



The Influence of Digitalized Examination of the Histology Laboratory Course on Medical and Dental Students: A Retrospective Study

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Background: Histology laboratory courses comprise the study of cell structures, tissues, and body organs, which are mainly examined using a microscope. Two types of examinations assess learning outcomes in these courses in Taiwan: the traditional, light microscope station (LMS) examination and the Microsoft PowerPoint (MS PPT) examination. Whether these examinations exhibit different influences on students' grade performances remains to be examined. **Aim:** The aim is to compare the grade performance and opinion of students in a medical center for the LMS and MS PPT examinations. **Methods:** We compared the grade performances of students who completed LMS (3 cohorts) or MS PPT (2 cohorts) examinations retrospectively and conducted a survey to investigate the students' learning attitude between these two types of examinations. **Results:** Grade performances in the MS PPT group were not significantly higher than those in the LMS group. The average scores of students who failed the LMS examination were significantly lower than those of students who failed the MS PPT examination. Questionnaire survey results showed that the MS PPT examination was easier for students and that they may spend less time studying for it. The LMS examination positively influenced learning attitudes among students with a rather low self-demand. **Conclusion:** Examination type may affect learning attitude, especially among students with a rather low self-demand. The MS PPT examination seems to be easier for students and was connected to remarks about less study time in the histology laboratory course, and for students with low self-demands, the traditional LMS examination may be a better option. We believe that with the advance of digital whole histology slide imaging, there is an opportunity to revolutionize both learning and evaluating for all medical school students.

Key words: Histology laboratory course, light microscope station examination, Microsoft PowerPoint examination, digitalization, learning motivation

INTRODUCTION

Histology, also called microscopic anatomy, refers to the morphologic study of the structure of the cells, tissues, and organs of the body, which are mainly examined with a microscope.^{1,2} It is a fundamental curriculum in medical school³ and serves as basic knowledge for the future study of pathology.⁴ Although it is a subject with a long history, histological studies remain a major challenge in medical schools.⁵

For the past decade, teachers gave lectures on histology and pathology by relying on sets of glass slides.⁶ Conventionally,

teachers coordinated the use of practical traditional light microscope laboratory exercises and video media demonstrations through lectures. Simultaneously, the students used the microscope and boxes of glass slides as the standard workhorses for learning. To study for examinations, students were required to be physically present in the laboratory and often wait in line due to the insufficient number of microscopes. Alternatively, students could review slides through videos recorded from the microscope camera, but in doing so, they lost the opportunity to learn how to distinguish the different morphology of typical structures by themselves.

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With the development of whole slide scanners notwithstanding, histology teaching methods have undergone several changes.^{7,8} Specifically, the teaching of histology using a practical microscope has been complemented with the use of computers,⁹ especially in laboratory courses.^{10,11} In fact, a current trend in histology laboratory courses is the replacement of the traditional light microscope with a virtual microscope.⁵

Students' motivation to learn histology includes career motivation, intrinsic motivation, self-determination, and grade motivation.^{12,13} A previous study demonstrated that high intrinsic motivation is associated with higher academic performance, especially among male students.¹⁴ Meanwhile, the teachers' attitude when assessing students' performance during examinations affects students' learning enthusiasm.¹⁵ Hence, examination type may be an important influencing factor of students' learning motivation.

As remarked, the method of examination used in the histology course has generally shifted from the traditional light microscope station (LMS) to the use of digitalized slides via Microsoft PowerPoint (MS PPT). In the medical center to which the authors are affiliated, we still utilized the LMS examination among dental students before the class of 2014, changing it to the MS PPT examination beginning with the class of 2015. For medical students, this shift occurred in the middle of the school year for the class of 2016. However, the advantages and disadvantages of this change have yet to be evaluated. Hence, this study compared students' opinions and academic performance regarding the LMS and MS PPT examinations in a medical center.

MATERIALS AND METHODS

Participants

Study participants were students from the school of dentistry or the school of medicine in a single medical center from the classes of 2011 to 2018. For dental students in the classes of 2011 to 2014 (3 cohorts), their histology laboratory grades were evaluated by LMS examination [Figure 1], so they responded to the LMS examination questionnaire only; those in the classes of 2015–2017 (2 cohorts) had their grades evaluated by MS PPT examination [Figure 2], so they responded to the MS PPT examination questionnaire only. In 2018, the medical students experienced both LMS and MS PPT examinations, then they responded to a structured questionnaire of opinion for the two types of examination. All individualized data has been anonymized to protect students' identities, except for the class year.

