Assessing the Effectiveness of 3D-Printed Testes and Ovary Biomodels in Veterinary Reproduction Education: Student-Centered Approach

Alper Koçyigit ■ Erhan Yuksel ■ Ozlem Yuksel

ABSTRACT

The use of biomodels is prevalent across multiple educational disciplines, with a particular emphasis on their utilization in teaching the anatomy of organs. These tools have not only enriched education, but have also provided an alternative to the ethical and cultural controversies, increased costs, and health and safety risks associated with the use of live animals and cadavers. However, while there is limited data on testes and ovary biomodels in the literature, no findings on their effectiveness in education have been reported. Understanding the morphology of testicular and ovarian tissues is vital for veterinarians. This study aimed to investigate the effectiveness of three-dimensional (3D) printed testes and ovary biomodels in veterinary reproduction education and students' perspective on them. To assess their educational effectiveness, biomodels created to align with specific learning objectives were evaluated against slaughterhouse materials. This comparison was carried out on a total of 94 students divided into two groups. A questionnaire containing 19 different judgments was administered to determine students' attitudes toward biomodels. Following the assessments, students reported that they perceived biomodels to be a more advantageous resource than the slaughterhouse materials for their practical training ($\bar{X}$: 3.12). In addition, they strongly ($\bar{X}$: 4.14) expressed their wish to use biomodels in other practical fields of veterinary medicine education. As a result, this study demonstrated for the first time that testes and ovary biomodels can be produced to cover learning objectives in veterinary medicine education. In addition, it was observed that veterinary students supported and demanded the use of these biomodels.

Key words: reproduction, ethics, student health and well-being, instructional, 3D printing, testes biomodel, ovary biomodel

INTRODUCTION

In veterinary medicine education, students need to gain examination and treatment skills in many areas besides theoretical knowledge.[1] Andrology and Gynecology form the basis of reproduction education in veterinary medicine. In order to understanding physiological processes, diagnose and treat infertility cases, as well as utilize reproductive biotechnology, veterinarians must develop a thorough learning of testicular and ovarian tissue morphology. However, the variety of materials used in education plays a decisive role in the quality of learning. Traditional methods of instructing on the morphological structure of the testes and ovaries consist of utilizing atlases, cadaveric and abattoir specimens, and live animal examinations. However, limitations in cadaver procurement due to reasons such as species diversity, risks posed by chemicals used in cadaver preparation,[2] responsibilities during the use of live animals, and ethical debates,[3] make the use of cadavers[4] and live animals[5] controversial beyond being a financial burden. On the other hand, it is reported that cadavers and slaughterhouse materials can cause anxiety in some students.[6–7] In summary, due to ethical and cultural[8] debates and costs and health risks, alternative tools are needed for use in education.[9]

In recent years, numerous studies suggest that the use of models,[10] plastinates,[11] digital content,[12] and biomodels[13–15] may be effective as an alternative to traditional methods in veterinary medicine education. Out of these resources, biomodels stand out as a pioneering tool due to their innovative characteristics. With advances in imaging technologies and graphics processing software, ever-decreasing production costs have accelerated the use of 3D printed models by educators.[16] The use of biomodels is prevalent across multiple disciplines, with a particular emphasis on their utilization in teaching organ anatomy within the health field.[17–18] It has been reported that 3D printed testes biomodel for use in andrology education was produced with high similarity to reference organs.[15] Studies on ovary models are very limited.[19] While there is existing literature on testes and ovary biomodels, there is a lack of studies reporting on their educational efficacy. In our study, we aimed to investigate the effectiveness of 3D printed testes and ovary biomodels in veterinary reproduction education and students' perspective on them. Thus, a student-centered evaluation was conducted to explore the potential of biomodels produced through innovative technologies as an alternative tool for learning.

MATERIALS AND METHODS

This study was carried out in the Biomodel Laboratory of Sivas Cumhuriyet University, Faculty of Veterinary Medicine, Department of Reproduction and Artificial Insemination. The methodology of the study included biomodel production, development and implementation of tests and questionnaires, and statistical evaluation of the data.

