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Enhancing histology learning in sport science education through a functional approach and virtual microscopy practical session

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ABSTRACT

Background Problems: Histology is a critical component of the sports science curriculum, as it thoroughly explains the connection between the structure and function of cells, tissues, and organs. **Research Objective**: This study investigates the improvement of histology learning among sports science students by employing a functional approach and practical sessions with virtual microscopy. **Methods**: The study adopted a quasi-experimental design with 103 students from the Sports Science program, enrolled in a histology course with two parallel classes. The students were divided into experimental (n = 56) and control groups (n = 46) using cluster random sampling based on their classes. The experimental group received instruction using virtual microscopy, while the control group was taught using light microscopy throughout the semester. Both groups were assessed on their learning outcomes at the end of the semester through a written exam. Experimental group students also provided feedback on the courses. Using the independent t-test, the learning outcomes were compared between groups. Students' feedback was analysed descriptively. **Findings and Results**: The results revealed that the average test scores for participants in the experimental group were significantly higher than those in the control group (74.9 ± 7.8 and 68.9 ± 9.6, respectively). Student feedback indicated that the majority concurred that the functional approach to histology teaching enhanced their understanding of histological structures. They also noted that practical virtual microscopy sessions improved their comprehension of the topics studied. Additionally, nervous tissue was identified as the most challenging tissue to learn, primarily due to visualisation difficulties in relating microscopic and macroscopic structures and the abundance of new terminology to remember. **Conclusion**: The findings suggest that combining a functional approach with virtual microscopy notably enhances the quality of histology education, equipping sports science students with a comprehensive understanding and essential practical skills for their academic and professional development.

Keywords: Histology learning; functional approach; virtual microscope; sport science students

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INTRODUCTION

Histology, the study of the microscopic structure of tissues and organs, offers crucial insights into their functions and interactions within the body (Cotter & Loda, 2017; Lu et al., 2016; Mescher, 2018). Microscopy was and still is an essential approach for the description of cellular components and their arrangements in living organisms (Hortsch, 2023). In the context of sports science, histology plays a vital role in providing a foundation for understanding both normal tissue structures and their pathological changes (Gurina & Simms, 2024; Hussein & Raad, 2015), particularly to exercise, training, and injury (Al Khader et al., 2020; Hortsch, 2023), and serves as a fundamental discipline that bridges the gap between macroscopic physical performance and microscopic tissue function (Chapman et al., 2020). Most importantly, an understanding of tissue structures, their normal functions, and their responses to injury, histology equips future sports scientists and practitioners to make informed decisions that optimise athlete health, performance, and overall well-being.

The study of histology, however, presents notable challenges for sports science students due to its intricate and detailed nature, which demands a deep understanding of the microscopic structures of tissues and organs (Chapman et al., 2020). One of the main difficulties lies in accurately identifying and distinguishing various cell types and tissues under a microscope. In addition, sports science students often have difficulties understanding complex technical terminology and biological processes. Franklin and Foa (2011) reported that many students feel overwhelmed by the vast amount of material they need to learn within a limited timeframe, which often leads to stress and mental fatigue (Barbayannis et al., 2022). Therefore, effective learning strategies and strong support from instructors are essential to help students overcome these challenges and succeed in histology (Woodward & McLernon-Billows, 2018).

A functional approach to histology involves linking microscopic structures to their physiological functions in the body. This method helps students understand not only the appearance of cells and tissues but also their roles and interactions in various physiological processes (Cotter & Loda, 2017). By integrating functional insights, students can contextualise histological features within broader biological systems, facilitating easier retention and application of their knowledge (Meyer, 2023). For instance, understanding how the structure of muscle tissue supports its function in contraction and movement provides a more comprehensive grasp compared to simple memorisation of slides (Biga et al., 2019). For sports science students, this means understanding muscle fibre adaptation to training, bone support in movement, and connective tissue responses to stress and injury. Emphasising these aspects helps students appreciate histology's impact on athletic performance and injury prevention. Using functional atlases, active discussions, and real-life applications in labs solidifies learning and prepares students for practical careers (Mashud et al., 2023, 2024).

