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# Student Satisfaction and Educational Outcomes: The Transformative Impact of a New Digitalized Histology Laboratory at the University of Medicine, Tirana

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**Abstract**

**Background**: The "Digitalization of the Histology Laboratory" project, funded under the 2023 higher education budget, aimed to modernize teaching laboratories by integrating advanced digital technologies. The project focused on improving the quality of the teaching process and facilitating the learning of histology-embryology as a core subject for students in medicine, dentistry, and pharmacy programs.

**Methods**: This was a cross-sectional study evaluating student satisfaction regarding the Histology Laboratory Unit at the University of Medicine, Tirana, with data collected between December 10 and 21, 2024. Of the 650 students, 407 participated in the study: General Medicine students mostly used both traditional and digitalized laboratories, Dentistry students mostly used the digitalized laboratory, and Pharmacy students mostly used the traditional laboratory. Data were collected via an online structured questionnaire evaluating demographics, satisfaction with resources, comparative experiences, and overall impressions. Statistical analyses comprised descriptive statistics (including Likert scale analysis), Mann-Whitney U tests, Fisher's exact test, and Wilcoxon signed-rank test.

**Results**: The students had a mean age of 19.33 years (SD = 1.12), predominantly female (83.5%), with 58.5% having experience with both classical and digital laboratories. Students rated the digital laboratory superior in equipment

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quality (mean 4.51 vs. 4.00), variety of histological slides (mean 4.10 vs. 3.77), support from academic staff (mean 4.53 vs. 4.21), ease of use (mean 4.49 vs. 3.99), and overall satisfaction (mean 4.49 vs. 4.00; all $p < 0.01$). Median satisfaction scores were significantly higher for the digital laboratory (87, IQR 22) compared to the traditional laboratory (72, IQR 43; $p < 0.001$). The digital laboratory achieved higher ratings for a comfortable environment (mean 4.33 vs. 3.80; $p < 0.01$) and alignment with international standards (mean 3.94), while its positive impact on improving knowledge and practical skills compared to the traditional laboratory was reflected in a mean score of $4.06 \pm 0.69$. Open-ended feedback underscored the positive impact of digital tools on learning while suggesting improvements in access and resources.

**Conclusions**: The digital histology laboratory significantly improved the learning environment, offering a more comfortable and modern setting compared to the traditional laboratory. Students expressed higher overall satisfaction, emphasizing that the digital tools enhanced their knowledge acquisition and practical skills, making the learning process more interactive and aligned with contemporary educational standards.

**Keywords**: Student Satisfaction, Digitalized Laboratory, Traditional vs. Digital Laboratory, Histology Education

## INTRODUCTION

The report is a detailed presentation with comprehensive descriptions of the entire process of implementing the project: "Digitalization of the Histology Laboratory Unit," part of a project within the framework of the internationalization of study programs for public higher education institutions, funded under the approved 2023 budget for the higher education program (09450) at the Faculty of Medicine, UMT. The primary aim of the project is the modernization of teaching laboratories for the subject of histology-embryology within the Histology Section of the Morphology Department, directly contributing to improving the quality of the teaching process, both in terms of transferring knowledge to students and facilitating the learning of this foundational subject in the educational formation of students in the following study programs: General Medicine, Dentistry and Pharmacy. The project's primary focus is the integration of digital technologies in teaching, creating an environment that assists students in study programs that include this subject in their curricula. Students will acquire their knowledge using advanced technological equipment, making the learning process interactive. Furthermore, these laboratories will enhance the quality of scientific research within the department and support teaching exchanges in international programs.

## METHODS

### Study Design and Target Population

This was a cross-sectional study evaluating student satisfaction with the functionality of the Histology Laboratory Unit at the Faculty of Medicine and Faculty of Dentistry. Data were collected between December 10 and 21, 2024.