Biomodel Production

Biomodel production consists of preparation of reference organs, 3D modeling, processing of data sets and 3D printing. The testes and ovary biomodels in our study were produced with reference to bull testes and bovine ovaries. For this purpose, a total of four testes from two bulls with an average age of 15 months and eight ovaries from four cows of different age groups were obtained from a local slaughterhouse (39°44′43.5″N 37°03′45.1″E). Both antemortem and postmortem examinations did not reveal any pathology in the animals and organs. Testes were brought to the laboratory within 30 minutes postmortem. They were washed with saline at room temperature to remove blood and secretions. Morphometric measurements were then performed.

Biomodel prints were produced referencing the organs for which morphological measurements had been completed in accordance with the methodology described by Kocyigit and Narlicay.[15] In this process, a 3D scanner (Structure Sensor, Occipital Inc, USA) was used to generate the data sets. Stock software was used for 3d scanning (Scanner—Structure SDK) and scanner calibration (Structure Sensor Calibrator). 3D graphics software (ZBrush, Maxon GmbH, Germany) was used to analyze and revise the data sets. Thanks to this software, geometric deviations caused by the 3D scanning process were checked. The redundant data points were removed and uninterrupted mesh was created. The biomodel data sets were transferred to a 3D printer (Raise 3D N2 Plus, Raise, USA) via a slicing program (ideaMaker 4.0.1, Raise, USA). Polylactic acid (Esun Skin PLA+, Shenzhen Esun Industrial Co, China) was chosen as the printing filament. Biomodel printing parameters are given in Table 1.

The printed and measured biomodels were colored with acrylic paint in accordance with the reference organs (Figures 1 and 2).

Evaluation of the Effectiveness of Models through Tests

The study consisted of 94 students who continued their education within the scope of the Veterinary Medicine Intern Training Program (VEHIP) in the Spring Semester of the 2020–2021 Academic Year at Sivas Cumhuriyet University Faculty of Veterinary Medicine. No sample selection was done and the entire population was included in the study. The research was conducted in three steps. In the first step, the knowledge level of the students was determined and scored with a pre-test consisting of four questions about ovary and testis. In the second step, two groups were formed by random selection. The first group was trained on ovary and testis with slaughterhouse material. The second group was trained on ovary and testis with biomodels. At the end of the training, a post-test was administered to determine the level of knowledge of the students. The learning level of the two groups was scored according to the pre-test and post-test data. Subsequently, students in both groups were given the opportunity to examine both the slaughterhouse material and the biomodels. For the ovary, learning objectives were limited to the detection of corpus luteum and dominant follicle structures. The learning objectives for the testis were defined to encompass the identification of the testis and respective locations of epididymis, the different segments of the epididymis, and the path of sperm. The questions used for the test are listed below.

Show the parts of the epididymis on the testes biomodel.

Show the path followed by the sperm on the testes biomodel.

If present, show the dominant follicle on the ovary biomodels.

If present, show the corpus luteum on the ovary biomodels.

Assessment of Student Satisfaction Concerning the Utilization of the Biomodels by Student Groups

In the third step, a questionnaire form was administered to the sample group on a voluntary basis by face-to-face interview technique. Data collection with the questionnaire was carried

Table 1: Printing parameters used in biomodel production

Nozzle	Layer thickness	Overall print speed	Nozzle temperature	Bed temperature
0.4 mm	0.30 mm	300 mm/s	215°C	60°C

