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Student Engagement and Performance Assessment as Associated with Three Types of Integument System Laboratory Activities

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STUDENT ENGAGEMENT AND PERFORMANCE ASSESSMENT AS ASSOCIATED WITH THREE TYPES OF INTEGUMENT SYSTEM LABORATORY ACTIVITIES

By

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ABSTRACT

Students participating in anatomy education, specifically an Anatomy and Physiology classroom, have shown difficulty in learning and retaining information on the various systems of the body. This study sought to assess the benefits of different learning activities associated with student engagement and performance on subsequent examinations regarding the integumentary system. For this study, three different hands-on laboratory activities (i.e., treatments) were given during different laboratory sessions. These hands-on activities included labeling a three-dimensional model, illustrating a model, or building a model of the integumentary system using materials provided. Students then completed a post-laboratory questionnaire regarding their enjoyment of their particular laboratory activity, whether they felt engaged during the activity, and their confidence in the learned material. Results from survey responses found that students felt the most confidence in their ability to visualize the integument system after participating in the build a model treatment. These students also indicated the highest levels of enjoyment out of their laboratory activity. Students in the build a model treatment also achieved the highest mean scores on the laboratory practical. These findings indicate that students' feelings of confidence and enjoyment may correlate with their ability to retain the information presented on the location, identity, and function of parts of the integument system. My results and observations suggest that more hands-on laboratory activities that students find enjoyable may result in higher mean laboratory practical scores in the Human Anatomy and Physiology and other biology laboratories.

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INTRODUCTION

Studies in anatomy education have shown that many college students consider the various systems of the body as simple issues of memorization compared to the real, active learning that should be done through visualization and reasoning (Miller, 2002). These studies are especially true for students taking part in an Anatomy and Physiology classroom along with the concurrent laboratory in many schools across the country.

A challenge in the modern Anatomy and Physiology classroom and laboratory, is how to engage and encourage students about anatomy in order to increase learning, all without relying on simple memorization methods of teaching (Miller, 2002). The engagement and encouragement of students is in jeopardy due to the ever-increasing use of virtual laboratory simulations as well as simple two-dimensional image visualization (Miller, 2002). Visual simulations, two-dimensional image visualization, and simple lectures have shown a decreased level of student engagement as well as decreased long-term learning compared to more interactive engagement methods (Prince, 2004). A qualitative questionnaire study of over 1,300 medical students has shown that students' concentration and engagement during lectures falls steadily after about 15 minutes (Stuart, 1978).

In contrast to these learning methods, a different approach, one more geared towards hands-on activities and demonstrations of teaching termed "active learning" has been broached as a better method for student learning (Prince, 2004). "Active learning" is not so much a set term as an understanding of being anything that requires students to have a more "active,"

engaged and involved part while in the process of working to understanding something in the classroom compared to the usual laboratory style of analyzing microscope slides to learn about different body systems (Bonwell, 1991). A telephone survey in 1997 of 1,000 high school students showed a majority (67%) claimed that more hands-on learning activities would increase their personal learning (Public Agenda, 1997).

One active learning process involves having students illustrate specimens that they are shown in the laboratory to learn the locations of various structures. Students in an Anatomy and Physiology Laboratory who were proven as to having hands-on experience illustrating the specimens presented for learning the integumentary system were shown to have marked increased mean scores compared to students who had not drawn the specimens (Cogdell, 2012). Students who participated in the 2004 study by illustrating to learn had scores that exceeded students that did not draw by values between 5.9% and 18.6% (Cogdell, 2012). Another active learning process involves students using three-dimensional models to enhance learning the identify and spatial relationship of various structures in the body. One study, using third- year Bachelor of Veterinary Medicine students from the Royal Veterinary College, University of London, sought to discover if using a three-dimensional physical model of an equine foot would be more effective in teaching students compared to learning the anatomical information from a textbook (Preece, 2013). This study showed that students who utilized the physical model had significantly higher answers correct (86.39%) compared to students who only had use of textbooks (62.61%) when identifying anatomical structures of the equine foot through magnetic resonance imaging (Preece, 2013).

At the University of Mississippi, the Anatomy and Physiology class is a four-credit course taken by students of whom the majority are attending their second year at the university

(Whitehead, 2022). The majority of these students are enrolled in a major in which a passing grade in Human Anatomy and Physiology I (Bisc 206) is a degree requirement (UM Catalog Fall 2021-2022). Students in the course are pursuing majors that range over several differing fields of science, including several in the allied health fields such as Nursing, Allied Health Studies, and Exercise Science (Hillhouse, 2017). The three-hour lecture for the course of Human Anatomy and Physiology includes instruction on the cells, tissues, integumentary, skeletal, muscular, and nervous systems within the human body. The two-hour laboratory coinciding with this course incorporates anatomical structure examinations using a variety of different methods including "models, imagery, dissected specimens, and computer simulations" (UM Catalog, Fall 2021-2022).

This research project proposed to investigate the differing techniques used in the Anatomy and Physiology laboratory to assess if more hands-on and engaging learning activities when studying the integumentary system would result in increased scores in both the laboratory practical as well as the lecture examinations for questions on the integumentary system. My hypothesis is that increased feelings of engagement in the laboratory setting will be positively correlated with improved performance demonstrated on integumentary system questions in the laboratory and lecture examinations. This research study will prove invaluable in contributing to the informing of educators on the effects that hands-on learning has on both student engagement and performance.

MATERIALS AND METHODS

Course Description

The Human Anatomy and Physiology I (Bisc 206) four credit course entails in part, learning the integumentary system through both a three-hour lecture as well as a two-hour laboratory lesson. Human Anatomy and Physiology I is the first semester of a two-semester sequence; where passing with a grade of C or above is required to move onto the next section, Human Anatomy and Physiology II (Bisc 207). Passing this course is a degree requirement for many pursuing a degree in the allied health fields.

Participant Information

The two hundred and ninety-six undergraduate students enrolled in Human Anatomy and Physiology I (Bisc 206) at the University of Mississippi were invited to participate in my study for the Fall 2021 semester. This experiment is approved under the Institutional Review Board protocol number 21x-260 and has been exempt under 45 CFR 46.101 (b)(#1) at the University of Mississippi. All students were informed that participation was voluntary, but that participation would result in compensation in the form of extra credit being awarded to them in the classroom. Students confirmed before beginning the survey that they were over the age of eighteen and that they agreed for their scores regarding the integumentary system for both the lecture examinations and laboratory practicals to be released to the principal investigator for use in the study. Two hundred and thirty-five students enrolled in the Human Anatomy and Physiology course agreed to participate in the survey and to have their de-identified scores used in the data collection.

Data Collection

The experiment was conducted in conjunction with the integumentary section of the laboratory lesson, one-third of this laboratory session topics correlated with bone tissues and two-thirds correlated with the integumentary system. Survey participation and the later grade release to the principal investigator was explained as being voluntary for all students attending the laboratory session. After completion of the consent forms, seating sign-in sheets were distributed for use in de-identifying scores in both laboratory and lecture. These seat numbers with student names were used to link survey responses to consent forms, as well as to later link survey responses to laboratory practicals and lesson examination scores.

The pre-laboratory survey (Appendix A) consisted of two questions used to gauge prior knowledge and experience regarding the integumentary system and its components. Answers to these survey questions were used to determine if there was an effect on examination or practical scoring due to prior knowledge. Two pre-laboratory survey questions were also asked regarding students' preference for types of hands-on learning activities. These survey questions were used for reference to whether their preference had effect on later examination and practical scores. This pre-laboratory survey was delivered on paper, without the students having prior knowledge of which hands-on learning activity they would later be participating in for the next step of the laboratory integument lesson.

Experimental Protocol

After completion of the pre-laboratory survey, students were given a worksheet to be completed in their lab group that pertained to the integument experiment. Laboratory sessions were divided into three separate groups depending upon which day the student's laboratory

section fell (Tuesday, Wednesday, Thursday). These laboratory days dictated which type of hands-on learning activity that would be given to each section. These learning activities varied from labeling an integumentary system model (Tuesday), illustrating a given model (Wednesday), and lastly building a model (Thursday), all using a given list of structures that students were required to know the function of, describe, and label for their given activity.

Labeling a Model treatment

This activity was conducted on Tuesday September 21, 2021, and consisted of four lab sections, each lasting two hours with a lab at 11 AM, 1 PM, 3 PM, with the last lab beginning at 5 PM. Labeling a Model Treatment consisted of requiring the laboratory students to label a three-dimensional model of the integumentary system by following the worksheet labeled "Day 1 In Class Activity Label a Model Worksheet" (Appendix B). The last page of the worksheet provided examples of three-dimensional models that students could see when performing their laboratory in class activity.

Illustrate a Model Treatment

The second activity was conducted on the Wednesday, September 22, 2021, which included three lab sections (11 AM, 1 PM, and 3 PM). The Illustrate a Model Treatment consisted of requiring the laboratory students to illustrate a model of the integumentary system following the worksheet labeled "Day 2 In Class Activity Illustrate a Model Worksheet" (Appendix C). While this activity was being conducted, some photographs were taken of students completing the worksheet and in class activity (Fig. 1A, 1B).

Build a Model Treatment

The third activity was conducted on Thursday, September 23, 2021, and included three laboratory sections (11 AM, 1 PM, and 3 PM). The Build a Model Treatment consisted of requiring the laboratory students to build a model of the integumentary system following the worksheet labeled "Day 3 In Class Activity Build a Model Worksheet" (Appendix D). Students were provided with a box of various materials such as construction paper, yarn, felt, pipe cleaners, etc. as shown in the list provided in Appendix D. Students were also provided with physical examples of already completed three-dimensional models constructed by the primary investigator before the laboratory lesson (Fig. 2A, 2B). Photographs were taken of students while the trials were being conducted as well as photos of the completed models (Fig.3A, 3B).

Experiment worksheets, illustrations, models, and photos were able to be taken home and used for study resources if the student desired. After completion of the laboratory activity, a post-laboratory survey (Appendix E) was distributed to participating students. This survey consisted of five Likert-style questions asking students to range a question on a scale from strongly agree (1) to strongly disagree (5). Three of these questions pertained to student confidence in identifying and visualizing the anatomy and structures of the integument system after the laboratory activity. The last two questions pertained to student's enjoyment of the activity and their feeling of overall engagement while the activity was taking place.

Two assessments were given that included questions on the integumentary system. The hands-on laboratory practical involved fifty, two-point questions, with five of those questions relating to the integumentary system. The laboratory practical was given in a free response format, required students to write down answers in blank spaces. These practicals were then manually graded with two points given for a completely correct answer, and one point given for

misspellings or similar responses given to the correct answer. A total of ten possible points were able to be awarded for the integumentary system questions on the laboratory practical. The lecture examination given involved forty-five questions in a multiple-choice format with answers A through E. Sixteen of those questions were related to the integumentary system and credit was given in an all-or-nothing format.

Analytical Methods

On the pre-laboratory survey, students were divided into those who had indicated a preference for their lab sections' actual activity. These preferences will then be compared to which ranking they assigned their actual lab sections' integumentary system activity and whether that preference had any preceding effect on their post-laboratory survey answers towards Likert scale rankings of personal feelings of engagement during the laboratory activity. Students who did not answer the pre-laboratory or the post-laboratory surveys while giving consent were not included into the statistical analysis.

Descriptive statistics for all response variables were calculated prior to performing all analysis. A two-way analysis of variance, with laboratory activity and time of day as independent variables, was used to analyze data for significant effects on response variables. With the level of significance set at $\alpha = 0.05$. Effect size for all significance results was estimated using the partial Eta value calculation. All statistical procedures were conducted using SPSSV27 software licensed to the University of Mississippi.

