduced lately for the excellent delivery of histopathology.⁸⁻¹⁰

As the medical curriculum is rapidly changing with an integrated approach with multiples disciplines, it's a considerable challenge to engage medical students solely by online, virtual or traditional teaching methods. Previous studies have proven that a combined didactic method of pathology teaching through integrating methods will help medical students to increase curiosity, to better correlate clinical cases with basic science, and to improve student interaction.¹¹ In pathology education, an integrated curriculum with the assistance of technologies will play an essential part in underpinning contextual learning in medical students.¹² This will enables students to construct the theory of pathology teaching

and learning and develop thinking skills to relate abstract ideas and practical applications in the context of the real world clinical scenarios.¹² In this study, we aimed to implement multiple learning and teaching strategies to improve medical student's pathology learning experience.

MATERIALS AND METHODS

Student groups

Students enrolled in the second year of the Doctor Medicine (MD) programme at Griffith University, Australia was asked to participate in this study. A total of 272 students from the 2015/16 graduands (n=131 in Year 1MD and n=141 in Year 2 MD) took part in sharing their learning experiences and investigating the impact of multiple learning and teaching resources delivered in pathology. During the MD programme, medical students are expected to know the pathophysiological mechanisms behind tissue changes in diseases as well as the resulting basic changes in macroscopic and microscopic alterations.

Study design and student evaluation

Multiple learning and teaching approaches including the use of online digitalised images (Figure 1A-D), virtual microscopy (Figure 2A&B), and lectures integrated clinical scenarios were introduced for practical pathology pre-learning. This was delivered along with the regular/conventional face-to-face lectures in pathology/histology and practical sessions. Within each teaching method, various indicators of the quality of the teaching, namely, delivery, academic interaction, innovation, gross specimens, clinical integration with other components of medical education, etc. were evaluated (Table 1). All these sessions were delivered during the academic period of 2nd year MD programme. Every histology,

pathology, and preparation for practise session (interactive sessions built around case vignettes and virtual microscopy) lectures were delivered in 2-hour sessions. For each pathology module, the class was divided into 3 repetitive sessions due to limited room size and each portion received 2-hour sessions. Potted pathology gross tissues from various body systems (Table 2) were used for assessing the usefulness of these specimens in pathology education.

Student evaluation and analysis

All students who participated in this study (n=272) were invited to complete a paper-based questionnaire rating the value of their learning experiences of the whole year after the completion of their final practical session. It is worth noting that a potential bias could have been introduced with the evaluation of learning experiences after the completion of the final practical session. As these sessions were placed in few weeks' difference, we assume that the potential bias due to retention of their learning experience would be minimal. All the students' responses to the questionnaires were anonymous. The different questionnaires were ranked on a scale between 1 to 5 (with 1 being strongly disagreed and 5 being of strongly agree). Qualitative responses regarding the effectiveness the workshop were also noted. Student responses were quantified, and open responses were content analysed and categorised according to a thematic framework.

Not all students who participated in this study have assessed the different components of these learning materials. They were noted as "missed" in Table 1. Student's satisfaction with these multiple learning methods was also evaluated by comparing their experience in the previous year (Year 1 MD) where only traditional methods in pathology teaching were used. A similar paper-based questionnaire survey was used at the end of Year 1 MD for data collection. In addition, student's suggestion regarding the best possible delivery method for

virtual microscopy were evaluated providing multiple choice options (1- should be given alone; 2- only light microscopy; 3- should be given in combination with light microscopy; 4- no microscopy session at all).

Statistical analyses were performed by utilizing the Statistical Package for Social Sciences for Windows (IBM SPSS, version 22, New York, NY, USA). Statistical correlations were analysed to compare the effectiveness of multiple learning and teaching methods in pathology compared to traditional methods.