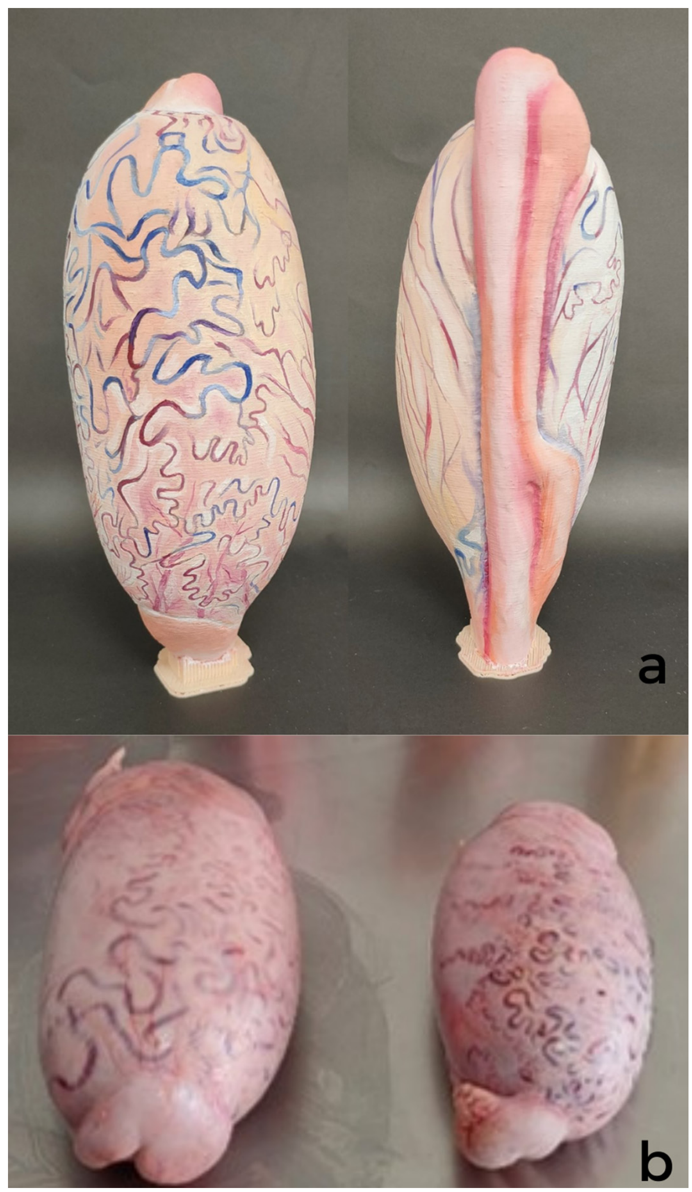

Figure 1: Testes biomodels (a) and reference testes (b)

Figure 2: Ovary biomodels (a) and reference ovaries (b)

out between March 15, 2021 and July 1, 2021. The questionnaire was structured into three distinct sections. The first section focused on gathering demographic data, such as gender, satisfaction with the veterinary faculty, and visual learning capabilities. The second part was designed to address feedback regarding the efficacy of the applied courses and the materials utilized throughout the veterinary medicine program. The third section comprised of 19 statements pertaining to the utilization of slaughterhouse materials and biomodels in the instruction of the testis and ovary. The participants were given following option: *Strongly Disagree* to *Strongly Agree*, to evaluate the judgments in the second and third sections using a 5-point Likert scale. Responses provided by the participants were evaluated based on a scoring system ranging from 1 to 5, corresponding to the options selected. The data obtained were analyzed with program SPSS version 26.

The necessary permissions were obtained from Sivas Cumhuriyet University Animal Experiments Local Ethics Committee (Decision No: 411, History: 12.03.2021).

RESULTS

Upon conducting a chi-square test to examine the relationship between the biomodel and slaughterhouse material groups with respect to the visual learning ability, preference for the veterinary faculty, intended field of study post-graduation, and gender demographics, no statistically significant associations were identified. The frequency distributions of the data obtained from these questions are presented in Table 2.

According to the demographic findings of the participants, it was concluded that almost two-thirds (67%) of the participants were male, almost all of them (89.4%) were satisfied with their preference of veterinary faculty, and almost all of the participating students (93.7%) characterized themselves as *good* and *very good* in terms of visual learning ability (Table 2).

The findings obtained from the questionnaire form, which is the data collection tool, were analyzed by arithmetic mean, median, skewness, kurtosis coefficients, and Kolmogorov–Smirnov test to determine whether the data of the pre-test and post-test levels of the groups using biomodel and

Table 2: Demographic information of the participants

Parameters	Subparameters	*n*/%
Gender	Female	31/33.0
	Male	63/67.0
Satisfaction with the preference of veterinary faculty	Yes	84/89.4
	No	10/10.6
Visual Learning	Not good	1/1.1
	Undecided	5/5.3
	Good	51/54.3
	Very good	37/39.4

n = frequency; % = percentage

slaughterhouse material were normally distributed, and it was found that data did not conform to normal distribution. Therefore, the analyses were continued with non-parametric tests. Regarding organ knowledge, there was statistically significant difference between the pre-test and post-test scores of the training given with both biomodel and slaughterhouse material for testis at 99% confidence level ($z = -8.395$; $p < .001$, $p < .01$). When the rank sums of the difference scores were taken into account, it was determined that these differences were positive ranks, that is, all of the post-test levels were higher than the pre-test levels. In addition, there is a statistically significant difference between the pre-test and post-test scores of the training given with both biomodel and slaughterhouse material for ovary at 99% confidence level ($z = -8.347$; $p < .001$, $p < .01$). When the rank sums of the difference scores were taken into account, it was determined that these differences were positive ranks, that is, all of the post-test levels were higher than the pre-test levels. Related data are presented in Table 3.