Ethics approval and consent to participate

The study was conducted in accordance with the

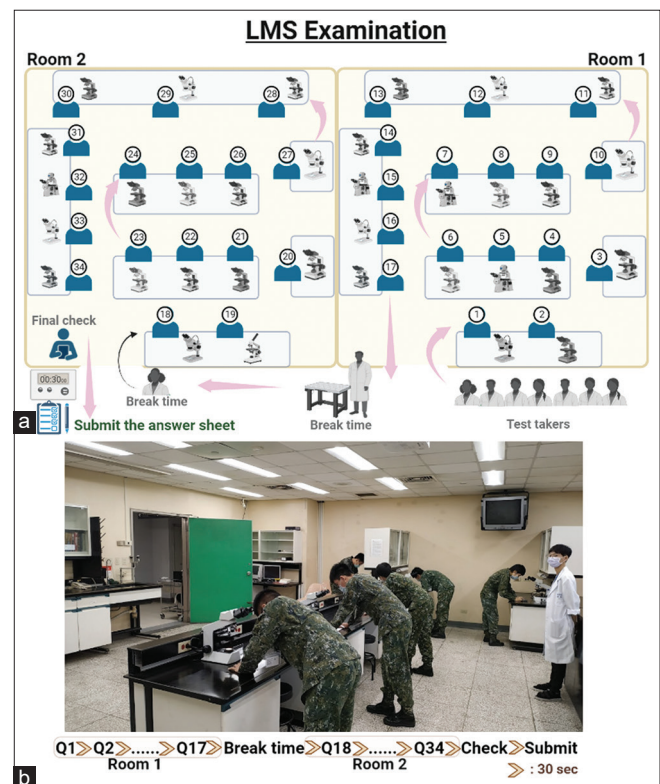


Figure 1: Implementation of the traditional LMS examination. (a) Test takers enter the examination room one by one every 30 s. They move from stations 1 to 34 in sequence. (b) The actual case of LMS examination. LMS: Light microscope station

Declaration of Helsinki and was approved by the institutional review board of the Tri-Service General Hospital (approval ID: C202205089). Informed written consent was obtained from all patients prior to their enrollment in this study. The results guarantee the anonymity of the participants.

The implementation of the traditional light microscope station and Microsoft PowerPoint examinations

Both dental and medical students responded to a 34-item examination questions in either examination type. In the traditional LMS examination, the test takers entered the examination room one by one. Then, the test taker moved from station 1 to station 34 in sequence [Figure 1]. One question was asked at each station, with one microscope showing a field of a tissue slide indicated by an arrow in the right eyepiece. The test taker had 30 s to write the answer on the answer sheet at each station. There were two break positions (between stations 17 and 18) and a check station (wherein students could check their answers for 30 s) after station 34.

In the MS PPT examination, the test taker sat in a fixed seat, and the questions were presented by a projector to a central screen in the front of the classroom [Figure 2]. The test takers

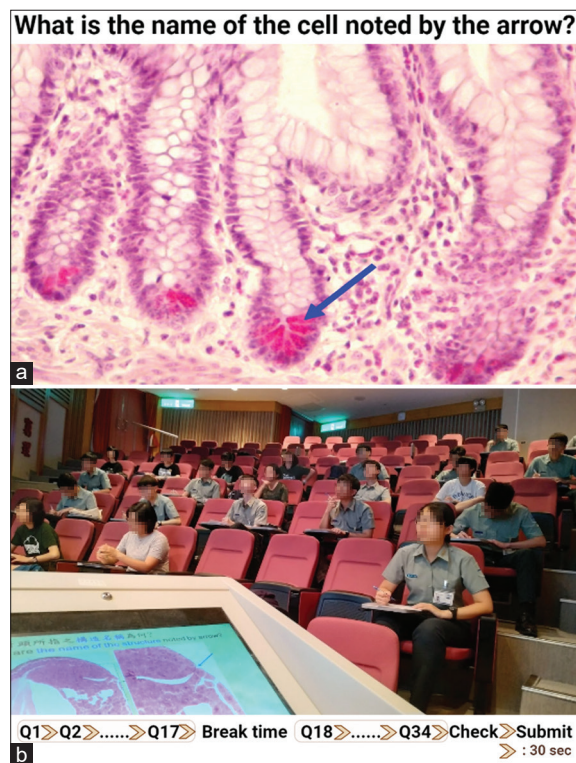


Figure 2: Implementation of the MS PPT examination. (a) An example of a question of the examination on the screen in front of the classroom. (b) Test takers remain seated in a fixed seat and questions are presented by a projector

had 30 s to write the answer on the answer sheet for each question. There was a 30-second break between questions 17 and 18 and students were allowed to take 30 s to check their answers after question 34.

All of the examination databases were extracted from 145 standard histology slides [Supplementary Table S1]. The difficulty of the questions for both examination types was similar, and the images for both were acquired from the same slides.