In practice, this approach entails aligning theoretical lectures with practical applications in laboratory settings. For example, lectures on muscle histology can delve into the structural characteristics of different muscle fibre types, their metabolic properties, and how these properties influence muscle performance during exercise. This theoretical knowledge is then reinforced through hands-on laboratory sessions where students analyse muscle tissue samples using microscopes (Bugarso et al., 2021). In histology learning, various types of microscopes are used to study tissue structures and functions. Light microscopes are commonly used for viewing stained tissue samples with visible light and lenses to magnify cellular structures. Virtual microscopes, such as digital microscopes, capture images electronically and display them on computer screens, combining traditional optical features with advanced digital imaging technology. This allows for easy image capture, analysis, and sharing, facilitating collaborative learning and detailed study of histological samples.

Virtual microscopes have revolutionised histology education by granting students access to high-resolution digital images of tissue samples (Then et al., 2023). In contrast to light microscopes that necessitate physical slides and have limited accessibility, virtual microscopes enable students to zoom in, pan across specimens, and annotate structures-all from a computer or mobile device (Souza et al., 2024). This accessibility not only enhances learning flexibility but also facilitates self-paced study and review. In the field of sports science, virtual microscopes allow students to study histological details relevant to their field without being limited by physical laboratory resources (Herodotou et al., 2022). This allows them to examine the microscopic structure of tendons, ligaments, and cartilage and understand how these tissues respond to mechanical stress and athletic

training. The interactive features, such as labelling exercises and virtual simulations, further engage students in the learning process, reinforcing theoretical concepts, and improving their microscopy skills (Bordoni et al., 2024). The implementation of virtual microscopy in histology education has gained attention in recent years, especially within medical and biological sciences (Amer & Nemenqani, 2020; Felszeghy et al., 2017; Wu & Chiang, 2022). Limited research has explored the unique challenges and opportunities associated with integrating virtual microscopy into the curriculum of sports science students, who often have different educational needs and career goals compared to traditional medical students. This research introduces a comparative analysis between virtual and traditional microscopy methods in the context of sports science, offering a new perspective on the pedagogical strategies that can be employed. The outcomes of this study may contribute to the broader adoption of digital tools in diverse educational fields, promoting more accessible and flexible learning environments. The study aimed to compare the effect of a virtual microscopy and light microscope on student comprehension among students in the sports science study programme.

METHOD

Type of Research

This study utilised a quasi-experimental design. The students were divided into experimental and control groups using cluster random sampling based on their classes. The experimental group received instruction integrating a functional approach and virtual microscopy, while the control group taught the functional approach using a light microscope throughout the semester. Both classes were carried out by a team teaching, integrating theory and practical sessions.

Participants

This study involved 103 students from the histology course in the Department of Sports Science, which consists of two parallel classes (class A and class B). We used class-based group random sampling to allocate students into the experimental group (n = 56) and control group (n = 46).

Research Procedures

Theoretical material was delivered before the practical sessions. The functional approach was applied by explaining the relationship between the structure and function of cells, tissues, and organs, as well as the morphological characteristics of cells and tissues. In the experimental group, students were guided to observe important histological images of various tissues or organs through a virtual microscope, using digitised slides studied via computer, while in the control group, the same approach was conducted using a light microscope. During practical sessions, students drew slides and identified key structures of tissues or organs, enabling them to identify appropriate histological structures that allowed them to interpret and establish a histological diagnosis. Students discussed the characteristics, classification, function, and regenerative potential of the tissues or organs on worksheets. Quizzes were held at the end of the practical sessions. The practical assignments were the same for both groups. The final grade for histology consisted of formative, summative, and practical scores.

Instruments

The instruments utilised in this study encompass a variety of tools designed to measure student engagement and learning outcomes. These instruments include practical work sheets, quizzes, formative tests, summative tests, and student feedback questionnaires.

Data Analysis

Data analysis used a between-groups comparison test using an independent t-test comparing the final histology grades. In the experimental group, a four-item feedback questionnaire related to the histology learning process was administered. The first two items were four Likert response options ranging from strongly agree to strongly disagree, asking about the student's perception of whether the functional approach and virtual microscope enhanced their learning. The third item asked what topic the students found most

difficult, while the fourth item was an open-ended question asking the students the reason why they found the topic difficult. The questionnaire was administered at the end of the learning process, and the data were analysed descriptively.

