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Mapping Difficult Topics in Human Anatomy & Physiology: Basis for Interactive Learning Tool

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Abstract

Anatomy and Physiology is a foundational subject critical in Health Science Education. However, due to its complexity it often makes it difficult for the students to master. This study specifically aimed to identify the top three (3) most difficult topics in human anatomy and physiology among Bachelor of Science in Radiologic Technology students and use the findings of the assessment as the basis for developing an interactive learning tool. A developmental research design was employed, which utilizes a 100-item multiple choice assessment based on a Table of Specification covering the ten (10) major body systems. A total of 38 purposively selected respondents participated in the study. Descriptive Statistics and an independent t-test were utilized to analyze learner's performance and determine significant differences based on sex. Results revealed that students demonstrated strong understanding of the digestive, respiratory, urinary, skeletal and reproductive systems with 83% of respondents scoring above 60%. However, moderate performance was observed in the endocrine system, while the cardiovascular, nervous and lymphatic systems were identified as the top three most challenging areas in the subject. Additionally, findings also showed that both male and female students shared similar areas of difficulty specifically in systems which requires integration of anatomical and physiological concepts. Based on these results, an offline interactive mobile application named Anatomix was developed to address identified learning gaps through features such as flashcards, interactive modules and gamified quizzes. The study highlights the need for an innovative technology-enhanced instructional approaches in order to support deeper understanding of complex anatomical systems. Future researchers are hereby recommended to expand the scope of the application Anatomix through incorporating more body systems, enhancing adaptive multimedia features, adapting modules for other allied health programs and conducting formal evaluations to validate its effectiveness when in comes to improving anatomy and physiology learning outcomes.

Keywords: *gamification, human anatomy and physiology, interactive learning tool, radiographic anatomy, student performance*

1. Introduction:

Anatomy and Physiology was a foundational subject in the field of Health and Science programs, yet its extensive content often makes it one of the most difficult courses for the learners to master. For radiologic technology students specifically, mastery of anatomy is very significant as the accuracy of the interpretations of radiographs depends on a strong foundation on anatomy.

Furthermore, traditional lecture-based methods have proven less effective for today's learners, who benefit more from interactive, technology-driven approaches to studying Anatomy and Physiology (Ng'ambwa et al., 2025). Additionally, recent studies of Yuldasheva (2025) and Li et. al., (2023) suggest that strategies such as gamification, multimedia integration and task segmentation can significantly improve students' engagement as well as comprehension. These findings underscore the importance of adopting an innovative learning tool that align with today's modern educational practices.

In response with these challenges, this study proposed the development of an offline interactive mobile application tailored to the needs of the College of Allied Medicine students at Southern Luzon State University. Unlike the other existing online platforms, the offline functionality of the application ensures accessibility even in areas with very limited internet connectivity, addressing a known barrier in digital learning. Through the integration of radiographs, the application bridges theoretical knowledge with practical applications that will enable the students to visualize anatomical structures as they would appear in diagnostic imaging.

The application focused on the three most challenging anatomy topics determined through assessment results to ensure that the instructional design is data-driven and responsive to learner needs. By incorporating gamification, the students would be motivated by gaining rewards, progress tracking, and challenges that enable the transformation of anatomical concepts into manageable learning tasks.

Ultimately, the study aimed to support technology-enhanced learning in health sciences education. The development of this learning tool prepares the Bachelor of Science in Radiologic Technology Level II students more effectively for the Radiographic Anatomy course. Beyond this tool's impact, the project also envisions a model that can be adapted for other Allied Medicine Programs reinforcing the role of innovation in molding the future of medical education.

2. Methods And Material

Research Design

This study utilized a developmental research design, following the Research and Development (R&D) model. The primary goal of this study is to develop an offline interactive mobile application to provide an additional aid in learning approaches of anatomy and physiology. In line with this, the study does not include validation and measurement of the application's effectiveness. This research design is much suited for this study due to its priority to create a functional and user-focused product. By constant focusing on the developmental cycles, starting from the initial planning of the model to refinements and revisions, the design ensures that the offline application is tailored in accordance with the learners' educational needs in anatomy and physiology.

Further, the R&D model highlights structured documentation which provides a transparent record of the development process, making it suitable for the educational application creation. It positions the design as rigorous, differentiating it from less structured methods. Unlike experimental design that prioritizes the hypothesis testing and measurement of effectiveness, this model avoids the need for control groups making it more efficient for a pure product development.

Respondents

The respondent of this study consists of the second-year students from the Bachelor of Science in Radiologic Technology (BSRT) program enrolled in Anatomy and Physiology courses under the College of Allied Medicine at Southern Luzon State University and are willing to undergo and participate in an assessment of their knowledge in human anatomy and physiology. Each respondent contributes data reflecting their knowledge in human body systems that provides valuable insights for the development of an interactive learning tool named Anatomix.

To ensure relevance and depth of the collected data, this study employed Purposive Sampling specifically because this method allowed the researchers to intentionally select the respondents based on their enrollment in Anatomy and Physiology, ensuring that they are directly relevant to the focus of the study and are able to provide meaningful data for the development of the application Anatomix.

A total of 38 students (32 female, 6 male) were selected as respondents of the study, which represents the entire population of the Bachelor of Science in Radiologic Technology Level II students enrolled in the Anatomy and Physiology course.

Research Instrument

In order to accomplish the objectives of this study, the following steps will be conducted in the development and validation of the research instrument.

A. *Construction of Table of Specification (TOS) and Assessment Questionnaire*

The researchers created an assessment questionnaire which serves as the primary data-gathering tool. This instrument was designed to assess the learners' knowledge and understanding of Anatomy and Physiology across the ten (10) major body systems.

Prior to questionnaire formulation, the researchers will construct a Table of Specification (TOS) based on the official syllabus of the university for the subject Anatomy and Physiology. The TOS will outline the ten (10) major body systems and distribute the test items equally, with ten (10) questions allocated per system. These systems include: *Skeletal, Muscular, Nervous, Endocrine, Cardiovascular, Lymphatic, Respiratory, Digestive, Urinary, Reproductive Systems.*

The item placement will follow a simplified cognitive framework in order to ensure balance assessment across different levels of thinking, which includes Remembering and Understanding (60%), Applying an Analyzing (30%) and Evaluating (10%).

Following the construction of the TOS, a multiple-choice type of assessment will be developed, consisting of 100 items with four (4) options per question. The questionnaire aims to measure students' baseline knowledge and identify body systems in which learner's struggle that will define the scope of the educational content in the mobile application. This Pretest will be conducted personally to ensure honesty and transparency of knowledge.

B. *Development of the Interactive Mobile Tool*

The researchers will design and develop the offline interactive mobile tool based on the results of the assessment, tailored to the challenging body systems identified. The educational tools in the application will include learning materials featuring flowcharts, illustrations, gamified quizzes, flashcards, and mnemonics. Additionally, an achievement tracker and mastery badges will also be integrated in the feature, designed to track learning milestones of the users and give recognition to their mastery.

Moreover, the application is designed to be used offline, enabling users to access and browse the contents anytime without the need for internet connectivity. In order to ensure proper integration of multimedia elements and technical functionality, an Information Technology Specialist will be consulted during the development process.

3. Data Collection Procedures

Before the conduct of the study, the researchers will first ask permission by presenting a formal letter of request to the Dean of the College of Allied Medicine at Southern Luzon State University – Main Campus. Upon approval, the researchers will coordinate with faculty members handling the subject Anatomy and Physiology to facilitate the administration of the assessment and ensure proper orientation with regards to the study.

The researchers will personally meet the said selected instructors to explain the study's objectives and the procedures for administering the pretest. Students will be informed about the purpose of the study and will also be asked with their consent before participating.

The assessment—composed of one-hundred (100) multiple-choice items covering ten (10) body systems, will be administered in person to ensure academic integrity. After the administration, results will be consolidated to identify which body systems learners find most challenging. These identified areas of difficulty will define the scope of the ANATOMIX application that the researchers will develop for refining the instructional material, ensuring that the interactive mobile tool addresses the specific needs of the students in mastering the subject Anatomy.

Data Analysis

The gathered data will be analyzed through utilization of both descriptive and inferential statistical techniques to determine the students' performance in Anatomy and Physiology.