Students' grade performance

Students' grade performance was defined by their grades in the examination. The differences in the scores for the midterm and final examinations between the LMS and the MS PPT examinations were analyzed. If students' average score for each examination was ≥ 60 , they passed; if it was < 60 , they failed.

Structure of the online anonymous survey

The results presented in this study are derived from an online survey that was administered to medical students. The questionnaire contained four questions: 1) Which examination is easier for you? 2) For which examination will you spend more time studying histology? 3) Which examination do you prefer? and 4) Which examination do you consider difficult? All responders provided anonymized responses, provided

informed consent for, and agreed to the publication of the results of this survey.

Statistical analysis

Statistical analysis was performed using GraphPad Prism (GraphPad Software, San Diego, CA, USA). Student's *t*-test was used to compare scores for the midterm and final examinations among students tested by the LMS or MS PPT examinations. Chi-square tests were used for analyzing the percentage of the scaled scores, and the percentage of students who passed and failed the examination. Statistical significance was set at a $P < 0.05$.

RESULTS

Comparison of students' performance by examination type

To identify how examination type influences students' grades in the histology laboratory course, we analyzed grade performance on the midterm and final examinations in the classes of 2011 to 2017.

The syllabus for undergraduate students is shown in Figure 3. It shows that the midterm examination included topics 1 (Orientation and The Cell) to 8 (Hemolymphatic System), and the final examination included topics 9 (Cardiovascular System) to 16 (Endocrine Organs). The syllabus was arranged over the years without major revisions.

The final grade for this course was calculated as follows: 30% from the attendance and class performance score, 35% from the midterm examination score, and 35% from the final examination score. The passing standard was a score of ≥ 60 . To avoid the interference of the 30% attendance/class performance score, we only analyzed the scores for the midterm and final examinations. The passing standard in each examination was also a score of ≥ 60 . The analyses of the midterm and final examination grades showed no statistically significant differences between the LMS and the MS PPT groups [Figure 4a and b].

To further clarify the influence of examination type, we compared the percentage by scaled scores. We found that the percentage of students with a score from 61–80 in the LMS group was significantly lower than that in the MS PPT group for the midterm examination [Figure 5a]. However, this difference was not observed in the final examination [Figure 5b].

In order to dissection the potential difference between the two types of examinations. We also analyzed the percentage of students who passed and failed the examinations by examination type. Interestingly, results showed that the percentage of students who failed in the MS PPT group was slightly higher than that in the LMS group for the midterm examination [Figure 6a].

However, this percentage in the final examination was no different [Figure 6b]. On checking the scores of students who failed in the midterm examination, we found that the average score of the MS PPT group was significantly lower than that of the LMS group [Figure 6c]. For the final examination among students who failed, the average score in the MS PPT group was slightly lower than that of the LMS group [Figure 6d]. That may be due to high-performing medical students tending to have initiative to improve their study skills and adapting to challenges when facing final exams.¹⁶

These results may have appeared because students could underestimate the difficulty of the MS PPT examination, leading to lower impetus to study for the midterm examination in the MS PPT group than LMS group. Nevertheless, those students, after experiencing a failure in the midterm examination, they may suffer a crisis from their failure, which might be associated with an increase in their learning impetus and lead them to spend more time studying for the final examination.

The attitudes of students who experienced both the light microscope station and Microsoft PowerPoint examinations

Medical students in the class of 2018 ($n = 133$) experienced both the LMS and MS PPT examinations, so we conducted a survey for investigating their attitude by examination style. For the first question (“what type of examination is easier for you?”), 54.7% of the medical students considered the MS

PPT examination to be easier, 24.5% considered the LMS examination to be easier, and 20.8% described both as having similar easiness [Figure 7a]. For the second question (“what type of examination will you spend more time studying histology for?”), only 3.8% of the students described that they would spend more time studying for the MS PPT examination, while 37.7% would do so for the LMS examination, and 58.5% would spend equal time on both [Figure 7b]. This result showed that only a few students would spend more time studying when they were to be examined using the MS PPT examination. For the third question (“what type of examination do you prefer?”), 47.2% of students preferred the LMS examination, 39.6% preferred the MS PPT examination, and 13.2% of students had no preference [Figure 7c]. This result indicated that although the MS PPT examination was easier for students, more students preferred to undergo the traditional LMS examination. For the last question (“what type of examination do you consider to be more difficult?”), 58.5% of students considered the LMS examination to be more difficult, 24.5% considered the MS PPT examination to be more difficult, and 17% considered both to be equally difficult [Figure 7d]. This may be related to the positioning of the picture during the examination, which may affect students’ performance in the MS PPT examination.