The study included three groups of students:

1. Second-year General Medicine students (427 students in total)
2. Second-year Dentistry students (112 students in total)
3. First-year Pharmacy students (111 students in total)

For second-year General Medicine students, a self-controlled crossover design was applied, as these students mostly used both the traditional (non-digitalized) and digitalized laboratories. This approach allowed them to compare their experiences with both laboratories. Second-year Dentistry students mostly used the digitalized laboratory, while first-year Pharmacy students mostly used the traditional laboratory, though students in both groups also have had opportunities to use the other laboratory modality or both. These groups provided additional perspectives on satisfaction with the respective laboratory modalities. All students enrolled in these programs were invited to participate in the survey.

Of 650 students in total, 407 students responded to the survey, providing a response rate of 62.6%.

**Data Collection Instrument**

The primary data collection tool was a structured questionnaire developed and distributed via SurveyMonkey, an online platform ensuring easy access and anonymity. The questionnaire was designed to capture:

- **Demographics and academic background**, including age, gender, field of study, year of study, and group assignment.
- **Satisfaction with laboratory facilities and resources**, such as the quality of microscopes, histological slides, digital materials, and support from academic staff.
- **Comparative experiences** focusing on equipment quality, usability, and the perceived impact on their learning outcomes in both laboratories.
- **Overall satisfaction**, rated on a scale of 0 (extremely dissatisfied) to 100 (extremely satisfied).
- **Open-ended feedback**, allowing students to provide additional comments or suggestions for improvement.

The questionnaire featured Likert-scale questions with five levels of agreement:

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

The levels of agreement were scored on a scale from 1 to 5, corresponding to "Strongly Disagree" to "Strongly Agree," respectively. In some cases, additional options such as "Other (specify)" were included to capture nuanced responses. For comparative questions, alternative scales (e.g., "Much better," "Slightly better," "The same") were utilized.

**Data Collection Procedure**

The questionnaire was first reviewed in consultation with experts in the field to ensure its relevance and alignment with the study objectives. It was then pretested on a convenient sample of students to assess clarity and feasibility. Feedback from both the expert consultations and the pilot group was subsequently addressed, leading to refinements in question phrasing and structure for the final version. The finalized questionnaire was administered by the faculty members leading the project, who distributed the SurveyMonkey link through social media platforms to collect the data. Students received the SurveyMonkey link and were invited to complete the survey online. The purpose of the study and the importance of their feedback were clearly explained at the beginning of the questionnaire. Participation was voluntary, and students could withdraw at any time without any repercussions.

**Data Analysis**

Survey responses were exported from Survey Monkey into statistical software for analysis, including Microsoft Excel 2021 and SPSS Statistics version 25.

Descriptive statistics, including frequencies and percentages, were used to summarize demographic data and satisfaction levels across the three groups. Mean and standard deviation were calculated for continuous variables, along with medians and interquartile ranges (IQR) to capture data distribution.

The Mann-Whitney U test and Fisher's Exact Test were employed to compare satisfaction scores and categorical distributions, respectively, between the traditional and digital laboratories across multiple variables, including the quality of microscopes and equipment, variety of histological slides, support and guidance from academic staff, ease of use of laboratory equipment, comfortable and appropriate laboratory environment, and overall satisfaction with the laboratory experience.

The Wilcoxon signed-rank test was used to compare the median satisfaction scores between the classical and digital laboratories among participants who used both laboratory settings. Likert-scale responses were analyzed to identify trends in satisfaction, and open-ended responses were reviewed thematically to highlight key insights and suggestions. A p-value $<0.05$ was considered statistically significant, while a p-value $<0.01$ was considered as highly statistically significant.

**Ethical Considerations**

Ethical approval for the study was obtained by University's Ethics Committee. Participation was anonymous, and no personally identifiable information was collected. Students were informed about the confidentiality of their responses and the use of the data solely for academic and research purposes. Consent was implied upon voluntary completion of the questionnaire.

