Scientific and Artistic Analysis of Animal Tissue Microscope Drawings by Science Teacher Candidates

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Recepción: 09.12.2025 | Aceptado: 02.02.2026

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Citar: Ulus, H, & Yalçin, FS (2026). Scientific and Artistic Analysis of Animal Tissue Microscope Drawings by Science Teacher Candidates. *REIDOCREA, 15*(02), 16-34.
Área o categoría del conocimiento: Education

Abstract: The convergence of visual arts with other disciplines is a unique topic that has been addressed only to a limited extent in the literature. This study aims to examine the drawings created by science teacher candidates on animal tissues from both scientific and artistic perspectives. The study was conducted with 12 teacher candidates enrolled in the third year of the science education department during the fall semester of the 2024-2025 academic year. The study used a case study, a qualitative research design. During the four-week process with science teacher candidates, students created drawings based on their observations of various animal tissues under a microscope. The researchers' drawing evaluation rubric and the drawing test related to the tissue topic were used as data collection tools in the study. The findings reveal that teacher candidates can convey scientific concepts about animal tissues in aesthetically appealing ways and that their performance is generally adequate. Although science teacher candidates don’t know about animal tissues, they are generally successful in conveying the formal characteristics of histological structures—such as cell layers, shapes, and connections—through drawing. However, they had more difficulty relating their microscope observations to their drawings and interpreting them. Consequently, the study highlights the potential of art-based approaches in biology education to improve observation skills and deepen conceptual understanding.

Keyword: Scientific and Artistic Analysis

Introduction

From the earliest ages of human existence to the present postmodern era, science and the art have continued to exist as two separate activities that feed off each other. Although these two disciplines have sometimes been separated from each other, interaction has been inevitable, and the “observation” and “creative impulse” that form the common interest of science and art have brought together two different perspectives on understanding, perceiving, and solving problems in the environment. According to Sommerer and Mignonneau (1998), the arts and sciences, which until recently were considered separate fields, have begun to collaborate again in the face of digitalization and technological innovation. According to Arnheim (2009), although people have perceived science and the art as two separate modes of thinking-“rational” and “aesthetic”-these fields have always interacted because they work together to make sense of the universe. It is almost impossible to make a sharp distinction between experience and nature, and therefore between art and science.

Experience and nature are inextricably linked to the art and sciences. Throughout history, societies have shared their cultural resources through interactions, science, and art, which form the basis of civilization (Kılıç, 2012). As a result, science and art, as independent but complementary components of humanity's growth, have advanced using various techniques aimed at a common goal. As highlighted in the research conducted by Lesen, Rogan, and Blum (2016), science, art, and education, as three essential and interconnected domains, possess the capacity to enhance learning experiences. Using art to express scientific ideas makes learning more meaningful by making abstract ideas more real and getting students more involved with their senses. Art-based science communication combines scientific thinking with creative processes to make it easier to explain complicated scientific ideas to a wider audience. This method improves education by giving students a broader view of different fields and helping them be more creative, think critically, and solve problems. Thus, art becomes a structure that helps people understand science better, and education connects the two fields.

This study demonstrates that pre-service science teachers' experiences in conveying scientific concepts through aesthetically informed drawings align with literature emphasizing the role of art in science and education. This study naturally aligns with existing literature on the interplay between science, art, and education by investigating how pre-service teachers amalgamate scientific knowledge with creative expression. Lesen, Rogan, and Blum (2016) assert that art-based methodologies can simultaneously stimulate cognitive and emotional domains, thereby enhancing observational skills and conceptual depth.

Science examines phenomena and events via cause-and-effect relationships, employing data that is widely accepted as valid. Art interprets previously presented facts and events via the subjective perspective of the creator, converting them into a tangible item. Science and art tackle issues distinctively, with science depending on elucidation and art on subjective interpretation (Hızıroğlu, 2019).

Despite varying perspectives on natural phenomena such as sunsets, both scientific and artistic methods provide a solid foundation. Scientists investigate physical variables, whereas artists see the same phenomenon as a sign of creative advancement (Johnson, 2022). This example shows how science and art are inextricably Link is becoming increasingly important as we seek to understand and express the universe through science and art.

The interplay of science and creativity promotes the development of a creative mindset resulting from divergent and convergent thinking patterns; it allows people to perceive reality using both sensory and logical ways (Erzen, 2006). Scientists and technology heavily influence artists, enabling them to employ a variety of creative strategies. This interaction demonstrates the complementary relationship between art's search for emotive answers to the query 'why' and science's development of rational answers to the question 'how.' Since the second half of the twentieth century, art, science, and technology have all contributed to the discovery of new perceptions as intertwined notions that shape culture and knowledge (Elmongi, 2019).

The STEAM approach, which has gained prominence in recent years, contributes to the development of creative thinking, problem-solving, and critical perspective by adding art to the fields of science, technology, engineering, and mathematics (Burnard and Colucci-Gray 2021). The integration of art and science is approached not only as interdisciplinary but also within a transdisciplinary framework, making learning processes sustainable, democratic, and multidimensional (Sausa & Pilecki, 2013; Ishak & Bakar, 2024).

The integration of scientific observation with artistic expression in histology education is one of the innovative approaches that enriches the learning process and creates an interdisciplinary field of interaction (Cracolici et al., 2019). Garcia et al. (2019) define histology, or microscopic anatomy, as a biological discipline dedicated to the analysis of the microscopic structure of biological tissues. In biology degrees, students are required to thoroughly comprehend the characteristics of living beings, spanning from the molecular level to cells, species, and biomes. Histology education has conventionally depended on theoretical lectures, photomicrographs, and laboratory practices.

Throughout this procedure, students employ light microscopes to examine, identify, and interpret slides containing histology specimens. Notwithstanding the incorporation of technological advancements, histology education poses numerous obstacles for students globally (Sung et al., 2016; Güneş and Demir Kaçan, 2016; Nugraha, 2018). The integration of art education into curricula, which provides motivating and innovative methodologies, has recently led to a substantial revolution in the histology teaching approach (Guo et al., 2024; Yu & Chiang, 2024). Integrating biological images obtained under a microscope with artistic activities transforms scientific observation into an aesthetic experience, thereby increasing students' active participation in the learning process (Lindsay, 2021). Art-supported teaching strengthens memory retention and develops creative thinking and visual literacy (McClure, 2009; Luff et al., 2018; Lindsay et al., 2025).

Science is a field of study that maintains a constant relationship with different disciplines due to its scope and conceptual richness (Bybee, 2010). Interdisciplinary projects both foster strategic thinking and collaboration and support innovative teaching methods. The role of art in this process is to strengthen scientific identity among underrepresented groups and make science more accessible within a cultural context (Matias, 2021; Yu & Chiang, 2024).