DISCUSSION

Histology, a compulsory subject in dental and medical schools, is core discipline of anatomy to identify cellular structures-function relationships. Most of the medical colleges

Date	Topic	#Chapter(s)
9/7	Orientation & The Cell	1~3
9/14	Epithelial Tissue	5
9/21	Connective Tissue	6 & 9
9/28	Integumentary System	15
10/5	Skeletal System (Hard Tissues)	7~8
10/12	Muscle Tissue	11
10/19	Nerve Tissue	12
10/26	Hemolymphatic System	10 & 14
11/2	***** Midterm Examination *****	
11/9	Cardiovascular System	13
11/16	Digestive Tract	16~17
11/23	Digestive Glands	18
11/30	Respiratory System	19
12/7	Urinary System	20
12/14	Male Reproductive System	22
12/21	Female Reproductive System	23
12/28	Endocrine Organs	21
1/4	***** Final Examination *****	

Figure 3: The syllabus for dental students. In total, there are 16 topics in the teaching course and two examinations

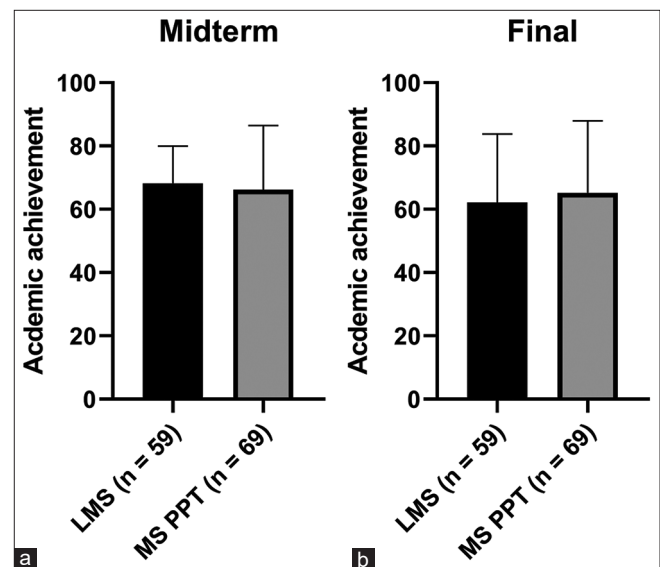


Figure 4: The analysis of grade performance for the midterm and final examination by examination type in dental students. The grade performance of (a) the midterm and (b) the final examination was evaluated using the LMS examination or MS PPT examination

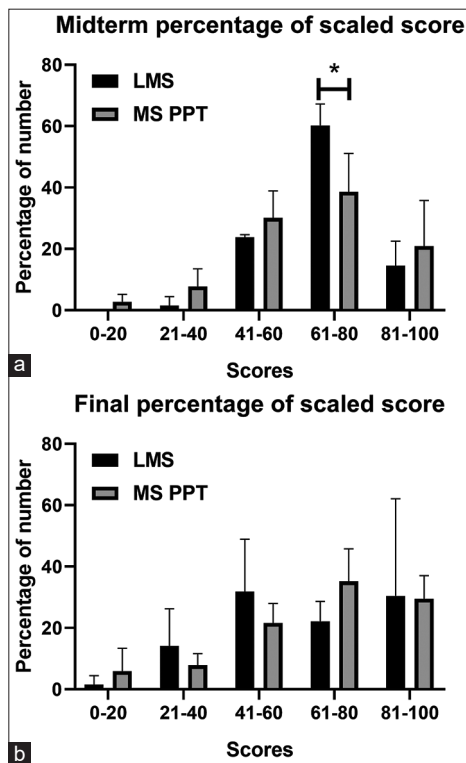


Figure 5: Percentage of scaled scores among dental students by LMS or MS PPT examinations. Scores in (a) the midterm and (b) the final examination. Data are expressed as mean $\pm$ standard deviation

divide this subject into lecture and laboratory courses. Learning histology and the laboratory course are traditionally involving the practical utilization of optical microscopes, which is an important part of medical students' professional curriculum.¹⁷ The assessment of learning outcomes regarding the histology laboratory course have tended to be made through MS PPT examinations, which replaced the traditional LMS examination, in recent years due to the transformation of digitalization. However, the influence of this change in examination type on grade performance and learning attitude had yet to be evaluated.¹⁸

Our analysis revealed that there was no difference on students' academic performance [Figure 4a], the scores of students who failed the examination were significantly higher in the MS PPT examination [Figure 7]. Although one prior study indicated that digitalized slides are not only an effective method for teaching histology but are also associated with higher learning satisfaction.¹⁹ This may be due to the distinctive features of digital slides, which enable students do not have to utilize LMS to review and access the image. Furthermore, when we analyzed the opinion of the medical students in the class of 2018 (i.e., they completed both examination types in that semester), we observed students thought that the MS PPT examination is easier for them [Figure 7].

