This is the accepted manuscript of an article published in Advances in Physiology Education. The version of record can be found here: https://doi.org/10.1152/advan.00101.2019

Challenging Endocrinology Students with a Critical Thinking Workbook

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Running head: CHALLENGING ENDO CRITICAL THINKING

Abstract

A central goal of science education is to help students develop higher order thinking skills to enable them to face the challenges of life. Accordingly, science instructors are now urged to craft their classrooms such that they serve not only as spaces for disseminating information, but also an arena through which students are encouraged to think scientifically and develop critical thinking skills. This project aimed to develop a workbook that helps postsecondary students learn endocrinology and engages them in critical thinking. Each of the five chapters focus on a different topic rooted within core biological concepts relevant to endocrinology. Such topics were identified upon cross referencing seminal reports on science education. Tenants of Numrich's Sequence of Critical Thinking Tasks were used to guide the development of chapter sections with the intent of engaging students in critical thinking over time by way of practice and scaffolded guidance. Chapter sections include modeling, event sequencing, clinical application, research and communication, and simulation, each of which target a different repertoire of skills presented in Numrich's framework. Students' learning, experiences, and behaviors were used to evaluate the workbook and inform the revision of the workbook into the publicly-available second edition.

Keywords: critical thinking, graduate students, undergraduate students, endocrinology, biology education

INTRODUCTION

Historically, the overarching goal of science has been geared towards providing society with a better understanding of the natural world. From knowledge about our solar system to the human body, researchers have and will continue to unearth scientific truths. A common characteristic of scientists is higher-order thinking skills (24). Moreover, students who think critically get better grades, are better at reasoning through daily decisions, and are often more employable (26). These skills are learned through practice and science education plays a key role in helping students develop higher-order thinking skills as well as didactic knowledge.

In 2011, the *Vision and Change* report provided undergraduate biology educators with a framework to enhance student understanding of core concepts and engagement in core scientific competencies by attending to developing students' biological literacy and critical thinking skills (1). The report concentrates on helping students become competent in the process of science, develop collaboration and communication skills, gain exposure to modeling, simulation and systems-level approaches to learning, as well as develop thinking skills and an appreciation for science (1). These objectives are built upon the idea that:

> "*Appreciating the scientific process can be even more important than knowing scientific facts. People often encounter claims that something is scientifically known. If they understand how science generates and assesses evidence bearing on these claims, they possess analytical methods and critical thinking skills that are relevant to a wide variety of facts and concepts and can be used in a wide variety of context*" (26 pg., 16).

Although the framework is targeted to undergraduate students, it also can serve as a solid foundation for students pursuing graduate and professional science programs. Out of students who enroll in graduate degree programs, biological science is one of the most common undergraduate fields of study (4).

While the *Vision and Change* framework is specific to the overarching discipline of biology, it also applies to sub-disciplines such as anatomy and physiology. With first year medical school enrollment hitting an all-time high, coupled with the fact that healthcare is the largest industry showing the highest amount of growth of any other field, the number of students enrolled in anatomy and physiology related courses continues to grow (3, 36). Endocrinology, as a sub-discipline of physiology, has been identified as one of the most difficult topics for students to grasp, particularly when critical thinking skills are weak (9). One way to address such difficulties would be to focus curriculum on engaging students' critical thinking skills for improved and longer lasting understanding of didactic material.

We developed an endocrinology workbook using an action research approach (22). The workbook aims to help upper level undergraduate and graduate endocrinology students engage in critical thinking and understand key physiological concepts related to endocrine systems. Below, we provide an explanation of a framework of critical thinking. Then, we describe how we used the framework and other research to inform the construction of the workbook. Finally, we describe our evaluation and revision of the workbook.