RESULTS

Pre-Laboratory Survey Data

Of the 265 Anatomy and Physiology students who agreed to participate in this research study, 57%, reported that they did not have previous experience in labeling the integumentary system. In a pre-laboratory survey using the five-point Likert Scale (1 = strongly agree, 5 = strongly disagree), 104 of these students reported "agree" while only 61 students reported "disagree" towards the question of whether they were "able to label the majority of the integumentary system" (Fig. 4).

Using the analysis of variance, it was shown that students in differing laboratory times (11 AM, 1 PM, 3 PM) showed significant differences in their assessment on whether or not they were able to label the integumentary system before knowing their specific laboratory exercise, with the 3 PM laboratory time having the majority of students indicate between "agree" and "indifferent", while the 11 AM laboratory time mostly indicated "indifferent" and the 1 PM laboratory students mostly indicated between "indifferent" and "disagree" ($F = 8.018$, $df = 2,190$, $P < 0.001$, partial Eta = 0.078; Fig. 5). This data also showed a significant difference when linked to the covariant of whether these students had labeled the integumentary system before ($F = 24.503$, $df = 1,190$, $P < 0.001$, partial Eta = 0.114).

Activity Preference

Students were asked to indicate any preference toward laboratory activities. For the 167 responses in the labeling laboratory activity, the largest preference indicated was toward labeling (43%), followed by illustrating activities with drawing and coloring combined (33%); building

(11%), with listing with the least preference (10%) (Fig. 6). For the 128 responses in the illustrating laboratory activity, the largest preference indicated was for labeling (40%); followed by illustrating (36%); listing (12%); with building having the least preference (9%) (Fig. 7). For the 127 responses for the building laboratory activity, the largest preference indicated was toward illustrating (42%); followed by labeling (38%); building (11%); with listing having the least preference indicated by students (7%) (Fig. 8).

Post-Laboratory Survey Data

Student Confidence

When students were asked if they were confident in their ability to visualize the anatomy of the integumentary system, there was a significant difference in the answers between laboratory activities (label, illustrate, build). Most of the students in the label and illustrate laboratory sections were agreeing or feeling neutral in their visualization abilities, while students in the build laboratory section mostly chose "agree" when asked about their confidence in visualization ($F = 3.164$, df = 2,173, $P = 0.045$, partial Eta = 0.035; Fig. 9). Student confidence in their ability to identify structures of the integumentary system was significant only in conjunction with the co-variant of the student having previous experience with labeling the integumentary system ($F = 11.267$; df = 1,173, partial Eta = 0.061; $P < 0.001$). There was a majority of students who responded to the post-laboratory question one "I am confident in my ability to identify the functions of the anatomical structures in the integument system" with an answer of "agree" (Fig. 10). This same post-laboratory question also had significance shown regarding the covariant of students having previous experience in labeling the integumentary system ($F = 5.294$; df = 1,142; $P = 0.023$, partial Eta = 0.036). There was a majority of students who responded to the post-laboratory question two "I am confident in my ability to mentally

visualize the anatomy of the integument system in three dimensions" with an answer of "agree" (Fig. 11).

Student Enjoyment and Engagement

When students were asked if they enjoyed doing this activity, significant differences were found in the responses between the different laboratory activities, with mostly "agree" being indicated by the build laboratory section, followed by the illustrate laboratory section, with the label laboratory section falling between "agree" and "indifferent" ($F = 3.634$, $df = 2,173$, $P = 0.028$, partial Eta = 0.040; Fig. 12). There were also significant differences for the covariant variable of the exam one raw score for student enjoyment.

Students were asked in the post-laboratory survey if they felt engaged during their laboratory activity. Significant differences were found between the differing laboratory times, with students in the 1 PM laboratory indicating mostly "strongly agree" and "agree", followed by students in the 11 AM laboratory strongly indicating "agree". This was followed by a less strong indication of "agree" by the 3 PM laboratory students ($F = 3.274$, $df = 2,172$, $P = 0.040$, partial Eta = 0.037; Fig. 13).

Graded Assessments

The scores for the integument in-class activity showed significant differences between the differing laboratory meeting times, with the 11 AM laboratory having the highest mean followed by the 3 PM laboratory, with the 1 PM laboratory scoring the lowest for the in-class activity ($F = 5.079$, $df = 2,193$, $P = 0.007$, partial Eta = 0.050; Fig. 14). This same activity showed significant differences between the laboratory meeting times in concert with the differing laboratory activities ($F = 5.881$, $df = 4,193$, $P < 0.001$, partial Eta = 0.109; Fig. 15). The 11 AM label laboratory section scored the highest on the in-class integument activity, followed by the 3

PM label laboratory section (F = 5.881, df = 4,193, P < 0.001, partial Eta = 0.109; Fig. 15). The 1 PM label laboratory section followed by the 3 PM illustrate laboratory section had the lowest mean score on the in-class integumentary system activity (F = 5.881, df = 4,193, P < 0.001, partial Eta = 0.109; Fig. 15). The exam one raw data covariant for this variable was also shown to have a significant decrease compared to the mean scores of the 11 AM laboratory time and a significant increase compared to the 1 PM laboratory time (F = 13.702, df = 1,193, P < 0.001, partial Eta = 0.066). The exam 1 raw data covariant for the in-class activity scores had a similar mean score (8.53) compared to the mean score of the 3 PM laboratory time (F = 13.702, df = 1,193, P < 0.001, partial Eta = 0.066). The scores for the second exam including only integumentary questions showed no significant differences between the laboratory meeting times or the laboratory activities. There was a significant decrease of almost four percentage points in the exam two integument system only question average score of 56.97 percent correct when comparing with the exam one raw data covariant of 60.94 percent correct (F = 150.949, df = 1,192, P < 0.001, partial Eta = 0.440).

The laboratory practical scores including only integumentary questions showed significant differences between the laboratory activities, with the build laboratory section achieving the highest scores, followed closely by the illustrate laboratory section, with the label laboratory section having the lowest scores (F = 7.439, df = 2,192, P < 0.001, partial Eta = 0.072). There were also significant differences between the scores when compared with the exam one raw data covariant, showing that there was a correlation between exam one raw data and scores for the laboratory practical (F = 55.356, df = 1,192, P < 0.001, partial Eta = 0.224; Fig. 16).

DISCUSSION

Looking at the scoring between the differing laboratory activities as well as the differing student responses for pre-laboratory and post-laboratory questions regarding preference, confidence, enjoyment, and engagement, there are clear factors that are important for student learning in an Anatomy and Physiology laboratory, which can then be applied to other learning laboratories. The surveys given to students sought to determine if there was a correlation between a students' confidence level towards identifying structures and functions of the integumentary system with the levels of student enjoyment reported due to the differing type of laboratory activities presented to the students. This information was then examined for correlation between confidence levels and enjoyment to later laboratory practical data along with exam data regarding the integumentary system. The differences between student preferences for the differing learning activities will also be discussed along with possible correlation between preference and students' feelings of engagement along with later relation with students' laboratory practical and examination scores.

Student Preferences

In the pre-laboratory survey, students were able to indicate preference for more than one type of hands-on learning activity (label, build, draw, color, list) without knowing the type of laboratory activity that they would be participating in later. From this survey, students were shown to have a clear preference towards labeling a model over other forms of laboratory

activities for exploring the integumentary system. Students in the label a model treatment, showed a majority (43%) preference towards their own, unknown at the time, laboratory activity (Fig.4). Students in the label a model treatment indicated a similar preference toward labeling (40%) and illustrating (draw and color) at 36% (Fig. 4, 5). Students in the build a model treatment indicated very little preference toward their own, unknown at the time, activity. With only 11% indicating a preference for this type of hands-on learning activity (Fig.6).

Post-Laboratory Survey Data

Having student use the five-point Likert Scale to report if they were feeling confident in their ability to visualize the integument system, the data from the post-laboratory survey suggests that there was a significant difference between the mean values of the student responses for their level of confidence that correlated with their laboratory activities. A lower mean value indicated stronger feelings of confidence in a students' ability to visualize the anatomy of the integumentary system in three dimensions. The three differing laboratory activities had relatively low mean categorical survey responses, which coincided with many students in the label and illustrate laboratories having responses varying mostly between "agree" and "indifferent" while the build laboratories mostly responded with "agree" in their confidence levels towards identifying anatomy of the integumentary system. The mean values of the student responses indicated that after their laboratory activity, the build a model treatment had the highest confidence in their ability to visualize the integument system in three dimensions.

Similar significant differences were indicated for the student responses towards if they "enjoyed the activity used to learn about the integument system." The three differing laboratory activities all had relatively low mean categorical survey responses, this coincided with students in the label and illustrate laboratories having varying responses between "agree" and

"indifferent," while the build laboratory had the majority of students respond with "agree" regarding their feelings of enjoyment for their differing laboratory activities (Fig. 9). These survey responses showed that similar to the feelings of confidence in students' abilities to visualize the integument system in three-dimensions, the majority of students in the build a model treatment also indicated feelings of enjoyment towards their laboratory activity to learn about the integumentary system.

The significant differences found between the differing laboratory activities indicated that students exhibited more confidence in their abilities to visualize the integument system in three dimensions and felt more enjoyment out of building a model of the integument system compared to the illustrate a model and label a model treatment students.

When students were asked if they felt engaged during their differing laboratory activities, there was significant differences in the student responses between the different laboratory meeting times. Students whose laboratory session met at one o'clock in the afternoon were shown to indicate stronger but similar feelings of engagement compared to students in the laboratories that met at eleven o'clock in the morning. Students that met at three o'clock in the afternoon agreed about feeling engaged but had the least indicated feelings compared to the other laboratory times. These results show that students who have a laboratory session in the morning and early afternoon are more likely to feel engaged during their laboratory activities.

Laboratory Practical and Exam Data Scores

The laboratory practical data for only the integumentary questions had significant differences between the mean scores for the differing laboratory activities. The highest mean scores were achieved by students in the build a model laboratory sections. These high scores

indicated that the more enjoyment and engaged a student is feeling during the learning process, the more likely the information is to be remembered and retained for a later date. These higher mean scores were correlated with the feelings of enjoyment students indicated experiencing during their different laboratory activities.

Significant differences were seen between exam one raw data covariant in both laboratory practicals and examination data scores. The exam one raw data covariant is recognized in the fact that higher raw scores for exam one usually correlates with higher scoring individuals regardless of their specific laboratory activity.

Data Applications

While there was little preference given towards building a model as a hands-on learning activity, the students that were required to build a model of the integumentary system during their laboratory reported that they felt the highest levels of confidence in their abilities to visualize the anatomy of the integument system in three-dimensions amongst the students from the different laboratory activities. These same students were also shown as having the highest mean levels of indicated enjoyment from their laboratory activity. These feelings of confidence and enjoyment may correlate to the students' ability to retain the information presented on the location, identity, and function of parts of the integument system. This is indicated in the students in the build a model laboratory sections having the highest mean scores on the laboratory practical. Another study, one done at the Uniformed Services University of the Health Sciences in Bethesda, Maryland with second year medical students, also found that course related enjoyment had a positive effect on student scores for the National Board of Medical Examiner's shelf examinations (Artino, 2010).