Over the past twenty years, the integration of visual arts into science education has gained increasing importance; this integration has been considered an effective tool for developing empathy in students, coping with uncertainty, and fostering a holistic perspective on scientific topics (Gobert & Clement, 1999). The intersection of art and science is considered an important approach that supports science education reforms aimed at developing observational skills (Gonzalez et al., 2024).

Since histology education requires understanding structures at the microscopic level, it is directly related to visual perception, attention, and interpretation-based cognitive processes; therefore, art-based approaches are increasingly recognized in educational literature as an effective pedagogical tool that enhances scientific observation and deepens learning (Cracolici et al., 2019). Integrating drawings with microscopic observations enables the use of art as a tool in histology education. This approach enables students not only to convey the formal characteristics of cellular structures but also to increase their conceptual depth by developing their observation skills. As emphasized in the literature, visual arts-based applications stand out as a unique method that supports learning in histology education (Cracolici, Judd, Golden, & Cipriani, 2019; Babayan, 2021).

Drawing and vision-based learning increase attention, observation accuracy, and conceptual understanding by enabling students to actively process information rather than passively receive it. The drawing process, in particular, contributes to lasting learning by helping learners distinguish structures, recognize relationships, and organize information. These visual-based approaches also develop spatial thinking and strengthen the mental representation of complex biological structures. The literature emphasizes that vision- and drawing-based learning has positive effects on analytical thinking, deep learning, and memorability in science and medical education (Ainsworth, Prain & Tytler, 2011; Cracolici et al., 2019). The significance of visual literacy in science education is growing; techniques like technical sketching enhance students' observational and communicative abilities (Zayeb et al., 2024). Drawing aids in the construction of mental models, the organization of concepts, and the enhancement of critical thinking by promoting the comprehension of scientific principles (Quillin & Thomas, 2015).

Illustrative and vision-centric applications substantially enhance learning processes in higher education. Ormancı and Balım (2016) employed the sketching method to ascertain science teacher candidates' perceptions regarding cells, highlighting the significance of this technique in the educational process. The drawing process is seen as both a skill and a "way of seeing" that enhances visual perception, cognitive capacities, and creative thinking skills (Fleury et al., 2020). The amalgamation of science and art, especially via sketching, allows students to materialize abstract concepts, enhance their observational abilities, and engage with scientific subjects in a more comprehensible manner (Ainsworth et al., 2011; Matias et al., 2021).

Furthermore, it has been observed that methods based on low-cost and simple technologies such as drawing and modeling make the learning process related to biology and tissue topics more accessible and interactive. Philp and Smith (2025) assert that such applications facilitate students' knowledge retention and expansion by offering engaging, entertaining, and repetitive experiences.

Art-based teaching methods enable students to participate not only as knowledge consumers but also as active creators and interpreters, fostering a holistic interaction of cognitive, visual, and advanced thinking skills. When combined with systematic assessment tools, these methodologies provide a long-term educational framework that improves learning quality, particularly by enriching the processes of observation, analysis, and interpretation with production-based activities such as drawing (Quillin & Thomas, 2015; Simmons, 2019; Moldavan & Johnson, 2023).Research on art education also indicates that it provides significant gains in visual perception, cognitive functions, and creative thinking. In this context, drawing stands out not only as a means of visualization but also as an effective assessment method that supports learning processes (Rafi et al., 2007; Prokop & Fančovičová, 2006; Quillin & Thomas, 2015).

The contribution of art-based drawing applications to learning processes becomes a powerful tool for both teaching and assessment when supported by analytical rubrics (Quillin & Thomas, 2015; Abdellatif & El-Wakeel, 2025). However, when aesthetic concerns limit functionality, strategies are needed to enhance content and composition (Simmons, 2019). In this context, analytical rubrics, observation-based drawing processes, and interdisciplinary group work stand out as effective strategies that strengthen content and composition (Quillin & Thomas, 2015; Rafi et al., 2007; Dinç & Karahan, 2021).

The contributions of art-based strategies to learning processes are becoming more pronounced, particularly in applied and experimental disciplines, such as health sciences and biology. In this context, biology education stands out as an important field that demonstrates the impact of art-integrated practices (Ezin et al., 2019; Dinç & Karahan, 2021). A study has shown that interruptions in art education lead to students participating in biology classes with limited preparation, which negatively affects their success in microscopic tissue studies (Ezin et al., 2019). However, observation and experimental processes structured with an interdisciplinary learning approach enhance learning quality; even students who have not received art education are able to produce aesthetically high-quality products (Dinç & Karahan, 2021). In one study, it was emphasized that students' interpretation of microscopic images of embryos from their own perspective developed their ability to perform detailed analysis and distinguish contrasts (Ezin et al., 2019). This process contributes to the development of self-criticism and feedback mechanisms, thereby supporting a more in-depth learning experience (Ridley & Rogers, 2010).

Drawing-based applications facilitate the conceptual interpretation of microscopic observations and enhance students' visual-analytical skills; this process, integrated with art, is considered an important tool that improves the quality of observation and learning outcomes in biology education (Quillin & Thomas, 2015; Dinç & Karahan, 2021). Technical flaws in the use of a microscope can limit learning outcomes, but practical instruction can help acquire these skills (Benzer & Demir, 2014). While virtual microscopic slides help with histology learning, scale inaccuracies in drawings can make it difficult to precisely express dimensions (Anyanwu et al., 2012; Tarnus et al., 2017). The conceptual density of animal tissues can be challenging for students and may trigger rote learning approaches. In contrast, drawing techniques offer an effective solution for understanding and integrating information. Research shows that art-based learning strengthens long-term knowledge retention, encourages higher-order thinking, and promotes more active student participation in the process (Anwar & Shafi, 2021). However, as this process requires high cognitive effort, it is important to use teaching strategies that support student adaptation.

Recently, there has been heightened emphasis on art in novel educational frameworks applicable to undergraduate and graduate education, as well as ongoing professional development in health sciences disciplines, including medicine (Cracolici et al., 2019), veterinary medicine (Beck et al., 2017), and dentistry (Yu & Chiang, 2024). It is observed that the most significant advancements in the application of art in teaching have occurred at medical faculties (Wilson et al., 2016; Chisolm et al., 2021; Zheng et al., 2024). Research has shown that art-based techniques effectively enhance the learning of anatomy (Gupta, 2021; Crossing et al., 2022).

Although there are various studies on this subject in the international literature, it is observed that research conducted with scientific and art-based approaches in the field of science education is quite limited. The subject of animal tissues creates conceptual difficulties for students due to abstract concepts and the inability to directly observe microscopic structures; this situation increases the tendency toward rote learning (Simatupang & Manik, 2020; Ningsih & Titin, 2021). Where traditional teaching methods fall short, visual representations and art-based approaches contribute to the concretization of concepts (DeHoff et al., 2011).