DEVELOPMENT OF THE WORKBOOK

Activities that meld learning content and thinking skills, such as the endocrinology workbook described here, have the capacity to have great value when properly constructed and integrated into science courses. The critical thinking skills practiced within the workbook are grounded in theory and previous research, including Numrich's Sequence of Critical Thinking Tasks, and are organized into the sections of modeling, event sequencing, critical thinking, research and communication, and simulation. The content of the workbook was guided by seminal reports on key concepts for undergraduate biology, anatomy, and physiology, which traverse the chapters on intracellular signaling, central endocrine control, metabolism, growth, and female reproductive cycling.

A scaffolding approach was interwoven throughout the workbook. Instructional scaffolding pertains to a pedagogical technique wherein the instructor provides students with temporary support structures to help them achieve difficult tasks that would be difficult for them to reach on their own without prior experience (30). Within the first chapter of the workbook, students were provided with examples and in some cases part of the activity completed for them. Subsequent chapters remove different supports. How individual sections applied and omitted scaffolding is described in the text below on the sections of the workbook.

To complete the first cycle of action research (22), we evaluated the workbook using student learning, experiences, and behaviors, and revised the workbook into the second edition, which is available in Supplemental Materials 1 (https://doi.org/10.6084/m9.figshare.8870990.v3).

Theoretical Framework

In order to best understand how to challenge students' critical thinking skills, one must first recognize its multiple facets. Critical thinking comprises both cognitive skills and dispositions. Facione (14) explains how critical thinking cognitive skills include analysis, inference, evaluation, interpretation, explanation and self-regulation. Critical thinking dispositions include truth-seeking, open-mindedness, orderliness, systematic and inquisitiveness, having good interpersonal and analytical thinking skills, as well as the ability to judge the reliability of information (37). These constructs are drawn upon differentially depending on the task at hand (19).

Education researchers have investigated the development of the cognitive skills and dispositions associated with critical thinking. Findings show that while cognitive skills can be developed in the short- and medium-term scales, changes in dispositions require more long-term efforts (32, 33). Therefore, instructors should create courses that present students with repeated and consistent practice with critical thinking skills and dispositions in order to help students develop complete critical thinking.

Numrich (28) argues that practice with critical thinking should be scaffolded in a specific sequence of related perspectives, tasks, and skills (Table 1). Students' first encounter with course material should involve observing their world through the context of the classroom and most often occurs during the lecture portion of a course or independent homework assignments (5). Next, students should be challenged to understand, organize and interpret the information. This can be achieved through ordering, classifying, explaining cause and effect, hypothesizing and making inferences. Such activities focus students on the content presented in the text. The last level students occupy in their development of critical thinking skills asks them to focus beyond the text by way of researching, synthesizing information, critiquing, making logical conclusions and problem solving. As students strengthen their critical thinking skills, they advance in their level of perspective wherein they engage in more complex critical thinking as reflected by the difficulty of the skills practiced.

[TABLE 1 HERE]

It can seem daunting for an educator to help students navigate through Numrich's sequence in only one semester. However, relatively simple changes can be made to a course curriculum to help make these goals more achievable (15). As an example, here, we describe how we have used Numrich's skills as a framework for developing exercises in an endocrinology workbook (workbook provided in Supplemental Materials 1 https://doi.org/10.6084/m9.figshare.8870990.v3) to help students repeatedly practice specific critical thinking skills (Table 2).

[TABLE 2 HERE]

Key concepts, learning goals, and objectives

Recently, several organizations have published recommendations outlining which content and concepts students should be learning. We analyzed recommendations from organizations relevant to our context of endocrinology, namely The American Association for the Advancement of Science (1), American Physiological Society (25) and Human Anatomy and Physiology Society (20, 21), and identified common and applicable concepts; these are homeostasis/systems, informational flow, structure and function, and scientific reasoning (Table 3).

[TABLE 3 HERE]

We used these concepts to guide development of learning goals and objectives for each chapter of the workbook (Figure 1). For example, in considering how to help students understand the core concept of homeostasis and systems, we crafted specific objectives, such as "generate endocrine axes and feedback loops", "explain how hormones act upon their specific effector organs" and "describe the collective actions of organs and organs systems in maintaining homeostasis." As seen in the overlap between information flow and homeostasis, some learning objectives supported the understanding of more than one core concept.