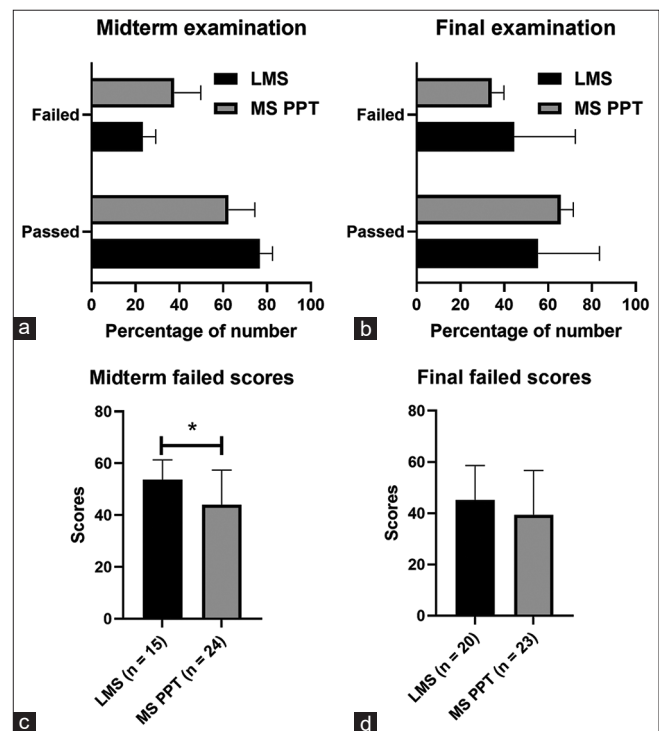


Figure 6: (a) The percentage of students who passed/failed in the midterm examination. (b) The same percentage as (a) but for the final examination. (c) Comparison of the average scores of students who failed in the midterm examination. (d) Comparisons like in (c) but for the final examination. Data are expressed as mean $\pm$ standard deviation

The analysis of the grades of dental students who failed in the midterm exam revealed that the scores in the MS PPT group were significantly lower than those in the LMS group [Figure 6c]. Meanwhile, the findings for the survey among medical students in the class of 2018 showed a specific trend: students tended to spend less time studying the histology laboratory course for MS PPT examination [Figure 7b]. This finding is consistent with a previous study, which remarked that the digital transformation of the examination might influence lowly motivated and motivated students differently.²⁰

Although the MS PPT examination is easier to implement than the LMS examination and is a time-saving assessment method, several other factors should be considered in its utilization for the assessment of learning outcomes. First, is examination fairness, which is mainly related to the position of test-takers in the examination room. Specifically, a worse positioning provides an inappropriate view of the picture presented on the screen, which may critically influence the performance of the test taker.²¹ The outcomes of this issue can be seen in the results of the survey of the medical students [Figure 7c], and they can be improved by using multiple examination classrooms or a computer classroom; both improvements will provide students with an individual screen and enable for an

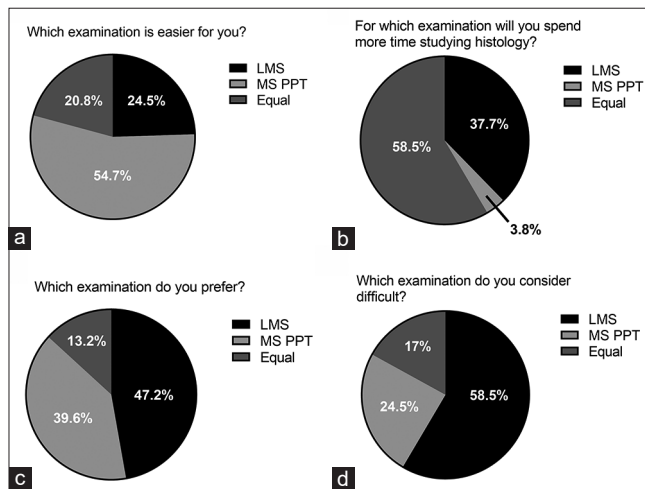


Figure 7: The results of the survey of undergraduate medical students in the class of 2018. The answers of the distribution for the main questions were divided into four pie charts. (a) What type of examination is easier for you? (b) What type of examination will you spend more time studying histology for? (c) What type of examination do you prefer? (d) What type of examination do you consider to be more difficult?

appropriate view of the image. The second is high-quality equipment (e.g., computers and projectors) in examination rooms that can support images with high pixel qualities. Third, although LMS examinations are time-consuming and not easy to learn and spend more time for studying, the students still prefer to use LMS as examination [Figure 7]. This may be due to the fact that medical students, in contrast to students who do not have high self-demands, are more likely to learn from challenging tasks (LMS exam) that will promote their learning motivation.¹² In addition, while obtaining light microscope skills might be desirable within clinical pathology internship curricula, the ultimate goal of histology and pathology courses is to teach students how to differentiate between normal and abnormal human microanatomy structure, not how to use the microscope.⁹

Limitations

First, the analyzed data stem from a single medical school. Future studies should include more medical schools and check whether they have students who have experienced both examination types.