Table 1. Histology Teaching and Learning

Theoretical Session	Practical Session	Equipment & Material	
		Experimental Group	Control Group
Teacher explains theoretical material with functional approach	The student observes slide, draw and participates in discussion	Virtual microscopy Worksheet	Light microscope Worksheet

RESULTS AND DISCUSSION

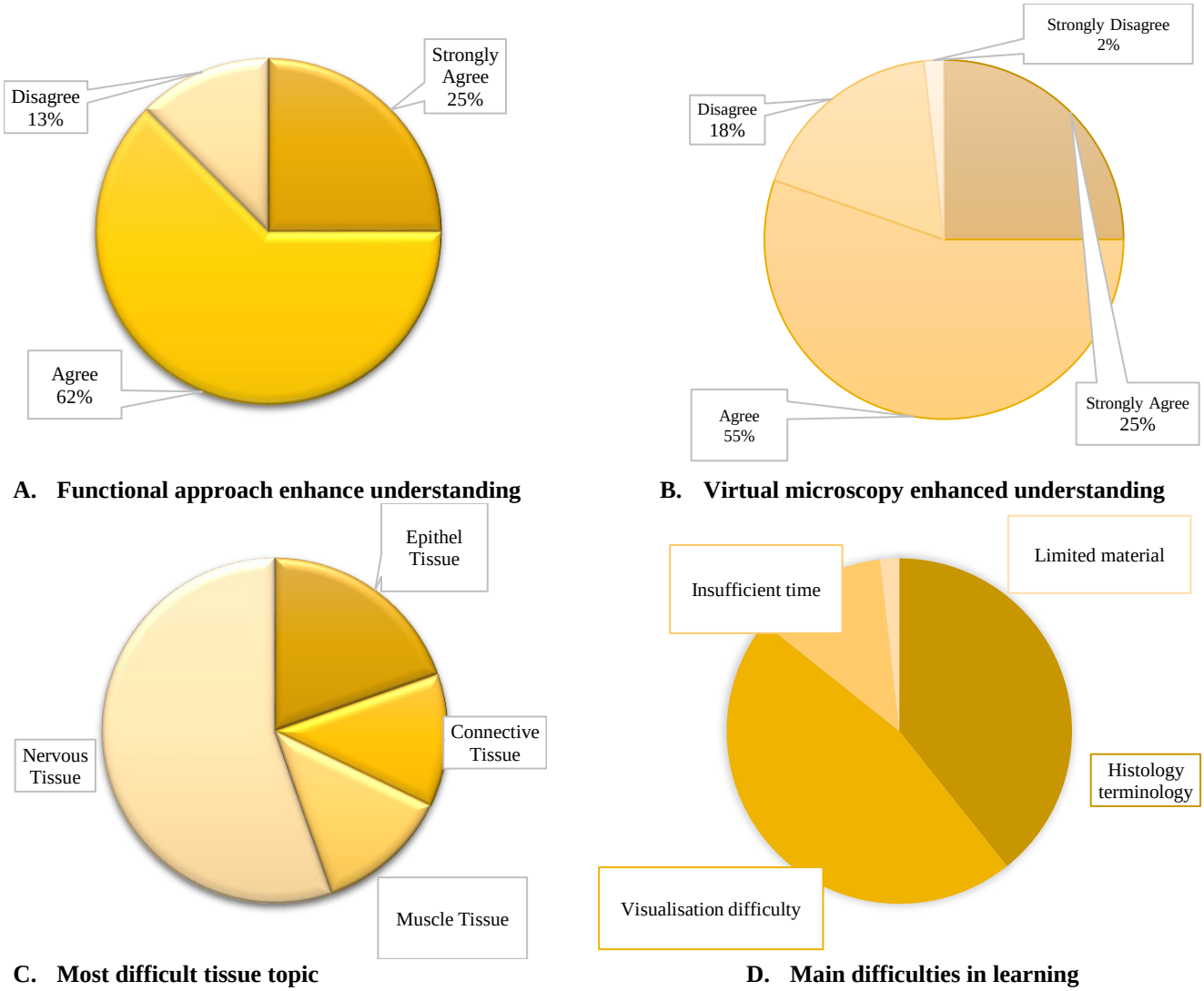
The participants in this study were 103 third-semester students enrolled in the Sports Science program, class of 2022. The group consisted of 76 males (73.8%) and 27 females (26.2%). The implementation of a functional approach in the histology course resulted in increased test scores in the subject of histology. At the end of the semester, we analyzed the test scores of the experimental group (n = 56) and the control group (n = 47) to assess the efficacy of the functional method in histology instruction.