Higher levels of engagement as indicated through the differing laboratory meeting times, does not seem to correspond to significantly different scores on either the laboratory practical or the examinations. While there was no significant difference between the laboratory practical mean scores between the differing laboratory times, the laboratory times where students indicated feeling more engaged (11 AM and 1 PM) did have higher mean scores on the laboratory practical compared to the 3 PM laboratory practical mean scores. This is also true for the exam one scores. Although the mean scores were not significantly different, there was a higher mean score for the laboratory times where students indicated feeling more engaged during their laboratory activity. These findings indicate that there may be a correlation between student engagement, scores, and laboratory timing if further studied. An obvious limitation in my study was the lack of Anatomy and Physiology laboratories that began at 8 AM, similar to many other laboratories on University of Mississippi's campus, which could show either higher or lower indications of student engagement earlier in the morning compared to late in the afternoon.

Conclusion

Several experimental studies have shown that students learn and retain information better when feeling more "engaged" with the information they have been given (Miller, 2002; Prince, 2004). I have found through my study that the feeling of "engagement" should be expanded upon when discussed and may be linked more to feelings of enjoyment when it comes to different laboratory activities rather solely focusing on students physically participating in an activity. Students' feelings of enjoyment are linked to "active learning" in that when someone enjoys doing something they are more likely to pay attention to and understand something compared to if they are solely going through the motions of finishing a laboratory session.

While the build a model treatment had the lowest student preference before the laboratory sessions, the build a model treatment also had the highest indicated enjoyment and even student confidence in visualizing structures of the integumentary system in three-dimensions. These high feelings of confidence and enjoyment also corresponded with higher mean laboratory practical scores compared to the other laboratory activity treatments. Through my data collections and observations, it can be proposed that an increase in hands-on, enjoyable laboratory activities in Human Anatomy and Physiology and other biology laboratories could lead to an overall increase in laboratory practical scores for students.

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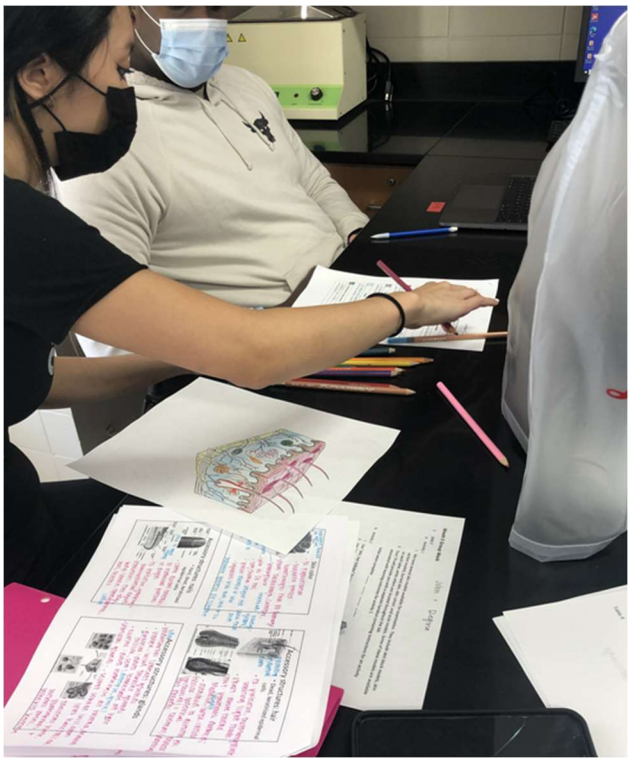


Figure 1A **Figure 1B**

FIGURE 1A, 1B. Photographs taken during Illustrate a Model Treatment

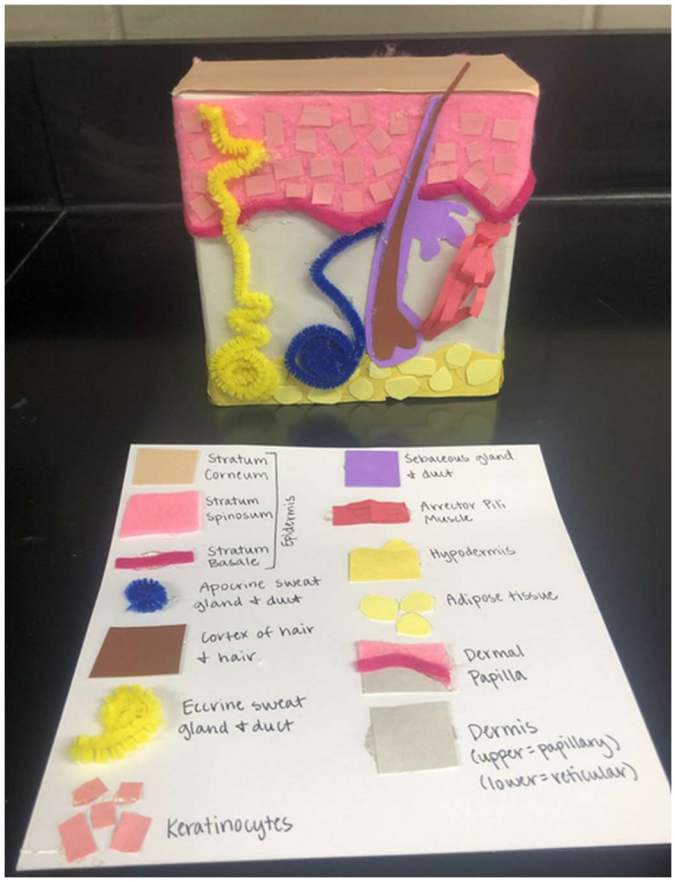


Figure 2A

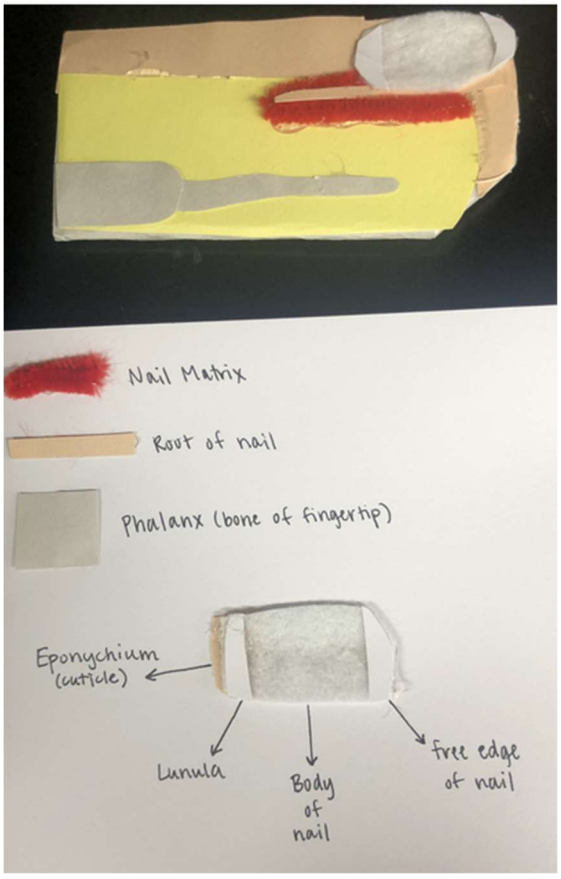


Figure 2B

FIGURE 2A, 2B. Photographs of the sample Build a Model

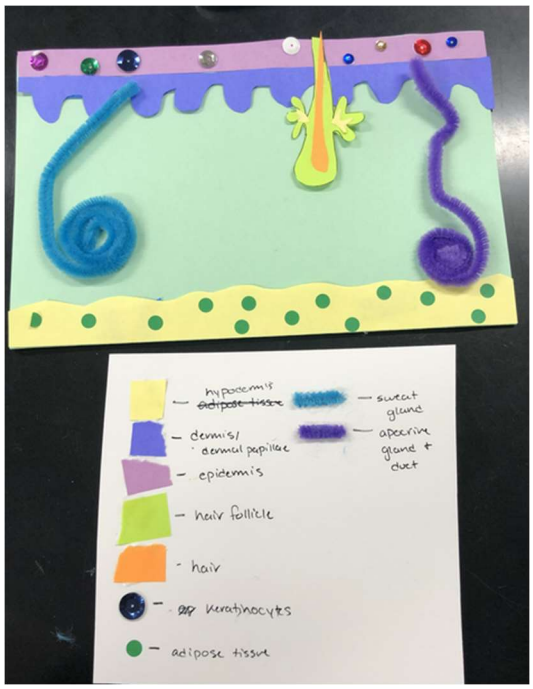


Figure 3A **Figure 3B**

FIGURE 3A, 3B. Photographs taken during Build a Model treatment

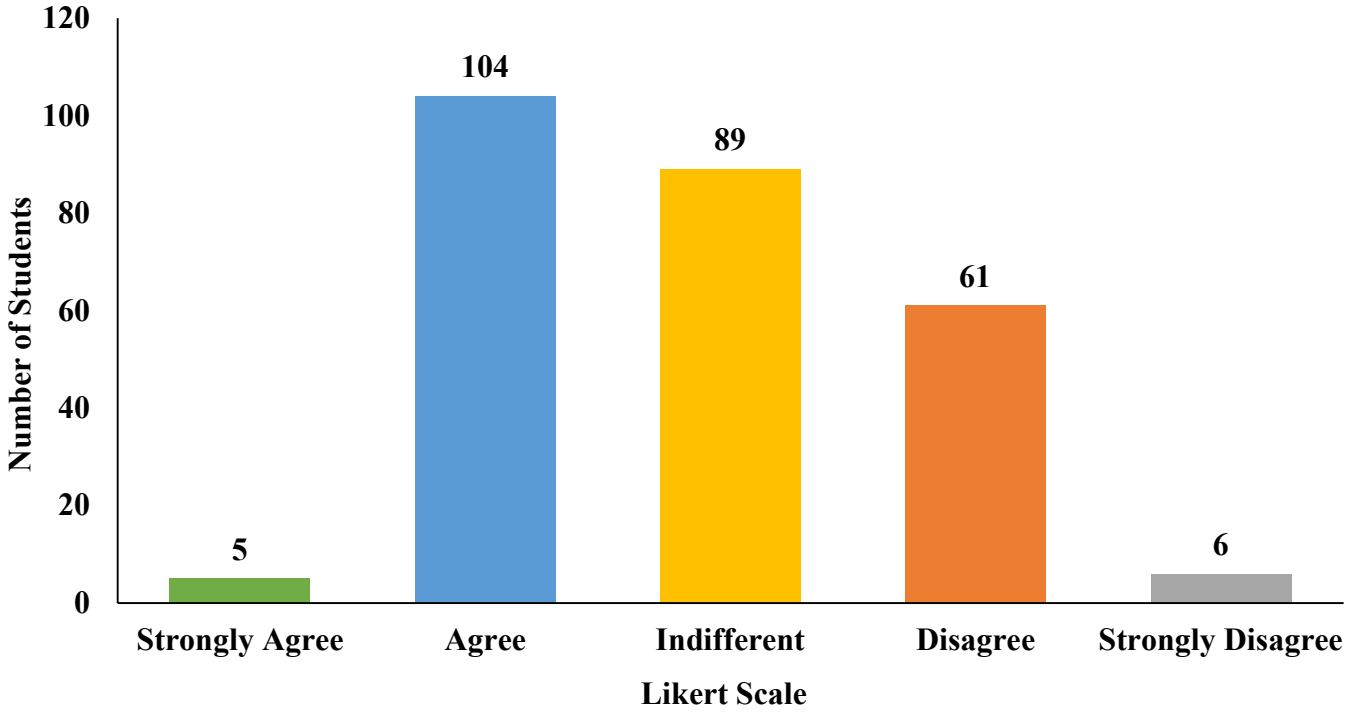


Figure 4: Student responses to Pre-Laboratory Survey Question 1, "I am able to label the majority of the Integumentary System".