**RESULTS**

The table 1 presents descriptive statistics summarizing the demographic and educational characteristics of the study participants. The majority of students were 19 years old (57.4%), followed by those older than 19 years (32.1%), and 18-year-olds (10.5%). The mean age of the students was 19.33 years (SD = 1.12), with a range of 18 to 29 years. Most participants were female (83.5%), with males accounting for 16.5%. Regarding their field of study, 70.6% were enrolled in General Medicine, 16.8% in Dentistry, and 12.6% in Pharmacy. The majority of students were in their second year of study (87.3%), while 12.7% were in their first year. In terms of laboratory experience, 58.5% had experience with both classical and digital laboratories, 25.1% had only used the classical laboratory, and 16.5% had only used the digital laboratory (Table 1).

**Table 1.** Demographic and Educational Characteristics of Study Participants

| Variables | Descriptive statistics: | |
|---|---|---|
| | Frequencies | Percentages % |
| **Age** | | |
| 18 years | 41 | 10,5 |
| 19 years | 225 | 57,4 |
| >19 years | 126 | 32,1 |
| **Gender** | | |
| Male | 67 | 16,5 |
| Female | 338 | 83,5 |
| **Field of Study** | | |
| Pharmacy | 51 | 12,6 |
| General Medicine | 286 | 70,6 |
| Dentistry | 68 | 16,8 |
| **Year of Study** | | |
| First Year | 51 | 12,7 |
| Second Year | 352 | 87,3 |
| **Laboratory Experience** | | |
| Only used the classical laboratory | 102 | 25,1 |
| Only used the digital laboratory | 67 | 16,5 |
| Experienced both laboratories | 238 | 58,5 |

The results of Table 2 highlight significant differences in student satisfaction between the traditional and digital histology laboratories. For quality of microscopes and equipment, the digital laboratory achieved a higher mean score (4.51 ± 0.62) compared to the traditional (4.00 ± 0.60), with most students strongly agreeing in the digital setting (47.5%) versus 16.4% in the traditional one. Similarly, for the variety of histological slides, the digital laboratory was rated higher (4.10 ± 0.81) than the traditional (3.77 ± 0.57), with 33.7% strongly agreeing in the digital lab compared to only 7.5% in the traditional. The support and guidance from academic staff showed higher satisfaction in the digital lab (4.53 ± 0.71 vs. 4.21 ± 0.72), where 62.4% strongly agreed, compared to 35.3% in the traditional.

For ease of use of laboratory equipment, the digital laboratory had a mean score of 4.49 ± 0.57, with 52.5% strongly agreeing, compared to 3.99 ± 0.54 and 13.4% in the traditional. Regarding the comfortable and appropriate environment, the digital laboratory (4.33 ± 0.77) surpassed the traditional (3.80 ± 0.77), with 47.5% strongly agreeing in the digital compared to 12.1% in the traditional. Lastly, for overall satisfaction, the digital laboratory received a mean score of 4.49 ± 0.57 (52.2% strongly agreeing), significantly higher than the traditional laboratory (4.00 ± 0.58, 15.2% strongly agreeing) (Table 2).