Table 2. Experimental and Control Group Test Scores Comparison

Group	n	Mean ± SD	p
Experimental	56	74.9 ± 7.8	0.001
Control	47	68.9± 9.6	

These findings are outlined in **Table 2**, indicating that implementing a functional approach in histology instruction resulted in a significant enhancement in the student's academic performance (p = 0.01). The results of this study suggest that the histology teaching method using a functional approach in combination with virtual microscopy outperforms traditional methods. The students in the experimental group exhibited notably better comprehension and retention of histological concepts when compared to the control group, as evidenced by their higher test scores (p = 0.01). This aligns with existing research that proposes interactive and contextually relevant teaching approaches as having the potential to improve student learning outcomes in scientific fields (Bloodgood & Chilton, 2012). Maity et al. (2023) found that a virtual microscope facilitated a more efficient learning process due to the accessibility of high-resolution images and the integration of interactive features that enhance understanding. The advantages of a virtual microscope include the ability to access a wide range of high-quality histological slides remotely and the consistency of digital images free from preparation artifacts. However, it is important to note that not all studies unanimously support the superiority of a virtual microscope over a light microscope. Başer and Büyük (2024) investigate the impact of virtual microscopy (VM) and light microscopy (LM) on the satisfaction of second-year medical students and their performance in different educational settings. They found that while VM is becoming essential in histology education due to its positive impact on exam performance and accessibility, LM remains highly valued by students for its hands-on experience and satisfaction levels, while Wu and Chiang (2022) found that the learning outcomes between virtual microscope and light microscope users were comparable, suggesting that both tools can be equally effective depending on the context and implementation. Factors such as the design of the histology course, the quality of the digital resources, and the level of instructor support play crucial roles in determining the effectiveness of each method.

Student feedback confirms the effectiveness of the functional approach and virtual microscopy in teaching histology. The functional approach offers a practical understanding by connecting theoretical knowledge with real-world applications, making the material more relatable and easier to comprehend. Only 13% of students disagreed, indicating minimal resistance to this teaching method. However, there is room for further improvement or refinement. This data is shown in **Figure 1**.



A. Functional approach enhance understanding

B. Virtual microscopy enhanced understanding

C. Most difficult tissue topic

D. Main difficulties in learning

Figure 1. Student Feedback on Functional Approach and Virtual Microscopy in Histology Learning

The response from students regarding the functional approach in histology learning is mainly positive. A significant 25% of students strongly agree and 62% agree that this method improves their understanding of histological structures, indicating that the functional approach is well-received. With a combined 87% positive response and only 13% disagreement, it is clear that integrating functionality into histology teaching effectively helps students grasp complex structural concepts (Figure A).

Regarding the practical model utilised, practical learning with virtual microscopy notably enhanced topic understanding for most participants. Specifically, 25% of the respondents strongly agreed with this statement, while a majority of 55% agreed. Conversely, 18% disagreed, and 2% strongly disagreed. This suggests a generally positive reception towards the use of virtual microscopy in improving topic comprehension, although there is still a noteworthy proportion of participants who did not find it effective (Figure B). Student perception of practical learning with virtual microscopy significantly enhances topic understanding for most participants, as evidenced by various studies. Research by Ahmed et al. (2022) found that the use of interactive virtual pathology slides significantly improves students' understanding of pathological disease processes. These findings collectively emphasise the positive impact of virtual microscopy on student perception and understanding in practical learning settings.

Feedback from students reveals that nervous tissue is the most challenging tissue to study. 55% of students identified nervous tissue as the most difficult topic, while 20% found epithelial tissue to be the second most challenging. Furthermore, 12% of students find it difficult to study connective tissues, while 13% find it

difficult to study muscle tissues (Figure C). This indicates that over half of the students find understanding nervous tissue to be most challenging, while a smaller yet significant proportion struggle with epithelial, muscle, and connective tissues as well. Nervous tissue is perceived as the most challenging tissue to study in histology due to its complex structure-function relationships, making it difficult for students to visualise the system (Lieu et al., 2018). The study by García et al. (2019) obtained the same results. Nervous tissue is perceived as the most challenging in histology due to its complex nature, difficult terminology, and limited teaching time, according to students' feedback in the study. These findings suggest that the intricate nature of nervous tissue, coupled with the need to understand both its structural components and functional aspects, contributes to students' perceptions of its complexity and difficulty in histology.