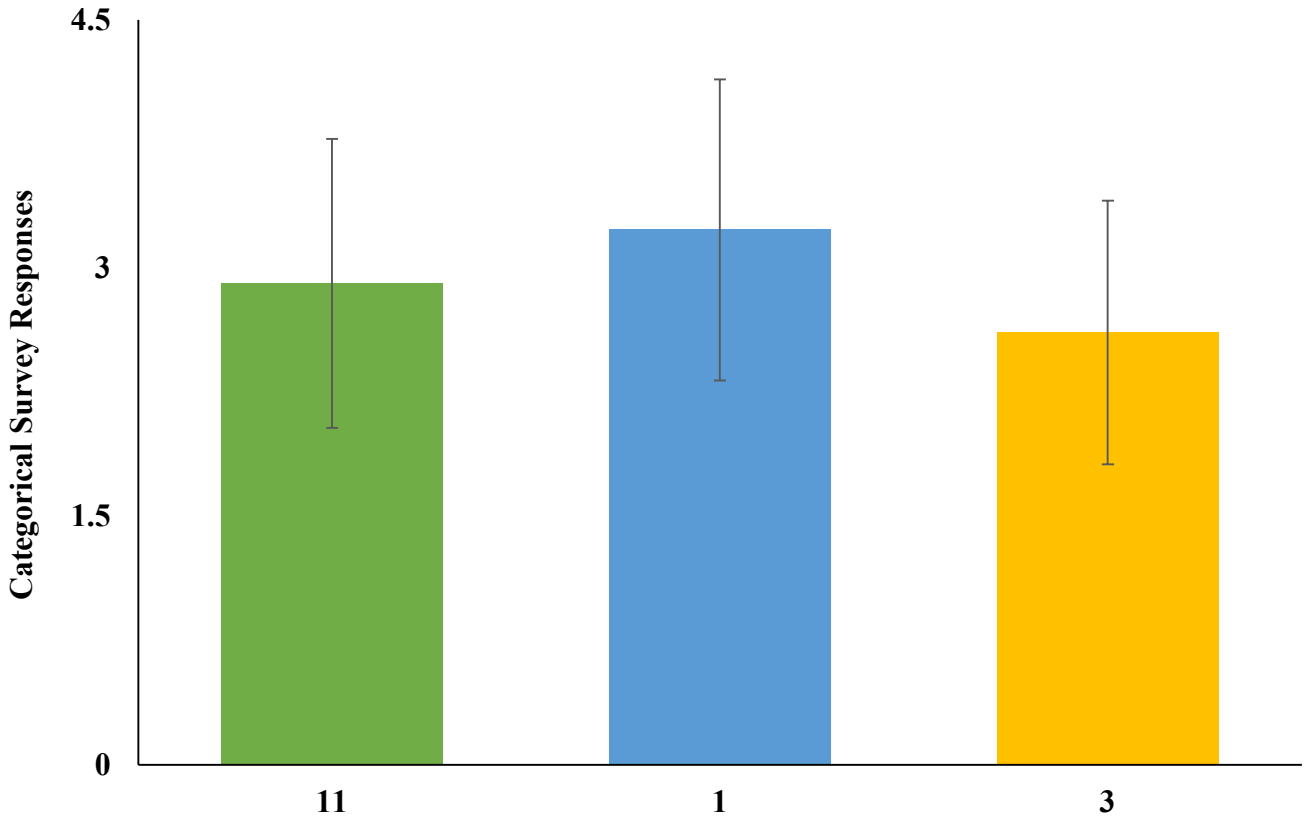


Figure 5: Mean categorical student responses ± 1 standard deviation to Pre-Laboratory Survey Question 1 "I am able to label the majority of the Integumentary System" using the five-point Likert scale (Strongly Agree = 1, Strongly Disagree = 5) for laboratory starting times (11 AM, 1 PM, 3 PM).

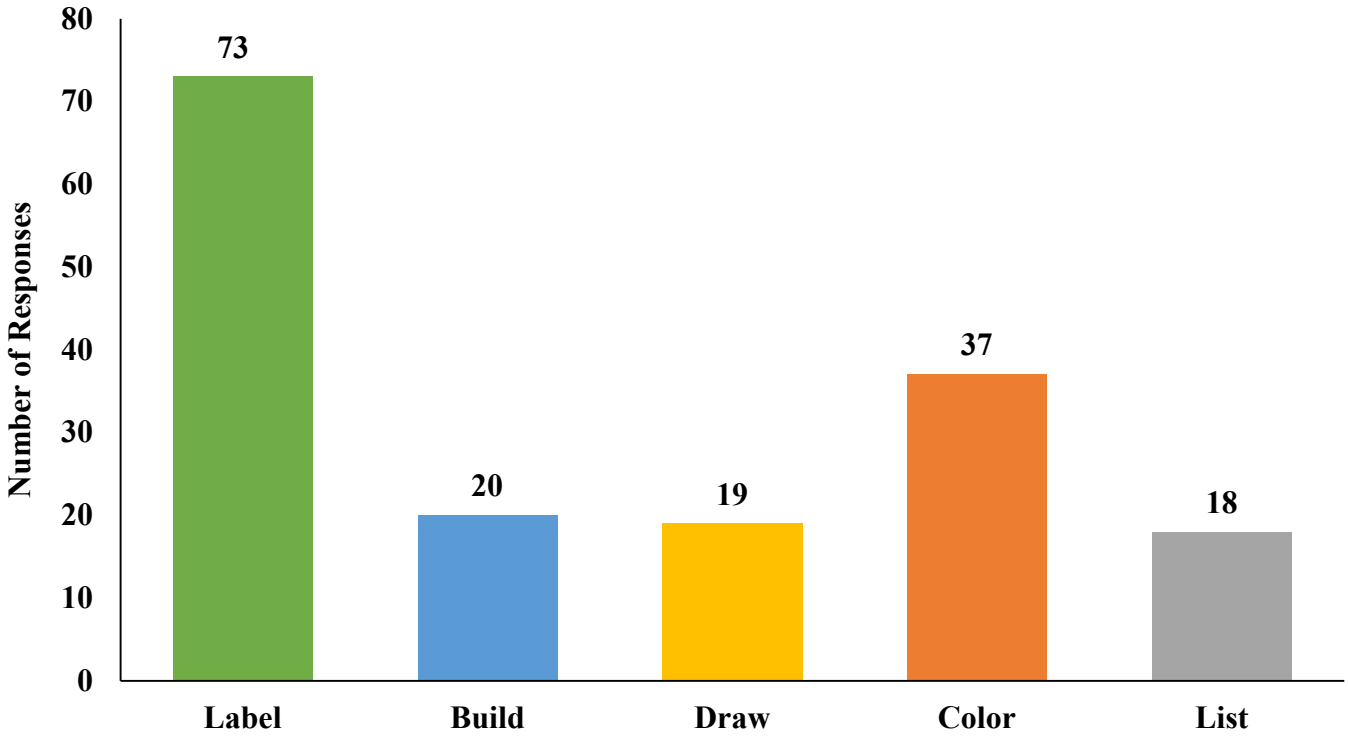


Figure 6: Label a Model student responses to Pre-Laboratory Survey Question 3, "Select your preferences for types of hands-on learning activities during labs". More than one answer was able to be selected.

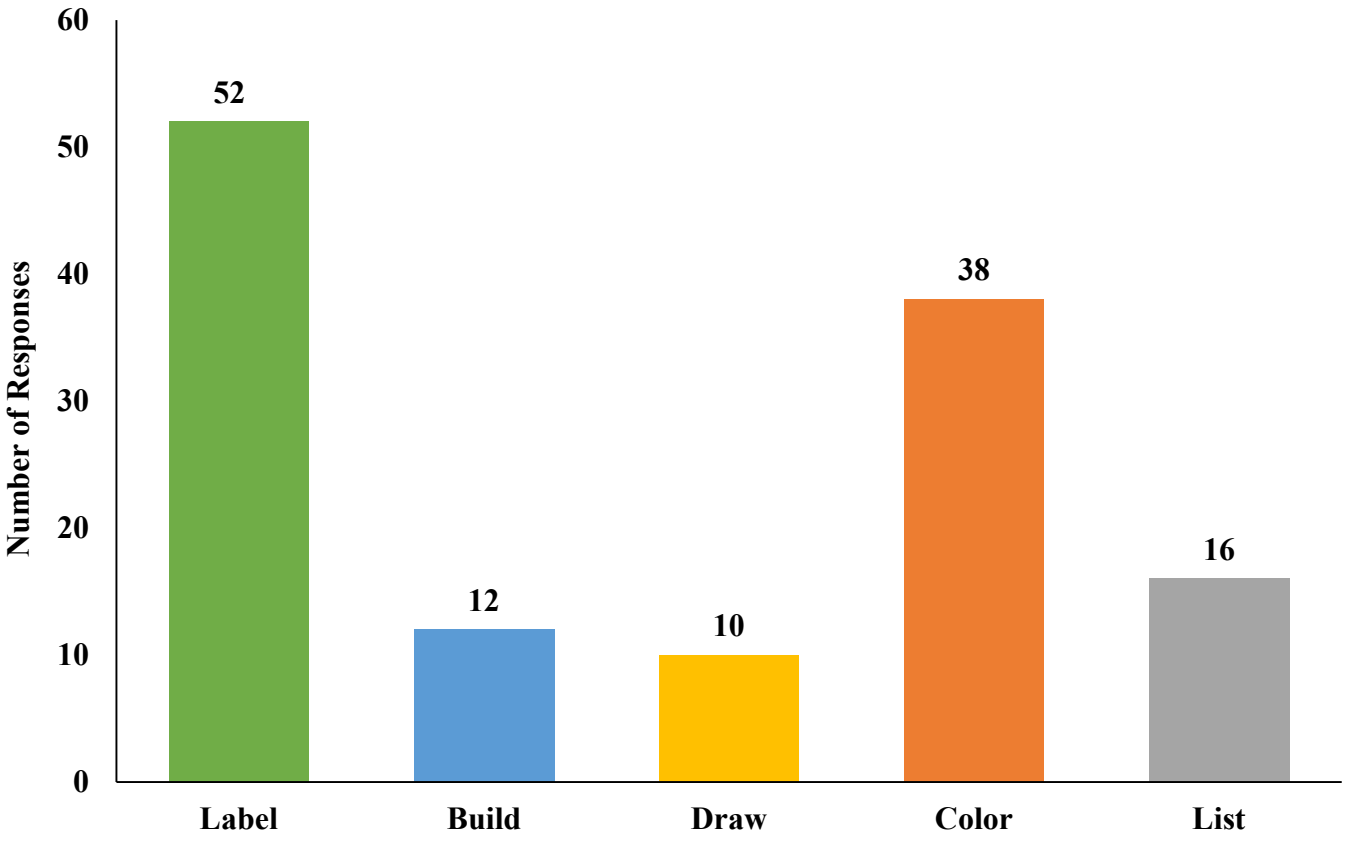


Figure 7: Illustrate a Model student responses to Pre-Laboratory Survey Question 3, "Select your preferences for types of hands-on learning activities during labs". More than one answer was able to be selected.