In this regard, teacher candidates expressing their abstract knowledge about animal tissues through drawing is considered an effective method for developing their conceptual structures. Furthermore, it is anticipated that visual art production will subjectively enrich the learning process and contribute to students incorporating art as a personal element into their future biology education. In this context, the aim of this study is to examine science teacher candidates' drawings of animal tissues in terms of scientific accuracy and artistic expression. The purpose of this study is to examine science teacher candidates' drawings of animal tissues in terms of scientific accuracy and artistic expression. Focusing on animal tissues and conducted using art-based methods, this research is expected to make a meaningful contribution to both national and international literature by emphasizing the importance of interdisciplinary approaches in science education.

Method

This research used a case study, a qualitative research approach, to evaluate teacher candidates' comprehension of animal tissue types and their visual representations. A case study is a qualitative research methodology that facilitates an in-depth analysis of a particular occurrence, individual, or group using a restricted sample. The objective of this design is not to generalize but to thoroughly describe and comprehend the issue being examined within its context. These investigations, executed with limited samples, facilitate the integrated use of several data-gathering methodologies (observation, interviews, document analysis, performance evaluation, etc.) (Yıldırım and Şimşek, 2021).

Sample Group

The study group for this research consists of 12 third-year teacher candidates enrolled in the Faculty of Education at a state university during the spring semester of the 2024-2025 academic year who are taking the elective course titled “The Convergence of Biology and Art.” When selecting teacher candidates for this course, attention was paid to ensure that they had already taken the courses “General Biology I” and “General Biology II.” Small sample groups were selected in accordance with the nature of the case study, and participants' performance throughout the process was examined in detail. In this context, participants were purposefully selected. This group was chosen to investigate the opinions of teacher candidates regarding the teaching process in art and science-based activities via the convenience sampling methodology, which was derived from purposeful sampling methods (Yıldırım and Şimşek, 2021). Eight women and four men made up the study's sample of teacher candidates, who were between the ages of 20 and 21.

Data Collection

The study used the performance and artistic expression drawing evaluation rubric devised by the researchers as a data-gathering medium, as well as the tissue-related drawing rubric. During the data collection process, teacher candidates were first informed about what they needed to do.

In the first phase of this study, drawings were evaluated to reveal the contribution of art as a learning tool in the processes of understanding animal tissues and distinguishing tissue structures from one another. In this evaluation, rubrics inspired by the “Pictorial Creativity Test” developed by Yolcu (2021) were used. Teacher candidates were asked to choose one of the permanent slide animal tissues and draw and color it on the provided paper using photomicrographs taken from microscope images.

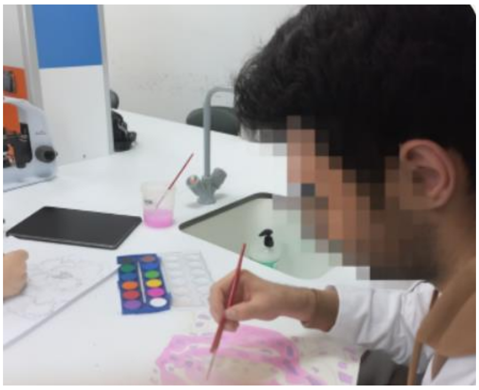
The evaluation of performance and artistic expression in the image was conducted using an analytical rubric developed by the researcher, which was divided into four main categories based on the reports of two field experts: “ratio-proportion,” “aesthetic value,” “creativity,” and “functionality.” Each category was scored at the levels of “inadequate,” “partially adequate,” and “mature,” enabling a multidimensional analysis of students' artistic expression proficiency.

In the second phase of the study, the teacher candidates' drawings of animal tissue samples were also evaluated histologically using a drawing test rubric prepared by the researcher. This drawing test section was structured based on similar studies conducted by Bland (2004), Ormancı and Balım (2016), Slominski et al. (2017), and Nugraha (2018); it also uses the Histology Atlas by Erbengi and Clara (1984) as a primary reference. It has been stated that what, how, and where they are positioned in animal tissue drawings is important. The evaluation framework developed by the researcher was divided into five basic categories and evaluated in line with the opinions of two field experts: ″morphological accuracy″, ″layer accuracy″, ″layer type suitability″, ″cellular density and detail″, and ″microscope observation skill″.

The Implementation Study

The first week of the study covered theoretical information about the conceptual and formal components of art, the relationship between science and art, and the use of art in educational settings. During the second week, students randomly selected permanent preparations of the trachea, ovary, epithelial tissue, artery, pancreas, connective tissue, stomach wall, heart muscle, testis, small intestine, stratified squamous epithelium, and blood tissue to examine under a microscope.Each teacher candidate examined the specimen they selected under a microscope, recorded the tissue structures they observed at 40x magnification in photomicrographs, transferred these micrographs onto drawing paper, and developed original designs. In addition, they labeled the tissue and cell types based on the histological drawing assessment, indicating the cell and tissue characteristics they observed under the microscope. In the third week, the tissue pictures prepared by the students were colored using watercolor, pastel, and felt-tip pens according to their preferences (Figure 1). The lesson duration was set at two hours per week. In the fourth week, the design works produced by the students at the end of the application process were evaluated.

Figure 1.
Science teacher candidates' animal tissue drawings.



Data analysis

During the first step of the analytic procedure, 12 teacher candidate drawings were subjected to a preliminary appraisal. At this level, each visual was evaluated for subject matter comprehension and visual suitability for analysis. To ensure coding reliability, the participants' drawings were labeled as P1B, P2B, …P12B.

In the initial phase of data analysis, the artistic evaluation involved a systematic assessment of teacher candidates' drawings of animal tissues by two subject matter experts, focusing on performance and artistic expression levels. This evaluation seeks to elucidate the impact of drawing-based observation and expression processes, as well as aesthetic-based learning methodologies, on cognitive development. In this process, the Performance and Artistic Expression Rubric developed by researchers on the subject of animal tissue was used. In developing the rubric, the relevant literature was first reviewed (Yolcu, 2001; Abdullah et al., 2024), existing measurement and evaluation tools were examined, and the rubric dimensions were structured based on the findings. In this context, the rubric was designed around four basic dimensions: “proportion,” “aesthetic value,” “creativity,” and “functionality.” Participants' drawings were evaluated and categorized as “inadequate,” “partially adequate,” or “mature” within each category (Table 1).

Table 1.
Drawing performance and artistic expression rubric

Dimension	Insufficient	Partially Meets Expectations	Well-Developed
Ratio and Proportion	The proportions are unclear, or the drawing is imbalanced.	The proportions are partially correct, but there are some inconsistencies.	The proportions are correct and balanced; the drawing is consistent.
Aesthetic Value	Visually weak; not eye-catching.	Visually acceptable; some aesthetic elements are present.	Visually impressive and harmonious.
Creativity	No originality; a non-creative approach.	Some creative elements are present, but they are limited.	An original and creative approach is clearly demonstrated.
Functionality	Does not serve its purpose; hard to understand.	Partially functional; some points are unclear.	A functional drawing that makes the purpose clear and meaningful.