[FIGURE 1 HERE]

Each chapter of the workbook concentrates on one topic that is presented as part of the lecture unit. While the workbook and lecture content run in tandem, there are some topics that are included in the workbook that are not touched upon in class. However, if they are presented in class, the workbook requires deeper understanding. While goals and objectives vary slightly amongst the five chapters, all chapters include the same sections. The following text describes the sections of the workbook, specifically how each section uniquely targets the development of critical thinking skills according to Numrich's sequence and additional research that supports their value in developing critical thinking skills.

Structure of the workbook

Background reading. A background reading section was placed at the beginning of each chapter to support the goal of making the workbook self-contained and not dependent on a certain textbook or lecture. Background readings are one to two pages and contain text and figures that describes the focused topic as well as references to relevant literature. The background reading is a resource for students to use while completing subsequent chapter sections.

Modeling. Next, the students engage in modeling in order to summarize and explain relationships presented in the background reading by placing concepts in boxes and connecting boxes with labeled arrows that describe the relationships or actions between the concept boxes (e.g., Supplemental Materials 1 page 8 https://doi.org/10.6084/m9.figshare.8870990.v3). The modeling activity is scaffolded so that, in the earlier chapters, students are provided with some of the concepts already filled in, whereas in the later chapters the models are either presented blank or students are asked to create their own models using a given set of terms.

The modeling activities are grounded in Numrich's framework and previous studies to promote critical thinking. By taking concepts presented in the background reading and constructing a model that represents their relationship amongst one another, students learn to summarize, distinguish relevant details, order, classify and explain cause and effect (Table 2). Additionally, Salleh, Tasir, and Shukor (34) reported that students' interaction, manipulation and creation of visuals throughout a modeling activity promoted students' ability to organize and process information thus challenging them to harness higher-order thinking skills.

Event Sequencing. Students are then asked to order events by using their models to place the provided statements in a primary order and then an alternative order. Sequencing activities are scaffolded so that, in earlier chapters, entire statements are provided, while by the end students are instructed to first complete a partial statement and then order the events correctly. The event sequencing activities are grounded in theories on critical thinking and teaching biological complexity to engage students in critical thinking and learn endocrine content.

Endocrine systems fulfill many of the characteristics that describe complex systems such as having many interacting agents, positive and negative feedback, showing patterns that arise both ordered and disordered (8). When first presenting complex systems to students, it is best to portray relationships as concrete and mechanistic (25). The first sequencing event activity integrates skills from the second level of Numrich's framework where students are focused on the text and begin to understand, interpret and organize information (Table 2). This encourages students to engage with the same content from the previous section in a different way, and also serves to simplify intricate concepts in the beginning stages of comprehension, both of which are integral for learning content involving complex biological systems (25).

Upon further exposure, it is important for students to recognize the complexity of biological systems (12). In the second sequencing activity, students create an alternative sequence (e.g., Supplemental Materials 1 page 9, “Part 2” https://doi.org/10.6084/m9.figshare.8870990.v3). This helps to show students that cellular and physiological events are more accurately dynamic, emergent and simultaneous. Moreover, this alternative sequencing activity encourages students to reflect on related ideas and re-evaluate assumptions, which occupies the third level of Numrich’s sequence.

Clinical Application. Students are provided a phenomenon as a clinical scenario and five potential explanations. Students must identify which explanation most accurately explains the phenomena. For the explanations they reject, students are to identify incorrect components and describe why they are wrong. For the one explanation the students accept, they must argue why it is a plausible explanation. This section aligns with Numrich's sequence by engaging students in critiquing when arguing for an acceptable explanation and rejecting invalid options (Table 2). Additionally, students engage in writing and argumentation.

