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Original Article

Drawing is an important tool to learn context-based histology in an integrated undergraduate medical curriculum

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الملخص

أهداف البحث: لاختبار ما إذا كان تعلم الأنسجة عن طريق الرسم متفوقًا في بعض الجوانب على التعلم من خلال الرؤية من خلال المجهر فقط.

طريقة البحث: تم تقسيم طلاب السنة الثانية في كلية الطب عن طريق أخذ عينات عشوائية بسيطة في المجموعة "أ" و "ب". كل مجموعة تتألف من 50 طالبا. تم التخطيط لهذه الدراسة ذات الطرق المختلطة في وحدة مدتها ثمانية أسابيع. خلال الأسابيع الأربعة الأولى من الوحدة الدراسية ، تعلم الطلاب في المجموعة "أ" علم الأنسجة عن طريق الرسم بينما تعلمت المجموعة "ب" من خلال رؤية النص والصور المجهرية. خلال الأسابيع الأربعة التالية، تم تبديل المجموعات بالتصميم المتقاطع. تم تقييم تأثير التعلم عن طريق الرسم بواسطة اختبارالاختيار من متعدد الأول والاختبار الثاني في نهاية أربعة وثمانية أسابيع على التوالي. تم تحليل الدرجات التي تم الحصول عليها في الاختبار الأول والاختبار الثاني عن طريق اختبار t للعينة المستقلة. تم تطبيق اختبار t للعينة الزوجية على الدرجات التي حصل عليها نفس الموضوع عندما يتعلمون بالرسم وبدون إستراتيجية الرسم. من أجل استكشاف تأثير الرسم على تعلم الأنسجة، أجريت دراسة جماعية مركزة. تم اختيار المشاركين الستة بأخذ عينات هادفة. تم تحليل البيانات الخاصة بأسئلة المقابلة شبه المنظمة من خلال تقنيات البحث النوعي للترميز والتصنيف وتوليد الموضوعات.

النتائج: أظهر اختبار t للعينة المستقلة أنه لا يوجد فرق ذو دلالة إحصائية في متوسط الدرجات التي حصلت عليها المجموعة "أ" والمجموعة "ب" في الاختبار الأول والاختبار الثاني. ومع ذلك، كان هناك فرق ذو دلالة إحصائية عندما يتم تعليم علم الأنسجة عن طريق الرسم مقارنة باستراتيجية عدم الرسم، كما هو موضح في اختبار t الزوجي. كشفت دراسة المجموعة المركزة أن الرسم له تأثير إيجابي على الاحتفاظ بالمعرفة وفهم المفاهيم الأساسية للأنسجة لتطبيقها في الأهمية السريرية.

الاستنتاجات: يساعد الرسم القائم على التعلم في علم الأنسجة في تطبيق المعرفة الأساسية في السياق السريري.

الكلمات المفتاحية: تشريح؛ منهاج دراسي؛ السياق السريري؛ رسم؛ علم الانسجة

Abstract

Objectives: To determine if learning histology by drawing is superior to learning by looking through a microscope only.

Methods: Second year MBBS students were divided by simple random sampling into Groups A and B. Each group comprised 50 students. This mixed-methods study was conducted in an 8-week module. For the first 4 weeks, students in Group A learned histology by drawing, whereas Group B learned by seeing the text and microscopic images. For the last 4 weeks, groups were swapped by crossover design. The impact of learning by drawing was assessed by multiple choice question (MCQ) test I and test II at the end of 4 and 8 weeks, respectively. Statistical analyses of the data were conducted with SPSS version 23. The scores obtained in test I and test II were analyzed by the independent samples *t*-test. The paired samples *t*-test was applied to scores obtained by the same subject when they learned with drawing and no drawing strategies. To assess the impact of drawing on learning histology, a focus group study was conducted in six participants selected by purposive sampling. Responses to the semi-structured interview questions were analyzed by qualitative research techniques of coding, categorizing, and generation of themes.

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Results: The independent samples *t*-test showed that there was no statistically significant difference in the mean scores obtained by Groups A and B in test I and test II. However, there was a statistically significant difference when the subject learned histology by drawing compared to no drawing, as shown by the paired samples *t*-test. The results from the focus group study revealed that drawing had a positive impact on knowledge retention and understanding the basic concepts of histology for its application in the clinical context.

Conclusion: Drawing-based learning in histology helps with the application of basic knowledge in the clinical context.