The content validity of the rubric developed to measure artistic expression and performance levels related to animal tissue was ensured in accordance with criteria established by reviewing the relevant literature; its reliability was supported by achieving 100% consensus by examining the consistency of independent ratings conducted by two field experts.

In the second stage of data analysis, data related to teacher candidates' histological drawings were evaluated according to the “Drawing Test Rubric Related to Animal Tissue” developed by the researchers. In the process of developing the rubric, the relevant literature was first reviewed, and the rubric dimensions were structured according to the findings obtained. Microscopic examination images (photomicrographs) of animal tissues were provided at two levels: low magnification (10x) and high magnification (40x). These images were selected by two biology field experts. Detailed scoring criteria were established for each photomicrograph, and five main categories were defined for the evaluation process: overall recognizability, component recognizability, use of labeling, use of contrast, field arrangement, and magnification. Scoring levels specific to each category were differentiated, and participants' performance was defined in four separate levels: “insufficient,” “limited,” “adequate,” and “excellent.” During the evaluation process, drawings were scored on a scale of 1 to 4 in five dimensions to measure their scientific accuracy and visual expression adequacy. The relevant rubric is provided in Table 2.

Table 2.
Animal tissue drawing test evaluation rubric.

Dimension	Dimension Description	Score Descriptions
1 – Overall Recognizability	Can the drawing be recognized as a whole?	1: Insufficient, unrecognizable 2: Limited, missing details 3: Adequate, moderately recognizable 4: Excellent, easily recognizable, similar to photomicrographs
2 – Component Identifiability	Are cell types, structures, and layers distinguishable?	1: Insufficient, unrecognizable 2: Limited, difficult to recognize 3: Adequate, moderately distinguishable 4: Excellent, clearly distinguishable with emphasized details
3 – Use of Labeling	Are cells, structures, and layers correctly and completely labeled?	1: Insufficient, no labeling 2: Limited, sparse or incorrect labeling 3: Adequate, basic structures labeled 4: Excellent, correct and complete labeling
4 – Use of Contrast	Are details emphasized using differences in line weight/thickness?	1: Insufficient, no contrast 2: Limited, slight or inconsistent contrast 3: Adequate, clear contrast 4: Excellent, strong and effective contrast
5 – Layout and Magnification	Is scale and spatial arrangement appropriate for microscope magnification?	1: Insufficient, disorganized layout or incorrect scale 2: Limited, poor layout or insufficient magnification 3: Adequate, acceptable layout and magnification 4: Excellent, well-organized layout and appropriate magnification

The content validity of the drawing test rubric for animal tissues was determined by evaluating measurement and evaluation studies in the relevant literature, as well as drawing features based on microscopic imaging. The rubric's dependability was assessed by four biology field specialists who scored it independently; inter-rater reliability confirmed the objectivity of the assessment method and the measurement tool with 100% agreement. In the study, drawings were evaluated using the Performance and Artistic Expression Rubric Related to the Animal Tissue Topic and the Drawing Test Rubric Related to the Animal Tissue Topic.

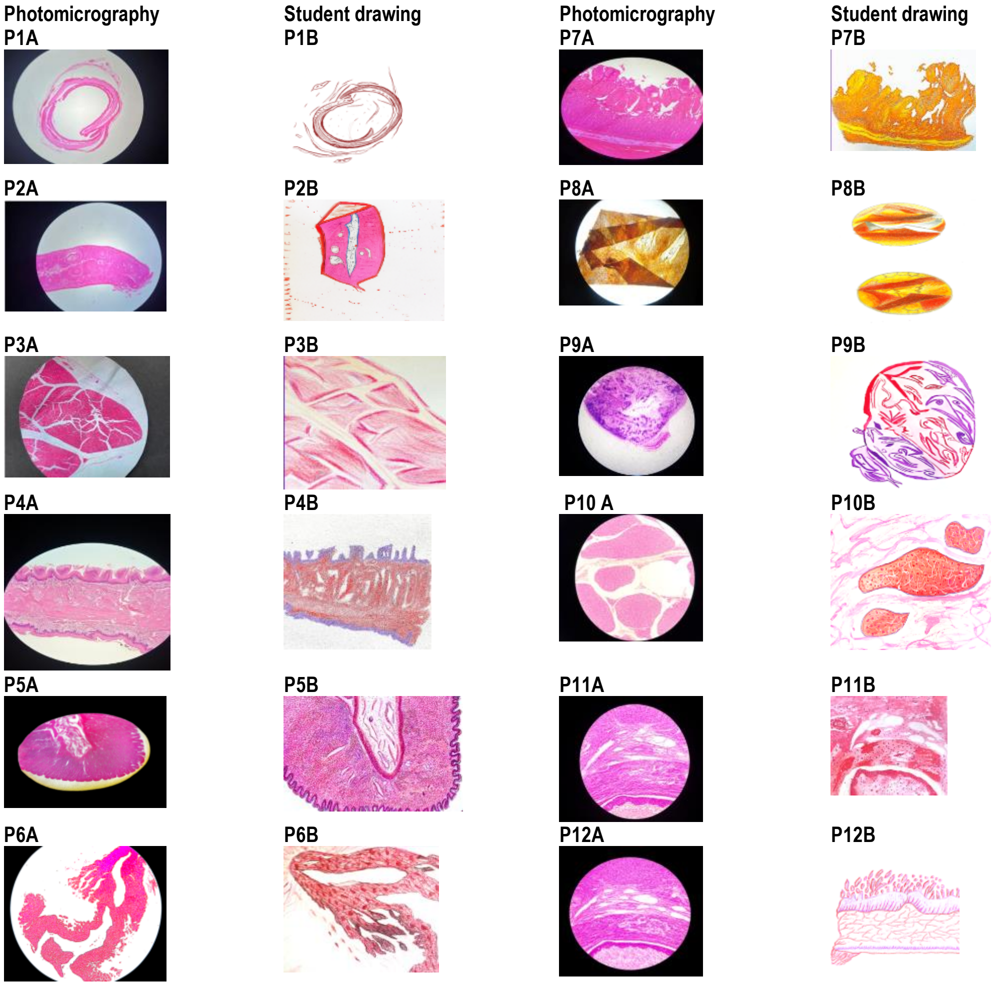
Results

The study findings consist of two main sections: 'Findings Related to the Art-Based Evaluation of Animal Tissue Drawings' and 'Findings Related to the Histological Evaluation of Animal Tissue Drawings.

Findings from Art-Based Assessment of Animal Tissue Drawings

Science teacher candidates analyzed prepared animal tissue specimens under a microscope and rendered drawings based on the photomicrographs they captured. Figure 2 displays these illustrations.