Writing benefits the development of critical thinking skills. Writing requires an individual to make their ideas explicit, as well as evaluate and choose among tools necessary for effective communication (2). Students exhibit larger gains in critical thinking skills when participating in biology courses that involve inquiry, writing, research, and analysis compared to students in traditional courses (32, 33). Writing is particularly influential if it provides an opportunity to think through and formulate arguments (13) potentially because the act of writing forces students to restructure knowledge in their own words (23). Furthermore, by generating complete thoughts and supportive claims when asked to defend ideas through writing, students practice skills associated with more advanced critical thinking (28, 31).

Research and Communication. First, students research a medication or pathology and describe how it works or results in the disease, as well as list and explain two symptoms or side effects that are often experienced. Second, they discuss with a classmate what they learned and write what they learned from their partner's research. Here, students practice Numrich's most advanced level of perspective (28) by going beyond the information provided in the background reading to do research (Table 2). Then, when educating a peer on the new information learned, students practice communication.

Students who participate in activities that require communication and collaboration perform significantly better on critical thinking tests compared to students who study individually (16). Exchanging ideas helps foster critical thinking skills because students are encouraged to make inferences, evaluate their preconceived notions, develop arguments and problem solve while in conversation (29, 35).

Simulation. Students are to formulate predictions, simulate cellular and physiological events, conduct and describe systematic observations, and evaluate their predictions using an online platform, Cell Collective (17, 18). These tasks engage students in critical thinking by providing an opportunity to hypothesize, theorize, and make logical conclusions, as well as interpret meaning and re-evaluate assumptions (Table 2). Additionally, simulations have been shown to help students develop critical thinking (34) and gain knowledge of biological systems (6, 7, 10–12).

Evaluation of the workbook

We evaluated the workbook by analyzing data on students' learning, experiences, and behaviors when the workbook was implemented in an Endocrinology course. The course was an upper-level undergraduate and graduate cross-listed elective of which had physiology or cell and molecular biology as prerequisites. This work was conducted with approval from the institutional review board (#HS17-0259).

Student learning. Students' learning was evaluated according to their performance on the workbook. Of the twelve students enrolled in the course, nine provided consent to have their performance included in this research. Students submitted chapters at the conclusion of each of the five lecture units. Students were able to drop their lowest grade; therefore, some students only completed four of the five chapters. Each chapter was graded out of fifty points, with modeling, sequencing, simulation, and clinical application sections worth ten points, and research and communication each worth five points (answer keys for the workbook chapters can be obtained from the authors upon request). However, extra credit was given for complicated simulation sections in chapters 3, 4 and 5, making those chapter worth a possible 53 points.

Overall, students performed well on the workbook chapters (mean = 47 out of 50 points, 94%, standard deviation (SD) = 3.1; Figure 2) suggesting that the workbook helped students learn the endocrine content. Additional factors that may have contributed to high overall scores include that students were able to skip one chapter of their choosing, work with one another, and were provided approximately two weeks to complete the chapter with any resources.

[FIGURE 2 HERE]

Despite overall high scores, there was some variation in performance among chapters (Figure 2). Chapter two on master endocrine control had the lowest average score (mean = 45 points, 90%, SD = 2.3) suggesting that students had the most difficulty learning how endocrine systems are regulated in the brain with the workbook. Additionally, the lower performance could be attributed to the fact that chapter two covers a greater variety of concepts. Unlike the other workbook chapters that dissect one topic presented in the unit, chapter two reviews all hypothalamic and pituitary hormones. Another contributing factor to the increased difficulty of chapter two could be the fact that some scaffolding, such as a few of the pre-filled terms in the modeling section, was removed.

Student performance was highest for chapter four on growth (mean = 49 points, 98%, SD = 2.1; Figure 2) suggesting that they learned the most about growth with the workbook. This could be attributed to students paying better attention to directions and providing more complete answers despite having more responsibilities, of which included generating their own models. Additionally, the simulation section was offered for bonus points, which accounts for the scores above 50 points seen in the last three chapters (Figure 2).

Student experience. Students' experiences with the workbook was evaluated according to their responses to an anonymous online survey given at the end of the semester (Supplemental Materials Table S1 https://doi.org/10.6084/m9.figshare.8870990.v3). Of the twelve students enrolled in the course and used the workbook, nine completed the survey. Quotes are provided as pseudonyms.