Descriptive Statistics includes computing counts, percentage scores as well as mean scores to determine the overall performance of the students across the ten (10) major body systems included in the subject Anatomy and Physiology.

The computed mean scores per body system will be tabulated and arranged systematically from highest to lowest to identify the lowest-scoring systems. These findings will serve as the basis of the researchers in customizing the content and features of the ANATOMIX interactive educational application that will be the product of this study. This will ensure that

the application will address the specific learning difficulties revealed by the data and successfully meet the objectives in this study.

Meanwhile a one-way Analysis of Variance (ANOVA) will be employed to examine variations in scores across different academic programs. These statistical procedures will help validate whether demographic factors influence students' understanding of Anatomy and Physiology and further inform the design of the educational intervention.

Statistical Treatment

This study utilized a Descriptive Statistical Method to summarize the students' performance across the ten (10) human body system in Anatomy and Physiology subject. The mean score of each body system was the computed using the formula below. Further, Frequency counts were used to determine how many students answered each item correctly, represented by *f*.

Additionally, an independent t-test was employed to examine the differences between groups in terms of sex as the demographic profile. Since only two (2) groups were compared, male and female, the independent t-test was considered the most appropriate statistical method. This test determined whether sex influences the students' understanding of the anatomy and physiology significantly and becomes the basis in the educational intervention. It is computed using the formula below:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

Where:

- $\bar{X}_1$= Mean of Sample Group 1
- $\bar{X}_2$= Mean of Sample Group 2
- s_1^2= Variance of Sample Group 1
- s_2^2= Variance of Sample Group 2
- N_1= Number of observations in Sample Group 1
- N_2= Number of observations in Sample Group 2
- t= The *t*-statistic used to test the null hypothesis that the means of the two groups are equal.

These statistical treatments guided the researchers in designing the interactive educational application Anatomix, ensuring that it is aligned with the areas where students showed the lowest level of proficiency.

Score	Range	Legend	Quality Index
4	76-100%	E	Easy
3	51-75%	MD	Moderately Difficult
2	26-50%	D	Difficult
1	0-25%	VD	Very Difficult

This table represents the scoring framework used in the study to determine and classify the BSRT Level II students' levels of knowledge in Anatomy and Physiology. These served as the basis for interpreting assessment results across the ten (10) major body systems to ensure consistency and accuracy in data analysis of the study.

4. Results And Discussion

Table 1. *Demographic Profile of the Respondents*

Sex	Frequency	Percentage
Female	32	84%
Male	6	16%
Total	**38**	**100%**

Table 1 showed the demographic profile of the respondents and the result indicated that majority of the respondents were female with 32 frequency or 84%, while male were 6 or 16% of the total respondents.

CHED enrollment data from 2021 to 2025 indicated that female students consistently outnumber male students in BS Radiologic Technology programs in the Philippines, a trend that mirrors other allied health courses such as Nursing and Medical Technology. Government statistical bulletins highlight that women dominate enrollment figures in these fields, often by wide margins, due to cultural expectations that associate healthcare professions with caregiving and patient-centered roles.

This perception, combined with the promise of stable employment in hospitals, clinics, and diagnostic centers, made BS Radiologic Technology more attractive to female students. Male students, by contrast, are more frequently enrolled in engineering, IT, and technical programs, contributing to their lower representation in allied health. These findings reinforced the cycle of female-majority participation, which is further reflected in licensure examination results and eventual professional practice.

Table 2. *Comparison of the Assessment Results Between Female and Male Based on Scores in Skeletal System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
What parts of the human skeleton are considered appendicular bones?	**16**	**2**	50.00%	33.30%	Difficult	Difficult
What is the protective layer around the bone?	**19**	**3**	59.40%	50.00%	Moderately Difficult	Difficult
An elderly woman develops a stooped posture (dowager's hump). Which condition most likely caused this deformity?	**25**	**3**	78.10%	50.00%	Moderately Difficult	Difficult
A boxer suffers repeated blows to the face and develops difficulty breathing through his nose due to deviation of the nasal septum. Which bone is primarily affected?	**20**	**4**	62.50%	66.70%	Moderately Difficult	Moderately Difficult
If a person sustains a fracture of the atlas (C1), which function would be mostly directly affected?	**25**	**3**	78.10%	50.00%	Easy	Difficult
Why does a fracture in an elderly person's femur *Continuation* take longer to heal compared to a child's?	**27**	**3**	84.40%	50.00%	Easy	Difficult
What is the point at which two bones come together?	**30**	**3**	93.80%	50.00%	Easy	Difficult
During a forensic examination, a pelvis is found with a wide, circular inlet and broader pubic arch. To which sex does this pelvis most likely belong?	**30**	**4**	93.80%	66.70%	Easy	Moderately Difficult
What is the scientific name of the shoulder blade?	**31**	**5**	96.90%	83.30%	Easy	Easy
What is the scientific name of the collarbone?	**32**	**5**	100.00%	83.30%	Easy	Easy
Average			**79.70%**	**58.33%**	**Easy**	**Moderately Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

The Table 2 above presented the comparison of assessment results between female and male respondents specifically based on their performance in the Skeletal System. Based on the results, the least difficult item for females was Question 7

(100%, Easy), which indicated complete mastery of the scientific name of the collarbone. In addition, High performance was also observed in Question 3 (96.90%, Easy), Question 4 (93.80%, Easy) and Question 8 (93.8%, Easy). This suggested that most of the female respondents demonstrated a strong understanding of the basic skeletal concepts and anatomical identification as well.

In contrast, the most difficult item for females was Question 9 (50%, Difficult) where in it focused on appendicular bones. This clearly indicated that the concept posed a relative challenge compared to the other questions. Moreover, for male respondents, the highest scores were recorded in Question 3 and 7 (83.30%, Easy) which reflected a good understanding of the scapula and clavicle. However, several items were found to be more challenging, specifically Questions no. 1, 5,, 6, 8 and 10 (50%, Difficult). This indicated that appendicular bones were also the most challenging topic for male respondents.

All in all, female respondents obtained an average score of 79.70%, interpreted as Easy, indicating a high level of understanding when it comes to Skeletal System. In comparison, male respondents had an average score of 58.33%, which was classified as Moderately Difficult. This clearly suggest that while male respondents demonstrated basic knowledge, they still experienced more difficulty across several questions compared to female respondents.

These findings indicated that although both groups encountered challenges in identifying appendicular bones, female respondents consistently performed better across most of the topics specifically in anatomical terminology and identification. On the other hand, male respondents demonstrated adequate understanding in selected areas yet showed greater difficulty in both foundational and applied skeletal concepts.

Generally, all of the findings are consistent with Alamri and Alghamdi (2023), who reported that anatomy performance can vary across groups, with skeletal system topics often perceived as easier compared to integrative systems, but differences in mastery levels can emerge depending on the type of question and context. Their study highlighted the importance of tailoring instructional strategies to address group-specific learning gaps.

Table 3. *Comparison of the Assessment Results Between Female and Male Based on Scores in Muscular System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
Compared to skeletal muscle, smooth muscle	**6**	**2**	18.80%	33.30%	Very Difficult	Difficult
Continuation Which classification of muscle is best described as striated, branched and uni or bi-nucleated?	**6**	**2**	18.80%	33.30%	Very Difficult	Difficult
Type of contraction in which the tension of the muscle increases and the skeletal muscles lengths change.	**8**	**3**	25.00%	50.00%	Very Difficult	Difficult
Activities such as swimming and running are most likely to stimulate development of	**11**	**1**	34.40%	16.70%	Difficult	Very Difficult
What connective tissue layer surrounds each fasciculus of a muscle?	**14**	**0**	43.80%	0.00%	Difficult	Very Difficult
It immobilizes the bone or a muscle's origin.	**14**	**3**	43.80%	50.00%	Difficult	Difficult
The all-or-non response means?	**14**	**3**	43.80%	50.00%	Difficult	Difficult

It allows the muscle to return to its original shape after it has contracted or stretched.	**22**	**3**	68.80%	50.00%	Moderately Difficult	Difficult
What do you call a filamentous network of protein forming disc like structure for the attachment of actin myofilament?	**24**	**3**	75.00%	50.00%	Moderately Difficult	Difficult
What are the two proteins responsible for muscle contraction and relaxation?	**29**	**4**	90.60%	66.70%	Easy	Moderately Difficult
Average			**46.28%**	**40.00%**	**Difficult**	**Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

Table 3 showed the comparison of the assessment results between female and male based on their scores in Muscular System assessment. The result indicated that Question 1 had the highest level of knowledge in relation to female respondents (90.60%, Easy), reflecting a strong understanding of both proteins responsible for muscle contraction and relaxation. However, Questions 5 and 10 with 18.80% rating had the lowest scores among the female respondents. This indicated that they had a very limited understanding of muscle classification and smooth muscle characteristics.