Figure 2.
Histologically, micrographs and student illustrations. PA: Micrographs (40x magnification) and student illustrations are incorporated. 1) Trachea; 2) Ovary. 3) Pancreas; 4) Dense Connective Tissue 5) Gastric Wall, 6) Artery, 7) Small Intestine, 8) Blood Tissue. 9) Gastric Wall, 10) Testicle, 11) Cardiac Muscle, 12) Duodenum.



Within the scope of this study, teacher candidates' photomicrograph drawings of various animal tissues were evaluated based on four fundamental dimensions: proportion, aesthetic value, creativity, and functionality. Each criterion was classified into three performance levels: advanced, partially effective, and inadequate. The evaluation results are presented in Table 3:

Table 3.
Findings on the drawing performance and artistic expression assessment of teacher candidates.

Dimension	Performance Level	Student Drawings	N
Ratio and Proportion	Insufficient	P5B, P8B	2
	Partially sufficient	P2B	1
	Sufficient	P1B, P3B, P4B, P6B, P7B, P9B, P10B, P11B, P12B	9
Aesthetic Quality	Insufficient	P12B	1
	Partially sufficient	P2B, P5B, P6B, P8B, P9B, P11B	6
	Sufficient	P3B, P5B, P6B, P9B, P11B	5
Creativity	Insufficient	—	–
	Partially sufficient	P1B, P5B, P8B	3
	Sufficient	P2B, P3B, P4B, P6B, P7B, P9B, P10B, P11B, P12B	9
Functionality	Insufficient	P11B	1
	Partially sufficient	P2B, P4B, P5B, P9B, P10B	5
	Sufficient	P1B, P3B, P5B, P7B, P8B, P12B	6

Table 3 shows that the **ratio-proportion** in drawings is an important parameter in assessing the accuracy of the dimensional relationships between the structures that form the tissue and the visual balance. This criterion also allows for the evaluation of the meaningful relationship established between the drawing paper, which forms the basis of the composition, and the subject being addressed. In this regard, the analysis was conducted: Two drawings that were evaluated as inadequate (P5B—*stomach wall*, P8B—*blood tissue)* contain significant deviations in terms of proportion, and anatomical integrity has not been achieved in the drawings. This situation demonstrates that students experience difficulties in transferring their microscopic observations to drawings due to their lack of scaling skills, which leads to significant proportional deviations. A drawing classified as partially effective (P2B– *Ovaryum*) often exhibits a satisfactory ratio but contains inconsistencies in specific structural regions. The drawing exhibits potential for establishing fu Nine drawings that were adequately evaluated (P1B – *Trachea*, P3B – *Pancreas*, P4B – *Connective Tissue,* P6B – *Artery*, P7B – *Small Intestine*, P9B – *Stomach Wall,* P10B – *Testis,* P11B – *Heart Muscle*, P12B – *Small Intestine*) successfully reflect the dimensional relationships of anatomical structures; the drawings present a balanced, consistent, and realistic visual structure. Fundamental proportional connections, but its visual equilibrium necessitates enhancement.

Overall, the vast majority of teacher candidates were able to express their micrographic observations using correct scales, indicating that the drawings have a strong foundation in terms of scientific accuracy. However, examples containing proportional deviations point to the need for more systematic integration of pre-drawing structural analysis and visual planning in the teaching process. This finding reveals that teacher candidates need supportive practices aimed at developing their pre-drawing structural analysis and visual balance skills.

The aesthetic value criterion is a key factor in assessing the visual quality of drawings and the intellectual pleasure they provide to viewers. In this context, the analysis revealed the following results: One drawing (P12B – *Small Intestine*) was rated as inadequate; it was found to be visually weak, with a scattered, unremarkable structure lacking aesthetic elements. Six drawings rated as Partially Effective (P2B – *Ovary*, P5B – *Stomach Wall*, P6B – *Artery*, P8B – *Blood Tissue*, P9B – *Stomach Wall,* P11B – *Heart Muscle*) generally displayed acceptable visuals, but issues with linear harmony and visual balance were noted across the work.

These drawings partially achieve aesthetic integrity, but the presentation requires more careful structuring. The five drawings that were evaluated as adequate (P1B – *Trachea,* P3B – *Pancreas*, P4B – *Connective Tissue*, P7B – *Small Intestine*, P10B – *Heart Muscle*) were prepared in a visually balanced, organized, and appealing manner. Aesthetic elements were used successfully in these drawings, and the presentation quality was found to be high.

Overall, teacher candidates demonstrate varying levels of performance in terms of aesthetic values. In particular, the high number of drawings rated as "somewhat effective" indicates that aesthetic awareness is developing, but there is a need for more guidance and practice in terms of drawing techniques and visual planning.

The creativity criterion was addressed with a view to evaluating the originality, individual interpretation, and creative expression power that students added to their drawings. In the analysis conducted in this context, no drawings were evaluated as insufficient. This indicates that all participants possessed at least a basic level of creative potential. Three drawings rated as partially adequate (P1B – *Trachea*, P5B – *Stomach Wall*, P8B – *Blood Tissue*) contained limited originality, and it was observed that the creative approach progressed more through formal repetitions. While these drawings include personal interpretations, there is room for improvement in terms of creative diversity and depth of expression. Nine drawings that were evaluated as sufficient (P2B – Ovary, P3B – *Pancreas*, P4B – *Dense Connective Tissue*, P6B – *Artery*, P7B – *Small Intestine*, P9B – *Stomach Wall*, P10B – *Testis*, P11B – *Heart Muscle*, P12B – *Small Intestine*) demonstrated strong expression in terms of originality, formal diversity, and individual interpretation. In these drawings, the students' microscopic observations were restructured from an artistic perspective, successfully reflecting their creative thinking skills.

When it comes to expressing themselves creatively, we observe that most teacher candidates do adequately. The fact that no participants turned in subpar artwork suggests that they all made at least some rudimentary use of their creative abilities. On the other hand, teacher candidates' artistic expression abilities will be enhanced by expanding their creative depth and introducing various innovative ways of expression.

The criterion of functionality was addressed in terms of evaluating the extent to which the drawings served their purpose, their explanatory power, and their comprehensibility. In this context, the analysis showed the following results:

A drawing rated as inadequate (P11B—*heart muscle*) was found to be visually complex and insufficient in terms of explanatory power. This drawing indicates that students experienced difficulty in conveying their micrographic observations in a clear and functional manner. Five drawings rated as Partially Adequate (P2B – *Ovary,* P3B – *Pancreas*, P5B – *Stomach Wall*, P6B – *Artery*, P10B – *Testis*) are generally understandable but contain ambiguities and structural deficiencies in some sections.