A majority of students found the directions to be clear and easy to follow (Figure 3A) and the difficulty of the questions to be appropriate (Figure 3B). Chapters three and four on appetite control and growth, respectively, were chosen by the most students as their favorite (Figure 3C). Student responses indicate that much of this preference was due to personal interest in the chapter topics. Tony stated that, “I like learning about something, then referring it back to myself, I always think about the various hormones that regulate my appetite and that to me is really cool.” Likewise, Lee’s preference stemmed from the fact that, “I love learning about growth,” while James liked appetite control the most because, “I thought this was the most interesting chapter.”

[FIGURE 3 HERE]

Five out of nine students indicated chapter one on intracellular signaling as being their least favorite (data not shown). Additionally, no student chose this chapter as their favorite (Figure 3C). However, there was little consensus as to why chapter one was the least favorite. Some example sentiments included, “This was the first chapter I did, so it took the longest amount of time” (Joy). While Whitney shared that, “I have never been a huge fan of cellular mechanisms. They are fundamental to the understanding of endocrinology, but I just have very little interest in the specifics of how cells communicate.”

When asked what section was their favorite, a majority of the students chose the event sequencing or clinical application sections (Figure 3D). Responses on the post-semester survey suggest that the event sequencing section helped simplify the complexity of the chapter topic and bring ideas together to improve their overall understanding of the topic in discussion. For example, Linda expressed that, “sequencing was my favorite section because it was the section that helped me the most in understanding the lesson. I believe that solving that section gives the students a great overview of the topic and delivers the main portion that needs to be understood."

Those that chose the clinical application as their favorite section described that they liked how the section integrated a real life scenario that they had to investigate which consequently allowed them to see the applicability of the topic in everyday life. Owen appreciated how the clinical application section, "gave a real life situation," while Martin stated that, "I enjoyed applying the concepts to actual scenarios." Similarly, Jared found that the clinical application section, "proposed questions that one would come across in the clinical setting. It challenged the reader to think deeper in order to figure out solutions to real life problems."

Student behavior. The instructors (authors AD and HBR) made observations of the students' behavior with the workbook while grading, when students had approached the instructors for help, and while students worked in groups to complete the workbook. In the modeling sections, many students did not properly label arrows with relationships between concept boxes and thus not properly explain how the terms related to one another. In the clinical application section, many students mistakenly chose two or more statements as being correct when only one statement is true. When students were asked to explain the mechanism of action or pathophysiology of their partner's medication or disorder in the communication section, students provided a wide range of detail depth. Students had difficulty navigating the computational modeling platform to simulate and/or create models of physiological relevance.

Revision of the workbook

As a result of the aforementioned evaluation, and following the next step in action research (22), we revised the workbook into a second edition, which is accessible and openly available in Supplemental Materials 1 (https://doi.org/10.6084/m9.figshare.8870990.v3). The only major change was the removal of the simulation sections. Minor changes included rewording directions to be clearer and providing examples.

CONCLUSION

We have described the development of an endocrinology workbook that integrates theory and evidence-based practices in order to best support student comprehension of endocrinology-related core concepts and engagement in critical thinking. This work was primarily guided by Numrich's view of critical thinking tasks as a hierarchy involving growth of higher-order thinking achieved over time by way of practice and proper guidance via scaffolding in addition to other pedagogical best practices for critical thinking. Our workbook sections of each chapter are modeling, event sequencing, clinical application, simulation, and research and communication, each targeting a different repertoire of skills presented in Numrich's framework. Our workbook chapters each focus on a different topic within core concepts relevant to post-secondary students' learning of endocrinology. We evaluated the workbook with data on student learning, experience and behavior. We found that student preferences of chapter arise from personal interest in the chapter topic. Section preferences stem from perceived utility in improving their overall understanding and valuing real-life applications. Common areas of confusion and difficulties were attributed to unclear instructions. We used these findings to refine the workbook into a second edition that is available for others to use. This work and others like it serves a dual purpose by helping students learn concepts and engage in critical thinking that benefits students regardless of what future science courses or careers they pursue.