**Table 2.** Comparative Analysis of Student Satisfaction Between Traditional and Digitalized Laboratories

| Variables | Traditional Laboratory | | | Digital Laboratory | | | P Value* |
|---|---|---|---|---|---|---|---|
| | N† | %† | M±SD‡ | N† | %† | M±SD‡ | |
| **Quality of microscopes and equipment** | | | | | | | |
| **Strongly Disagree** | 0 | 0.0 | 4.00 ± 0.60 | 1 | 0.3 | 4.51 ± 0.62 | p<0.01 |
| **Disagree** | 1 | 1.5 | | 1 | 0.6 | | |
| **Neutral** | 9 | 13.4 | | 8 | 5.3 | | |
| **Agree** | 46 | 68.7 | | 103 | 46.3 | | |
| **Strongly Agree** | 11 | 16.4 | | 142 | 47.5 | | |
| **Variety of histological slides** | | | | | | | |
| **Strongly Disagree** | 0 | 0.0 | 3.77 ± 0.57 | 1 | 0.4 | 4.10 ± 0.81 | p<0.01 |
| **Disagree** | 0 | 0.0 | | 8 | 3.1 | | |
| **Neutral** | 20 | 29.9 | | 41 | 16.1 | | |
| **Agree** | 42 | 62.7 | | 119 | 46.7 | | |
| **Strongly Agree** | 5 | 7.5 | | 86 | 33.7 | | |
| **Support and guidance from academic staff** | | | | | | | |
| **Strongly Disagree** | 0 | 0.0 | 4.21 ± 0.72 | 2 | 0.8 | 4.53 ± 0.71 | p<0.01 |
| **Disagree** | 2 | 2.9 | | 3 | 1.2 | | |
| **Neutral** | 6 | 8.8 | | 12 | 4.7 | | |
| **Agree** | 36 | 52.9 | | 79 | 31 | | |
| **Strongly Agree** | 24 | 35.3 | | 159 | 62.4 | | |
| **Ease of use of laboratory equipment** | | | | | | | |
| **Strongly Disagree** | 0 | 0.0 | 3.99 ± 0.54 | 0 | 0.0 | 4.49 ± 0.57 | p<0.01 |
| **Disagree** | 0 | 0.0 | | 1 | 0.4 | | |
| **Neutral** | 10 | 14.9 | | 6 | 2.4 | | |
| **Agree** | 48 | 71.6 | | 114 | 44.7 | | |
| **Strongly Agree** | 9 | 13.4 | | 134 | 52.5 | | |
| **Comfortable and appropriate laboratory environment** | | | | | | | |
| **Strongly Disagree** | 0 | 0.0 | 3.80 ± 0.77 | 2 | 0.8 | 4.33 ± 0.77 | p<0.01 |
| **Disagree** | 6 | 9.1 | | 4 | 1.6 | | |
| **Neutral** | 9 | 13.6 | | 23 | 9.0 | | |
| **Agree** | 43 | 65.2 | | 105 | 41.2 | | |
| **Strongly Agree** | 8 | 12.1 | | 121 | 47.5 | | |
| **Overall satisfaction with the laboratory experience** | | | | | | | |
| **Strongly Disagree** | 0 | 0.0 | 4.00 ± 0.58 | 0 | 0.0 | 4.49 ± 0.57 | p<0.01 |
| **Disagree** | 1 | 1.5 | | 0 | 0.0 | | |
| **Neutral** | 8 | 12.1 | | 9 | 3.5 | | |
| **Agree** | 47 | 71.2 | | 113 | 44.3 | | |
| **Strongly Agree** | 19 | 15.2 | | 133 | 52.2 | | |

*†: Indicates that frequencies and percentages (N (%)) were calculated for categorical variables.*
*‡: Indicates that mean and standard deviation (M±SD) were calculated for continuous variables.*
**: Indicates p-values derived from the Mann-Whitney U test for continuous variables, showing highly significant results (p<0.01).*

The same level of significance was also confirmed through Fisher's Exact Test for categorical comparisons.

The descriptive analysis of the new digitalized laboratory reveals high satisfaction levels among students across various aspects. The highest-rated feature was the comfort and suitability of laboratory desks (4.33 ± 0.77), followed closely by the overall satisfaction with the laboratory experience (4.30 ± 0.66) and the quality of trinocular microscopes (4.29 ± 0.76). Visual content provided through the projector also received strong approval (4.12 ± 0.87). Areas such as access to learning materials (4.00 ± 1.07), imaging software efficiency (3.88 ± 0.95), and the quality of auxiliary devices (3.86 ± 1.02) showed positive but slightly lower satisfaction levels. The laboratory's alignment with international standards was rated at 3.94 ± 0.89, reflecting overall confidence in its infrastructure (Table 3).