Keywords: Anatomy; Clinical context; Curriculum; Drawing; Histology

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Introduction

Gross and microscopic anatomy is indispensable for safe clinical practice. The paradigm shift from a traditional to integrated curriculum has resulted in radical changes in basic science education. The integrated curriculum emphasizes that basic science concepts should be taught in the clinical context. Evaluation of an integrated curriculum has shown that students cannot completely and systematically comprehend histology in a modern integrated curriculum. Lack of retention of basic science knowledge and its clinical application has been observed.[1]

A negative consequence of weak basic science knowledge about normal histology has also been observed in pathology residency programs. Most of the trainees had a poor basic knowledge of normal histology and could not appreciate the pathological changes in histological preparations.[2] The Association of Pathology Chairs has also identified deficient basic science knowledge among resident doctors. They noted that it is difficult to schedule remedial sessions during the training period due to time constraints.[3]

Image-intensive disciplines such as histology and pathology have also witnessed another paradigm shift in the replacement of conventional microscopy with computer-aided instruction. Digital images have been introduced because light microscopy is a luxury that can no longer be afforded due to a lack of resources, equipment, staff, space, funding, and time allocated to deliver the content.[4] Virtual microscopy provides flexible learning[5] and decreases the curricular time,[6] and the digital annotation of virtual slides marks the specific area of diagnostic relevance.[7] However, research has shown that digital photomicrographs and posters are not ideal tools to teach and learn histology because they do not engage the student with the learning material for developing good interpretive skills by closely observing the material.[4]

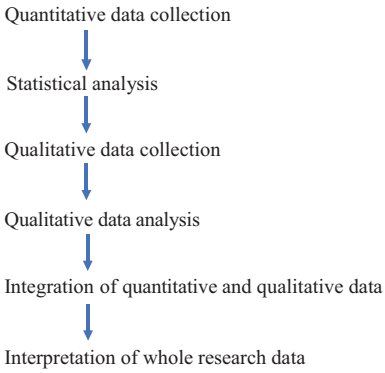
Drawing microscopic images remains a useful pedagogy for teaching and learning histology based on the belief that it allows the development of creativity and autonomy, leading to self-discovery learning.[8] Clinical practice requires the retention and application of basic science knowledge. Lack of retention and application of knowledge have prompted medical educationists to devise teaching strategies based on adult learning theories in order to promote learning and application of knowledge in later clinical years. Drawing is considered an important pedagogical tool for a constructivist classroom where the learner engages in observation, comprehension, and abstract conceptualization of the structure under study.[9]

This has called for devising teaching strategies based on adult learning theories to promote learning and application of knowledge. There is a need to emphasize the advantages of making drawings because it encourages the deep learning process through engagement with the learning material. However, there is scant literature addressing the pedagogical methods in histology that facilitate application of knowledge in the clinical years. This is a very important issue to consider because the integrated curriculum is designed for clinical relevance of basic science. The goal of this study was to determine if learning histology by drawing is superior to learning without drawing.

Materials and Methods

A research design was selected that aligned with the goal of the study, which was focused on the studying the impact of drawing on learning histology. A mixed-methods research design was adopted to help understand both the breadth and depth of the central phenomenon of research. The numerical data for quantitative study were collected using a quasi-experimental design. The qualitative data were collected using the focus group study design.

The scheme for the mixed-methods research approach is presented as:



Brief introduction of teaching and learning histology at Shifa College of Medicine

Shifa College of Medicine has an integrated modular system-based curriculum. The basic medical science is taught with clinical relevance to facilitate the application of basic science knowledge in the clinical context. Normal histology is taught in the first two pre-clinical years. The teaching and learning strategies for histology integrates the basis of disease

and clinical presentation by correlating the basic structure with function. Histology is taught in large group interactive sessions followed by small group discussions using clinical vignettes as a trigger to promote critical thinking and problem solving among the students. The histology practical laboratory session reinforces the concept where the instructor explains the slide on a teaching microscope.

This provides the opportunity to study the detailed morphology of the tissue under study. Later, the students are encouraged to study the slides individually under a microscope with the aid of a histology atlas.

Instrument for collecting the quantitative data

The impact of learning histology using drawing and no drawing strategies was assessed by administering a multiple choice question (MCQ) test at the end of 4 weeks (test I) and 8 weeks (test II). Type A MCQs were developed for the application of basic science knowledge in the clinical context (Blooms level C2). The test was developed by subject experts and validated by medical educationists regarding its content and construct validity. There were 30 MCQs in both test I and test II.