ACKNOWLEDGEMENTS

We thank Morgan Newport, Jason Wack, Christina Cline, and Collin Jaeger for their assistance on the workbook and this research. This project was supported by the Department of Biological Sciences, College of Liberal Arts and Sciences, and the Division of Research and Innovative Partnerships at Northern Illinois University.

DISCLOSURES

No potential conflict of interest was reported by the authors.

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TABLE LEGENDS

Table 1. Numrich's Sequence of Critical Thinking Tasks according to Beaumont (5).

Table 2. Endocrinology course workbook sections (left column) with their alignment to Numrich's critical thinking skills (right column).

Table 3. Recommended core concepts from seminal reports (and references in parentheses) relevant to endocrinology used to create workbook goals and objectives.

FIGURE LEGENDS

Figure 1. Relationships among the core concepts of biology and physiology from seminal reports (Table 3) and the learning goals and objectives of the Endocrinology workbook.

Figure 2. Student workbook scores by chapter. Fifty points were possible for chapters one and two while 53 points were possible for the last three chapters due to extra credit for the simulation section. The y axis begins at 40 points. Open circles represent individual data points (i.e., student scores). The ends of each box (i.e., hinges) represent the upper and lower quartiles of scores so as to span the interquartile range (25-75 percentiles). The horizontal line within each box marks the median. Whiskers represent data that is within 1.5 times the interquartile range of the hinge.

Figure 3. Frequencies of student responses to questions about workbook direction clarity (A), question difficulty (B), favorite chapter (C), and favorite section (D).

Table 1.

Levels of Perspective	**Critical Thinking Tasks**	**Skills Practiced**
I. Focus on the students' world	Observing	Looking Listening Sharing background
	Identifying assumptions	Expressing opinions Clarifying values
II. Focus on the text	Understanding and organizing	Summarizing Distinguishing relevant details Ordering Classifying
	Interpreting	Comparing and contrasting Explaining cause and effect Making inferences Interpreting meaning Hypothesizing Theorizing
III. Focus beyond the text	Inquiring further	Surveying the public Interviewing a specialist Researching
	Analyzing and evaluating	Synthesizing information Critiquing Reflecting on related idea Making logical conclusions Re-evaluating assumptions Proposing solutions Problem solving Taking action Participating

Table 2.

Workbook Section	**Numrich's Critical Thinking Skills Practiced** (Beaumont, 2010)
Modeling	Summarizing Distinguishing relevant details Ordering Classifying Explaining cause and effect
Sequencing	Ordering Classifying Reflecting on related ideas Re-evaluating assumptions
Clinical Application	Critiquing Making logical conclusions Synthesizing information
Research and Communication	Participating Researching
Simulation	Hypothesizing Theorizing Making logical conclusions Interpreting meaning Re-evaluate assumptions

Table 3.

Report	**Core Concept**			
	Homeostasis/ Systems	Information Flow	Structure and Function	Scientific Reasoning
Vision and Change in Undergraduate Biology Education: A Call to Action (1)	Systems	Pathway and transformation of energy and matter Information flow, exchange and storage	Structure and function	Ability to understand the relationship between science and society Ability to apply the process of science
The Core Concepts of Physiology Teaching (25)	Homeostasis	Causality Cell-cell communication Flow-down gradients	Structure and function	Scientific reasoning
Anatomy-Only Learning Outcomes (20)	Describe the major functions of the endocrine system	Compare and contrast how the nervous system and endocrine system control body function. Explain the role of the hypothalamus in the release of anterior pituitary hormones. Explain the role of the hypothalamus in the production and release of posterior pituitary hormones.	Describe the major functions of the endocrine system. Describe the locations of and the anatomical relationships between the hypothalamus, anterior pituitary and posterior pituitary. Describe each endocrine organs' anatomy, location in the body, and list the major hormones secreted by each.	