**Table 3:** Descriptive Analysis of Student Satisfaction with Key Features of the Digitalized Laboratory

| Variables | Mean ± Standard Deviation |
|---|---|
| Professional trinocular microscopes provide high-quality magnification, illumination, and image stability during lectures and demonstrations. *(1 = Strongly Disagree, 5 = Strongly Agree)* | 4.29 ± 0.76 |
| Computers and auxiliary devices (monitor, microscope camera, and color printer) meet students' laboratory needs. *(1 = Strongly Disagree, 5 = Strongly Agree)* | 3.86 ± 1.02 |
| The microscope imaging software is efficient and easy to use, offering useful functions for analyzing and saving images. *(1 = Strongly Disagree, 5 = Strongly Agree)* | 3.88 ± 0.95 |
| The projector and the ability to display images during lectures provide high-quality visual content for teaching. *(1 = Strongly Disagree, 5 = Strongly Agree)* | 4.12 ± 0.87 |
| Laboratory desks are comfortable and provide suitable conditions for practical work. *(1 = Strongly Disagree, 5 = Strongly Agree)* | 4.33 ± 0.77 |
| Access to learning materials outside laboratory hours is possible and helps in independent preparation for the subject. *(1 = Strongly Disagree, 5 = Strongly Agree)* | 4.00 ± 1.07 |
| I believe that laboratory equipment and infrastructure align with international standards for histology education. *(1 = Strongly Disagree, 5 = Strongly Agree)* | 3.94 ± 0.89 |
| Overall, how satisfied are you with your experience in the new digital histology laboratory, considering the quality of equipment, learning environment, and didactic support? *(1 = Very Dissatisfied, 5 = Very Satisfied)* | 4.30 ± 0.66 |

Participants rated the quality of laboratory equipment, including microscopes, monitors, and auxiliary tools, in the digital laboratory as superior compared to the traditional laboratory, with a mean score of 4.35 ± 0.88. Similarly, the ease of using equipment and accessing necessary materials in the digital laboratory was rated significantly higher, with a mean score of 4.66 ± 0.65. Furthermore, the digital laboratory's positive impact on improving knowledge and practical skills compared to the traditional laboratory was reflected in a mean score of 4.06 ± 0.69 (Table 4).

**Table 4:** Comparative Ratings of Laboratory Equipment, Accessibility, and Educational Impact Between Traditional and Digitalized Laboratories

| Variables | Mean ± Standard Deviation |
|---|---|
| How would you rate the quality of laboratory equipment (microscopes, monitors, and auxiliary tools) compared to the laboratory you used previously? (*1 = Very Poor, 5 = Excellent* ) | 4.35 ± 0.88 |
| How easy was it for you to use the equipment and access the necessary materials in the digital laboratory compared to the laboratory you used previously? (*1 = Very Difficult, 5 = Very Easy* ) | 4.66 ± 0.65 |
| To what extent do you think the digital laboratory positively impacted the improvement of your knowledge and practical skills compared to the laboratory you used previously? (*1 = Not at All, 5 = Very Much* ) | 4.06 ± 0.69 |