According to student perception, the primary reason for difficulties in learning histology is the challenge of visualising microscopic structures, as identified by 46% of students. Additionally, 39% of students found histology terminology to be a significant barrier to their understanding. Insufficient time accounted for 13% of the difficulties, while limited teaching material was the least cited reason, affecting only 2% of the students (Figure D). This emphasises the need for improved visualisation tools and clearer explanations of terminology to enhance histology learning.

The positive feedback from a significant number of students suggests that educators should consider integrating functional approaches into other parts of the curriculum. It may be valuable to conduct a more comprehensive analysis of the factors contributing to the 13% discrepancy to modify the approach to better meet the needs of every student. The evidence strongly indicates that the functional approach significantly enhances the learning experience in histology. Most students responded favourably to these methods, noting that incorporating practical, real-life applications into histology education greatly improved their understanding. Virtual microscopy has been highly praised for its ability to provide intricate and easily accessible visualisations of tissue samples, which play a crucial role in comprehending histological concepts (Sharmin et al., 2023).

The data suggests that virtual microscopy is more effective than traditional methods in improving topic understanding for most students. However, it is important to consider and support those who may not derive as much benefit from this technology. Feedback also highlighted certain challenges, such as the intricate nature of visualising the connections between microscopic structures and their larger-scale counterparts in nervous tissue, which was identified as the most challenging to comprehend. A significant hurdle reported by 46% of students is the struggle to visualise microscopic structures, which plays a vital role in mastering histology. Incorporating advanced visual aids and interactive tools like high-resolution virtual microscopy could potentially address this issue and enable students to better understand the material (Taş, 2022).

Students also found that the extensive use of technical language in histology posed a major obstacle, demanding a considerable amount of memorisation and mental exertion. Understanding histology terminology presents a significant challenge for many students, with 39% of them considering it a major obstacle. Educators may consider placing greater emphasis on providing clearer and more gradual explanations of scientific terms by incorporating glossary tools, conducting frequent reviews, and incorporating contextual examples within lessons (Wong et al., 2020). A lack of sufficient time, reported by 13% of students, suggests that insufficient time affects the difficulty of studying histology because it is a subject that requires detailed observation and understanding of microscopic structures. Without adequate time, students may struggle to thoroughly analyse and comprehend these complex details. This can lead to gaps in knowledge, reduced retention of information, and increased difficulty in mastering the subject (Door, 2023).

While this study suggests that the use of virtual microscopes is superior to traditional light microscopes among science students, several are acknowledged. Firstly, the quasi-experimental design, while practical, may not control for all confounding variables, potentially affecting the internal validity of the results. The modest sample size of 103 students, though reasonable, might limit the generalisability of the findings to broader populations or different educational settings.

CONCLUSION

This research has shown that virtual microscopes are more beneficial compared to traditional teaching methods using light microscopes in histology learning. However, it is to be noted that both tools can be equally effective depending on the context and implementation. Thus, the choice of type of microscope used in the histology learning should consider the specific context. In this context, factors such as the design of the histology course, the quality of the digital resources, and the level of instructor support may play crucial roles in determining the effectiveness of each method. Future research should explore the long-term impacts of combining VM and LM on student learning outcomes and skill development. Investigating the effectiveness of hybrid teaching models that integrate both tools in histology curricula can provide insights into optimising educational strategies.

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CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

REFERENCES

Ahmed, S., Habib, M., Naveed, H., Mudassir, G., Bhatti, M. M., & Ahmad, R. N. (2022). Improving Medical Students' Learning Experience of Pathology by Online Practical Sessions through Virtual Microscopy. *Journal of Rawalpindi Medical College*, *26*(1), 122-127. https://doi.org/10.37939/jrmc.v26i1.1824

Al Khader, A., Obeidat, F. N., Shahin, N. A., Khouri, N. A., Kaddumi, E. G., Al Qa'Qa', S., Al-Shatanawi, T. N., Jaber, H., Al-Saghbini, M., & Amer, N. (2020). Medical Students' Perceptions of Pathology and a Proposed Curricular Integration with Histology: A Future Vision of Curricular Change. *International Journal of Morphology*, *38*(1), 28-42. https://doi.org/10.4067/s0717-95022020000100038