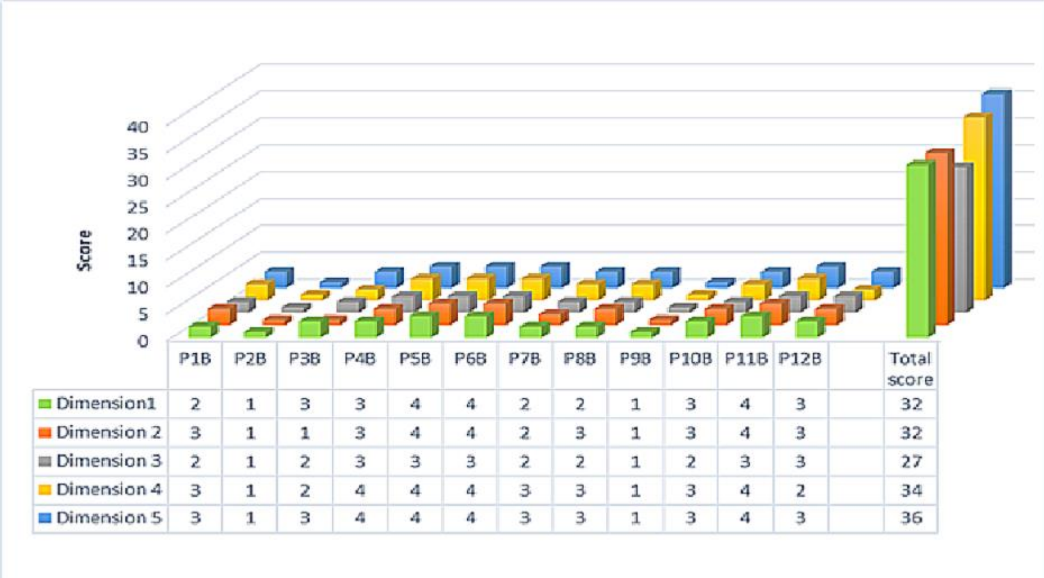
Despite the partial functionality of these drawings, they lack the visual clarity necessary for effective education. The six drawings that were evaluated as adequate (P1B – *Trachea*, P4B – *Connective Tissue*, P5B – *Stomach Wall*, P7B – *Small Intestine*, P8B – *Blood Tissue*, P12B – *Small Intestine*) were clear, concise, and instructive. In these drawings, micrographic observations have been successfully visualized and presented in a way that directly contributes to students' understanding of the subject.

Overall, the vast majority of teacher candidates demonstrated sufficient success in terms of functionality in their drawings. This finding reveals that micrograph drawings can be used effectively not only as an artistic tool but also as an educational one. However, examples with low explanatory power indicate that visual narration needs to be structured more systematically.

Findings from the histological evaluation of animal tissue drawings

In the study, science teacher candidates were asked to create drawings based on photomicrographs obtained from animal tissue images observed under a microscope. The resulting drawings were evaluated in five dimensions according to the histological "Drawing Test Rubric Related to Animal Tissue." Each dimension was scored based on the drawings of 12 students (Figure 3).

Figure 3.
Distribution of scores according to rubric dimensions for teacher candidates' animal tissue drawings.



	P1B	P2B	P3B	P4B	P5B	P6B	P7B	P8B	P9B	P10B	P11B	P12B	Total score
Dimension1	2	1	3	3	4	4	2	2	1	3	4	3	32
Dimension 2	3	1	1	3	4	4	2	3	1	3	4	3	32
Dimension 3	2	1	2	3	3	3	2	2	1	2	3	3	27
Dimension 4	3	1	2	4	4	4	3	3	1	3	4	2	34
Dimension 5	3	1	3	4	4	4	3	3	1	3	4	3	36

When examining Figure 3, the total score of 32 points in the **Overall Recognizability** dimension indicates a high level of success in the overall recognizability of the drawings. In this context, the P5B-*Stomach Wall*, P6B-*Artery*, and P11B-*Heart Muscle* drawings received 4 points each for their visual integrity and likeness to photomicrograph drawings. P3B-*Pancreas*, P4B-*Connective Tissue*, P10B-*Testis*, and P12B-*Small Intestine* drawings were rated at a relatively rapid recognition level of 3 points. In contrast, the P2B-*Ovary* and P9B-*Stomach Wall* drawings were classified as unrecognizable when compared to photomicrographs, scoring 1 point; the P1B-*Small Intestine* and P8B-*Blood Tissue* drawings scored 2 points, showing limited recognizability due to a lack of detail.

A total score of 32 points on the **Component Recognizability** dimension reflects a generally excellent ability to distinguish cell types, structures, and layers in the images. The pictures for P5B-*Stomach Wall*, P6B-*Artery,* and P11-*Heart Muscle* received a score of 4 points, indicating outstanding visual clarity and detailed knowledge of cell types and layers. P1B-*Trachea*, P4B-*Connective Tissue*, P8B-*Stomach Wall*, P10B-*Testis,* and P12B-*Small Intestine* drawings were rated 3 points for relatively quick recognition of cells and layers. The P7B-Small Intestine drawing scored 2 points, showing limited recognizability of cells and tissue layers; P2B-*Ovary*, P3B-*Pancreas*, and P9B-*Stomach Wall* were classified as examples where components could not be distinguished, earning 1 point.

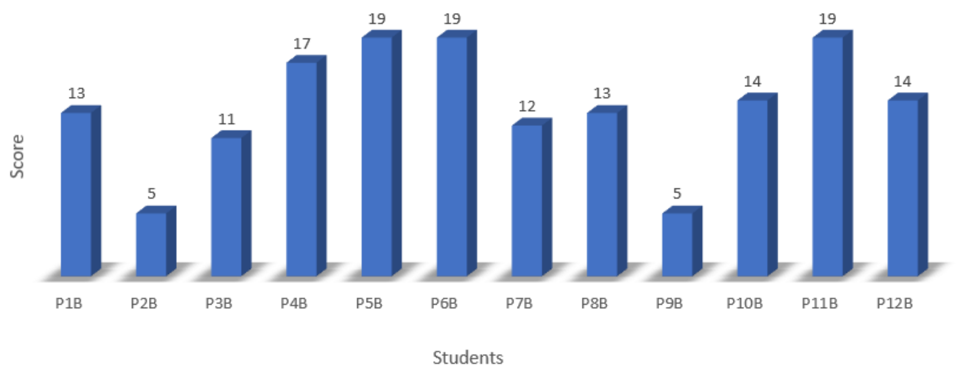
A total score of 27 points in the **Labeling Usage** dimension shows that the drawing skills are generally low. As a result, no participant scored 4 points, suggesting a lack of success in labeling. The drawings of P4B-*Tight Connective Tissue*, P5B-*Stomach Wall*, P6B-*Artery*, P11B-*Heart Muscle*, and P12B-*Small Intestine* received a rating of 3 points, indicating that the labeling of basic cell and tissue layers was deemed adequate. The P1B-*Trachea,* P3B-*Pancreas*, P7B-*Small Intestine*, P8B-*Blood Tissue*, and P10B-*Testis* drawings were awarded 2 points due to limited and partially incorrect labeling. In contrast, the P2B-*Ovary* and P9B-*Stomach Wal*l were identified as having no labeling, resulting in a score of 1 point.