The content included in test I comprised the histology of endocrine organs, pituitary, thyroid, parathyroid, adrenal, and the endocrine pancreas. The content included in test II included the histology of reproductive organs in males and females, namely the ovary, mammary gland, fallopian tube, uterus, prostate, seminal glands, ductus deferens, and testis. The time allocated for both tests was 40 min. The students were informed that both tests were formative assessments.

Quantitative data collection (quasi-experimental study design)

The study was conducted in 8-week endocrinology and reproduction modules.

The class was research project-oriented. All second year MBBS students, who consented for the study and were willing to take both tests, were included in the study. Students who did not take any test were excluded from the study. The students were selected with the random sampling technique using the random number function in Microsoft Excel. The class of 100 students was equally divided into Groups A and B.

For the first 4 weeks of the module, the instructor explained the microscopic details of the slide on a close-circuit TV attached to a teaching microscope. Then the students in Group A were advised to learn histology by looking through the microscope and drawing the well-labeled microscopic image in a notebook with eosin and hematoxylin pencils. The students in Group B were advised to learn histology by looking through the microscope only and not drawing the image. At the end of the 4 weeks, test I comprising MCQs at the application level (C2) of Blooms taxonomy were administered to both Groups A and B. For the next 4 weeks of the module, the groups were swapped using the crossover group design such that Group A learned histology by looking through the microscope only, whereas Group B learned histology by looking through the microscope and drawing the images in a notebook. At the end of the 4 weeks, MCQ test II was administered to the entire class.

Quantitative data analyses

The MCQ tests were subjected to post-hoc analysis to calculate Cronbach's alpha reliability coefficient. The p values for test I and test II were 0.71 and 0.78, respectively. Then the numerical data obtained in test I and test II were analyzed using SPSS version 23. The Kolmogorov Smirnov test was applied to determine if the data were normally distributed. The p value for test I and test II was greater than 0.05, suggesting a normal distribution of scores in both tests. Therefore, the independent samples *t*-test was employed to determine the statistical significance of the mean scores obtained by Groups A and B in tests I and II. We also determined the statistical difference between the mean scores obtained using drawing and no drawing strategies by the same student using the paired sample *t*-test.

The results of the paired samples t-test were further explored by using the focus group discussion to understand the impact of drawing on learning.

Qualitative data collection (focus group study design)

Setting up the focus group

The interview questions were developed to explore the participants' perceptions about common learning experiences regarding the comprehension and application of histology in clinical relevance using drawing and no drawing strategies.

The study was pilot tested with four potential participants before the actual study. The pilot study followed the same protocol of consent taking, interview guide preparation, and scheduling the time and location of the focus group. The pilot study helped in evaluating the intended meaning, wording, and phrasing of the questions and time required to complete the focus group. It also helped to evaluate the effectiveness of the moderator. The questions were reviewed after the pilot study (Table 1). Six students from the same class were selected for the focus group study by the non-probability purposive sampling technique. The participants who consented for the study were informed via e-mail of the time and location of the focus group discussion. The focus group discussion began with a welcome and brief introduction of the topic. The ground rules were communicated and the participants were assured of confidentiality.

A large segment of the discussion was spent probing the learning experiences with drawing and no drawing strategies. My viewpoint and influence on the participants remained neutral throughout the discussion; however, I used cues and prompts to explore the phenomenon of interest. Everyone was involved in the discussion, and different viewpoints of the participants were moderated effectively.

Suitable probes helped provide an understanding of the differences noted between the drawing and no drawing strategies. At some point in the discussion, the levels of agreement and disagreement were further probed to generate rich data. The process continued until no new answer emerged in the discussion. The response was recorded. The focus group lasted 30–40 min.

Qualitative data analyses

The data were transcribed files. All files were kept in separate e-folders. The data were analyzed manually from

the transcripts by the author and co-authors. The interviews were listened twice. Later, they were transcribed on Google docs using the dictation mode. All efforts were made to transcribe the original words spoken by the interviewee. No names were used in the transcript to ensure the confidentiality of the participants. The participants' understanding of the situation resulted in the formation of patterns, categories, and themes.

An independent reviewer helped crosscheck the codes. The themes were developed on the generalized concepts and correlations of the ideas. The process of review continued, the redundancy of theme was addressed, and several overlapping and duplicate ideas were removed. The category formation was stopped when no new theme emerged from the data, meaning that the data had been saturated.[10] Every theme was supplemented with a written memo, which was continuously updated with appearance of a new idea or view until the point of saturation. The memos were kept in electronic file folders to produce the relevant data for an audit trail. The methodological rigor was established by credibility, dependability, conformability, and transferability.[11]

Results

Interpretation of quantitative data

The quantitative data were scores obtained in test I and test II. There was no significant difference in the scores obtained in both tests between Groups A and B (Tables 2 and 3).