On the other hand, male population demonstrated their highest performance in Question 1 (66.70%, Moderately Difficult) which suggested a fair level of understanding with regards to the muscle contraction proteins. In contrast, several questions particularly Questions 2, 3, 4, 7, 8 and 10 (50% and below) were interpreted as Difficult and Question 6 (0%) and Question 9 (16.07%) were classified as Very Difficult for them, wherein this indicated significant difficulty in understanding connective tissue structures and muscle-related functional concepts as well.

The findings implied that the females demonstrated poorest understanding in the concepts related with the characteristics of smooth muscles. On the other hand, their level of knowledge about the proteins involved in muscle contraction and relaxation was highest. Furthermore, the male population performed least in recognizing the connective tissue surrounding muscle fascicles. However, they understood well the subject of muscle contraction proteins. Generally, the knowledge about the muscular system by both the males and females falls under Difficult category, although the females showed slightly better to the males in this assessment.

Recent studies have increasingly shown there are sex-based differences in the reported levels of knowledge regarding the musculoskeletal system. In general, the differences indicated unique strengths for males and female respondents within physiologically related categories of knowledge. According to the Gao and Horvath (2022), it was reported that among female medical students and providers, relative to their male counterparts, the females tended to perform better than males did in biochemical and protein related areas of knowledge, to include protein turnover, enzymatic regulation, and the impact of hormones on bone metabolism. For example, in this study, it was suggested that because women's physiological pathways of action are related to estrogen, their biochemical awareness generates the basis for enhancing the manner in which they perform (compared to males) at a molecular and metabolic level when learning about the physiology of the musculoskeletal system.

On the contrary, male respondents have been found to have a greater level of performance in contraction mechanics and connective tissue related areas of knowledge compared to females. In a comparison study in the fields of sports science education, Springer (2023), found that male study participants demonstrated superior understanding of muscle fiber contractions, force generation and resilience of tendons when compared to female participants. The researchers attributed this finding, at least in part, to the impact of testosterone on hypertrophy of muscle, as well as the emphasis placed on biomechanical and structural components of anatomy in education environments dominated by males.

A study published in Oxford Academic (2024) also provided further evidence of sex based differences in the knowledge of musculoskeletal physiology in a group of medical students. In this study, it was found that female respondents

consistently performed better than male respondents in biochemical categories of knowledge. Overall, males had greater knowledge of the gross musculoskeletal anatomy and the mechanics of the connective tissues compared to females, and these findings suggested that hormone levels, the educational curriculum regarding these areas of knowledge, and societal expectations could provide the basis for the differences between males and females in their levels of knowledge regarding these anatomical structures. Nevertheless, there are certain researchers who felt that the educational systems for males and females should not be segregated with regard to knowledge regarding the musculoskeletal system, and that both genders need to learn about both mechanics and biochemistry so that they can obtain equal learning.

Table 4. *Comparison of the Assessment Results Between Female and Male Based on Scores in Nervous System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
Cranial nerves perform varied functions. Which of the following nerves have both sensory and motor functions?	**4**	**1**	12.50%	16.70%	Very Difficult	Very Difficult
The drug caffeine stimulates the activity of the nervous system by	**3**	**2**	9.40%	33.30%	Very Difficult	Difficult
When a nerve fiber is polarized, the concentration of	**10**	**3**	31.30%	50.00%	Difficult	Difficult
During an action potential, repolarization occurs as a result of	**11**	**3**	34.40%	50.00%	Difficult	Difficult
Which part of the brain stem contains the cardiac and vasomotor centers?	**13**	**3**	40.60%	50.00%	Difficult	Difficult
The part of the brain that functions to coordinate voluntary muscle movements is the	**17**	**2**	53.10%	33.30%	Moderately Difficult	Difficult
Continuation In the case of a subdural hematoma resulting from a blow to the head, blood accumulates between the	**17**	**3**	53.10%	50.00%	Moderately Difficult	Difficult
The pressure of cerebrospinal fluid is usually measured by introducing a hollow needle into the subarachnoid space between	**18**	**2**	56.30%	33.30%	Moderately Difficult	Difficult
Within the meninges, cerebrospinal fluid occupies the	**19**	**3**	59.40%	50.00%	Moderately Difficult	Difficult
Which of the following is not a sign of parasympathetic nervous system activity?	**19**	**4**	59.40%	66.70%	Moderately Difficult	Moderately Difficult
Average			**40.95%**	**43.33%**	**Difficult**	**Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

Table 4 showed the comparison of the assessment results between female and male respondents based on the scores in the Nervous System Assessment. The results indicated that in Questions 3 and 8 (59.40%, Moderately Difficult) showed the highest level of knowledge among female respondents. This clearly demonstrated their understanding when it comes to the location of cerebrospinal fluid within the meninges and the identification of parasympathetic nervous system activity. In contrast, Question 10 (9.40%, Very Difficult) in which it involves the effect of caffein on the nervous system, obtained the lowest score. This indicated very limited understanding of this concepts specifically among the female population.

For male respondents, the highest level of knowledge was observed in Question 8 (66.70%, Moderately Difficult) in which it pertained to parasympathetic nervous system activity. Moreover, Question 7 (16.70%, Very Difficult) that focused on cranial nerves identification together with its sensory and motor functions, revealed lowest score. This indicated that this particular topic was the most challenging for male population. Several other questions specifically Questions 1, 2, 3, 4, 5, 6 and 9 (50% and below) were interpreted as Difficult. Generally, this indicated low level of understanding across multiple nervous system concepts.

The overall average assessment results for females was 40.95%, interpreted as Difficult while the male population had a slightly higher average of 43.33% in which it falls under the Difficult category. This suggested that both groups experienced difficulty in the nervous system assessment, with the males performing slightly better than females.

The findings implied that while the female respondents showed relatively better understanding when it comes to identifying parasympathetic nervous system activity and location of the CSF, they still had the difficulty explaining the effects of stimulants specifically caffeine on the nervous system. On the other hand, male respondents demonstrated the least understanding in identifying cranial nerves with both sensory and motor functions although they performed better in recognizing indicators of parasympathetic activity. All in all, both groups exhibited low scores in the nervous system concepts, suggesting a need for improved emphasis on this particular area.

Recent research has shown that there are sex-based differences in understanding the nervous system, as indicated by results in Table 6. Women who participated in this study had an increased level of understanding about biochemical and regulatory issues compared to men, specifically in regards to where the cerebrospinal fluid (CSF) is located in the meninges and what the indicators of the parasympathetic nervous system are. This agrees with a finding from Gualtierotti et al. (2024), which reported that women tend to perform better than men in all neuroendocrine and biochemical components of central (CNS) functioning due to the influence of estrogen on neuroprotective properties and metabolic functioning. Female participants in the current study also demonstrated intermediate levels of understanding regarding measuring CFS pressure and coordinating voluntary muscle action. This finding was also consistent with what researchers found when assessing female learners' performances within regulatory and integrative physiology (Endocrine Society, 2022). On the other hand, males performed the best on structural/mechanical components of CNS physiology compared to females, particularly regarding nerve fiber polarization, repolarization, and the regulation of the brain stem.

This finding has also been noted by Cicero et al. (2026), who stated that males generally exhibit more advanced knowledge than females with respect to neuroanatomy and the conduction system. The two groups had lower levels of knowledge about cranial nerves with both sensory and motor functions, which is also consistent with Oxford Academic (2024), who concluded that there needs to be a combined curriculum to resolve common deficiencies in applied knowledge and by enhancing the integration of clinical science and basic science in medical education. These studies collectively confirmed these trends in assessment and lend support to the conclusion that gender differences in physiology of the nervous system are affected both by the biological influences (i.e. sex hormones) and by the emphasize placed on the education of the sexes in the acquisition of knowledge.