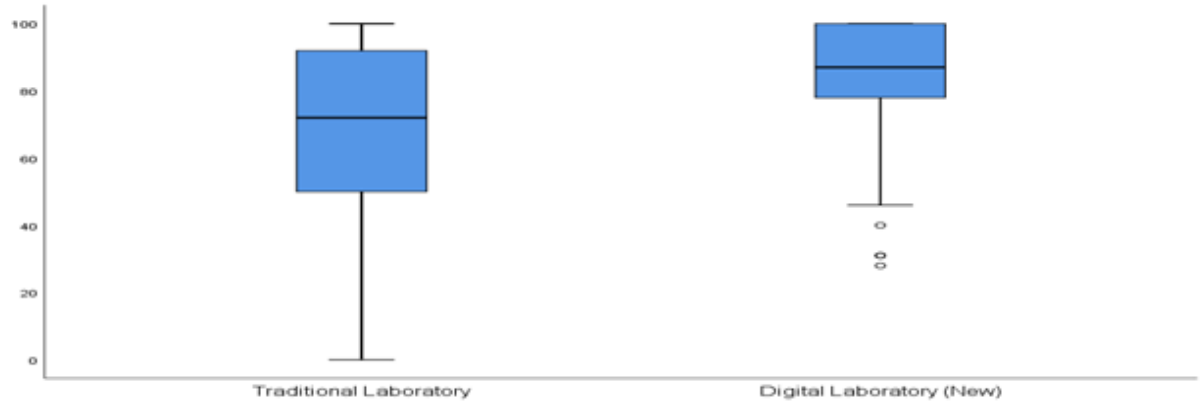


**Figure 1:** Comparison of Satisfaction Scores between Classical and Digital Laboratories among those that utilized both laboratories

Within the cohort that utilized both laboratories, the median satisfaction scores were 72 (IQR = 43) for the classical laboratory and 87 (IQR = 22) for the digital laboratory, $p < 0.001$ (Figure 1).

The open-ended feedback provided valuable insights into students' experiences and suggestions for improvement. Many students emphasized the transformative impact of the digital laboratory, particularly its advanced technology, such as digital microscopes and high-resolution imaging, which significantly enhanced understanding and engagement. Students appreciated the practical integration of theory with advanced tools, describing the experience as effective and enriching.

For the classical laboratory, feedback was mixed. Several students highlighted the absence of practical sessions, with some reporting reliance solely on theoretical lectures.

Many requested more opportunities for hands-on learning, emphasizing the need for diverse histological slides, additional microscopes, and improved equipment such as functional projectors and adequate heating systems.

Students universally praised the guidance provided by academic staff. They expressed satisfaction with the infrastructure while suggesting enhancements, including greater access to laboratory facilities outside class hours and more histological slides for specialized topics like the eye, endocrine glands, ear, and tooth.

## DISCUSSION

The field of histology has evolved significantly from its early beginnings with the use of simple lenses and rudimentary microscopes. Over the centuries, key figures such as Robert Hooke, Antoni van Leeuwenhoek, and Marcello Malpighi made foundational discoveries that shaped our understanding of cellular structures and tissues (1, 2, 3, 4). Hooke's work *Micrographia* (1665) introduced the term "cell," while Leeuwenhoek's powerful lenses, capable of magnifying objects up to 200 times, led to the discovery of bacteria and other microorganisms, marking significant milestones in histological research. In the 19th century, figures like Marie-François-Xavier Bichat, Carl Mayer, and Rudolf Virchow made further contributions, helping to establish histology as a critical area of biological and medical science (5, 6 ,7, 8).

However, despite these significant contributions, the study and teaching of histology were limited by the availability and quality of equipment. Early microscopes were bulky and relatively crude, making precise observation and tissue analysis challenging. It was not until the development of more advanced microscopy technologies in the 19th and 20th centuries that histology became more accessible and its techniques more refined. For example, advancements in tissue fixation and sectioning techniques, like formalin fixation and the use of the microtome, allowed for more accurate study of tissue morphology and pathology (9, 10, 11, 12).

Laboratory equipment for the Histology course has been provided since the establishment of the Higher Medical Institute, initially by U.S., and later by East Germany, primarily Zeiss microscopes. Later, in 1985-1986, a shipment of Polish Studar microscopes was acquired, and in the mid-1990s, another significant shipment of microscopes was obtained. Histology laboratories have also received teaching and research equipment through the World Bank and Ministry of Education and Science projects from 2008-2012 (13, 14, 15, 16, 17, 18, 19, 20).