RESULTS

Students learning experience in histology and pathology lectures

In both years of the survey, overall feedback score from the medical students was high (mean score $\geq 4.4/5$) for histology and pathology lectures. Students highly appreciated delivery styles, visual presentations and clinical correlations throughout the lecture sessions. However, integration of lectures with the weekly problem-based learning (PBL) sessions and student's monthly clinical skill sessions have received the lowest score (mean score = $3.7 \pm 0.91/5$). When the majority (61%, 164/268) of students agreed, the remaining 39% (104/268) students disagreed or were neutral to their experience in integrating the histology/pathology lecture sessions with rest of the medical education mainly PBL and clinical skills. As clinical skills and PBLs are the backbones of medical education in years 1 and 2, pathology education has to be more incorporated into the remaining medical curriculum.

Introduction of virtual microscopy and web/electronic resources

Virtual microscopy and web/electronic resources were introduced for the first time for these student cohorts. These modules were highly evaluated by students (mean overall score 4.54 (± 0.62) and 4.40 (± 0.72) respectively (Table 1). Surprisingly, 16% (44/272) of the

students have not accessed the web based learning modules in pathology practical sessions.

This could potentially attributed to the self-efficiency in certain students in learning pathology without web/electronic resources. Also, for the histology lectures, over 50% (141/131) of students did not provide feedback on the quality of image section. This might be due to lack of similar modules in year 1 and no alike online tools to compare with.

Qualitative comments suggested that the virtual microscopy sessions along with clinical scenario based learning during preparation for practise sessions were extremely useful for students' learning in pathology. Students have valued these newly introduced web/electronic resources as "brilliant", "useful for home study", "awesome", "best change so far", "excellent resource", "a great source for revision", "useful for self-learning" and "informative". On the other hand, some students have suggested having "easy access to their learning site", "normal images to compare", "and deeper explanation with labels", "additional notes and more pathology cases". A thematic analysis of all positive and negative comments is detailed in table 3.

The delivery of virtual microscopy sessions, its innovation and incorporation with clinical scenarios were also highly appreciated by students (mean score $\geq 4.5/5$). Approximately 93% of the students (230/246) have agreed that these sessions have helped them in better preparing for the lab-based practical classes (mean score = $4.54 \pm 0.63/5$). In addition, students have commented these sessions as "highly effective", "easy to interpret", "best aid to prepare for labs" and "a great way to learn pathology". Some students have also liked this as a real application of histopathology into "clinical situations". In response to a multiple choice questionnaire regarding the delivery style of virtual microscopy integrated lecture sessions, 88% of the students (22/252) recommended delivering these sessions in combination with light microscopy from corresponding organs. Only 9% of the participated students have suggested the delivery of virtual microscopic sessions alone.

Experience in practical sessions and correlation with other learning methods

While the majority of students (73%, 190/259) agreed or strongly agreed with the usefulness of gross pathology specimens, 27% (69/259) students disagreed or were neutral. Compared to the views on gross specimens, students have highly valued the usefulness of learning pathology via microscopic slide presentations (87% versus 73%, $p < 0.05$). Approximately 53% positive correlation was noted for the overall responses between virtual microscope guided pathology modules and practical sessions ($p < 0.001$), indicating the impact of virtual microscopy on enhancing student's learning experience in microscopic pathologies. However, there was no correlation noted for feedback scores between traditional pathology lectures and practical sessions ($p = 0.222$).

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DISCUSSION

This study has evaluated the impact of multiple pathology teaching methods in improving the learning experience in medical students. The teaching in pathology actively combines didactic lectures with practical pathology sessions as well as integration with clinical cases through gross tissue specimens (Figure 3A&B) and digitised images. The main objective of this method was to expose medical students simultaneously to the clinical presentation of patients and also to morphological changes at tissues levels. Also, this study presented students with short clinical vignettes followed by a visual demonstration of microscopic pathology by means of live digital pathology slides using scan-scope based virtual microscopy system. This was followed by series of self-assessment questions (Supplementary figure) to cover the essential aspects of each disease entity. Results of student evaluation showed that these teaching approaches had enabled students to experience an interactive learning environment in pathology by integrating multiple learning tools. This method also helped students to expand their learning experience beyond the classroom setting and in turn prepare them for self-directed learning which is one of the core elements of medical education. These findings were in consensus with previously reported literature.¹¹⁻¹⁵