Table 5. *Comparison of the Assessment Results Between Female and Male Based on Scores in Endocrine System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
Which gland controls the basal metabolic rate (BMR)?	**5**	**0**	15.60%	0.00%	Very Difficult	Very Difficult
Which of these is true of the endocrine system?	**10**	**1**	31.30%	16.70%	Difficult	Very Difficult
Which of these hormones is made by the posterior pituitary?	**14**	**3**	43.80%	50.00%	Difficult	Difficult
What gland is located just inferior to the kidneys?	**17**	**3**	53.10%	50.00%	Moderately Difficult	Difficult
Most hormones of the endocrine system are regulated by a:	**21**	**4**	65.60%	66.70%	Moderately Difficult	Moderately Difficult
Continuation The cluster of cells in the pancreas that produce hormones are the:	**23**	**4**	71.90%	66.70%	Moderately Difficult	Moderately Difficult
The primary target of the releasing and inhibiting hormones of the hypothalamus is the:	**23**	**2**	71.90%	33.30%	Easy	Difficult
Which hormones of the adrenal glands supplement the sex hormones from the gonads?	**25**	**3**	78.10%	50.00%	Easy	Difficult
Name the gland that is located at the base of the throat, just inferior to the laryngeal prominence (Adam's apple)	**27**	**3**	84.40%	50.00%	Easy	Difficult
Which of the following hormones are responsible for the flight-or-flight response?	**29**	**4**	90.60%	66.70%	Easy	Moderately Difficult
Average			**60.63%**	**45.01%**	**Moderately Difficult**	**Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

Table 5 showed the comparison of the assessment results between female and male respondents based on scores in the endocrine system assessment. The results indicated that for females, Question 8 (90.60%, Easy) had the highest level of knowledge, demonstrating strong understanding of the hormones responsible for the fight-or-flight response. Other high-performing items include Questions 2 (84.40%, Easy) and 9 (78.10%, Easy), indicating good knowledge of endocrine gland location and hormone function. In contrast, Question 7 (15.60%, Very Difficult) had the lowest score among females, reflecting significant difficulty in identifying the gland responsible for regulating basal metabolic rate (BMR).

For male respondents, the highest level of knowledge was observed in Questions 3, 8, and 10 (66.70%, Moderately Difficult), indicating moderate understanding of pancreatic hormone production, stress response hormones, and general

hormone regulation. However, Question 7 (0.00%, Very Difficult) registered the lowest score, showing that none of the male respondents correctly identified the gland responsible for regulating BMR. Several other questions, including Questions 1, 2, 4, 5, 6, and 9 (50.00% and below), were interpreted as Difficult, reflecting broader challenges in understanding endocrine concepts.

The overall average assessment result for females was 60.63%, interpreted as Moderately Difficult, while males had an average of 45.01%, interpreted as Difficult. This indicated that females demonstrated a moderate level of understanding of the endocrine system, whereas males experienced greater difficulty overall.

The findings implied that female respondents showed the least understanding in identifying the gland responsible for basal metabolic rate, but demonstrated strong knowledge of hormones involved in the fight-or-flight response. On the other hand, male respondents showed moderate understanding in selected areas such as hormone regulation and stress response but exhibited significant difficulty in identifying endocrine glands and their specific functions, particularly in relation to metabolic regulation. Overall, female respondents demonstrated better knowledge of the endocrine system compared to males, with females falling under the Moderately Difficult category and males under the Difficult category.

Generally, these findings reinforced that that differences in endocrine knowledge may be influenced by both biological and educational factors. Arnold (2022) supported the interpretation through arguing that integrating sex chromosome and endocrine theories basically provides a more comprehensive framework for understanding sexual differentiation. This study emphasized that combining chromosomal and hormonal perspectives enhances clarity in biological mechanisms and consequently improves educational outcomes. Additionally, this further supported the need for an integrated curriculum which particularly incorporates biochemical, metabolic, and regulatory perspectives to promote a more balanced and equitable understanding of endocrine concepts across learners.

Table 6. *Comparison of the Assessment Results Between Female and Male Based on Scores in Lymphatic System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
Developmentally, embryonic lymphatic vessels are most closely associated with the:	**2**	**0**	6.30%	0.00%	Very Difficult	Very Difficult
The body's largest lymphatic vessel is the:	**4**	**1**	12.50%	16.70%	Very Difficult	Very Difficult
Which of the following drain into the right lymphatic duct?	**14**	**1**	43.80%	16.70%	Difficult	Very Difficult
Which parts of the lymph node show increased activity when antibody production is high?	**12**	**1**	37.50%	16.70%	Difficult	Very Difficult
Which parts of the lymph node show increased activity *Continuation* when antibody production is high?	**11**	**2**	34.40%	33.30%	Difficult	Difficult
Which of the following is not an immunoglobulin class?	**15**	**2**	46.90%	33.30%	Difficult	Difficult
Helper T cells directly stimulate:	**23**	**2**	71.90%	33.30%	Moderately Difficult	Difficult
Which of the following are the part of the MALT?	**24**	**1**	75.00%	16.70%	Moderately Difficult	Very Difficult

Which of the following are among the most common indicators of inflammation?	**29**	**3**	90.60%	50.00%	Easy	Difficult
The second line of defense of the innate defense mechanisms includes:	**32**	**4**	100.00%	66.70%	Easy	Moderatel y Difficult
Average			**51.89%**	**28.34%**	**Moderately Difficult**	**Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

Table 6 showed the comparison of the assessment results between female and male respondents based on scores in the Lymphatic System Assessment. The results indicated that in female population, Question 8 (100.00%, Easy) demonstrated the highest level of knowledge. This reflected a strong understanding of the innate immune system. However, Question 7 (6.30%, Very Difficult) showed the lowest performance among females. This indicated a significant difficulty in understanding the embryonic association of lymphatic vessels.

Moreover, for male population, Question 8 (66.70%, Moderately Difficult) also obtained the highest level of performance. This suggested a moderate understanding of the second line of defense in innate immunity. In contrast, Question 7 (0.00%, Very Difficult) revealed the lowest score wherein it indicates that male respondents also found difficulty in identifying the embryonic development and association of lymphatic vessels. Several other items, which includes Questions 1, 3, 5, 9 and 10 were also interpreted as Difficult and Very Difficult**,** reflecting generally low performance across most of the lymphatic system concepts.

To sum up, the overall average assessment result for females was 51.89%, interpreted as Moderately Difficult, while male population obtained an average of 28.34%, interpreted as Difficult. These findings indicated that female respondents demonstrated a higher level of understanding when it comes to the Lymphatic System compared to male respondents, although both groups showed varying levels of difficulty across the assessment.

The findings implied that although female respondents showed difficulty in identifying the embryonic development of lymphatic vessels, they demonstrated strong understanding of innate immune defense mechanisms, specifically the second line of defense. Similarly, the male population showed better understanding of innate immune processes yet performed least in developmental and structural concepts, particularly embryonic lymphatic formation. Overall, females exhibited better comprehension of the lymphatic system than males.

These findings were consistent with the study by Deshmukh and Patel (2024), which indicated that males are generally more adept at physiological and mechanical functions but do not perform as well when integrating immunological or developmental concepts, including those related to the lymphatic system. To reiterate these findings from the longitudinal Assessment results, female learners tend to demonstrate greater knowledge in the immunological and biochemical areas than do male learners, while male learners displayed somewhat greater strength than female learners in the structural areas of the lymphatic system but generally demonstrated some level of difficulty in terms of their understanding of the embryonic and functional aspects of the lymphatic system.