The latest project in Histology has met all the needs of the Histology-Embryology course with teaching tools, including microscopes for students, histological slides for microscopic examination, trinocular microscopes for tutors, video projectors for displaying microscopic images, and computer and laser color printing equipment for microscopy images. Currently, the Histology-Embryology course can accommodate laboratories for 50-60 students at a time, efficiently using the labs for student learning. These facilities support four modern optical microscopy laboratories for the Histology-Embryology course, serving students from all

three Master of Science programs at the University of Medicine, Tirana, as well as postgraduate specialists and doctoral candidates from the Morphology Department and beyond

The role of modern histology equipment in education and research cannot be overstated. Today, the ability to provide students and researchers with state-of-the-art tools is crucial for advancing both scientific discovery and medical training. The transition from traditional histology laboratories to digitalized, technologically enhanced laboratories represents a major shift in how histology is taught and practiced. This transition not only enhances learning but also improves the quality of research, making it possible to study tissues in unprecedented detail.

Recent data from a study comparing digital and traditional histology laboratories highlights the significant benefits of digital technology in the educational environment. When it comes to the comfort and appropriateness of the laboratory environment, the digital laboratory received a significantly higher rating compared to the traditional laboratory. Notably, 47.5% of students strongly agreed that the digital environment was comfortable and appropriate, in contrast to only 12.1% in the traditional setting. This difference underscores how digital laboratories can enhance the student experience by providing a more user-friendly, comfortable, and efficient learning environment.

In terms of overall satisfaction, the digital laboratory again outperformed the traditional laboratory in terms of mean satisfaction score. This significant difference in satisfaction reflects the positive impact that digital technologies, have on students' overall learning experience. These tools make histology more engaging and accessible, allowing students to interact with specimens in real-time and enhancing their ability to grasp complex concepts.

Moreover, students who had only used the traditional laboratory overwhelmingly agreed that the introduction of the digital laboratory would improve the quality of their learning and practical experience. Among these students, 50.7% agreed, and 42.0% strongly agreed with the statement that the digital laboratory would enhance their educational experience. This suggests that the students recognize the value of modern equipment in improving not only their understanding of histology but also their practical skills.

The positive impact of digital technology on improving knowledge and practical skills is further supported by a mean score of $4.06 \pm 0.69$ for the digital laboratory's effectiveness in comparison to the traditional laboratory. This result reflects the fact that digitalized laboratories provide students with tools that offer clearer images, more efficient ways to study specimens, and the ability to collaborate in real-time using shared data. These features contribute significantly to enhancing both theoretical knowledge and practical skills, allowing students to better understand the structures they are

studying and improve their ability to analyze tissue samples.

The integration of modern histology equipment in educational settings, such as digital laboratories, not only boosts student satisfaction but also plays a key role in improving the quality of research and education and enhancing the students ability to study morphology, pathology, and even the molecular structure of tissues.

In addition to benefiting students, the availability of high-quality equipment also supports researchers in advancing scientific knowledge. In histology, precise observations and accurate data are essential for understanding diseases, discovering new biomarkers, and developing treatments. The shift towards digital laboratories aligns with the growing demand for high-resolution imaging and data-sharing capabilities, providing a more accurate and comprehensive approach to studying tissues and cells. This evolution in histology education and research is crucial for maintaining the pace of scientific progress and ensuring that future generations of scientists are well-equipped to tackle the challenges of modern biology and medicine.

## CONCLUSIONS

In conclusion, the evolution of histology has been closely linked to the development of microscopy technologies, and the advent of digital laboratories has further transformed both teaching and research. The results of recent studies comparing digital and traditional laboratories highlight the significant advantages of modern equipment in improving the learning environment, student satisfaction, and practical skills. As educational institutions continue to invest in advanced histology equipment, the quality of both student education and scientific research will continue to improve, paving the way for future breakthroughs in medical science and healthcare.

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