In the second part of the questionnaire, a set of questions was administered in which the participants were asked about the degree of agreement with some judgments about the education offered in the veterinary faculty and the materials used in the education. Analysis of the data revealed that students enrolled in the veterinary faculty placed significant importance on visual learning ability and interacting with practical materials during their training. Furthermore, it was observed that these students did not exhibit any reluctance toward handling cadaveric or slaughterhouse materials when studying reproductive organs within applied courses. In addition, many students expressed a desire for biomodels to be incorporated into these applied courses. No statistical significance was found between the answers given to the questions in the set (Table 4).

In the last part of the questionnaire, used as a data collection tool, participants were asked about the degree of agreement with the judgments regarding the testes and ovary biomodels used in reproduction education. The analysis of the collected data revealed that the respondents expressed an advantage for using biomodels of the testes and ovaries over slaughterhouse materials in practical courses. However, despite this preference, the participants felt that working with the slaughterhouse materials was more conducive to learning. In addition, both the testes and ovary biomodels were found to be anatomically equivalent to the slaughterhouse materials. Table 4 presents the data and statistics for all the judgments used for the participants' assessment in this section. No statistical relationship was found between the responses to the statements (Table 5).

DISCUSSION

This study consisted of students attending education of the last semester in the academic year Spring 2020–2021 of Sivas Cumhuriyet University Faculty of Veterinary Medicine, who visited the Department of Fertilization and Artificial Insemination in weekly groups. The sample was randomly grouped as 50 students for training with the slaughterhouse material and 44 students for training with the biomodel. The fact that the number of students is not equal in both sample groups of the study does not constitute a statistical handicap. However, this situation can be counted among the limitations of the research.

In the demographic findings of the study, almost two-thirds of the senior students were male (Table 2). It can be said that these findings are in line with the results on gender distribution in similar studies. Başağaç et al.[20] highlighted that even though there has been a growth in the number of women pursuing a career in veterinary medicine over time, the higher number of male students may be attributed to the fact that the veterinary field in Turkey has traditionally been viewed as a profession mainly dominated by men. On the other hand, no correlation was found between gender and the perception on the use of biomodels.

In the study, it was observed that almost all of the participants answered *Yes* to the question about satisfaction with choosing the veterinary faculty (Table 2). In another study, conducted on students at Kafkas and Adnan Menderes University's Faculty of Veterinary Medicine, a significant majority (86.9%) of the students expressed a voluntary preference for pursuing their studies in the veterinary faculty.[21] Özen et al.[22] emphasized that despite noticing that veterinarians and veterinary students lacked adequate knowledge about the profession during the stage of making their career choice, the fact that the student participants included the veterinary faculty as their top preference in the order of options suggests that they are beginning to make an informed decision. In the light of these findings, it could be argued that there has been a recent increase in awareness among students who choose to study at veterinary faculties in Turkey and that these students are continuing their education and training with enthusiasm, indicating their satisfaction with their decision.

In this study, it was concluded that the education about the anatomy and physiology of organs given with both biomodel and slaughterhouse material made a difference in the post-test levels of the students, all of which were higher than the pre-test levels, and that this difference was statistically significant at 99% confidence level ($p < .01$) (Table 3). Based on this perspective, it can be inferred that the training provided in the study using both the biomodel and slaughterhouse materials was effective in teaching about the ovary and testis. In other words, it can be concluded that the use of ovary and testes biomodels is equally effective as the use of slaughterhouse material for learning purposes. These results were similar to those of cardiac models[23] testes biomodels[15] and bronchial models[24] which are innovative alternatives in veterinary medicine education. At the beginning of the targeted learning outcomes for testicular biomodels were the differentiation of testicular epididymis tissues and understanding the path of the sperm. These outputs are targeted because they are of critical importance

Table 3: Wilcoxon signed-rank test results for the differences of testis and ovary knowledge groups according to pre-test and post-test levels