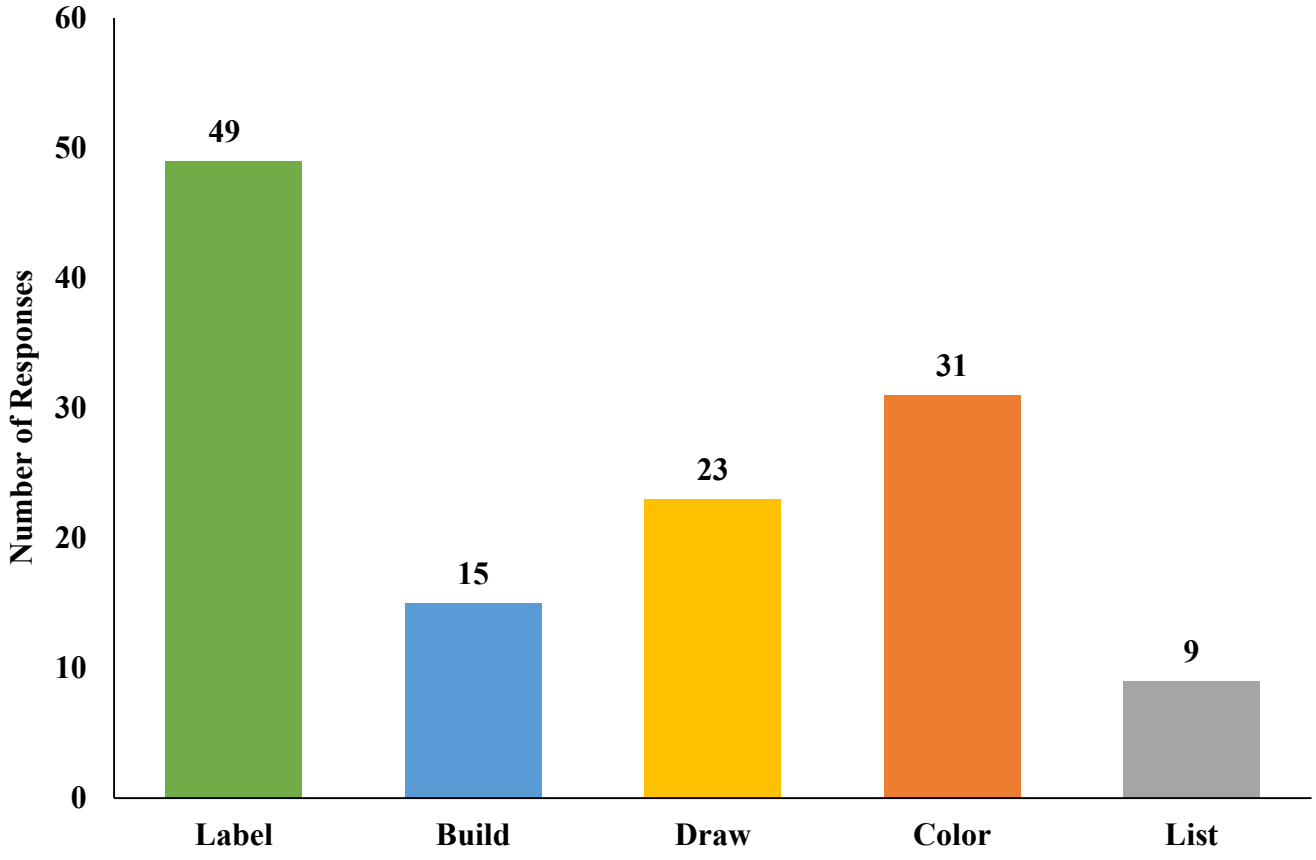


Figure 8: Build a Model student responses to Pre-Laboratory Survey Question 3, "Select your preferences for types of hands-on learning activities during labs". More than one answer was able to be selected.

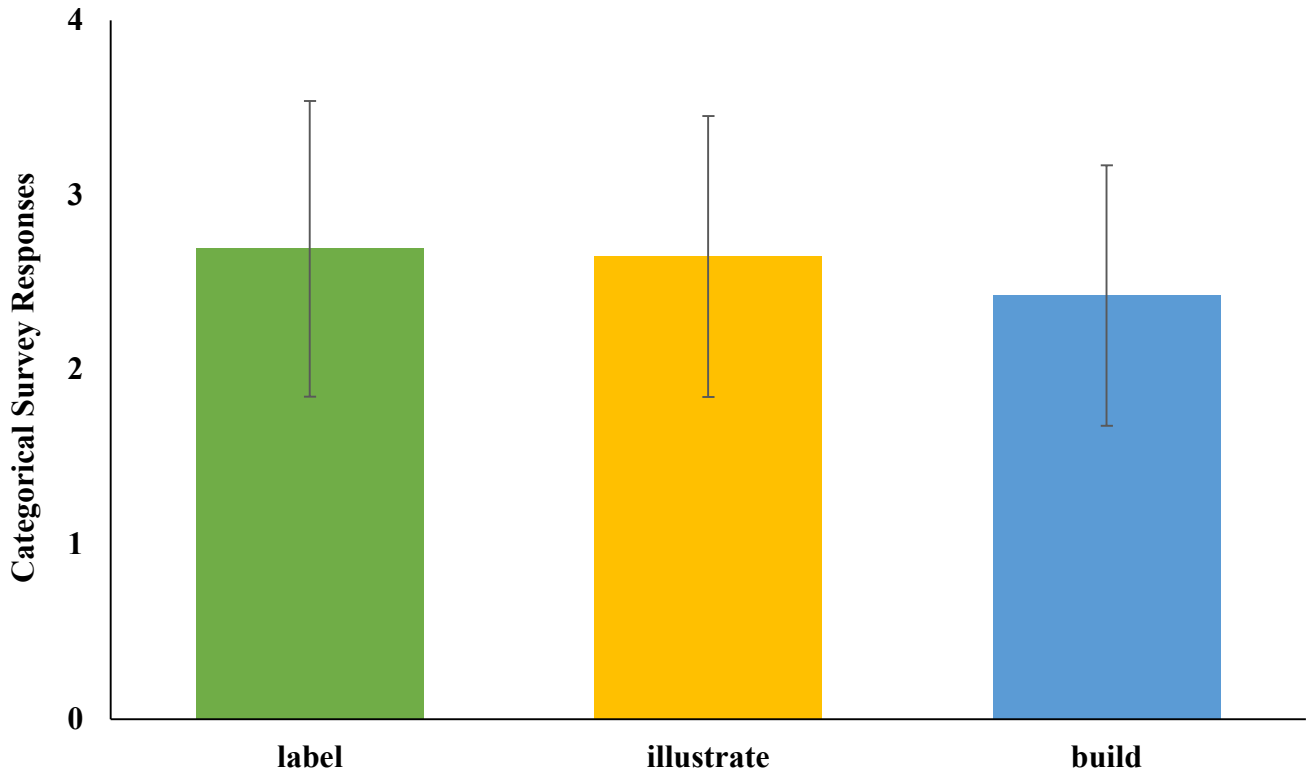


Figure 9: Mean categorical student responses ± 1 standard deviation to Post-Laboratory Survey Question 2 "I am confident in my ability to mentally visualize the anatomy of the integument system in three dimensions" using the five-point Likert scale (Strongly Agree = 1, Strongly Disagree = 5) for differing laboratory activities (label, illustrate, build).

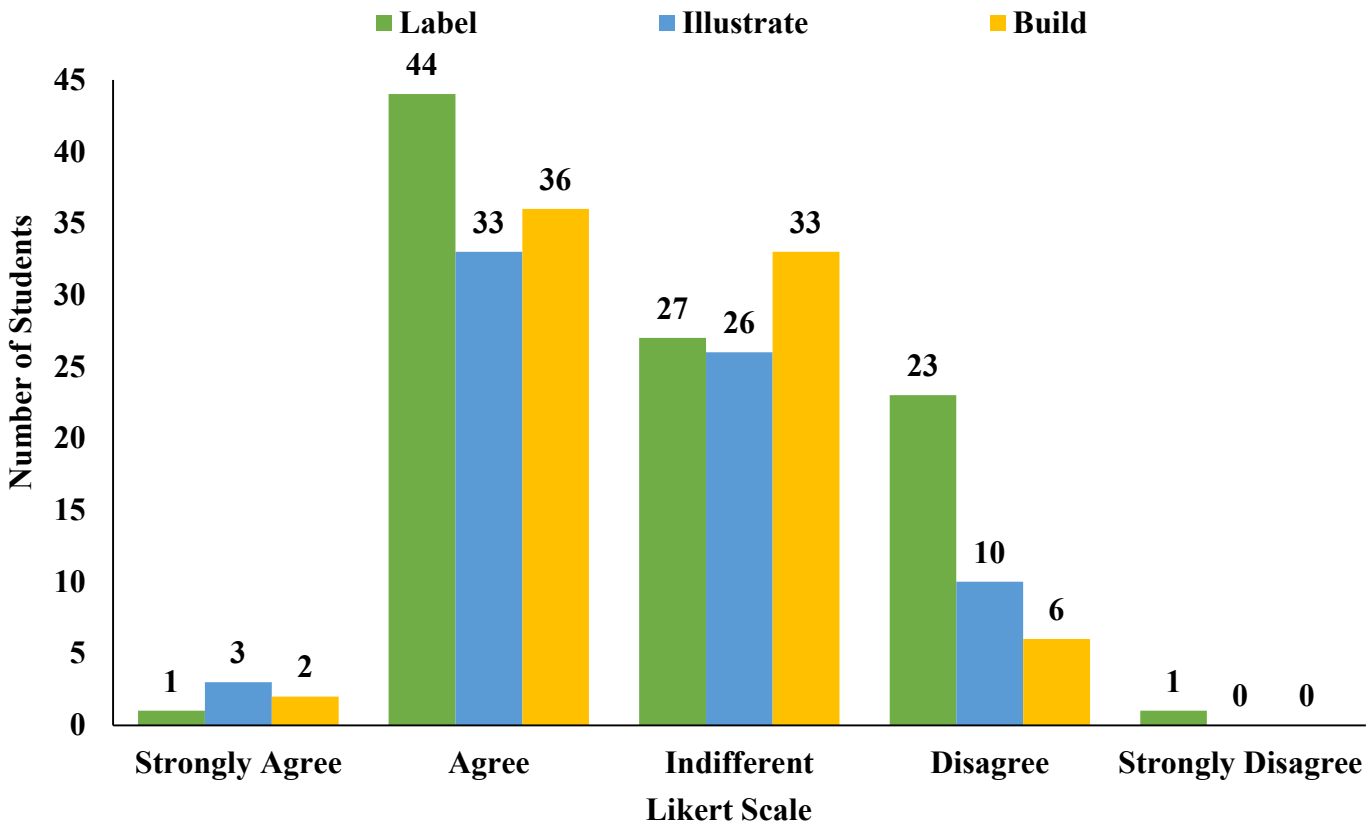


Figure 10: Student responses to Question 1 on the Post-Laboratory Questionnaire; "I am confident in my ability to identify the functions of the anatomical structures in the integument system."