To determine the impact of drawing in the same subject while learning with drawing and no drawing strategies, statistical analyses of the data were conducted by applying the paired samples *t*-test. There was a significant difference in the mean score of the individual subject when he/she learned by drawing compared to when he/she did not learn by no drawing, as seen in Table 4.

Table 1: Semi-structured interview questions for the focus group study.

	Semi-structured interview questions	Probes
1.	What do you think is the role of drawing in learning histology?	Helps in understanding, fun to draw
2.	What difference did you find in your learning skills when you learned while using drawing and no-drawing strategies?	Comprehension, retention, application relating text with the picture
3.	What do you think is the most appropriate strategy to teach and learn histology, and why?	Better understanding, contextual learning

Table 2: Test I results of Group A and Group B when they learned with drawing and no drawing strategies.

First 4 weeks	Mean ± SD	p value
Group A (n = 47) Drawing	14.53 ± 3.2	$p > 0.05$
Group B (n = 49) No drawing	15.14 ± 3.6	$p > 0.05$

Table 3: Test II results of Group A and Group B when they learned with drawing and no drawing strategies.

Last 4 weeks	Mean ± SD	p Value
Group B (n = 47) Drawing	11.79 ± 4.9	$p > 0.05$
Group A (n = 48) No drawing	11.27 ± 3.7	$p > 0.05$

Interpretation of qualitative data

Themes derived from the qualitative data

The following themes were derived from the qualitative data.

Drawing is a time-consuming job

The common perception among participants was the time required to complete the drawing. The lack of interest in drawing was attributed to the lesser weight assigned to histology in the assessment. One of the respondents (AS#4) said, "*We are overwhelmed by the course content of gross and developmental anatomy. We have little time to study histology. The histology is just confined to one or two stations in IPE (Integrated practical examination) related to identification and points of identification.*"

SK#2, "*It's basically how your seniors educate you about your study. Most of us think it's just ten marks station in IPE. But after attempting the MCQs, I have realized that there is much more than beyond identification.*"

One of the participants acknowledged that drawing promotes engagement with the text. It gave a three-dimensional perspective to understanding when they related the text and drawing with the microscope image. While talking about drawing histological images in the laboratory session, MF#6 said, "*I have always loved drawing since my childhood. It makes things easier for me to understand. It gives a clear picture to my imagination.* In medicine, as we had been told that every function takes place at a cellular level, understanding cellular morphology makes things pretty easy to

Table 4: Results of test I and test II of the same subjects when they learned with drawing and no drawing strategies.

	Mean ± SD	p value
Group A		
Test I (n = 47) (Drawing)	14.3 ± 3.2	$p < 0.05$[a]
Test II (n = 48) (No drawing)	11.2 ± 3.7	
Group B		
Test I (n = 49) (No drawing)	11.7 ± 4.9	$p < 0.05$[a]
Test II (n = 47) (Drawing)	15.4 ± 3.5	

N = number of students.
[a] $p < 0.05$ = significant.

understand. When I draw with understanding from the text, it imprints in my memory and I find no time to recall the structure and its relevance in the disease process."

The participants of the study realized that they should change the perspective of teaching and learning anatomy by encouraging the use of manual drawing.

Drawing improves the comprehension of text

One question explored the students' perspectives on their involvement with making histological drawings. Whether they had a clear understanding of why the structure was round, polygonal, tubular, or ovoid? How the structure corresponded to the function and disease process?

The participants acknowledged that the assessment provided them with an opportunity to identify their strengths and weaknesses, the performance reflected their understanding of histology, and feedback was quite helpful to self-regulate their learning.

The students did admit that drawing the histological sections in the laboratory session helps them develop the fine psychomotor skills. Those who drew during the sessions appreciated the fine relationship between structure and function.

AS#4, *I can very well understand the active and inactive stage of thyroid gland when I draw the histological sections in both the physiological states of the gland. The fine cellular details were easy to understand when I drew them in the histology manual. It became easy for me to relate the structure with function in hypothyroid and hyperthyroid state of the organ."* Although fine cellular details can only be resolved with an electron microscope, here he meant that he can appreciate the cell shape in the active and inactive states of thyroid function.