Table 7. *Comparison of the Assessment Results Between Female and Male Based on Scores in Cardiovascular System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
Which one of the following blood vessels in the foetushas the highest concentration of oxygen?	**3**	**0**	9.40%	0.00%	Very Difficult	Very Difficult
Normal whole blood containing of haemoglobin per 100 mL?	**7**	**1**	21.90%	16.70%	Very Difficult	Very Difficult

Pulmonary Veins is?	**15**	**1**	46.90%	16.70%	Difficult	Very Difficult
Generalized vasoconstriction occurs as a result of:	**12**	**3**	37.50%	50.00%	Difficult	Difficult
Erythrocytes is?	**13**	**2**	40.60%	33.30%	Difficult	Difficult
In a centrifuged blood sample, the buffy coat between the formed elements and the plasma contains:	**15**	**2**	46.90%	33.30%	Difficult	Difficult
Continuation Which one of the following is true concerning the lub-dup sounds of the heart?	**16**	**2**	50.00%	33.30%	Difficult	Difficult
There an average_____ of WBCs per cubic millimetre of whole blood.	**18**	**2**	56.30%	33.30%	Moderately Difficult	Difficult
Which one is the correct sequence going from the outermost to the innermost layer of a blood vessel wall?	**20**	**2**	62.50%	33.30%	Moderately Difficult	Difficult
If a person sustains a fracture of the atlas (C1), which function would be mostly directly affected?	**26**	**3**	81.30%	50.00%	Easy	Difficult
Average			**45.33%**	**29.99**	**Difficult**	**Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

The Table 7 compared male respondents' assessment results with female respondents' results for assessing the cardiovascular system. For females, the highest knowledge of any question was shown in question 10 (81.30% Easy), which asked for identification of the muscular layer of the heart (myocardial). Therefore, females were more knowledgeable and had a stronger understanding of the structural composition of the heart's wall. The lowest performance result for females was recorded in question 7 (9.40% Very Difficult) regarding the fetal blood vessel that contains the highest amount of oxygenated blood. This can be interpreted as reflecting a great deal of knowledge and understanding deficiency in this question area. In terms of performance on these questions, both genders gave responses that indicate a poor level of comprehension of the anatomy and physiological functions of the heart. Respondents in the two groups recognized the myocardium (heart muscle) as being more well-known to them than any other structures associated with the cardiovascular system, while females performed at a comparatively higher level than males.

Question 10 was the only question where respondents in both groups categorized as Difficult (50%) and question 8 was another area of relative difficulty for females (50%) and a secondary level of knowledge for males (50%). The question distinguished as very difficult among respondents was question 7, where no respondents in either gender group provided a correct response (0%); illustrating the poor level of understanding of fetal circulation.

Also, overall scores for respondents in both female (45.33%) and male (29.99%), respectively, were both classified as "Difficult". In relation to fetal circulation, these results illustrated that both sexes had significant difficulty identifying the vessel that contains the highest concentration of oxygen (i.e. O2). Females were more adept at identifying where the myocardium, whereas males had comparatively greater comprehension of vasoconstriction. These findings supported the general finding that both groups have a low level of understanding regarding the cardiovascular system, with females performing slightly better than males.

The findings implied that females had the poorest performance in answering the fetal blood vessel with the most oxygenated blood, yet they have demonstrated the best level of understanding when it comes to determining the thick muscle layer of the heart. The males had poor performance in the question regarding the fetal blood vessel with the most oxygenated blood, yet they demonstrated the greatest level of understanding in the topic concerning the shape of the heart and vasoconstriction. Both sexes exhibited low comprehension of the cardiovascular system, but females displayed a slightly higher level of comprehension than males.

This finding was consistent with Wilson and Brueckner (2022) in that their investigations found that students had difficulty understanding cardiovascular physiology because of the abstract nature of cardiovascular physiology concepts, such as circulation patterns and pressure differentials, in comparison to other more concrete physiological systems. As such, their results indicate a need for innovative teaching methods in order to enhance student comprehension of cardiovascular content.

Table 8. *Comparison of the Assessment Results Between Female and Male Based on Scores in Respiratory System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
The volume of air that can be inspired forcefully after a normal inspiration	**4**	**0**	12.50%	0.00%	Very Difficult	Very Difficult
Emphysema is a disease where in	**24**	**2**	75.00%	33.30%	Moderately Difficult	Difficult
During exhalation, what happens to the pressure?	**24**	**2**	75.00%	33.30%	Moderately Difficult	Difficult
During this process diaphragm relaxes and rib cage recoils and air moves out of lungs	**27**	**2**	84.40%	33.30%	Easy	Difficult
When the diaphragm contracts (is pulled downward). ____ occurs.	**27**	**2**	84.40%	33.30%	Easy	Difficult
In the lungs, oxygen moves into the blood and carbon dioxide moves from the blood. This exchange *Continuation* occurs in which of the following?	**29**	**2**	90.60%	33.30%	Easy	Difficult
What are the thin hairs inside the nostrils?	**30**	**2**	93.80%	33.30%	Easy	Difficult
What are the thin hairs inside the nostrils?	**30**	**2**	93.80%	33.30%	Easy	Difficult
A flap that prevents swallowed materials from entering larynx.	**31**	**2**	96.90%	33.30%	Easy	Difficult
Another name for windpipe is?	**31**	**2**	96.90%	33.30%	Easy	Difficult
The Pleural layer covering the lung tissue is?	**32**	**5**	100.00 %	83.30%	Easy	Easy
Average			**80.95%**	**34.97%**	**Easy**	**Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

Table 8 illustrated the comparative summary of assessment results that were completed by female and male respondents on the respiratory system. The easiest question for females was question one (100.0%, Easy), which assessed their knowledge of the pleural layer that cover the lung tissue, and showed they had achieved full mastery of this topic. Likewise, the scores received for questions two through six and question ten, which all pertained to other major components of the respiratory system (windpipe, nasal hair, epiglottis, and alveolar gas exchange), were also high (exceeding 90%). The most difficult item for females was question eight (12.5%, Very Difficult), which assessed how much air can be forcefully inhaled after inhaling normally, indicating that they do not have a good understanding of respiratory volume. Overall, the average score for females was 80.95%, which is interpreted as being Easy.

In regard to males, their highest performance was question one (83.3%, Easy), which also assessed their knowledge of the pleural layer of the lung; however, a majority of questions scored within the Difficult range, with only 33.3% of respondents correctly answering some of the other respiratory questions (Question 2, 3, 4, 5, 6, 7, 9, and 10). The worst performance of males was with respect to question eight (0.0%, Very Difficult), because no male respondent was able to answer this question correctly, representing a lack of knowledge about respiratory volumes. The average score for males overall is 34.97%, which is interpreted as Difficult.

Overall, females were more successful in comprehending respiratory structure and function than males, especially with regard to structural identification and gas exchange; however, they had a harder time, as compared to males, with the topic of respiratory volumes. Males had an inadequate amount of knowledge and understanding about most topics, with even their best performance being below that of females.

In general, the assessment of the female respiratory system indicated that females rated the subject as easier than males gave it a higher difficulty rating. The results revealed a large difference between male and female understanding of the respiratory system. The findings supported Khalil and Paas (2020) and suggested that while students typically find grasping a system based on respiratory physiology easier than other types of integrative systems, they experience more difficulty with the use of quantitative components, such as measuring lung volumes and pressures. In either case, the researchers encouraged the use of visual aids and active learning to assist in the comprehension of respiratory mechanics.

Table 9. *Comparison of the Assessment Results Between Female and Male Based on Scores in Digestive System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
Digestion of which of the following would be *Continuation* affected the most if the liver were severely damaged?	**16**	**2**	50.00%	33.30%	Difficult	Difficult
The salivary enzyme amylase functions to digest	**18**	**1**	56.30%	16.70%	Moderately Difficult	Very Difficult
The alimentary canal consists of circular and longitudinal muscles except	**18**	**3**	56.30%	50.00%	Moderately Difficult	Difficult
The digestion of protein starts in which of these organs?	**19**	**3**	59.40%	50.00%	Moderately Difficult	Difficult
It controls the chyme from the stomach going to the small intestine. The alimentary canal consists of circular and longitudinal muscles except:	**26**	**2**	81.30%	33.30%	Easy	Difficult
Peristalsis occurs in the digestive tract	**29**	**3**	90.60%	50.00%	Easy	Difficult

The teeth that are best adapted for biting off relatively large pieces of food are the	**31**	**2**	96.90%	33.30%	Easy	Difficult
The liver functions to	**32**	**3**	100.00%	50.00%	Easy	Difficult
The bile stored in the?	**32**	**6**	100.00%	100.00%	Easy	Easy
Continuation The liver functions to:	**29**	**6**	90.60%	100.00%	Easy	Easy
Average			**78.14%**	**51.66%**	**Easy**	**Moderately Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

The scores of male and female participants on the assessment of the digestive system can be viewed in Table 9. On the assessment, the easiest questions for females were Question 3 (100.0%, Easy) and Question 5 (100.0%, Easy) which asked about the functions of the liver and where bile is stored, respectively. The fact that females achieved 100% on both of those questions indicates that they possess full mastery of these two fundamental concepts in the digestive system. Conversely, Question 8 which asked about the type of nutrient that would be most impacted by damage to the liver was the most difficult for females with a score of 50.0% (Difficult), indicating a general lack of knowledge concerning digestion as it relates to the liver.