The total score of 33 points in the **Contrast Usage** dimension was deemed adequate for emphasizing details in drawings produced with the drawing tool. In this context, the P4B-*Tight Connective* Tissue, P5B-*Stomach Wall*, P6B-*Artery,* and P11B-*Heart Muscle* illustrations garnered 4 points, signifying optimal contrast for tissue cells, layers, and staining. In these paintings, drawing and coloring are employed consistently, and tissue details are accentuated. The P1B-*Trachea,* P7B-*Small Intestine*, P8B-*Blood Tissue*, and P10B-*Testis drawings* were scored at a distinct contrast level of three points. The P3B-*Pancreas* and P12B-*Small Intestine* drawings scored two points, showing limited contrast; P2B-*Ovary* and P9B-*Stomach Wall*, on the other hand, received one point for no contrast.

The total score of 36 points in the **Layout and Magnification** dimension indicates a satisfactory level of success in the appropriate use of scale and space in the microscopic drawings. In this context, the drawings of P4B-*Tight Connective* Tissue, P5B-*Stomach Wall*, P6B-*Artery*, and P11B-*Heart Muscle* each received 4 points. This score reflects the ideal evaluation of the cells and layers within the tissues, both in terms of their area placement and the magnification scale used by the microscope.P1B-*Trachea*, P3B-*Pancreas,* P7B-*Small Intestine*, P8B-*Blood Tissue*, P10B-*Testis*, and P12B-*Small* Intestine drawings all received three points, demonstrating proper tissue arrangement and microscope magnification. However, the P2B-*Ovary* and P9B-*Stomach Wall* drawings received one point for being unsatisfactory in terms of tissue arrangement and microscope magnification.

The examples that received the highest total score (19 points) among the 12 drawings evaluated in five dimensions according to the "Drawing Test Rubric on Animal Tissue" for teacher candidates are the P5B – *Stomach Wall*, P6B – *Artery*, and P11B – *Heart Muscle* drawings (Figure 4).

Figure 4.
Score distribution for student drawings evaluated using the Animal Tissue Drawing Test Rubric.



These drawings stood out in terms of both visual integrity and scientific accuracy. In contrast, the drawings with the lowest total score (5 points) were P2B – Ovary and P9B – Stomach Wall, where significant deficiencies were observed in dimensions such as recognizability, component detailing, and labeling.

Discussion

In the first phase of this study, teacher candidates' photomicrograph drawings related to animal tissues were evaluated using the “Performance and Artistic Expression Related to Animal Tissue” rubric, based on four fundamental dimensions: ratio-proportion, aesthetic value, creativity, and functionality. Each dimension enabled a multidimensional analysis of the drawings in terms of scientific accuracy, aesthetic qualities, originality, and educational functionality.The results indicate that the vast majority of teacher candidates demonstrated fundamental proficiency in illustrating microscopic observations through drawing (Table 2). This study revealed that teacher candidates' photomicrograph drawings demonstrated a more varied performance distribution regarding artistic and aesthetic worth than other aspects. Although notable success is evident in areas directly associated with scientific observation, such as proportion and creativity, the presence of drawings lacking in aesthetic value and functionality suggests that teacher candidates have not adequately internalized aesthetic arrangement and visual planning as systematic learning outcomes. This finding aligns with the quantitative data derived from the rubric in the initial phase of the study, indicating that aesthetic value predominantly evolves from individual intuition.

There are research in the literature that report comparable outcomes. Simmons (2019) highlights that students frequently confine aesthetic concerns in educational drawings to formal adornment, which can overwhelm functionality. This study involving teacher candidates reveals that the inadequate visual integrity and presentation quality observed in many drawings of poor aesthetic value correspond to the aesthetic-functionality dilemma articulated by Simmons (2019). Therefore, the findings suggest that the development of aesthetic value involves both creative sensibility and deliberate visual organization.

Quillin and Thomas (2015) assert that aesthetic value in scientific drawings is not an intrinsic quality; instead, it is an educational outcome that necessitates established criteria, exemplars, and primary evaluative tools. Although our study used an analytical rubric to make aesthetic value measurable and discussable, the broad performance dispersion seen in the aesthetic dimension suggests that the training process, like the evaluation, should be structured. This incident demonstrates that the use of rubrics alone is insufficient; aesthetic awareness must be addressed systematically throughout the instructional process.

Ezin et al. (2019) argue that visual arts-based realistic drawings raise students' knowledge of the visual organization and aesthetic integrity of microscopic structures. In this perspective, the fact that several drawings in our study that provide strong instances of aesthetic value (e.g., P1B, P3B, P4B) are more consistent in terms of both scientific truth and visual balance lends credence to the notion that artistic direction might help build aesthetic quality. However, the small number of such examples demonstrates that aesthetic growth did not proceed at the same rate for all subjects.

Similarly, Ishak and Bakar (2024) state in their study that histopathological images have inherent aesthetic potential; however, this potential can only be fulfilled through an interdisciplinary approach and deliberate visual editing. In this study, the aesthetic value of teacher candidates' drawings remained limited; this situation indicates that the aesthetic potential of histological images is not sufficiently utilized in the teaching process. This finding reveals that aesthetic value is not a natural outcome of scientific content but rather a competency area developed through pedagogical guidance.

Yu and Chiang (2024) studied the integration of art and humanities into dental education through a photomicrography competition. The visually appealing graphics created by students using digital techniques applied to oral tissue sections were a novel teaching method that combined science and art, creating a full educational experience. Similarly, art-based practices in the field of health care have been shown to make significant contributions to learning and professional development. Research in this context has revealed that engaging with the fine arts not only enhances clinicians' intellectual curiosity and critical thinking skills but also strengthens diagnostic accuracy and empathetic approaches toward patients (Wilson et al., 2016; Chisolm et al., 2021; Zheng et al., 2024).

In this context, both teacher candidates' photomicrograph drawings and clinicians' interactions with art demonstrate that visual perception, aesthetic sensitivity, and creative expression skills provide a common ground that supports professional competence. With advances in information technology, the visual arts have emerged as an effective pedagogical tool, particularly in histology and anatomy education (Elmongi, 2019). Consequently, studies in the literature align with and support the findings of this research. The inclusion of artistic elements in histology education is explained by dual coding theory, which allows individuals to encode the learned content through both verbal and visual mental models and establish relationships between these models (Paivio, 1990).

The findings obtained in this study regarding artistic and aesthetic value criteria reveal that aesthetic quality does not develop spontaneously, as emphasized in the literature; rather, it must be supported by teaching based on clear criteria, systematic visual guidance, and interdisciplinary approaches. Considering the high performance demonstrated by teacher candidates in the dimensions of proportion and creativity, it can be said that aesthetic value, when supported by similarly structured instructional strategies, offers an important learning gain that strengthens scientific and artistic integrity in histology education.