In the recent years, medical education has witnessed a revolution in the use of multimedia and information technology to integrate multiple core clinical and pre-clinical disciplines. As a reflection of these changes, there was a gradual disappearance of the traditional use of pathology specimens, autopsies and microscopy in pathology teachings despite their proven utility in medical education.¹⁵⁻¹⁷ However, the traditional pathology education based on lectures and practical sessions using light microscopy is still shown to have an effective impact on students' learning and teaching.^{11, 18-19} The current teaching practice with traditional approaches has limitations in assessing practical study materials such as slides and gross specimens outside the teaching facility and this make a significant impact

in vertically integrate pathology learning materials during students' hospital placement in years 3 and 4.

In many medical schools, understanding of the pathological process in tissues is experienced by viewing and exploring gross specimens and pathological tissue under light microscopy. In the last decade, technological advancements have provided enormous opportunities to academics in improving the teaching and learning of pathology for medical students.²⁰ One of the major steps in this field is the introduction of virtual microscopy based digital pathology which has proven to be a great tool in providing better access to students in microscopy.²¹ Previous studies have proven that this digital imaging system has excellent use in the demonstration of histology and pathology slides and to provide online access to students for self-study during on and off campus.^{6-7 22-25}

Introduction of digital pathology using virtual microscopy in conjunction with other traditional teaching methods will play a significant role in vertically integrate the pre-clinical (years 1&2) and clinical years (years 3 &4) of the medical curriculum. Also, this will help students to translate these learning experiences during their hospital internship and future training in surgery, oncology, radiology, pathology and other clinical specialities. Virtual microscopy brings forth the advantage of computer-assisted education in pathology; it emulates the pan, and zoom features of traditional microscopy. Also, studies have proven that it has an enormous impact on tracking student participation, creating continuing professional development and self-assessment study modules in pathology.^{3, 18} In addition, digital pathology will help in exploring the unlimited opportunities in telepathology through which long-distance interaction and consultation with multiple pathologists and other clinicians are possible for a single slide at the same time.^{3, 23} This is highly relevant to specialist pathology colleges and tumour boards in many countries. Thus, exposing medical

students early in their pre-clinical years with digital pathology will help them to develop conceptual ideas about pathology in a clinical management context.

Additional advantages of digital pathology teaching are its capacity to teach multiple medical students simultaneously, avoidance of ethical and biological risks implicit in using human specimens, cost-effectiveness, and better distribution of clinically relevant knowledge to medical students.^{20, 26} Despite its role in enhancing students learning experience, the benefits of digital pathology when compared to traditional teaching methods are still under evaluation.¹¹ In this study, we have noted a significant positive correlation between clinically integrated virtual microscopy sessions and positive learning experience in pathology practical sessions.

There was no major difference between students' overall experience in digital pathology modules (virtual microscopy lectures and web/electronic resources) and conventional teaching methods (pathology/histology lectures and practical sessions) (Table 1). These results are in alignment with the findings of Scoville and Trent who demonstrated that first-year medical students learned equally well in virtual or light microscopy slides.¹⁹ Similarly, Koch et al. have reported that there was no difference in diagnostic interpretations between virtual slides and glass microscopy slides despite the preference for the virtual slides at pathology residents level.¹⁸ Taken together, it can be hypothesised that these digital pathology resources such as virtual microscopy and other web/electronic resources are an extremely valuable resource for improving students' learning experience in pathology, especially for those who are slow learners or limited comprehension in histopathology. Further studies in conjunction with impact on student learning outcome via analysing assessment items is needed to assess the full capacity of virtual microscopy in medical education.

To conclude, clinically integrated teaching modules including virtual microscopy guided digital pathology sessions, as well as traditional pathology lectures and practicals, have improved students' learning experience in pathology. Also, students' experience in digital pathology modules was positively correlated with their preparation for pathology practical sessions. These findings are in consensus with the previous reports. Thus, priority must be given to traditional teaching methods, and the approaches in digital pathology should be supplemented with the conventional systems for a better experience in pathology learning and teaching.