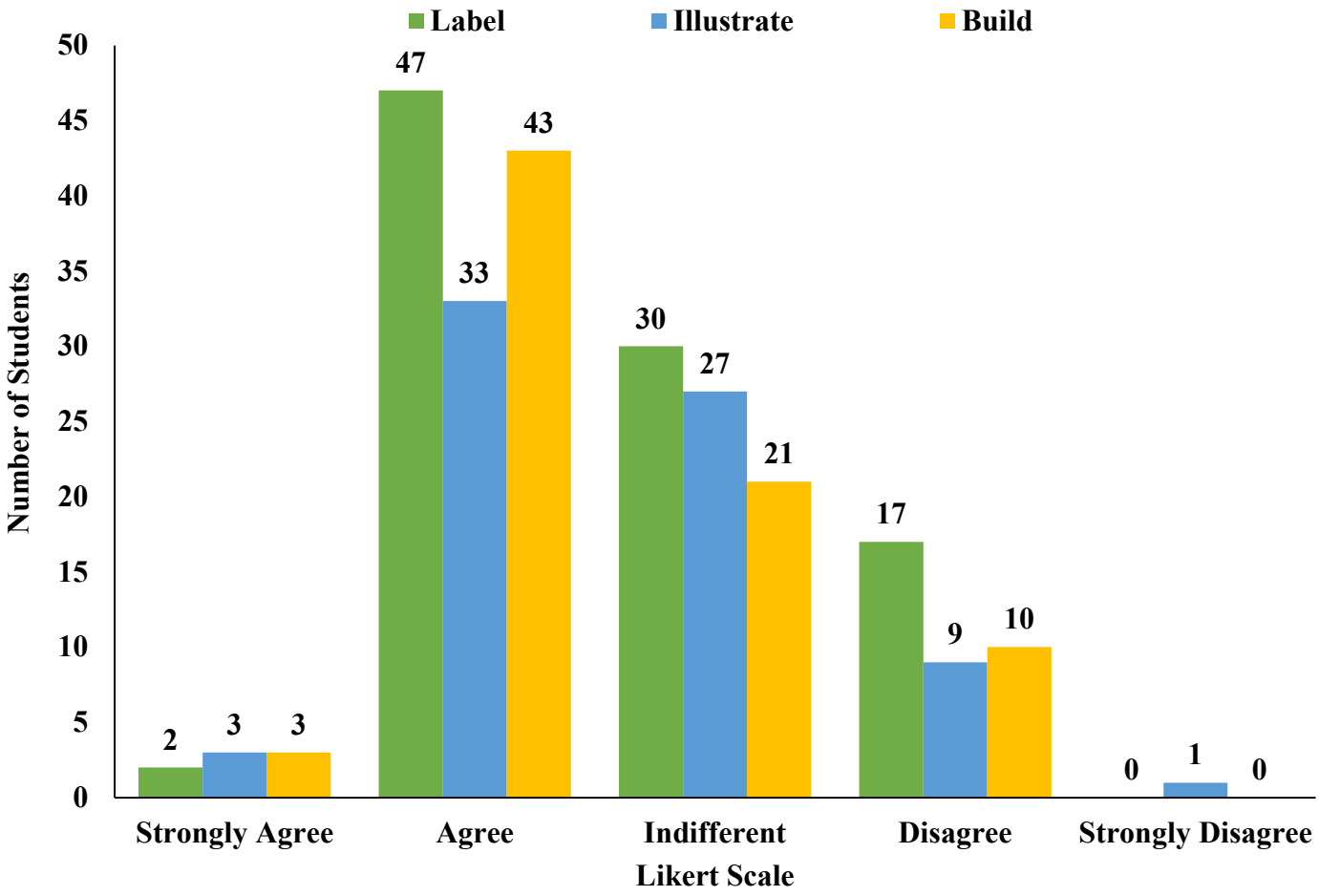


Figure 11: Student responses to Question 2 on the Post-Laboratory Questionnaire: "I am confident in my ability to mentally visualize the anatomy of the integument system in three dimensions".

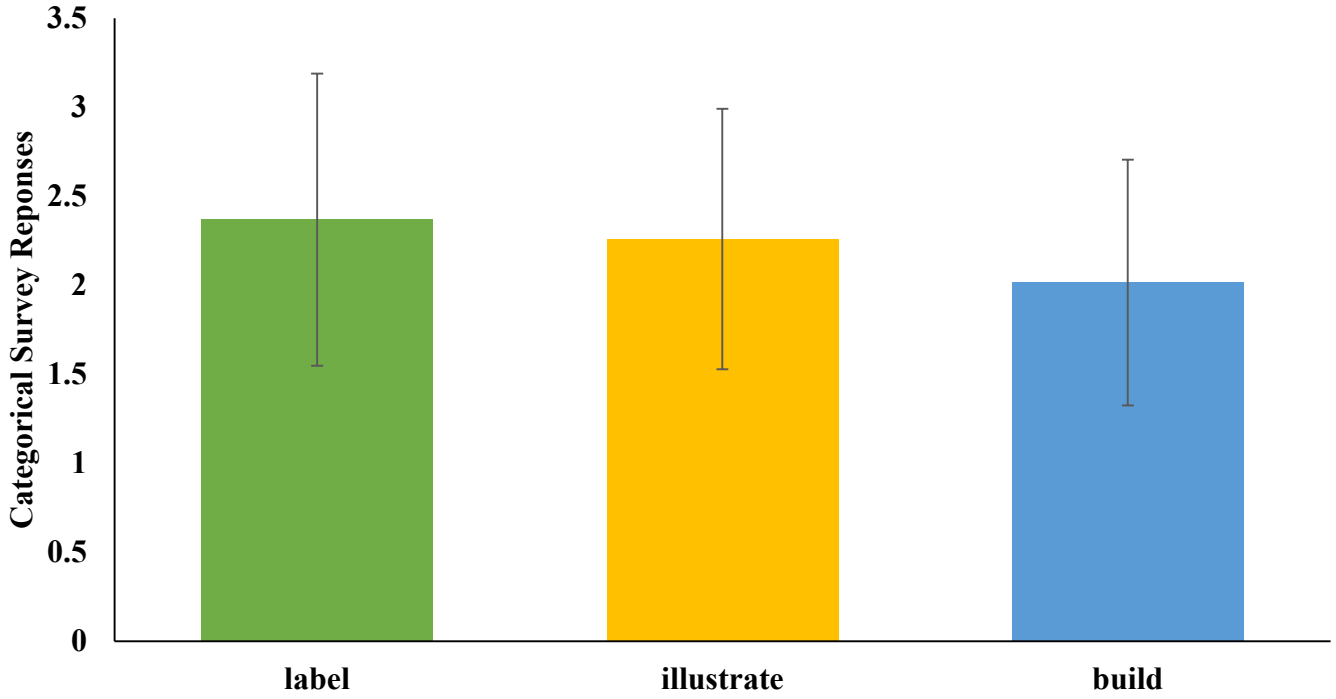


Figure 12: Mean categorical student responses ± 1 standard deviation to Post-Laboratory Survey Question 4 "I enjoyed this activity used to learn about the integument system" using the five-point Likert scale (Strongly Agree = 1, Strongly Disagree = 5) for differing laboratory activities (label, illustrate, build).

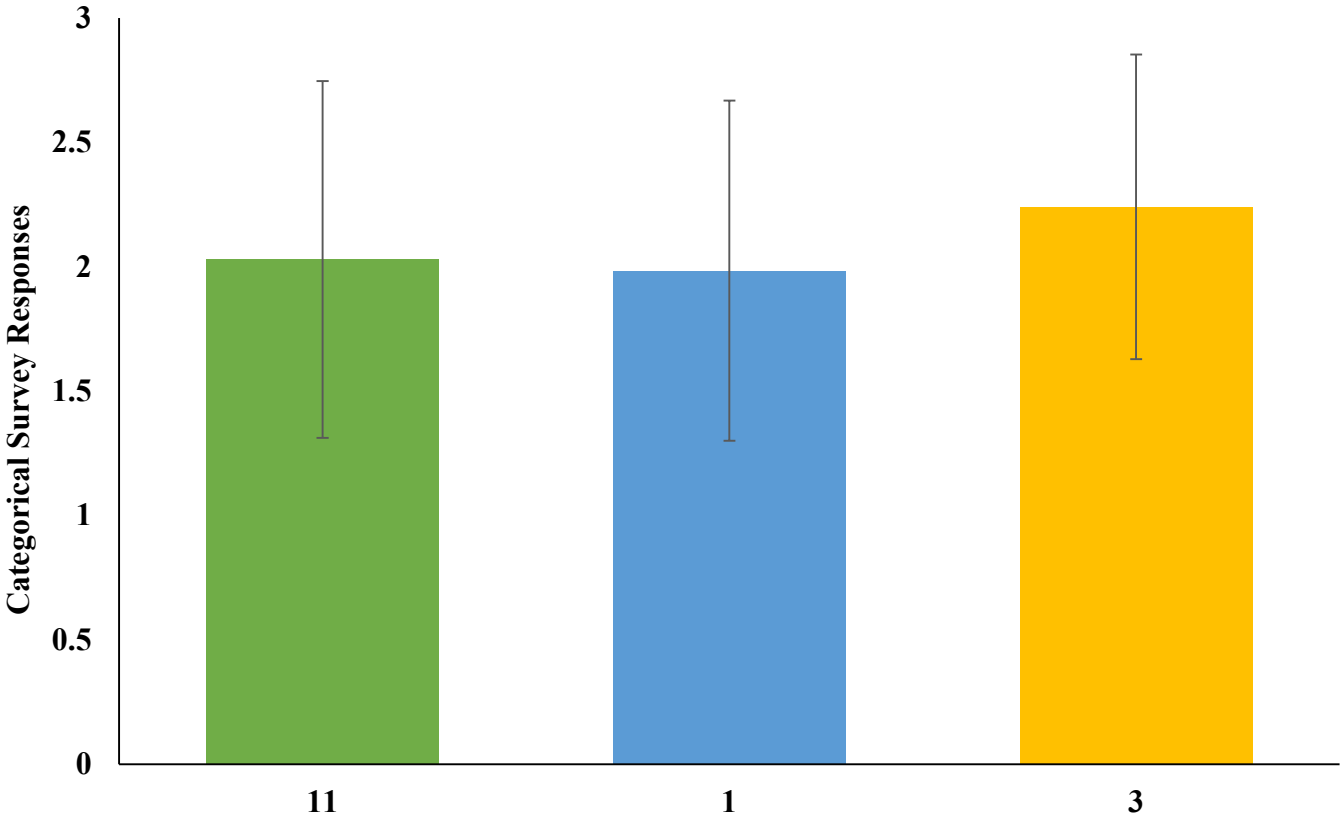


Figure 13: Mean categorical student responses ± 1 standard deviation to Post-Laboratory Survey Question 5 "I felt engaged during the learning activity" using the five-point Likert scale (Strongly Agree = 1, Strongly Disagree = 5) for laboratory starting times (11 AM, 1 PM, 3 PM).