In the second phase of this study, science teacher candidates' photomicrograph drawings of animal tissues were histologically graded in five dimensions using the "Drawing Test Rubric for Animal Tissue." The findings revealed that candidates had varying degrees of proficiency in depicting microscopic observations in their drawings (Figure 3). The basic level of proficiency, as measured in terms of general recognizability, component recognizability, and morphological accuracy, indicates that teacher candidates have reached a certain level of proficiency in expressing their microscopic observations through drawing. The relatively high success achieved in the morphological accuracy dimension, in particular, supports drawing-based practice. This finding aligns with the work of Rafi and Anwar (2007), which revealed that transferring microscopic images through drawing deepens histology learning; it demonstrates that drawing supports conceptual accuracy as an observation-based learning strategy. Similarly, Ezin and colleagues (2019) emphasize the pedagogical contribution of drawing and visual representations in histology learning, noting that visual models strengthen students' structural awareness.

The literature emphasizing application-based approaches strengthens mental representations of histological structures and significantly contributes to students' clearer understanding of structure-function relationships. Quillin and Thomas (2015) and Prokop and Fančovičová (2006) have stated that drawing is not only a visualization tool but also an effective assessment method that supports learning. In this study, it is observed that teacher candidates' drawings of histologically distinct structures, such as the trachea, pancreas, small intestine, and dense connective tissue, constitute more mature examples from both scientific and artistic perspectives. This situation demonstrates that drawing-based applications contribute to the holistic structuring of histological concepts.

In contrast, the observation of low scores in drawings of sections with high structural complexity, such as the ovary and stomach wall, revealed difficulties in accurately and completely conveying histological details. This situation indicates that as structural complexity increases in histology, cognitive load also increases, which can negatively affect drawing accuracy. Marriott and Torres (2019) state that students may struggle with selection, discrimination, and concentration skills in histological sections with increased structural complexity, and that this limits the accuracy of drawings. Similarly, Ormancı and Balım (2016) found that teacher candidates showed limited performance in reflecting the spatial relationships of cellular structures. On the other hand, Ezin and colleagues (2019) reported that drawing applications based on visual arts, conducted as part of an atlas study on chicken embryos, improved students' observation and drawing skills and enabled them to accurately depict cell morphology in a more proportionate, detailed, and morphologically differentiated manner. When these findings are evaluated together, it is understood that drawing-based applications make an important pedagogical contribution to developing both students' observation skills and their ability to accurately convey histological details.

The low overall success rate in labeling indicates that teacher candidates are unable to sufficiently meet the criteria established by the rubric in terms of instructional clarity and terminological accuracy. The literature addresses this situation as a persistent problem area in histology teaching. García and colleagues (2019) emphasize that interpreting microscopic images and labeling them with the correct terminology is one of the most challenging aspects of histology learning for students. Similarly, studies examining drawing-based applications in histology laboratories have also indicated that deficiencies in labeling and naming have a limiting effect on students' conceptual understanding and learning outcomes (Güneş & Demir Kaçan, 2016; Nugraha, 2018). In this context, the relatively low performance of the labeling dimension in the current study is consistent with findings reported in the literature and illustrates the importance of terminological support and instructional guidance. Prospective teachers' drawings generally performed adequately in the contrast and spatial arrangement dimensions. In particular, the drawings of the stomach wall and arteries provided strong examples in terms of highlighting histological details and scaling appropriate for microscopic magnification. In contrast, some drawings were found to lack sufficient detail and to have shortcomings in terms of proportion and scaling. This situation reveals that teacher candidates' skills in visual emphasis and drawing to a microscopic scale are developing; however, these skills were not consistently demonstrated in all examples. However, it has been determined that teacher candidates experience difficulties in the technical components of microscope use, particularly in focusing and structure identification. This finding is consistent with the study by Gül and Köse (2019), which reported skill deficiencies in microscope use. When evaluated in terms of drawing techniques, scale, proportion, detailing, and labeling elements were found to be the fundamental factors determining drawing accuracy. Tarnus and colleagues (2017) state that scaling errors in student drawings lead to inconsistent size depictions and misrepresentation of structural relationships. In this context, proportionality and scale emerge as critical elements in the accurate representation of structural relationships between tissues.

The literature also highlights the positive effects of reconstructing microscopic images through drawing on learning. Cogdell and colleagues (2012) found that drawing microscopic photographs significantly improved students' academic achievement; Çetin and Cengiz (2021), in their study with science teacher candidates, showed that laboratory observations of tissues significantly improved teacher candidates' cell recognition and laboratory skills. In this context, low-cost and low-tech applications such as drawing and modeling have been found to make the learning process more accessible and interactive in biology education, particularly in abstract and visually intensive content such as histology. According to Philp and Smith (2025), such activities reduce the barriers individuals perceive to learning; they support the consolidation and deepening of knowledge through enjoyable, engaging, and repeatable experiences. Similarly, Isaacson and colleagues (2016) note that hands-on activities offered in accessible learning environments increase participation and enable scientific knowledge to reach wider audiences.

However, a lack of art education stands out as one of the main reasons for limitations in the level of understanding histological details. Ezin and colleagues (2019) emphasize that the inadequacy of art-based approaches in biology education makes it difficult to correctly analyze structures in terms of proportion, detail, and spatial relationships. This finding demonstrates that visual arts-based applications offer significant potential for developing students' structural awareness and enabling Overall, the histology drawing rubric used in this study allowed for a multidimensional examination of teacher candidates' drawing accuracy; it revealed that components such as morphological accuracy, contrast, field arrangement, and labeling were related to learning outcomes at different levels. When considered alongside the literature, it is understood that drawing-based assessments are a powerful pedagogical tool in histology education; however, when rubric-based measurement is not supported by systematic instruction, clear guidance, and structured feedback, the accurate transmission of histological details may be limited. In this regard, it can be said that drawing and art-based applications supported by rubrics offer an effective and sustainable learning approach for improving histological observation accuracy and teaching competence.them to analyze histological details more effectively.

In conclusion, this study revealed that science teacher candidates demonstrated varying levels of performance in their drawings of animal tissues in terms of both histological accuracy and artistic expression. The findings show that art-based applications make significant contributions to students' ability to convey microscopic observations, develop structural awareness, and integrate scientific observation skills with artistic expression. However, the process needs to be structured more systematically, and supportive educational applications need to be developed, particularly in areas such as visual planning, aesthetic awareness, and pedagogical clarity. Although art-based histology studies in medicine and health sciences are found in the literature, it is noteworthy that research on the use of visual arts in histology education for undergraduate science students is limited. In this context, incorporating visual arts into the learning process will enrich students' subjective learning experiences and lay the groundwork for them to personally integrate art into science education in the future. Such interdisciplinary applications based on the interaction between art and biology have the potential to offer a more holistic and effective learning experience pedagogically by strengthening students' critical thinking, creativity, and scientific observation skills.

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