Most of the participants acknowledged that the drawing strategy offers different possibilities to students to improve understanding and self-discovery learning. The viewing of slides under a microscope is a self-directed learning technique in which the student explores the relationship of cells and tissues by moving the tissue and changing the magnification independently. This added a totally different dimension to learning because most of the static images do not resemble the function of the microscope.

> AA#5 "*I realized that basic science foundation is important to understand the clinical science*."

The participants reflected and talked about their experience in studying histology without drawing. They added that simply looking at the pictures and relating them to the text helped them understand it, but when they appeared in the histology test, they find it difficult to recall it. Most of the questions were related to the role of the structure in the disease process.

The interpretation of data showed that we should integrate the structure with function for meaningful understanding of histology and its clinical relevance. The assessment with drawing should focus on measuring the students' understanding of the basic structure rather than artistic ability.

> MF#6, *I found it difficult to attempt the MCQs in the test because they were higher-order thinking based on the clinical relevance of histology*."

Almost all of the students agreed that if they had to memorize a large volume of knowledge, they had to use all of their mental resources to retain the material for a long period for later application. They also expressed that they would use the drawing for knowledge retention in subjects other than histology as well.

Drawing clarifies misconceptions regarding the understanding from text alone

The students were asked for suggestions about a teaching and learning strategy for histology using their experience in this study. "*Drawing is a worthwhile adjunct tool for learning cellular details and clinical correlation generates interest in studying the microscopic anatomy," said one of the respondents (SA#1)*.

When the students copied it from the board without understanding, the misconceptions in understanding were revealed by drawing. The respondents of the study acknowledged that when they drew an image during the first half of this study, they were able to connect the concepts and process the data efficiently to understand and solve the MCQs based on problem solving at the cognitive level. One of the respondents (AA#5) revealed, *"Drawing motivates me and helps me to reveal my misconception. It makes me self-aware of my own learning."*

The respondents were also asked about the different ways to learn histology and compare the different methods to learn histology. They shared their experience in first year MBBS where they drew without consulting the text and understanding the relationship between structure and function. They were unable to understand the applied histology later on. Similarly, they were not asked in the examination to draw the image. This practice has been abandoned in integrated curricula because of the weight and time allocated to histology teaching. SA#1 suggested, "*Drawing skills should be made part of summative assessment and it should be used as a frequent formative assessment tool. The teachers should invest more time and effort in assessment by drawing to help us improve learning."*

The respondents of the study stressed the need that the objectives for learning histology be very clear and the interventions to achieve those objectives be well aligned to achieve those objectives. Similarly, the assessment strategy should be aligned as well.

Most of the respondents (65%) opined that histology teaching should be given due place in the curriculum, and instructors should reinforce the concepts taught in lecture in the histology practical sessions by relating the basic morphological details to its function.

The histology discipline is more than looking through the microscope. Examination of a specimen under the microscope involves reading a slide of a section of the tissue and relating what is seen to what is known about the histologic structure of the specimen.

Discussion

This study was conducted to promote "drawing to learn" in parallel with "writing to learn".[12] The present study provides evidence that drawing is an active engaging learning strategy. The randomized crossover design ensured that the student had been exposed to drawing and no-drawing strategies for learning histology. It also ruled out confounding variables. The time allocated, difficulty level, and content were the same for

both written MCQ tests I and II. The MCQs were developed at an application level of Bloom's taxonomy,[13] assessing the clinical relevance of histology. Modern histology teaching uses digital imaging, which has resulted in learning by observation only. It enables the student to learn how to read a slide but not remember a specific image.

Almost 70 years ago, Abraham Flexner emphasized that the basic sciences should be taught with clinical relevance.[14] Learning histology in real clinical cases is a new learning method in an integrated modern curriculum.[15] The purpose of this study was to identify better educational strategies for the meaningful learning of histology. This study provides evidence that drawing, the oldest known pedagogy for teaching and learning histology, should not be compromised in an integrated medical curriculum.