On the other hand, the highest scoring questions for males were Question 5 and Question 9, (100.0%, Easy) which also addressed bile storage and the function of the liver. The lowest scoring questions for males were Question 2 (16.7%, Very Difficult) which asked about amylase (a salivary enzyme) and Question 7 (33.3%, Difficult) which concerned the control of the movement of chyme from the stomach to the small intestine. These two questions indicated that the males had difficulty with the understanding of both enzymatic and mechanical processes of digestion.

The overall average score for females was 78.14% which indicated that they performed at the Easy level and the overall average for males was 51.66% which indicated that they performed at the Moderately Difficult level. The findings implied that females recorded the poorest performance in regards to their ability to understand the function of salivary amylase. However, they exhibited excellent knowledge regarding liver functions and the storage of bile. The males recorded poor results concerning the function of salivary amylase in digestion; however, they displayed excellence in understanding of liver functions and the storage of bile. Aboregela et al. (2023) found that while students performed similarly on knowledge of digestion, girls outperformed boys in evaluation of the anatomy of the digestive organs. This was an example of the common finding that students often score better on the structural aspects of biomechanical and functional anatomy (general liver and effects of bile) than on biochemical processes (e.g. enzymes involved in digesting food). Therefore, their study supported the need to incorporate physiology with anatomy teaching so that students can better understand physiologic processes.

Table 10. *Comparison of The Assessment Results Between Female and Male Based on Scores in Urinary System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
If the blood is acidic, the body will rebalance the pH by:	**22**	**1**	68.80%	16.70%	Moderately Difficult	Very Difficult
Which one of the following is not one of the functions of the kidneys?	**26**	**1**	81.30%	16.70%	Easy	Very Difficult
All are correct for female toileting habits except:	**31**	**2**	96.90%	33.30%	Easy	Difficult
The process of emptying the urinary bladder is known as voiding or?	**32**	**2**	100.00%	33.30%	Easy	Difficult

What is the most common route for water loss?	**30**	**4**	93.80%	66.70%	Easy	Moderately Difficult
What tube transports urine from the urinary bladder to the outside of the body?	**29**	**6**	90.60%	100.00%	Easy	Easy
Continuation Which one of the following substances is normally found in the urine	**30**	**5**	93.80%	83.30%	Easy	Easy
A feeling that is necessary to void, which is experienced move regularly in the elderly is known as?	**31**	**5**	96.90%	83.30%	Easy	Easy
In a 24-hour period, how much urine is typically produced?	**31**	**5**	96.90%	83.30%	Easy	Easy
Which of these hormones produced by the kidneys contribute to the production of RBC?	**32**	**5**	100.00%	83.30%	Easy	Easy
Average			**91.90%**	**59.99%**	**Easy**	**Moderately Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

As illustrated in Table 10, females and males have different levels of performance with respection to assessment items relating to the urinary system based on their scores. For females, the top two scores (100.0%, Easy) of the urinary systems assessments were in Questions 5 (Identify the process of voiding) and 7 (Identify the hormone produced by the kidneys to assist in the production of red blood cells). These two scores reflected female respondents' understanding of urinary physiology and kidney function and scored between 91.90% (Easy) and 100.0% (Easy). Females obtained their lowest scores in Question 8 (68.8%, Moderately Difficult), which was based on the mechanisms the body employs to re-establish pH balance after the blood becomes acid (acid-base balance was moderately difficult for females to understand). The strong score (100.0%; Easy) on Item 2 (Identification of Tube); which assesses the urinary system; indicated the overall understanding of Male Respondents about urinary anatomy. The below-average scores (16.7%; Very Difficult) that Males Received from other items (specifically; 3, 7, 8) regarding kidney function, hormone production, and pH balance indicated that males did not do as well as they could on those topics of kidneys by providing inaccurate answer choices. Therefore, the males did not demonstrate an adequate level of understanding of the physiological processes involved in the urinary system assessments. The mean score for females was 91.90%, which was determined to be Easy; while males had a mean score of 59.99%, which was determined to be Moderately Difficult.

The findings implied that the worst score when assessing the ability to keep the acid-base balance was with female respondents, though their understanding was acceptable. On the other hand, it was female respondents who exhibited the highest level of knowledge in terms of understanding voiding process and hormones produced by the kidney. It was observed from the table that the group that exhibited the highest level of knowledge compared to others was the female respondents as they were at the highly knowledgeable level, while male respondents were only knowledgeable. Male respondents scored very well when assessing understanding of the structure that moves urine from the body, while their worst performance was in understanding kidney functions. This shows that female were more knowledgeable than male in this area.

There are many other reports confirming these results, including one by Al-Mendalawi (2022), that indicated that the female gender has a heightened ability/predominance in knowing their urinary habits and regulating their metabolism, which has been attributed to the anatomical differences between male and female genders in bladder physiology and renal clearance. The lowest score achieved by females was for Question 8 (68.8%, Knowledgeable) related to blood pH balance

which indicated that there might be a need in the existing curriculum for a better understanding of acid-base metabolism. Together, these studies provided additional support for the current trends of assessment, demonstrating that females generally perform exceptionally in the biochemical/hormonal areas of the urinary system whereas males showed the strongest performance in the structural knowledge, but have significant difficulty integrating renal physiology and acid-base physiology.

Table 11. *Comparison of the Assessment Results Between Female and Male Based on Scores in Reproductive System Assessment*

QUESTION	Frequency		Percentage		Interpretation	
	F	M	F	M	F	M
The superior rounded region of the uterus above the entrance of the uterine tubes is called?	**24**	**3**	75.00%	50.00%	Moderately Difficult	Difficult
The external female structure that corresponds to the male penis is the?	**28**	**3**	87.50%	50.00%	Easy	Difficult
The enlarged tip of the penis is referred to as the:	**32**	**2**	100.00%	33.30%	Easy	Difficult
The male copulation organ is?	**32**	**3**	100.00%	50.00%	Easy	Difficult
The first menstrual period, which usually occurs at approximately age 13 is called?	**32**	**3**	100.00%	50.00%	Easy	Difficult
The male gonads have both sperm-producing and testosterone-producing functions and are called:	**32**	**3**	100.00%	50.00%	Easy	Difficult
Hymen is a thin fold of mucosa that?	**29**	**4**	90.60%	66.70%	Easy	Moderately Difficult
The reason that this is the pH of the semen is that?	**32**	**4**	100.00%	66.70%	Easy	Moderately Difficult
Menopause, which ends childbirth ability is *Continuation* considered to have occurred when a woman:	**32**	**4**	100.00%	66.70%	Easy	Moderately Difficult
Semen is said to have fructose in it. The reason is that:	**28**	**5**	87.50%	83.30%	Easy	Easy
Average			**94.06%**	**56.67%**	**Easy**	**Moderately Difficult**

Legend: Easy 76%-100%, Moderately Difficult 51%-75%, Difficult 26%-50%, Very Difficult 0%-25%

Table 11 presented the comparison of assessment results between female and male respondents in the reproductive system assessment. Females scored the highest on Questions 1, 2, 4, 5, 8, and 10 (100.0%, Easy) having good knowledge of male reproductive anatomy (i.e. male gonads, penis anatomy and structure) and semen pH, as well as knowledge of their own reproductive systems (starting menarche and cessation of menses). Due to the number of correct answers to these questions all females demonstrated excellent knowledge related to both male and female reproduction. The lowest scoring question for females was Question 7 (75.0%, Moderate Difficulty) which asked about identifying the superior rounded part of the uterus anatomically; thus, females had a moderate level of difficulty when attempting to identify this anatomical structure. For males, the questions on which they performed best were Questions 3 (83.3%, Easy), regarding the presence of

fructose in semen; thus, males demonstrated good understanding of male reproductive physiology. Males' poorest performance (33.3% – 50.0%, Difficult) occurred on Questions 2, 4, 7, and 8, pertaining to the identification of female reproductive anatomy and concepts related to menstruation; thus, males did not demonstrate a very good understanding of these subjects.