		Measurement	*N*	Row mean	Row total	*Z*	*p*
Organ	Testis	Negative raw	0[a]	.00	.00	-6.166	**.000****
		Positive rank	50[b]	25.50	1275.00		
		Equal	0[c]				
	Ovary	Negative raw	0[d]	.00	.00	-6.044	**.000****
		Positive rank	48[e]	24.50	1176.00		
		Equal	2[f]				
		****p < .01, testis pre-test mean = 28.90, testis post-test mean = 93.80, ovary pre-test mean = 20.10, ovary post-test mean = 83.40**					
		Measurement	*N*	**Row mean**	**Row total**	*Z*	*p*
Model	Testis	Negative raw	0[a]	.00	.00	-5.739	**.000****
		Positive rank	43[b]	22.00	946.00		
		Equal	1[c]				
	Ovary	Negative raw	0[d]	.00	.00	-5.791	**.000****
		Positive rank	44[e]	22.50	990.00		
		Equal	0[f]				
		****p < 0.01, testis pre-test mean = 20.45, testis post-test mean = 90.45, ovary pre-test mean = 9.32, ovary post-test mean = 70.00**					
		Measurement	*N*	**Row mean**	**Row total**	*Z*	*p*
General	Testis	Negative raw	0[a]	.00	.00	-8.395	**.000****
		Positive rank	93[b]	47.00	4371.00		
		Equal	1[c]				
	Ovary	Negative raw	0[d]	.00	.00	-8.347	**.000****
		Positive rank	92[e]	46.50	4278.00		
		Equal	2[f]				
		****p < .01, testis pre-test mean = 24.95, testis post-test mean = 92.23, ovary pre-test mean = 15.05, ovary post-test mean = 77.13**					

[a]Testis post-test < testis pre-test
[b]Testis post-test > testis pre-test
[c]Testis post-test = testis pre-test
[d]Ovary post-test < ovary pre-test
[e]Ovary post-test > ovary pre-test
[f]Ovary post-test = ovary pre-test
Z: test statistical value

in the diagnosis of testicular pathologies and disorders that affect sperm quality. On the other hand, learning outcomes for ovarian biomodels were determined to distinguish functional structures on the ovarian surface. On the other hand, learning outcomes for ovarian biomodels were determined to distinguish functional structures on the ovarian surface. As it is known, these structures are important findings showing the sexual cycle period of the animal. Significant differences between test scores showed us that the biomodels provided an acceptable level of learning. The fact that the pre-test scores of the students at this level remained <50% for both organs (testis 20.45% and ovary 9.32%) strikingly indicates that the current classical education is limited to the theoretical level.

Considering that almost all of the participants (93.7%) in the survey assessing visual learning ability rated themselves as either *good* or *very good* (Table 2) and showed a positive opinion ($\bar{X}$:4,77) to the statement "I think the capacity for visual learning holds significant importance within the context of veterinary medicine education" (Table 4), the success achieved in both groups during training could be attributed to the significance of visual learning ability in education and the high level of this characteristic among students.

Table 4: Answers to some judgments about the education offered by the Faculty of Veterinary Medicine and the materials used in education

Judgments		Strongly disagree	Disagree	Undecided	I agree.	Strongly agree	$\bar{X}$	S.S.
I am satisfied with the veterinary medicine education offered by the faculty	*n*	11	25	34	23	1	2.77	.988
	%	11.7	26.6	36.2	24.5	1.1		
I think the instructional materials employed in our education offer an adequate level of diversity	*n*	19	30	23	20	2	2.53	1.104
	%	20.2	31.9	24.5	21.3	2.1		
I think the capacity for visual learning holds significant importance within the context of veterinary medicine education	*n*	2	-	1	12	79	**4.77**	.679
	%	2.1	-	1.1	12.8	84.0		
It is crucial to physically interact with the materials during applied courses	*n*	1	-	1	9	83	4.83	.580
	%	1.1	-	1.1	9.6	88.3		
I hesitate to touch the cadaver/slaughterhouse material when learning reproductive organs in the practical lessons	*n*	63	23	3	3	2	1.49	.877
	%	67.0	24.5	3.2	3.2	2.1		
I am interested in seeing the integration of biomodels in other areas of practical veterinary medicine education	*n*	4	5	11	28	46	4.14	1.093
	%	4,3	5,3	11,7	29,8	48,9		
Cronbach's alpha = 0.562								