Second, we compared only two types of examinations. Although there have been novel assessment methods for measuring learning outcomes, some of them have failed in being efficient. For example, a computer-based examination with student self-scheduling has been tested, but it does not appear to improve grade performance and may even be detrimental to such performance.²²

Third, we did not examine the influence of examination-type changes on teachers. It is not only students but also teachers

who require a better assessment strategy for the histology laboratory course. Teachers often experience high levels of stress due to their high job demands and examination-related workloads.^{23,24} Moreover, research shows an interaction effect between teachers' teaching methods and students' learning motivation.²⁵ Therefore, it remains highly worthwhile to identify novel ways of assessing learning outcomes within the context of histology laboratory courses.

CONCLUSION

We concluded that types of examination can affect students' learning attitude in the histology laboratory course, especially among students with a rather low self-demand. Despite the MS PPT examination seems to be easier for students and was related to remarks of spending less time studying for the examination in the histology laboratory course, the challenging task such as LMS learning may be suitable for some medical students, especially among students with few self-demands or low interest in the course. Furthermore, future study still needs to evaluate the influence of the digital transformation on both examination and teaching method (completely replace the LMS method). Collectively, we believe that with the advance of digital whole histology slide imaging, there is an opportunity to revolutionize both learning and evaluating for all medical school students.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, GJ Lin, upon reasonable request.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Calligaro A, Calligaro AL. The museum for the history of the university of pavia and the birth of histology. *J Hist Neurosci* 1999;8:106-12.
- Heidger PM Jr, Dee F, Consoer D, Leaven T, Duncan J, Kreiter C. Integrated approach to teaching and testing in histology with real and virtual imaging. *Anat Rec* 2002;269:107-12.
- Milliken PD. Happy birthday, histology! *J Histotechnology* 1989;12:87.
- Rosai J. Why microscopy will remain a cornerstone of surgical pathology. Laboratory investigation. *J Technical Meth Pathol* 2007;87:403-8.
- Higazi TB. Use of interactive live digital imaging to enhance histology learning in introductory level anatomy and physiology classes. *Anat Sci Educ* 2011;4:78-83.
- Foster K. Medical education in the digital age: Digital whole slide imaging as an e-learning tool. *J Pathol Inform* 2010; 1. doi:10.4103/2153-3539.68331.
- Bloodgood RA, Ogilvie RW. Trends in histology laboratory teaching in united states medical schools. *Anat Rec B New Anat* 2006;289:169-75.
- Hortsch M. Virtual biology: Teaching histology in the age of facebook. *FASEB J* 2013;27:411-3.
- Harris T, Leaven T, Heidger P, Kreiter C, Duncan J, Dick F. Comparison of a virtual microscope laboratory to a regular microscope laboratory for teaching histology. *Anat Rec* 2001;265:10-4.
- Cotter JR. Laboratory instruction in histology at the University at Buffalo: Recent replacement of microscope exercises with computer applications. *Anat Rec* 2001;265:212-21.
- Michaels JE, Allred K, Bruns C, Lim W, Lowrie DJ Jr, Hedgren W. Virtual laboratory manual for microscopic anatomy. *Anat Rec B New Anat* 2005; 284:17-21.
- Campos-Sanchez A, Lopez-Nunez JA, Carriel V, Martin-Piedra MA, Sola T, Alaminos M. Motivational component profiles in university students learning histology: A comparative study between genders and different health science curricula. *BMC Med. Educ.* 2014; 14:46. doi:10.1186/1472-6920-14-46.
- Kunanithaworn N, Wongpakaran T, Wongpakaran N, Paiboonsithiwong S, Songtrijuck N, Kuntawong P, *et al.* Factors associated with motivation in medical education: A path analysis. *BMC Med Educ* 2018;18:140.
- Cortright RN, Lujan HL, Blumberg AJ, Cox JH, DiCarlo SE. Higher levels of intrinsic motivation are related to higher levels of class performance for male but not female students. *Adv. Physiol Educ* 2013;37:227-32.
- Singh S, Pai DR, Sinha NR, Kaur A, Soe HHK, Barua A. Qualities of an effective teacher: What do medical teachers think? *BMC Med. Educ.* 2013; 13:128.
- Foong CC, Bashir Ghouse NL, Lye AJ, Khairul Anhar Holder NA, Pallath V, Hong WH, *et al.* A qualitative study on self-regulated learning among high performing medical students. *BMC Med Educ* 2021;21:320.
- Johnson S, Purkiss J, Holaday L, Selvig D, Hortsch M. Learning histology - Dental and medical students' study strategies. *Eur J Dent Educ* 2015; 19:65-73.
- Gribbin W, Wilson EA, McTaggart S, Hortsch M. Histology education in an integrated, time-restricted medical curriculum: Academic outcomes and students' study adaptations. *Anat Sci Educ* 2021. doi:10.1002/ase.2127.
- Amer MG, Nemenqani DM. Successful use of virtual microscopy in the assessment of practical histology during pandemic COVID-19: A descriptive study. *J Microsc Ultrastruct* 2020;8:156-61.
- Darici D, Reissner C, Brockhaus J, Missler M. Implementation of a fully digital histology course in the anatomical teaching curriculum during COVID-19 pandemic. *Ann Anat* 2021;236:151718.
- Adams Azubuike ASA. Students' common difficulties in manipulating microscope selected schools in Kano State, Nigeria *Creative Educ* 2014; 5:1125-31.
- Burns ER, Garrett JE, Childs GV. A study of student performance on self-scheduled, computer-based examinations in a medical histology course: Is later better? *Med Teach* 2007;29:990-2.
- Clunies-Ross P, Little E, Kienhuis M. Self-reported and actual use of proactive and reactive classroom management strategies and their relationship with teacher stress and student behaviour. *Educ. Psychol* 2008;28:693-710.
- Harmsen R, Helms-Lorenz M, Maulana R, van Veen K. The relationship between beginning teachers' stress causes, stress responses, teaching behaviour and attrition. *Teachers Teach* 2018;24:626-43.
- Han J, Yin H. Teacher motivation: Definition, research development and implications for teachers. *Cog Educ* 2016;3:1217819.