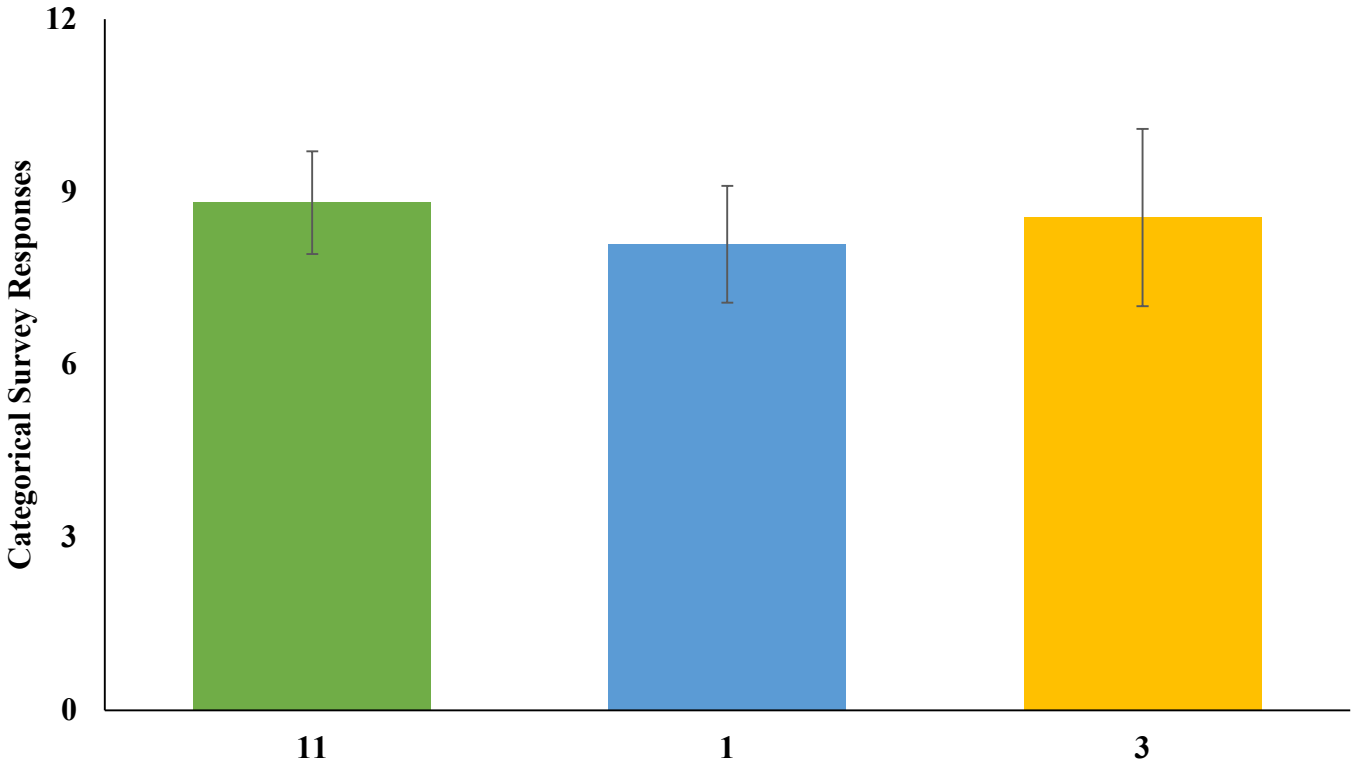


Figure 14: Mean categorical student scores ± 1 standard deviation for the in-class laboratory activity for the integumentary system for differing laboratory starting times (11 AM, 1 PM, 3 PM).

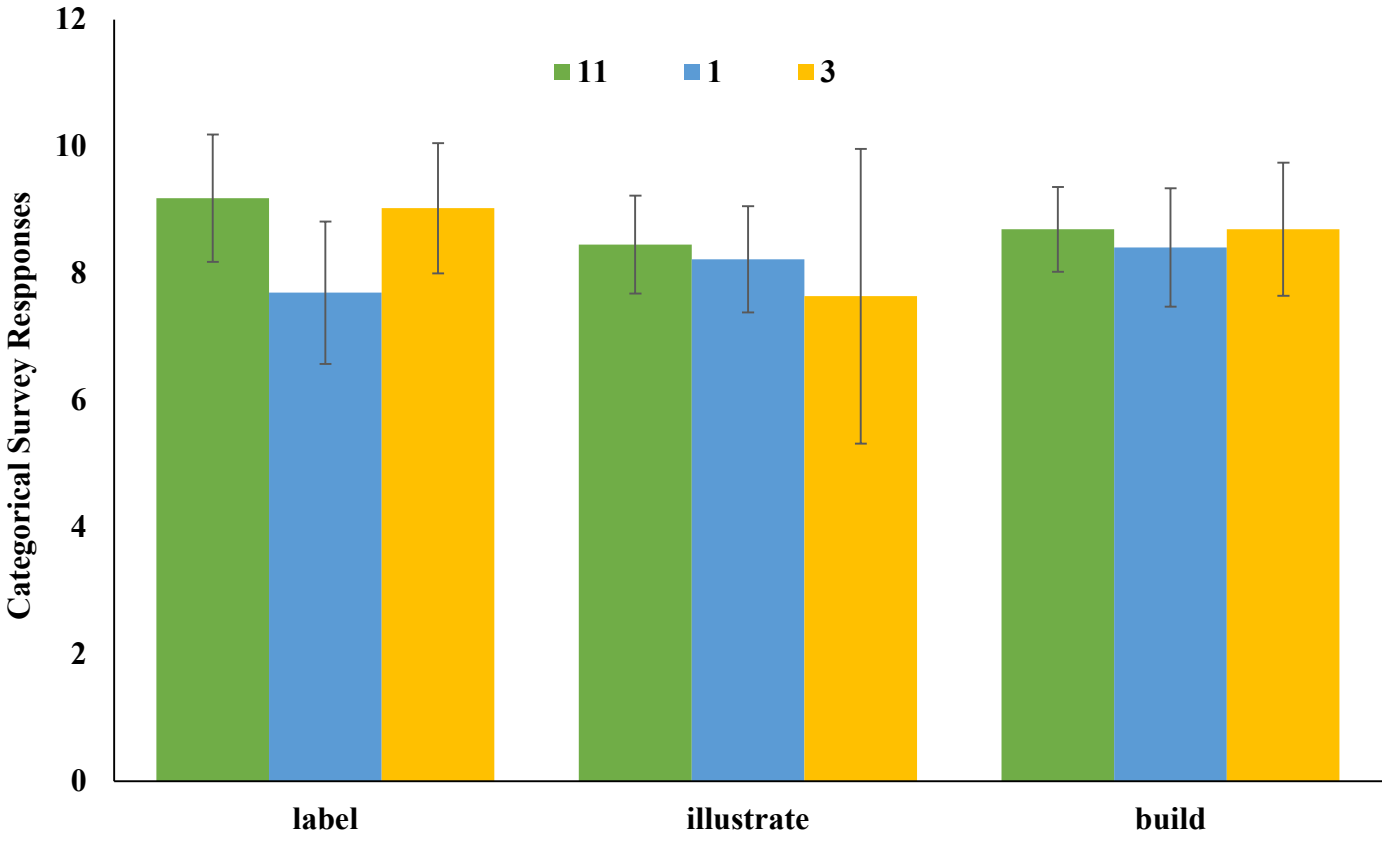


Figure 15: Mean categorical student scores ± 1 standard deviation for the in-class laboratory activity for the integumentary system for differing laboratory starting times (11 AM, 1 PM, 3 PM) in concert with the differing laboratory activities (label, illustrate, build).

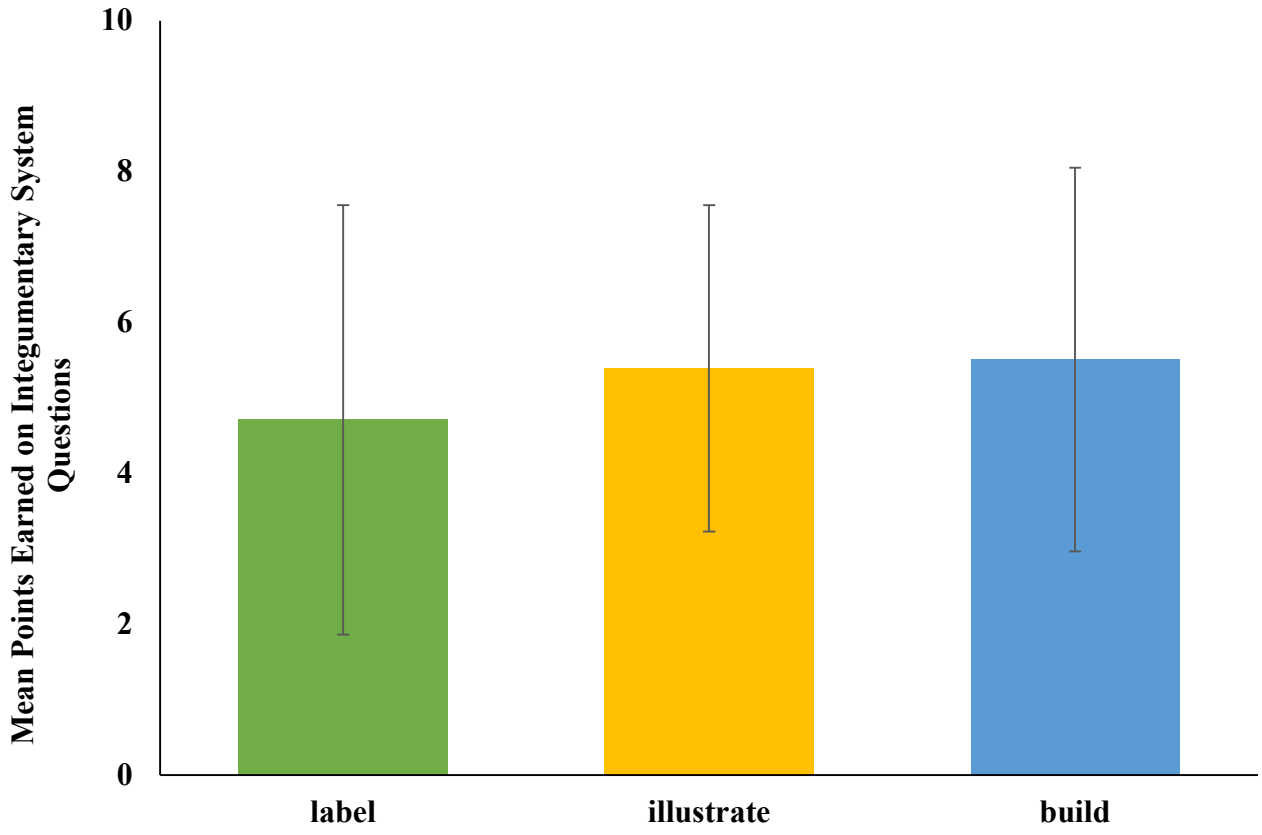


Figure 16: Mean categorical student scores ± 1 standard deviation for the laboratory practicals regarding only integumentary system questions for differing laboratory activities (label, illustrate, build).

APPENDIX A

Pre-Laboratory Survey

Lab section: _____

Seat # _____

Please circle the response that matches your response.

1. I am able to label the majority of the integument system

Strongly Disagree Disagree Indifferent Agree Strongly Agree

2. I have labeled the integument system before

Yes No

3. Select your preferences for types of hands-on learning activities during labs

Labeling Building Drawing Coloring Listing

4. Rank your top 3 selected activities from Favorite (1) to least favorite (3)

1. _____
2. _____
3. _____

APPENDIX B

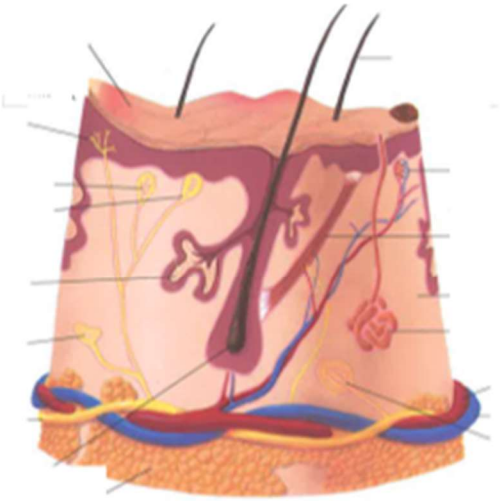
Day 1 In-Class Activity Label a Model Worksheet

Name: _____ Lab Section: _____

Integument System Worksheet:
Please label each of these structures on your skin model. (Examples of the skin models are shown on the last page). Give a brief description of the function of each structure in the table below. Take a picture for study purposes! Please note that you will use your labelled model for the identification, round-robin quiz at the end of the lab session.