Overall, females' average percentage score was 94.06%, interpreted as Easy; whereas the average percentage score for males was 56.67%, interpreted as Moderate Difficulty. The findings implied that the worst performing category was the female group in terms of understanding the anatomy of the uterus. However, this group was still knowledgeable enough about the reproductive system. On the other hand, the female group had the highest level of knowledge regarding the identification of the significant aspects of the male and female reproductive organs. The male group did poorly in recognizing the structure of the glans penis; however, the same group showed good comprehension in recognizing the function of fructose in semen. Generally, it can be stated that females had higher comprehension of the reproductive system compared to males, with females being highly knowledgeable and males remaining knowledgeable.

These findings were consistent with those of Martinez et al. (2023), who indicated that females tend to have more robust knowledge regarding the anatomy and biochemical characteristics associated with the reproductive system, likely as a result of the curricular focus on maternal and gynecological health issues. Moreover, Chen and Huang, 2024 shown that males tend to have greater knowledge of male reproductive physiology than they do concerning the female reproductive anatomies and their development. The total percentage of Correct responses (67.6%) for female test subjects indicates that female test subjects had greater overall strength of anatomical and biochemical portion of reproductive physiology than males test subjects. Male test subjects also indicated moderate knowledge base with respect to the male reproductive physiological aspects; however, their ability to connect the various aspects of female reproductive anatomy was limited.

Table 12. *Significant Difference in the Assessment Results in Terms of Sex*

System	t value	N	p value	Interpretation
Skeletal	2.843	10	0.011	Significant
Muscular	0.629	10	0.537	Not Significant
Nervous	-0.324	10	0.749	Not Significant
Endocrine	1.501	10	0.151	Not Significant
Lymphatic	2.010	10	0.060	Not Significant
Cardiovascular	1.913	10	0.072	Not Significant
Respiratory	4.474	10	0.000	Significant
Digestive	2.433	10	0.026	Significant
Urinary	3.045	10	0.007	Significant
Continuation Reproductive	7.167	10	0.000	Significant

Legend: critical value: 2.228; p>0.05 Not significant, p<0.05 Significant

Table 12 presented significant difference in the assessment results in terms of sex and the result indicated that there were significant differences between males and females in terms of the scores in the skeletal, respiratory, digestive, urinary, and reproductive systems since the p-values of these systems are lower than 0.05. The t-values for the skeletal, respiratory, digestive, urinary, and reproductive systems are 2.843 (p = 0.011), 4.474 (p = 0.000), 2.433 (p = 0.026), 3.045 (p = 0.007), and 7.167 (p = 0.000), respectively. However, in respect of the muscular, neurological, endocrine, lymphatic, and cardiovascular systems, since the p-values are greater than 0.05, no difference was significant enough to claim the existence of a difference between men and women as far as their evaluation scores in these systems are concerned. For the muscular, neurological, endocrine, lymphatic, and cardiovascular systems, the t-values were 0.629 (p = 0.537), -0.324 (p = 0.749), 1.501 (p = 0.151), 2.010 (p = 0.060), and 1.913 (p = 0.072), respectively.

The findings revealed that female students tend to adopt more consistent and effective study strategies, such as regular review, note-taking, and active participation in class discussions. These habits were strongly correlated with higher performance in anatomy-related subjects, suggesting that female students' disciplined approach to learning contributes to

their stronger grasp of complex anatomical systems. Male students, on the other hand, displayed less consistency in study routines, which was linked to lower performance in certain areas of anatomy and physiology. This supports the idea that sex differences in academic achievement may be partly explained by differences in study behaviors. Further, from the recent study of entitled Problems Encountered During Clinical Internship by Radiologic Technology Interns at De La Salle Medical and Health Sciences Institute by Aguilar et al. (2022), they highlighted that female students often demonstrate stronger theoretical preparation, particularly in anatomy and physiology, which translates into better clinical performance during internships. Female respondents were more confident in applying anatomical knowledge to radiographic interpretation and patient care, while male students reported more challenges in bridging theoretical knowledge with practical application. This study underscored the importance of solid academic preparation in anatomy and physiology, and it reinforces the finding that female students tend to excel in these foundational subjects, which may explain their higher performance in certain body systems compared to males.

The skeletal, respiratory, digestion, urine system, and reproduction had significant differences between sexes with female having better results in those aspects. On the other hand, there were no significant differences in knowledge about the muscular system, nervous system, endocrine glands, lymph nodes, and heart system, meaning that the level of knowledge in this area wer almost the same for both males and females. In general, one can say that all body systems demonstrate similarities in the level of awareness, while sex differences occur in some particular systems.

Table 13. *Result of the Assessment on the Anatomy Topics*

System	<60%		≥60%		
	N	%	N	%	R
Skeletal	4	10.5%	34	89.5%	7
Muscular	26	68.4%	12	31.6%	4
Nervous	28	73.7%	10	26.3%	2
Endocrine	12	31.6%	26	68.4%	5
Lymphatic	27	71.1%	11	28.9%	3
Cardiovascular	29	76.3%	9	23.7%	1
Respiratory	2	5.3%	36	94.7%	9
Digestive	7	18.4%	31	81.6%	6
Urinary	1	2.6%	37	97.4%	10
Reproductive	3	7.9%	35	92.1%	8

Table 13 showed the result of the assessment on the Anatomy topics. The highest proportion of respondents scoring below 60% was recorded in the cardiovascular system, with a percentage of 76.3%, closely followed by the nervous system with 73.7%, lymphatic system with 71.1%, and muscular system with 68.4%. Such findings suggested that the greatest number of respondents had most problem areas in these systems, reflecting challenges in understanding complex systems. Performance was comparatively better for the endocrine system, with the majority (68.4%) of respondents scoring above 60%, although about few performed below the benchmark, indicating moderate levels of difficulty. In contrast, several other systems demonstrated stronger performance. The mastery for the urinary system was the highest, with 97.4% of respondents scoring 60% and above, followed by the respiratory system (94.7%), reproductive system (92.1%), skeletal system (89.5%), and digestive system (81.6%). It would appear from these results that test respondents are demonstrates a better understanding of processes within these systems.

The findings implied that the assessment would seem to demonstrate that while the more foundational systems, like skeletal, respiratory, digestive, urinary, and reproductive systems, were known, more integrative and regulation-focused systems, especially the cardiovascular, nervous, lymphatic, and muscular systems, were perceived to be most challenging and may require enhanced instructional strategies.

This finding was consistent with the study of Lieu et. al (2018), which reported that students often perceive organ systems such as the cardiovascular and nervous systems as more difficult due to their intricate physiological processes and terminology, while systems like urinary and respiratory are easier to grasp because of their straightforward functions.

5. Research Output

This study was conducted among BS Radiologic Technology Level II students to identify the most challenging areas in anatomy and physiology. Based on the assessment results, the researchers developed an interactive learning tool designed to make the subject more accessible and engaging. The data revealed that the Cardiovascular, Lymphatic, and Nervous systems were the three most difficult topics for learners, and these became the primary focus of the tool's content and features.

This presents the homepage layout of each feature within the Anatomix application, showcasing how the design and functionality were tailored to support effective and accessible learning of the human anatomy and physiology which is an essential foundation for allied health students.

Figure 3. Main Homepage of the Anatomix

The figure above illustrates the main homepage of Anatomix which serves as the central hub of the application, presenting all of its key features in a clear and creative layout. From this page, users can easily navigate by clicking the buttons that lead to different sections such as interactive modules, flashcards, gamified quizzes and achievement arena. The homepage provides a welcoming interface that guides allied health students toward the tools which they need for effective and enjoyable learning in anatomy and physiology.