Table S1: Microscope slides for histology laboratory

100 slides/set
001 Zymogen granules, chromidial substances, pancreas, cat
002 Simple squamous, cuboidal, and columnar epithelium, kidney, cat
003 Pseudostratified columnar epithelium, trachea, monkey, c.s.
004 Stratified squamous and cuboidal epithelium, esophagus, c.s.
005 Transitional epithelium, urinary bladder, nondistended, c.s.
006 Mucous tissue, umbilical cord, c.s.
007 Subcutaneous tissue, vital stain, w.m.
008 White fibrous tissue, tendon, c.s. and l.s.
009 Reticular tissue, lymphoid gland, bielschowsky stain
010 Yellow elastic fibrous tissue, ligamentum nuchae, c.s. and l.s.
011 Hyaline cartilage, trachea, c.s.
012 Elastic cartilage, auricle
013 Fibrocartilage, intervertebral disc
014 Developing cartilage bone, section showing endochondral bone formation, infant, l.s.
015 Membranous developing bone, skull, fetal pig
016 Ground bone, c.s. and l.s.
017 Bone, decalcified, femur, rabbit, l.s.
018 Skeletal muscle, c.s. and l.s.
019 Muscle-tendon
020 Heart muscle, intercalated disc, monkey, l.s.
021 Muscle, 3 types, monkey
022 Cerebrum, cat, vertical section
023 Spinal cord with nissl bodies, c.s.
024 Spinal ganglion, sec.
025 Sympathetic ganglion, sec.
026 Myelinated nerve, masson stain, c.s. and l.s.
027 Motor end plate, teased preparation, GC-FC stain
028 Blood smear, wright's stain
029 Red bone marrow smear, giemsa stain
030 Tonsil, palatine
031 Lymph node
032 Thymus, infant
033 Spleen
034 Heart, purkinje fibers, through interventricular wall
035 Aorta, c.s.
036 Medium artery and vein, Weigert's elastic tissue stain
037 Small artery and vein, c.s.
038 Arteriole, venule, and capillary, mesentery, rabbit, w.m.
039 Vena cava, elastic tissue stain, l.s.
040 Lymphatic vessel (showing valves), w.m.
041 Skin composite

Contd...

Table S1: Contd...