APOCRINE SWEAT GLAND AND DUCT	**HYPODERMIS**
ARRECTOR PILI M.	**KERATINOCYTES**
CORTEX OF HAIR	**LUNULA**
DERMAL PAPILLA	**NAIL BODY**
DERMIS	**NAIL MATRIX**
ECCRINE SWEAT GLAND AND DUCT	**NAIL ROOT**

EPIDERMIS	PAPILLARY LAYER OF DERMIS
EPONYCHIUM	RETICULAR LAYER OF DERMIS
FREE EDGE OF NAIL	SEBACEOUS GLAND AND DUCT
HAIR	STRATUM BASALE
HAIR (DERMAL) PAPILLA	STRATUM CORNEUM



APPENDIX C

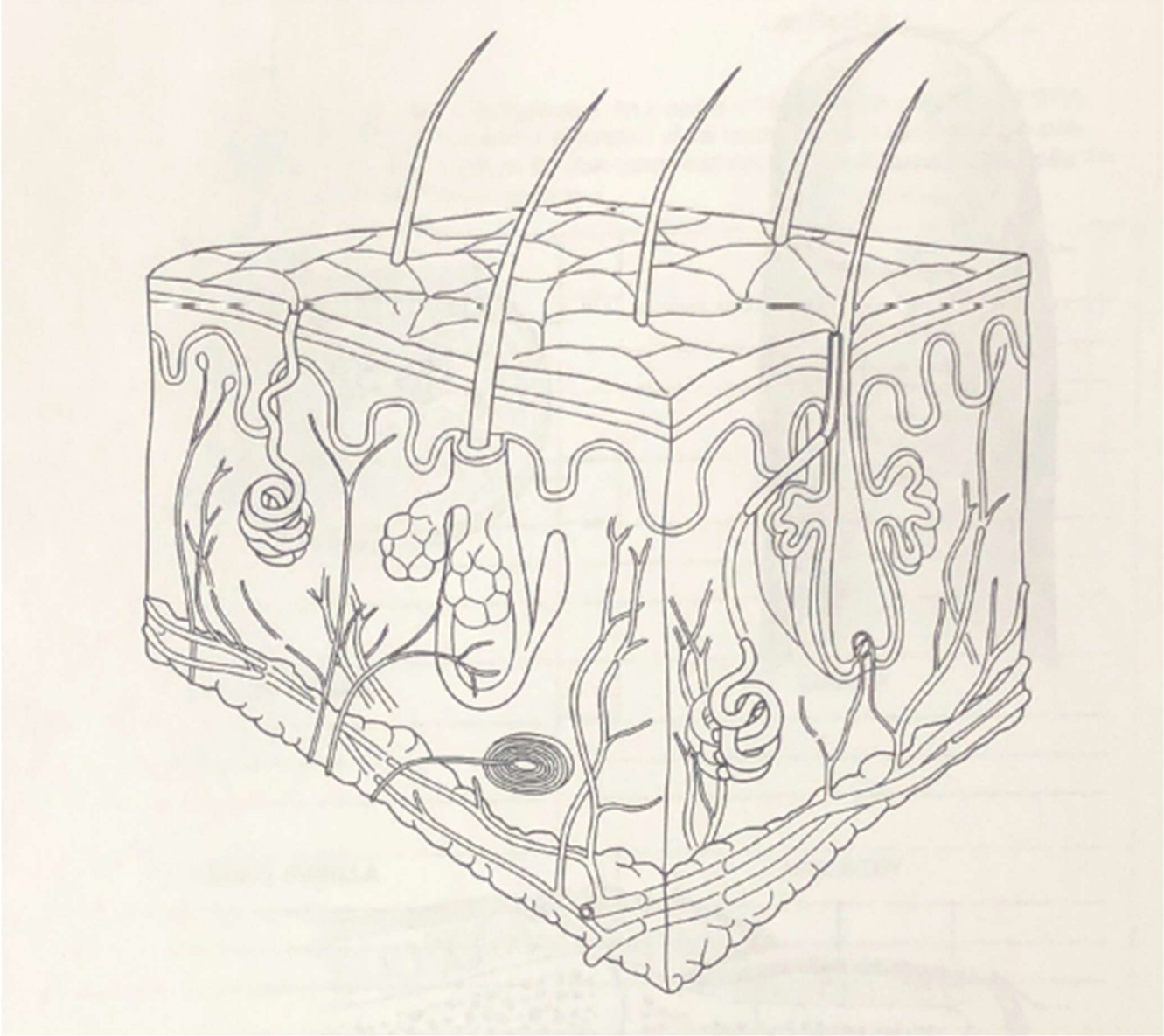
Day 2 In-Class Activity Illustrate a Model Worksheet

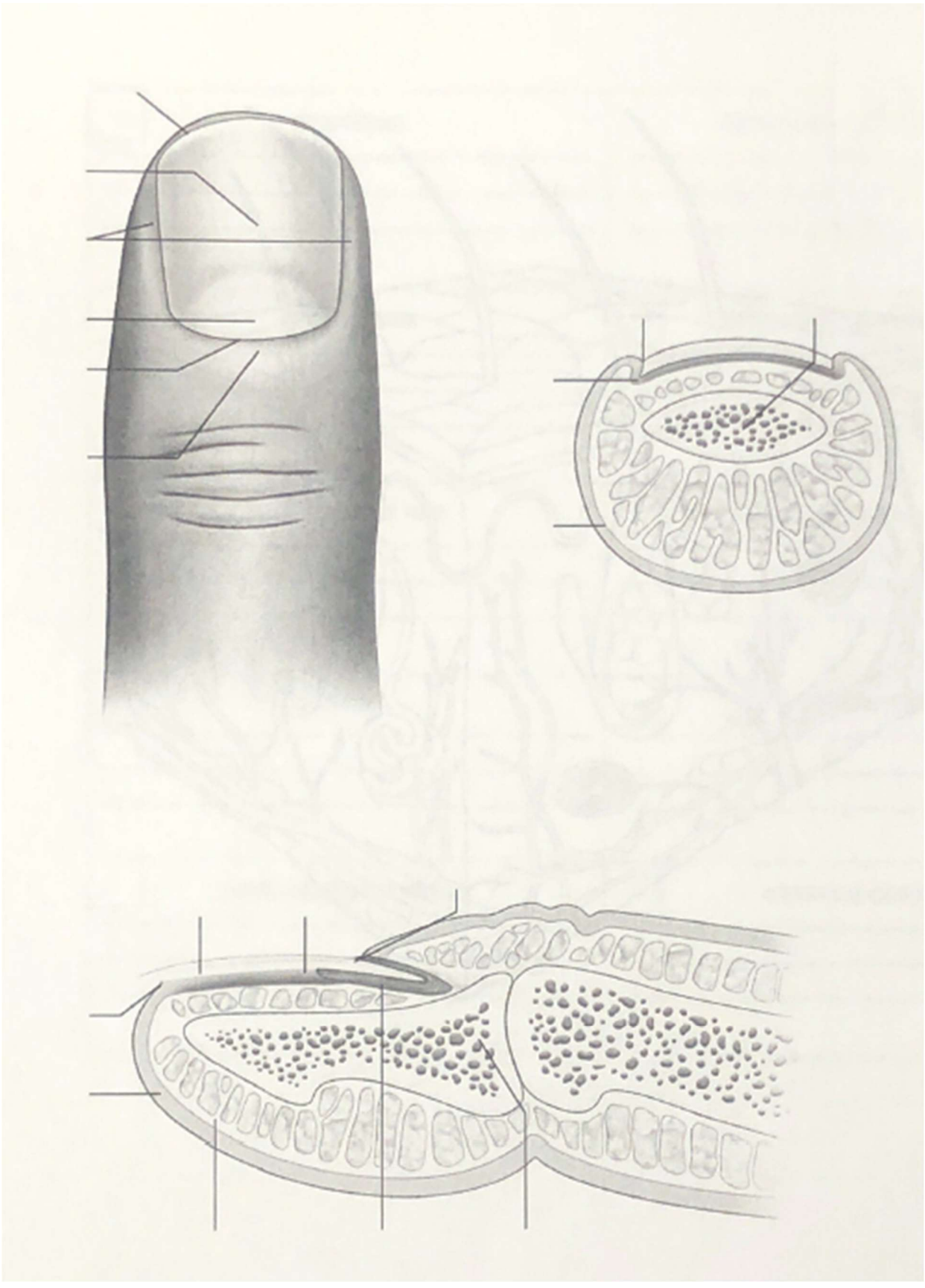
Name: _____ Lab Section: _____

Integument System Worksheet:
Please color each of these structures on your skin illustration. Fill in the color key (small box) for each structure and give a brief description of the function of each structure in the table below. Please note that you are not to write on the illustrations and you will be using your illustration for the identification, round-robin quiz at the end of the lab session.

APOCRINE SWEAT GLAND AND DUCT	HYPODERMIS
ARRECTOR PILI M.	KERATINOCYTES
CORTEX OF HAIR	LUNULA
DERMAL PAPILLA	NAIL BODY
DERMIS	NAIL MATRIX
ECCRINE SWEAT GLAND AND DUCT	NAIL ROOT

EPIDERMIS	PAPILLARY LAYER OF DERMIS
EPONYCHIUM	RETICULAR LAYER OF DERMIS
FREE EDGE OF NAIL	SEBACEOUS GLAND AND DUCT
HAIR	STRATUM BASALE
HAIR (DERMAL) PAPILLA	STRATUM CORNEUM





APPENDIX D

Day 3 In-Class Activity Build a Model Worksheet

Name: _____ Lab Section: _____

Integument System Worksheet:
Please include each of these structures in your skin model. Describe what materials are being used to build your model and give a brief description of the function of each structure in the following table. Drawing structures on model is prohibited.

Please note that you will use your model for the identification, round-robin quiz at the end of the lab session.

Supplies provided for model construction:

- Scissors
- Pipe cleaners (assorted colors)
- Red and blue yarn
- Glue
- Construction paper (various colors: pink, orange, red, yellow)
- Felt (various colors: pink, orange, red, yellow)
- Printed label list

APOCRINE SWEAT GLAND AND DUCT	HYPODERMIS
ARRECTOR PILI M.	KERATINOCYTES
CORTEX OF HAIR	LUNULA
DERMAL PAPILLA	NAIL BODY
DERMIS	NAIL MATRIX
ECCRINE SWEAT GLAND AND DUCT	NAIL ROOT
EPIDERMIS	PAPILLARY LAYER OF DERMIS

EPONYCHIUM	**RETICULAR LAYER OF DERMIS**
FREE EDGE OF NAIL	**SEBACEOUS GLAND AND DUCT**
HAIR	**STRATUM BASALE**
HAIR (DERMAL) PAPILLA	**STRATUM CORNEUM**

APPENDIX E

Post-Laboratory Survey

Student Confidence and Enjoyment:

1. I am confident in my ability to identify the functions of the anatomical structures in the integument system.

Strongly Agree Agree Indifferent Disagree Strongly Disagree

2. I am confident in my ability to mentally visualize the anatomy of the integument system in three dimensions.

Strongly Agree Agree Indifferent Disagree Strongly Disagree

3. I am confident in my ability to identify the anatomy of the integument system during a practical exam

Strongly Agree Agree Indifferent Disagree Strongly Disagree

4. I enjoyed this activity used to learn about the integument system

Strongly Agree Agree Indifferent Disagree Strongly Disagree

5. I felt engaged during the learning activity.

Strongly Agree Agree Indifferent Disagree Strongly Disagree