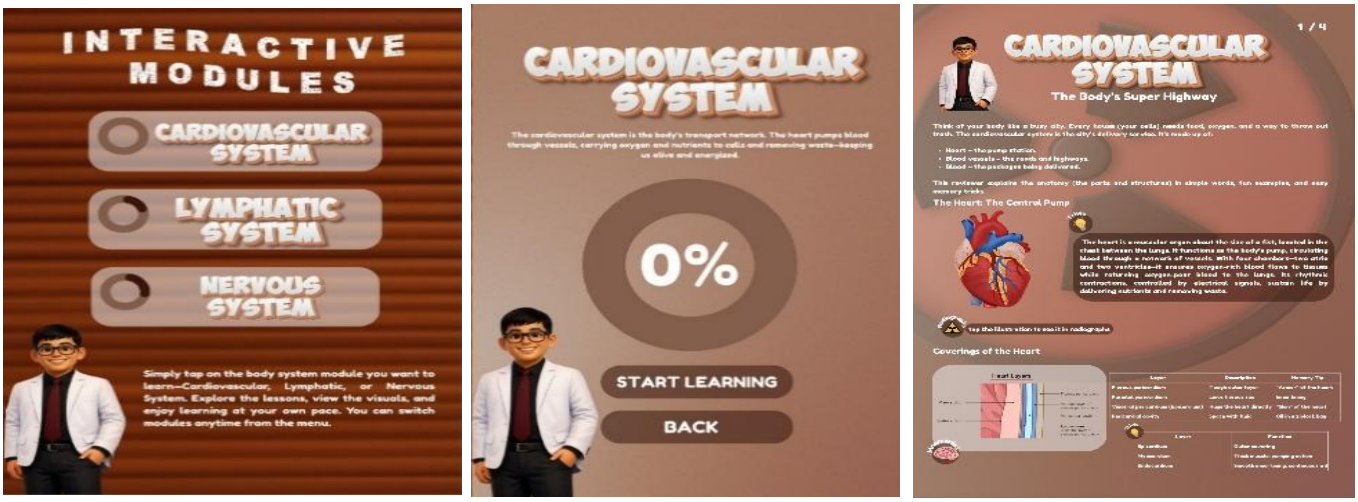

Figure 4. Interactive Module

This illustrates the interactive module homepage which allows users to select specific body systems such as Cardiovascular System, Lymphatic System and Nervous System to begin learning structured lessons. Each interactive module provides clear explanations together with a visuals and a progress tracker that monitors the users learning completion, ensuring that students can follow their advancement at their own pace.

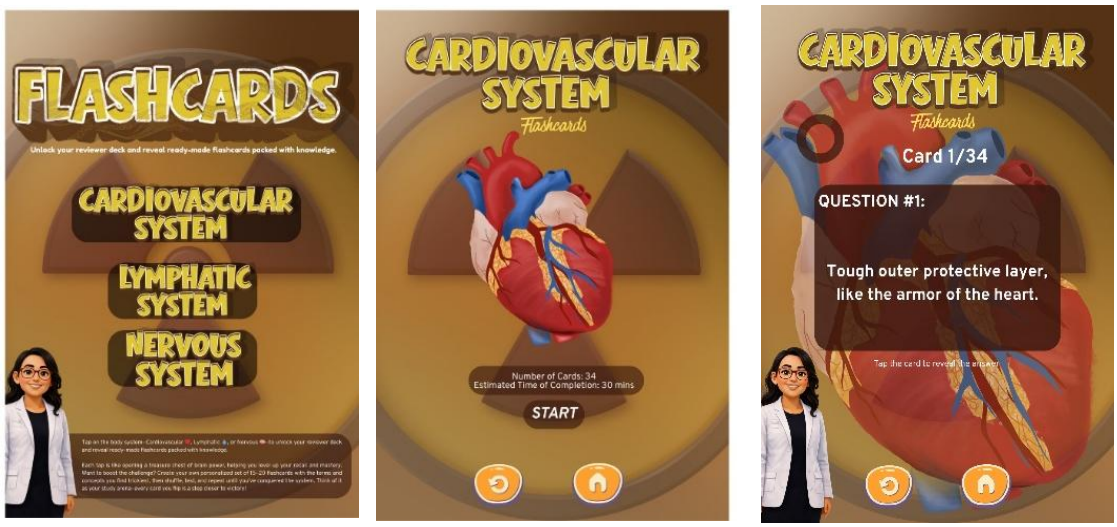

Figure 5. Flashcards Reviewers

The figure above represents the flashcard homepage that provides users with ready-made reviewer decks for the three (3) body systems specifically Cardiovascular System, Lymphatic System and Nervous System. Each deck contains a set number of cards with estimated completion time which allows the student to practice recall, reinforce key concepts and track their progress.

Figure 6. Gamified Quizzes

This illustrates the gamified quizzes in Anatomix that provides the users interactive ways to test their knowledge in Anatomy and Radiologic concepts. In RadRush, learners answer questions ranging from easy to difficult while their character runs and choose the correct pathway based on their answers. Moreover, in RadSpot, learners select radiographs from specific modalities such as X-ray, CT Scan, MRI or Ultrasound and label the anatomical structures being asked in the radiograph. These games are both challenging and fun at the same time, which reinforces mastery through interactive participation of the users.

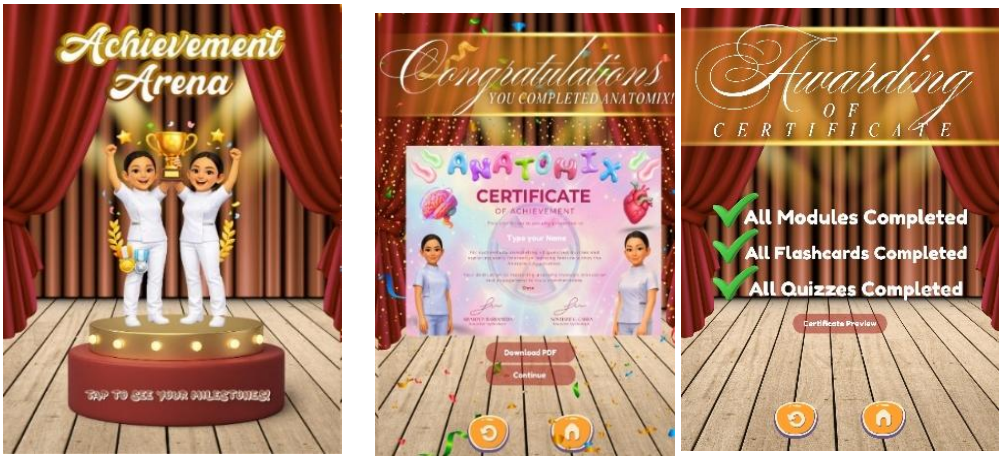

Figure 7. Achievement Arena

This figure illustrates the Achievement Arena area that allows users to track their learning progress, view earned badges and see their milestones within the Anatomix application. Furthermore, upon completing all features, users are awarded a certificate of achievement which recognizes their dedication and mastery of anatomy through interactive and gamified learning. This feature motivates learners by combining both recognition with a sense of accomplishment.

Figure 8. QR Code of the Anatomix

This figure presents the QR code that provides direct access to the Anatomix application. By scanning the code, users can conveniently open or download the platform on their devices.

6. Conclusion

The aim of this study which involved 32 female and 6 male Level II Bachelor of Science in Radiologic Technology students, was to discover which anatomical systems were the hardest for each group. Both groups of participants found examining the cardiovascular, nervous, and lymphatic systems to be the hardest systems anatomically speaking, while females outperformed males in the urinary, respiratory, digestive, skeletal, and reproductive systems and vice versa in the respiratory, skeletal, endocrine, urinary, and reproductive systems. However, there were certain systems that both male and female students had the hardest time with when trying to identify anatomical structures they would be required to use in their future practices as Radiologic Technology professionals. The results of this research formed the basis for the creation of a new and innovative learning tool called ANATOMIX. This learning tool is an interactive application designed for use on the web and/or with mobile devices that will help students master anatomy, physiology, and imaging modalities needed to successfully visualize the structures necessary for the practice of Radiologic Technology through the use of multiple modules, each of which combines anatomy information with radio-graphic images, trivia, flash cards, quiz games (RadSpot and RadRush), and an accomplishment arena to assist in tracking a student's progress toward obtaining their degree and to provide a certificate of achievement for successfully completing the anatomy learning modules.

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