100 slides/set
042 Thin skin, axilla, c.s.
100 slides/set
043 Scalp, showing hair follicle, sebaceous and sweat glands, l.s.
044 Finger nail, infant, l.s.
045 Lip, monkey, sagittal sec.
046 Tooth, developing late stage of dentine, pig fetus
047 Tooth, ground thin, median l.s.
048 Tongue, circumvallate papillae
049 Esophagus composite, c.s.
050 Cardiac and fundic stomach, l.s.
051 Small intestine 3 regions (duodenum, jejunum, ileum), c.s.
052 Ileum, paneth cells, PI stain, l.s.
053 Appendix, c.s.
054 Large intestine, colon, c.s.
055 Salivary glands composite
056 Pancreas
057 Ampulla of vater (with duodenum), monkey, c.s.
058 Liver
059 Liver, phagocytosis, rabbit
060 Liver, bile canaliculi
061 Gallbladder
062 Nasal septum, bone and nasal epithelium, monkey, c.s.
063 Larynx, monkey, frontal sec.
064 Trachea, c.s.
065 Bronchus, c.s.
066 Lung
067 Kidney
068 Ureter, c.s.
069 Urinary bladder, dilated, mammal, l.s.
070 Pituitary gland
071 Pineal body
072 Thyroid-parathyroid glands
073 Adrenal gland
074 Testis, seminiferous tubules and straight tubules
075 Testis and epididymis, showing rete testis and ductile efferentes
076 Epididymis (with efferent ductules)
077 Spermatic cord (vas deferens and blood vessels), c.s.
078 Seminal vesicle
079 Prostate gland, young
080 Prostate gland, older
081 Penis, c.s.

Contd...

Table S1: Contd...

100 slides/set
082 Ovary, immature, showing developing follicles
083 Ovary, mid-age, Showing corpus luteum
084 Ovary, corpus luteum
100 slides/set
085 Ovary, aged, corpus albicans
086 Uterine tube (imfundibulum - fimbria)
087 Uterine tube (ampulla), c.s.
088 Uterine tube (isthmus), c.s.
089 Uterus, showing proliferative stage
090 Uterus, showing secretory stage
091 Uterus, showing active menstruation
092 Uterine cervix, l.s.
093 Placenta, early stage of pregnancy
094 Placenta, late stage , cross section through uterine wall
095 Vagina, l.s.
096 Eyelid, showing conjunctiva, monkey, sag. sec.
097 Eye (with lids and ocular muscle), monkey, vertical sec.
098 Eye (choroid and sclera), monkey, horizontal sec.
099 Crista ampullaris, guinea pig
100 Internal ear, near median section of cochlea helicotrema, guinea pig
P.S. human sections and H-E stained if not indicated
Slides for demonstration of histology laboratory
45 slides/set
27 slides for demonstration of his lab
D01-1 Golgi apparatus, spinal ganglion, dog, Co-AgNO ₃
D01-2 Golgi apparatus, epididymis, mouse, OsO ₄
D01-3 Glycogen, liver, mouse, (right, control; left) saliva digested), Abs. alc./PAS/Hx 6
D02 Omentum, mouse, AgNO ₃
D20 Cardiac muscle and Purkinje fibers
D21 Ileum-cecum, contracted smooth muscle
D22 Cerebellum
D35 Aorta (large artery), c.s.
D36 Medium (muscular) artery, c.s., Weigert's elastic tissue stain
D39 Vein composite, c.s.
D41-1 Thick skin, showing stratum lucidum
D41-2 Thick skin, showing Meissner's and pacinian corpuscles
D44 Nail, monkey, c.s.
D48-1 Tongue, rabbit l.s.
D48-2 Tongue, foliate papilla, monkey
D50 Fundic stomach
D58 Liver, pig

Table S1: Contd...

P.S. human sections and H-E stained if not indicated
Slides for demonstration of histology laboratory
45 slides/set
27 slides for demonstration of his lab
D62 Olfactory mucosa
D63 Epiglottis
D81-1 Female urethra, mammal, c.s.
D81-2 Female urethra, c.s.
D75 Testis and epididymis, showing straight tubule and rete testis
P.S. human sections and H-E stained if not indicated
Slides for demonstration of histology laboratory
45 slides/set
27 slides for demonstration of his lab
D80 Prostate gland, dog
D82 Ovary, immature, showing developing follicles, sec.
D70 Pituitary gland, monkey. l.s.
D72 Thyroid-parathyroid glands, dog
D98 Optic nerve
18 slides of nerve tissue for integrated course
Slide 01 93w3617 multipolar neurons
Slide 05 93w3627 neurofibrillae
Slide 04 93w8115 astrocytes, oligodendrocytes and microglia
Slide 06 93w6322 protoplasmic astrocytes
Slide 07 39w3635 fibrous astrocytes
Slide 09 93w3639 peripheral nerve, l.s.
Slide 10 93w3643 peripheral nerve, c.s.
Slide 11 93w3647 peripheral nerve, c.s.
Slide 12 93w3650*peripheral nerve, c.s. and l.s.
Slide 14 93w3657*motor end plate
Slide 15 93w3659 muscle spindle
Slide 16 93w3711 spinal ganglion
Slide 18 93w3695 spinal ganglion
Slide 19 93w3715 sympathetic ganglion
Slide 35 93w6435 cerebrum
Slide 31 93w3755 cerebellum and choroid plexus
Slide 41 93w6412 cerebellum
Slide 21 93w3707 spinal cord, c.s.
GC-FC: Gold chloride-formic acid

Contd...