The results of this study showed that the student performed well on written examination when he/she learned histology by drawing compared to learning by looking through a microscope only ($p < 0.05$). The results are supplemented with the fact that drawing encodes the memory very efficiently. Drawing uses visual memory, kinesthetic memory of the hand, and active engagement utilizing semantic memory.[16]

A similar study was previously conducted to identify better teaching and learning strategies for histology. One group of students studied histology by drawing the image, whereas another group of students learned by labeling the prepared images. The study concluded that learning by drawing and learning by labeling the prepared image were equally effective strategies to acquire and remember the factual information.[17]

In another quasi-experimental study, the students were divided into two groups. One group learned the science material by writing the paraphrase and other group learned by drawing the material. The learning material was the same in both the groups. The immediate post-test score revealed the significant result. The drawing group performed better than the group that wrote paraphrases only.[18] While drawing, the student identified the relevant text information and made inferences, thereby constructing a mental model. In this way, the students perform well in achievement tests that assess the deep learning and higher level of comprehension.[19]

Histology as a discipline has not been given due importance. Students are assessed for identification of the tissue but are not assessed for its relevance in clinical medicine. So most students forget the basics of medicine in clinical years.[20]

The present study took the students' perspectives because they are important stakeholders of the undergraduate program. Students' perspectives hold great significance in curriculum planning and development because they are important stakeholders of the program, and international regulatory bodies such as the World Federation for Medical Education and local regulatory bodies such as the Pakistan Medical and Dental Council have mandated the representation of students in the curriculum committee.[21] They can highlight the shortcomings of the system. Their valid suggestions can be incorporated into the curriculum for better utilization of curricular hours allocated to teaching and learning histology. This would improve the quality of teaching as well.[22]

The learners self-monitor themselves by detecting errors in drawing in relation to the text, which in turn, leads to deep learning.[23]

Most participants of the study were asked for the relevance of the use of microscope skills and knowledge in preclinical years. They were provided the opportunity to self-reflect and self-direct their learning. They considered histology to be related to tissue identification by simply looking at it, and they did not relate it to its functional organization and anatomical features. A similar question was asked in a research survey in one of the studies. The physicians' perspectives working in rural and urban areas were taken regarding their knowledge of studying histology slides on a light microscope versus digital imaging. This study was based on the fact the after graduation, physicians have to work in rural areas where there is no facility for digital laboratory; 90% of them feel that both rural and urban physicians must acquire microscope skills and basic tissue identification skills and also discover that there are anatomical variations among different tissues.[24] Seeing a real tissue has no substitute. It has a positive psychological impact as well.[25]

Some students commented that drawing is a very time-consuming process and some had difficulty using the microscope. The time constraint is one of the important factors that de-values drawing as an important pedagogic tool. The student's engagement with the complexity of drawing requires sufficient time for effective learning to occur. However, the accuracy of drawing is important for learning compared to the esthetic aspect of drawing. The accuracy of drawing improves the learner comprehension.[26]

It can also be explained that students with different preferred learning styles might find it difficult to draw the image. In a workshop on "drawing as a model for teaching anatomy", the participants were students of dentistry, medicine, and allied health science programs. Most of the participants acknowledged that they did not use drawing to learn anatomy due to a lack of time and poor drawing skills. Only 13% of the students used drawing for learning.[27]

Almost 50% of the respondents of this study acknowledged that they understand the basics of histology very well when they draw the images by relating it to text. They stressed the need that histology be assessed in clinical relevance formatively throughout the first two pre-clinical years. This would have a significant impact on understanding the applied aspects of histology. It would also strengthen their basics in clinical application later on in clinical years. This is very valuable feedback given in this study. The student's voice should be given a good listening ear. This is in line with the findings in the present study.

The curricular planners should encourage the use of drawing as an important pedagogical tool that utilizes the psychomotor and cognitive skills for knowledge retention and understanding for its application in clinical years.

Limitations of the study

1. Pre-clinical years I and III were not included in the study. This would have generated rich data with a good sample size.
2. Assessments were done by administering MCQs. Drawing and labeling the histological images was not included.

Conclusion

Learning by drawing helps students remember the useful and clinically relevant aspects of histology. Drawing-based learning should be made an essential part of the modern integrated curriculum. Microscopic anatomy forms the basis of molecular biology and research in genetics; therefore, more curriculum time is needed for teaching and assessing clinical context-based histology in an integrated curriculum.

Abbreviations: Anatomy, anat; Curriculum, curr; Histology, histol; Drawing, dwg.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

This mixed-methods study was carried out after approval from the institutional review board and ethics committee (IRB &EC), SIH in 2017 (IRB#734-009-2017). All participants provided written consent. The respondents of the focus group were assured that transcripts and audio recording would not be shared and remained confidential.

Authors contributions

AR conceived and designed the study, conducted the research, provided the research materials, and collected and organized the data. **MIA** analyzed and interpreted the data. **SM** wrote the initial and final drafts. **SA** proofread the draft and provided logistic support. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

Submission declaration and verification

The present work is a part of an academic thesis. Only the quantitative part of the mix-method research was previously published in 2018.

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