Amer, M., & Nemenqani, D. (2020). Successful Use of Virtual Microscopy in the Assessment of Practical Histology during Pandemic COVID-19: A Descriptive Study. *Journal of Microscopy and Ultrastructure*, *8*(4), 156-161. https://doi.org/10.4103/jmau.jmau_67_20

Barbayannis, G., Bandari, M., Zheng, X., Baquerizo, H., Pecor, K. W., & Ming, X. (2022). Academic Stress and Mental Well-Being in College Students: Correlations, Affected Groups, and COVID-19. *Frontiers in Psychology*, *13*, 1-10. https://doi.org/10.3389/fpsyg.2022.886344

Başer, A., & Büyük, B. (2024). Bridging the Gap in Medical Education: Comparing Analysis of Light Microscopy and Virtual Microscopy in Histology. *PeerJ*, *12*, e17695. https://doi.org/10.7717/peerj.17695

Biga, L. M., Bronson, S., Dawson, S., Harwell, A., Hopkins, R., Kaufmann, J., LeMaster, M., Matern, P., Morrison-Graham, K., Oja, K., Quick, D., & Runyeon, J. (2019). *Anatomy & Amp; Physiology*. Oregon State University.

Bloodgood, J. M., & Chilton, M. A. (2012). Performance Implications of Matching Adaption and Innovation Cognitive Style with Explicit and Tacit Knowledge Resources. *Knowledge Management Research and Practice*, *10*(2), 106-117. https://doi.org/10.1057/kmrp.2012.3

Bordoni, B., Black, A. C., & Varacallo, M. (2024). *Anatomy, Tendons*. StatPearls Publishing.

Bugarso, J. M. S., Cabantugan, R. E., Tapiculin, Q. D., & Malaco, A. C. (2021). Students' Learning Experiences and Preference in Performing Science Experiments Using Hands-on and Virtual Laboratory. *Indonesian Journal of Teaching in Science*, *1*(2), 147-152. https://doi.org/10.17509/ijotis.v1i2.41122

Chapman, J. A., Lee, L. M. J., & Swailes, N. T. (2020). From Scope to Screen: The Evolution of Histology Education. *Advances in Experimental Medicine and Biology, 1320,* 75-107. https://doi.org/10.1007/978-3-030-47483-6_5

Cotter, M. B., & Loda, M. (2017). Introduction to Histology. In *Pathology and Epidemiology of Cancer*. Springer International Publishing, 11-26. https://doi.org/10.1007/978-3-319-35153-7_2

Door, R. E. (2023). Skill Acquisition in Histology Education. In *Microscopy Techniques for Biomedical Education and Healthcare Practice*. Springer. https://doi.org/10.1007/978-3-031-36850-9_10

Felszeghy, S., Pasonen-Seppänen, S., Koskela, A., & Mahonen, A. (2017). Student-Focused Virtual Histology Education: Do New Scenarios and Digital Technology Matter? *MedEdPublish*. https://doi.org/10.15694/mep.2017.000154

Franklin, M. E., & Foa, E. B. (2011). Treatment of Obsessive Compulsive Disorder. *Annual Review of Clinical Psychology*, *7*, 229-243. https://doi.org/10.1146/annurev-clinpsy-032210-104533

García, M., Victory, N., Navarro-Sempere, A., & Segovia, Y. (2019). Students' Views on Difficulties in Learning Histology. *Anatomical Sciences Education.* 541-549. https://doi.org/10.1002/ase.1838

Gurina, T. S., & Simms, L. (2024). *Histology, Staining*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK557663/

Herodotou, C., Aristeidou, M., Scanlon, E., & Kelley, S. (2022). Virtual Microscopes and Online Learning: Exploring the Perceptions of 12 Teachers about Pedagogy. *Open Learning*. 1-25. https://doi.org/10.1080/02680513.2022.2112661

Hortsch, M. (2023). Histology as a Paradigm for a Science-Based Learning Experience: Visits by Histology Education Spirits of Past, Present, and Future. In *Anatomical Sciences Education*, 378-383 https://doi.org/10.1002/ase.2235

Hussein, I. H., & Raad, M. (2015). Once Upon a Microscopic Slide: The Story of Histology. *Journal of Cytology & Histology, 6*(6), 377-381. https://doi.org/10.4172/2157-7099.1000377