$\bar{X}$ = arithmetic mean; S.S. = standard deviation

In the study, veterinary faculty students were not satisfied with the education offered by the faculty ($\bar{X}$:2.77) and the diversity of course materials used in education ($\bar{X}$:2.53) (Table 4). It can be said that these results are in line with those reported by Özen et al. in which both veterinarians and veterinary faculty students found the education offered by veterinary faculties in Turkey inefficient and emphasized the inadequacy of practical training as the weakness of education.[22]

Considering the results ($\bar{X}$: 4.14) that education with the biomodel group is effective and that students demand the use of biomodels in applied courses, it can be argued that the use of biomodels in testes and ovary training may improve the quality of education in veterinary faculties and contribute to the variety of materials used. Despite the participants' opinions that testes and ovary biomodels were not superior than both slaughterhouse material and live animals ($\bar{X} \leq 3$), they reported that these biomodels were more advantageous than slaughterhouse material ($\bar{X}$: 3.12) (Table 4). Furthermore, in another question of the survey, it was evident that the students expressed a strong preference for the utilization of biomodels in other practical aspects of veterinary medicine education ($\bar{X}$: 4,14). However, it was also noted that the students believed that working with slaughterhouse material was more beneficial for learning, despite recognizing the advantages of using testes and ovary biomodels ($\bar{X}$: 3.71) (Table 4).

Although the literature has documented studies in which being exposed to cadavers can increase anxiety levels among students and even discourage them from attending practical lessons,[8–25] the students in the current study reported that they did not feel uncomfortable while handling the slaughterhouse material and were not bothered by its smell, texture, or appearance (Table 4). Similarly, in a study conducted by Küçükaslan et al., the students had the opinion that they were not uncomfortable with the use of cadaver material in the anatomy courses in the veterinary faculty curriculum.[7] One could suggest that the participants' positive views on the use of cadavers in the study may be attributed to the fact that they are in the final semester of their veterinary education and have been exposed to cadavers' multiple times during their studies. They may have come to accept that they will encounter cadavers regularly in their future careers and have become accustomed to the situation. Again, the students' disagreement with the statements "It is a more ethical approach to use testes and ovary biomodels instead of live animals in education" ($\bar{X}$: 2.78) and "I am disturbed by the idea that the slaughterhouse material belongs to a previously living animal" ($\bar{X}$: 1.62) suggest that despite the numerous benefits associated with the use of biomodels in veterinary education and its alignment with ethical principles,[26] the use of cadavers remains prevalent in veterinary faculties, indicating a lack of awareness of ethical codes concerning this issue.

In the study, it was concluded that veterinary faculty students had the opinion that both testes and ovary biomodels were identical to the slaughterhouse material in terms of anatomical formations and appearance (Table 4). However, they disagreed on the face that testes and ovary biomodels were indistinguishable from slaughterhouse material in terms of tactile sensation. This may be explained by the fact that veterinary faculty students are accustomed to the tactile sensation in the slaughterhouse material, as well as the different morphological structure of ovaries, especially in different cycle periods. The biomodel design process in the study aimed solely at facilitating the visual understanding and recognition of organs and their structures. From this point of view, it can be argued that in both testes and ovary biomodel printing, attention should be given to the choice of filament in order to obtain a sense of touch similar to the slaughterhouse material, the data processing stage should be developed to reflect different cyclic