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Conflict of interest statement

None declared

Figure Legends

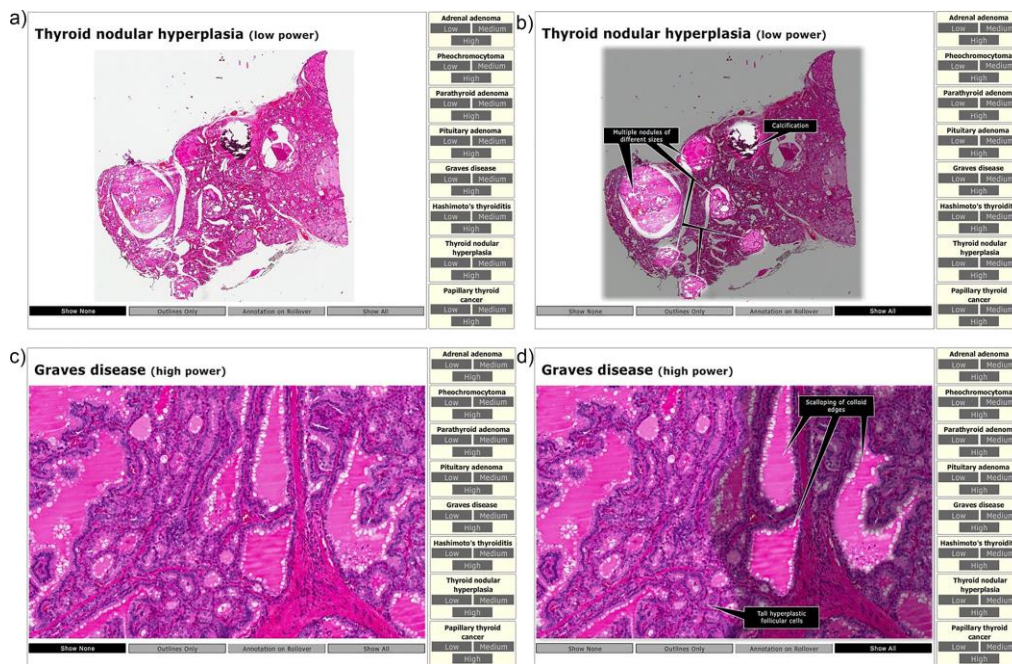


Figure 1A-D: Representation of the web/online based pathology modules. A- Nodular hyperplasia of thyroid gland in low power without any annotation; **B-** Annotations highlighting the key histopathological features such as hyperplastic nodules and calcification; **C-** Diffuse hyperplasia of thyroid (Graves's diseases) in high power without annotations; **D-** Annotations showing the scalloping effect of the colloid and hyperplasia of follicular cells.