Lieu, R., Gutierrez, A., & Shaffer, J. (2018). Student Perceived Difficulties in Learning Organ Systems in an Undergraduate Human Anatomy Course. *HAPS Educator, 22*(1), 84-92. https://doi.org/10.21692/haps.2018.011

Lu, X., Cheng, X., Li, K., Lee, K. K. H., & Yang, X. (2016). Integration of Histology Lectures and Practical Teaching in China. *International Journal of Higher Education, 5*(4), 157-164. https://doi.org/10.5430/ijhe.v5n4p157

Maity, S., Nauhria, S., Nayak, N., Nauhria, S., Coffin, T., Wray, J., Haerianardakani, S., Sah, R., Spruce, A., Jeong, Y., Maj, M. C., Sharma, A., Okpara, N., Ike, C. J., Nath, R., Nelson, J., & Parwani, A. V. (2023). Virtual Versus Light Microscopy Usage among Students: A Systematic Review and Meta-Analytic Evidence in Medical Education. In *Diagnostics, 13*(3), 558. https://doi.org/10.3390/diagnostics13030558

Mashud, M., Arifin, S., Warni, H., Samodra, Y. T. J., Yosika, G. F., Basuki, S., Suryadi, D., & Suyudi, I. (2024). Physical Fitness: Effects of Active Lifestyle Internalization Through Physical Literacy Awarenes Based Project. *Retos*, *51*, 1299-1308. https://doi.org/10.47197/retos.v51.101662

Mashud, Warni, H., Putra, M. F. P., Haris, M. Al, Samodra, Y. T. J., Tantri, A., Kristiyandaru, A., & Suryadi, D. (2023). Integrating the Project-Based Learning and the Inclusive Teaching Style: An Innovation to Improve Freestyle Swimming Skills. *International Journal of Human Movement and Sports Sciences*, *11*(5), 956-964. https://doi.org/10.13189/saj.2023.110503

Mescher, A. L. (2018). *Histology & Its Methods of Study. In Junqueira's Basic Histology: Text and Atlas* (15th Editi). McGraw-Hill LANGE. https://accessmedicine.mhmedical.com/

Meyer, G. T. (2023). Online, Interactive, Digital Visualisation Resources that Enhance Histology Education. In *Advances in Experimental Medicine and Biology*, *1421*. 125-160. https://doi.org/10.1007/978-3-031-30379-1_6

Sharmin, N., Chow, A. K., & Dong, A. S. (2023). A Comparison Between Virtual and Conventional Microscopes in Health Science Education. *Canadian Journal of Learning and Technology, 49*(2), 1-20. https://doi.org/10.21432/cjlt28270

Souza, F. M. De, Karapurkar, N. M., Meleena, Q. C., & Alvares, J. J. (2024). Integrated Virtual Teaching, Learning and Testing In Histology: A Student's Perspective. *Journal of Medical Education Development 17*(53), 72-81. https://doi.org/10.61186/edcj.17.53.72

Taş, F. (2022). Health Sciences Students' Viewpoint on Innovative Approaches in Histology Course. *Journal of Surgery and Medicine, 6*(12), 981-985. https://doi.org/10.28982/josam.7581

Then, S. M., Kokolski, M., Mbaki, Y., Merrick, D., & Anderson, S. (2023). An International Collaborative Approach to Learning Histology using a Virtual Microscope. *Journal of Veterinary Medicine Series C: Anatomia Histologia Embryologia*, 21-30. https://doi.org/10.1111/ahe.12888

Wong, C. L., Chu, H. E., & Yap, K. C. (2020). A Framework for Defining Scientific Concepts in Science Education. *Asia-Pacific Science Education*, *6*(2), 615-644. https://doi.org/10.1163/23641177-bja10010

Woodward, A., & McLernon-Billows, D. (2018). Undergraduate Medical Education in Sierra Leone: A Qualitative Study of the Student Experience. *BMC Medical Education, 18,* 298. https://doi.org/10.1186/s12909-018-1397-6

Wu, Y. H., & Chiang, C. P. (2022). Comparison of Virtual Microscopy and Real Microscopy for Learning Oral Histology Laboratory Course among Dental Students. *Journal of Dental Sciences, 17*(3) 1201-1205. https://doi.org/10.1016/j.jds.2022.04.008