Table 5: Responses to the judgments about testes and ovary biomodels

Judgments		Strongly disagree	Disagree	Undecided	I agree	Strongly agree	$\overline{X}$	S.S.
Testes biomodels present more effective tool for learning than slaughterhouse material	*n*	5	34	27	26	2	2.85	.961
	%	5.3	36.2	28.7	27.7	2.1		
Testes biomodels present more effective tool for learning than live animal material	*n*	6	34	30	21	3	2.80	.968
	%	6.4	36.2	31.9	22.3	3.2		
Ovary biomodels present more effective tool for learning than slaughterhouse material	*n*	9	34	29	20	2	2.70	.982
	%	9.6	36.2	30.9	21.3	2.1		
Ovary biomodels present more effective tool for learning than live animal material	*n*	8	32	31	19	4	2.78	1.007
	%	8.5	34.0	33.0	20.2	4.3		
Testes and ovary biomodels are more advantageous than slaughterhouse material for applied courses	*N*	4	29	22	30	9	3.12	1.086
	%	4.3	30.9	23.4	31.9	9.6		
It is more ethical to use testes and ovary biomodels instead of live animals in education	*n*	11	36	18	21	8	2.78	1.175
	%	11.7	38.3	19.1	22.3	8.5		
It is more ethical to use testes and ovary biomodels instead of slaughterhouse material in education	*n*	14	38	14	21	7	2.67	1.195
	%	14.9	40.4	14.9	22.3	7.4		
Despite the advantages of testes and ovary biomodels, interacting with slaughterhouse material is more effective for learning	*n*	5	8	16	45	20	3.71	1.064
	%	5.3	8.5	17.0	47.9	21.3		
I am disturbed by the odor when handling slaughterhouse material	*n*	33	28	8	20	5	2.32	1.297
	%	35.1	29.8	8.5	21.3	5.3		
I feel uncomfortable with the texture when handling slaughterhouse material	*n*	44	43	3	2	1	1,63	,749
	%	47,3	46,2	3,2	2,1	1,1		
I am uncomfortable with the appearance of slaughterhouse material when handling it	*n*	43	44	4	2	1	1.66	.756
	%	45.7	46.8	4.3	2.1	1.1		
I am disturbed by the idea that the slaughterhouse material belongs to a previously living animal	*n*	51	33	6	3	1	1.62	.831
	%	54.3	35.1	6.4	3.2	1.1		
Testes biomodel is identical to slaughterhouse material in terms of tactile sensation	*n*	32	29	18	13	2	2.19	1.119
	%	34.0	30.9	19.1	13.8	2.1		
Testes biomodel is identical to slaughterhouse material in terms of anatomical formations	*n*	7	16	17	42	12	**3.38**	1.137
	%	7.4	17.0	18.1	44.7	12.8		
Testes biomodel is identical in appearance to the slaughterhouse material	*n*	7	14	14	42	17	3.51	1.171
	%	7.4	14.9	14.9	44.7	18.1		
Ovary biomodel is identical to slaughterhouse material in terms of tactile sensation	*n*	29	39	12	13	1	2.13	1.039
	%	30.9	41.5	12.8	13.8	1.1		
Ovary biomodel is identical to slaughterhouse material in terms of anatomical formations	*n*	12	19	18	36	9	3.12	1.217
	%	12.8	20.2	19.1	38.3	9.6		
Ovary biomodel is identical in appearance to slaughterhouse material	*n*	11	22	19	31	11	3.10	1.228
	%	11.7	23.4	20.2	33.0	11.7		
Cronbach's Alpha = 0.858								

$\overline{X}$ = arithmetic mean; S.S. = standard deviation periods, especially for the ovary, and the coloring should be enriched and 3D printing should be diversified.

In our opinion, the negative views expressed by certain members of the sample group regarding biomodels could be attributed to factors such as being in the final stages of their education, familiarity with live animals or slaughterhouse materials, and a lack of ethical awareness regarding alternative educational practices. This situation also shows that alternative and innovative educational tools should be made available to students at earlier stages. It can be said that these negative views can be eliminated in the future with the widespread use of biomodels, raising awareness about ethical codes in education, and improving biomodel production processes.

In conclusion, this study demonstrated for the first time that testes and ovary biomodels can be produced to cover learning objectives in veterinary medicine education. It has been observed that veterinary students support and demand the use of these biomodels. We believe that it is important to create and promote the utilization of such and similar biomodels.

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AUTHOR INFORMATION

Alper Koçyigit, DVM, PhD (https://orcid.org/0000-0001-9639-5497), is an Associate Professor, Department of Reproduction and Artificial Insemination, Veterinary Faculty, Ondokuz Mayis University, Samsun 55139, Turkey. Email: vhkalper@gmail.com.

Erhan Yuksel, DVM, PhD (https://orcid.org/0000-0002-0735-0375), is an Assistant Professor, Department of Veterinary History and Deontology, Veterinary Faculty, Sivas Cumhuriyet University, Sivas 58140, Turkey. Email: eyuksel@cumhuriyet.edu.tr.

Ozlem Yuksel, DVM, PhD (https://orcid.org/0000-0003-0635-3256), is an Assistant Professor, Department of Veterinary History and Deontology, Veterinary Faculty, Sivas Cumhuriyet University, Sivas 58140, Turkey. Email: ozlemyuksel@cumhuriyet.edu.tr.