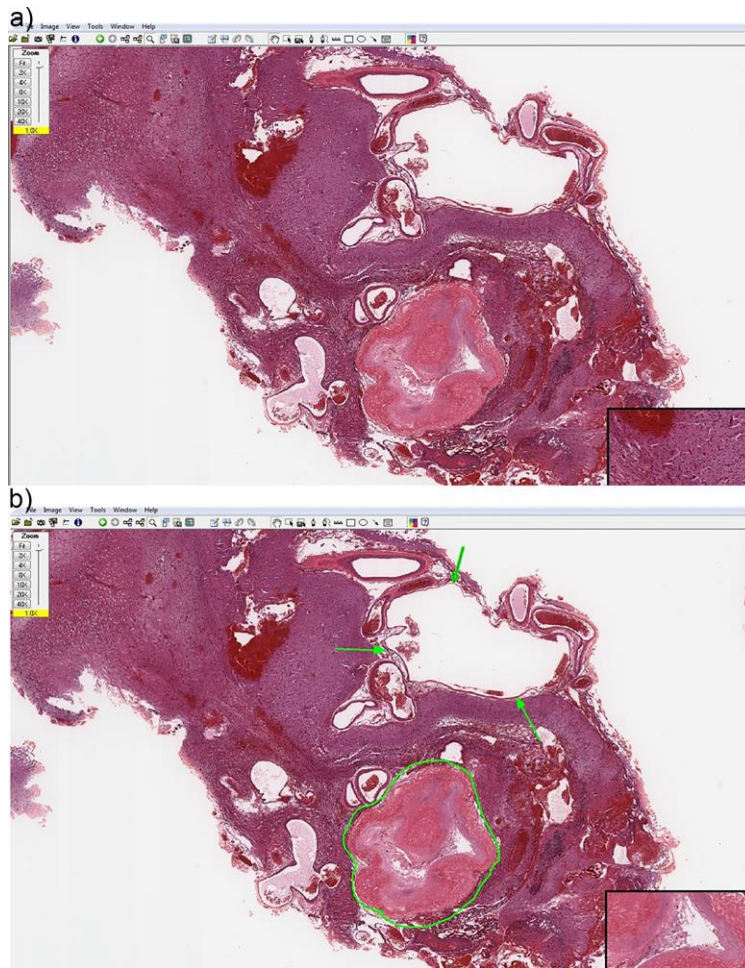


Figure 2A & B: Visual representation of live virtual microscopy session. A- Arteriovenous malformation in the brain without annotation; **B-** Demonstration of the flexibility of the software to annotate the features in different representation styles. Hyalinization of the blood vessel is highlighted in a circle. Tortuous and malformed blood vessels are indicated by arrows during the live lecture sessions.

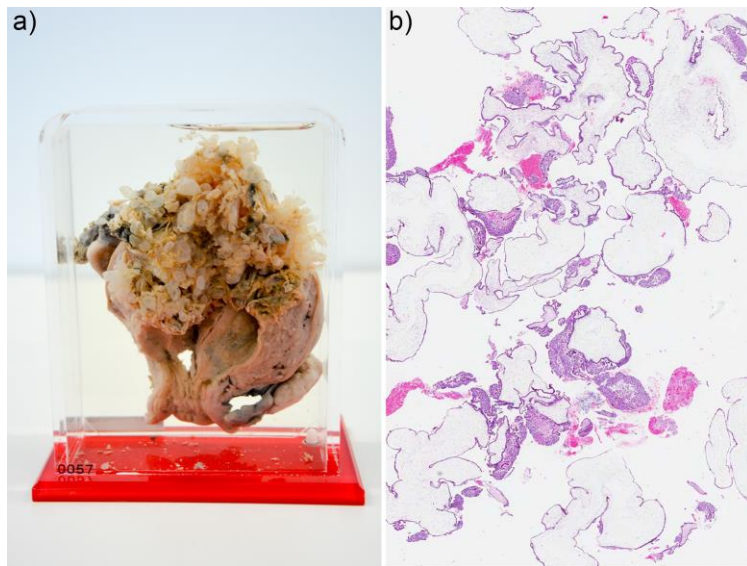


Figure 3A&B: Integration of gross/macroscopic pathology specimens in teaching microscopic pathology. **A-** Specimen is showing molar pregnancy with prominent chorionic villi macroscopically. **B-** The Microscopic appearance of the molar pregnancy showing proliferation of trophoblasts with enlarged, scalloped and vascular chorionic villi with central cavitations.

Supplementary figure:

Self-assessment modules: An example of a self-assessment module made is shown here. Answers and explanations were provided to students few days after the large group or practical sessions. As shown in the figure, radiological images were often used to prompt to students to integrate pathology with other clinical disciplines.

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Table 1 Student ratings of multiple learning experience in pathology

Question	Total/Missing	Student rating (1 = strongly disagree, 5 = strongly agree)					Mean	Median
		1	2	3	4	5		
Pathology Lectures								
Delivery	268/4	0	0	16	114	138	4.46 (\pm 0.61)	5
Inclusion of visual presentations	268/4	0	1	9	90	168	4.59 (\pm 0.58)	5
Inclusion of clinical correlation	268/4	0	2	14	80	172	4.57 (\pm 0.63)	5
Integration with PBL cases and clinical skills	268/4	4	16	84	108	56	3.73 (\pm 0.91)	4
Overall		0	1	14	125	128	4.42 (\pm 0.61)	4
Histology for pathology lectures								
Usefulness	261/11	2	3	24	87	145	4.42 (\pm 0.77)	5
Delivery	260/12	0	0	17	77	166	4.57 (\pm 0.61)	5
Quality of images	141/131	0	0	7	56	78	4.50 (\pm 0.59)	5
Overall	259/13	0	2	12	95	150	4.52 (\pm 0.62)	5
Web/Electronic resources (Interactive histopathology presentations)								
Usefulness	228/44	2	4	25	82	115	4.33 (\pm 0.81)	5
Quality of images	228/44	0	1	19	77	131	4.48 (\pm 0.67)	5
Overall	228/44	0	5	17	87	119	4.40 (\pm 0.72)	5
Virtual Microscopy Lectures								
Innovation	246/26	0	2	16	80	149	4.53 (\pm 0.64)	5
Delivery	247/25	0	2	14	77	154	4.55 (\pm 0.64)	5
Incorporation into clinical scenarios	246/26	0	1	24	82	139	4.46 (\pm 0.69)	5
Effectiveness in preparation to lab practical sessions	246/26	0	1	15	85	145	4.52 (\pm 0.63)	5
Overall	245/27	0	0	16	81	148	4.54 (\pm 0.62)	5
Pathology practical session								
Usefulness of slide presentations	259/13	0	2	31	86	140	4.41 (\pm 0.73)	5
Usefulness of pathology gross specimens	259/13	2	8	59	91	99	4.07 (\pm 0.89)	4
Delivery	259/13	0	0	26	96	137	4.43 (\pm 0.67)	5
Interaction with tutors	259/13	0	2	35	88	134	4.37 (\pm 0.74)	5
Overall	258/14	0	0	29	105	124	4.37 (\pm 0.68)	5

Table 2 Details of the gross tissue pathologies

Body system	Gross pathologies
Male genital	Seminoma of testis, mixed germ cell tumour of testis, embryonal carcinoma of testis, epididymo-orchitis, nodular hyperplasia of prostate
Female genital/Breast	Breast fibroadenoma, ductal carcinoma of breast, uterine fibroids (leiomyoma), endometrial carcinoma, hydatidiform mole, adenomyosis of uterus, ovarian serous cyst, mature cystic teratoma, endometrial hyperplasia, bi-cornulate uterus, endometrial stromal sarcoma, ovarian fibroma
Renal	Polycystic kidney disease, pyelonephritis, renal cell carcinoma of kidney, non-Hodgkin's B-cell lymphoma of kidney, oncocytoma of kidney, angiomyolipoma of kidney, urothelial carcinoma of bladder
Central nervous	Metastatic melanoma, Intra cerebral haemorrhage, cerebral infarction, arteriovenous malformation, meningioma
Bone and musculoskeletal	Knee- pigmented villonodular synovitis, osteochondroma

Table 3 Overall qualitative and open responses (selected) received during the questionnaire.

Positive	Negative	Suggestions
VM sessions were brilliant	Not every material was easily assessable	Deeper explanation with labels
Useful for home study	Some lectures not recorded	Additional notes and more pathology case studies
Awesome learning experience	Less assistance in practicals	Normal histology images to compare pathology
Overcome the grief from last year	Not enough time for practical sessions	Better integration with PBL and clinical skills
Helped in self learning	Lack of descriptions/labels for gross specimens	Long break between lectures
Highly effective sessions	Inadequate study time	Summary prior to lecture sessions
Easy to interpret pathology slides/images	Variation between academics	More discussion/explanation with gross specimens
Best aid to prepare for labs		Normal gross specimens to compare pathology
Very good and systematic approach		Need all lectures to be recorded
Lectures were clinically relevant		Pathology excursions to hospital pathology labs
Preparation lectures helped in applying learnt knowledge		Introduce pathology handbook
Continue the same for the following cohorts		More pathophysiology to learn disease mechanism
Perfect mix of multiple learning methods		Make web resources with edit options for students
Significant improvement in student attendance		Starting point should be more basic
		Use pathology for summative exams
		Make pathology sessions a routine (E.g. 1hr/week)

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