Course Guidelines for Undergraduate Instruction of Human Anatomy and Physiology (21)	Application of homeostatic mechanisms	Control of hormone secretion	General functions of the endocrine system Chemical classification of hormones and mechanism of hormone actions at receptors Identity, source, secretory control, and functional roles of the major hormones produced by the body	Predictions related to homeostatic imbalance, including disease states and disorders

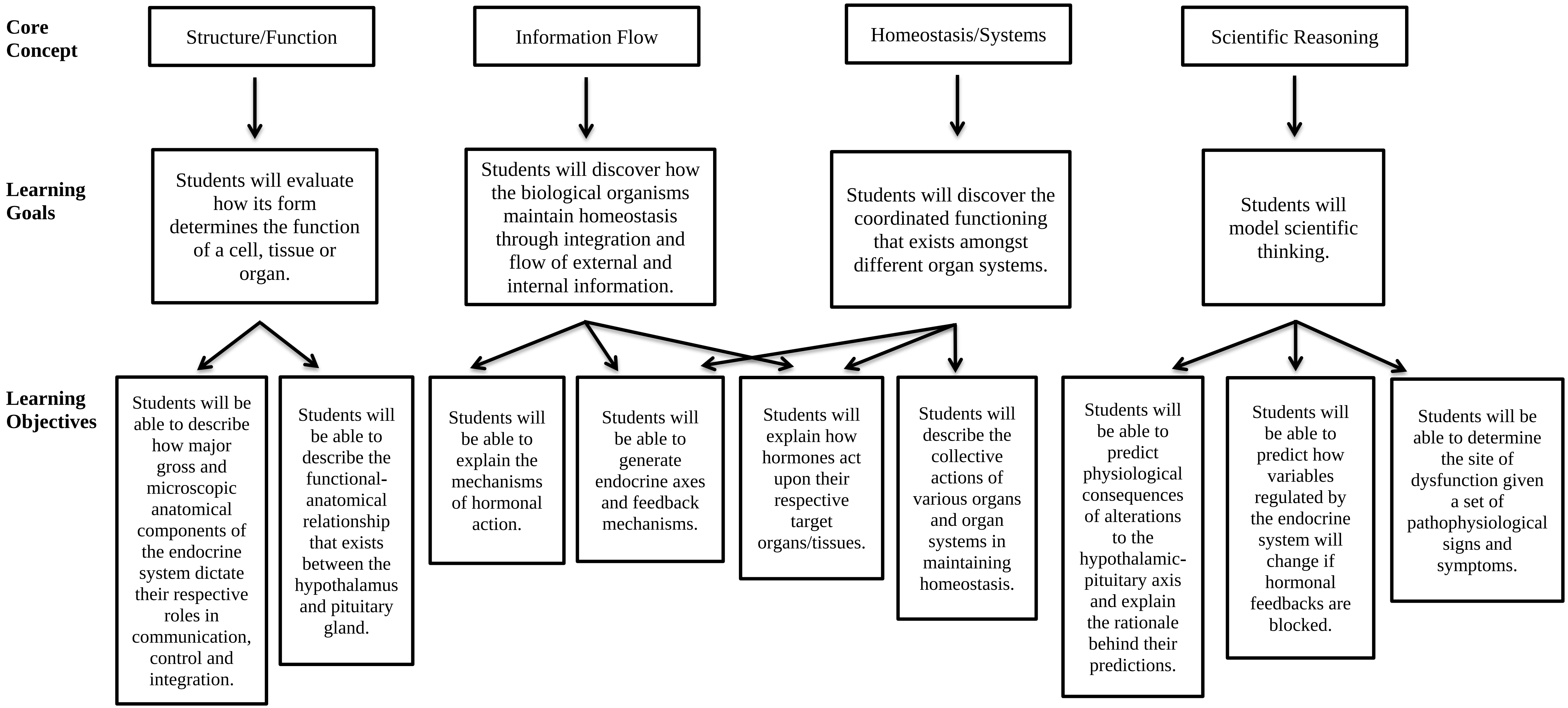
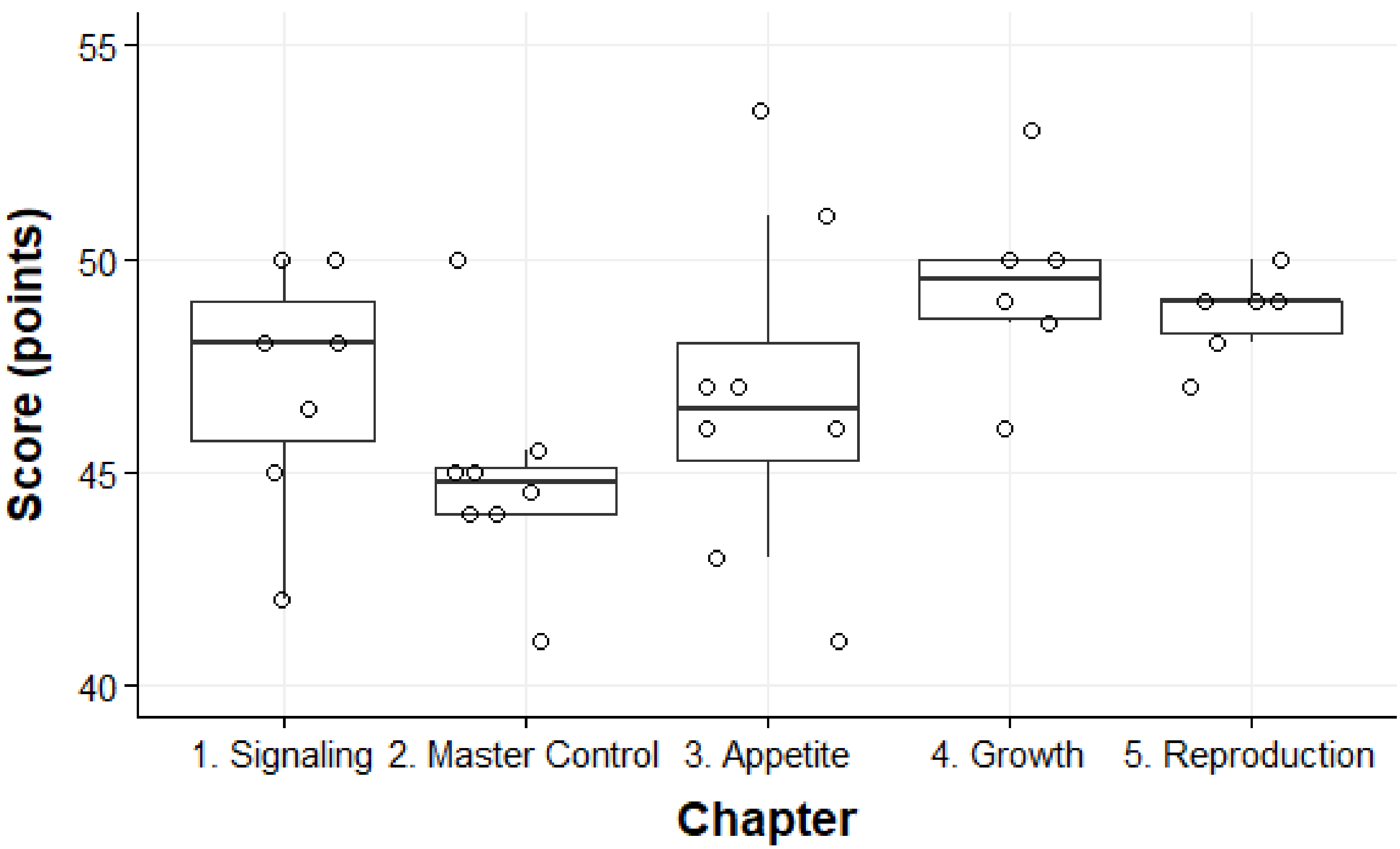
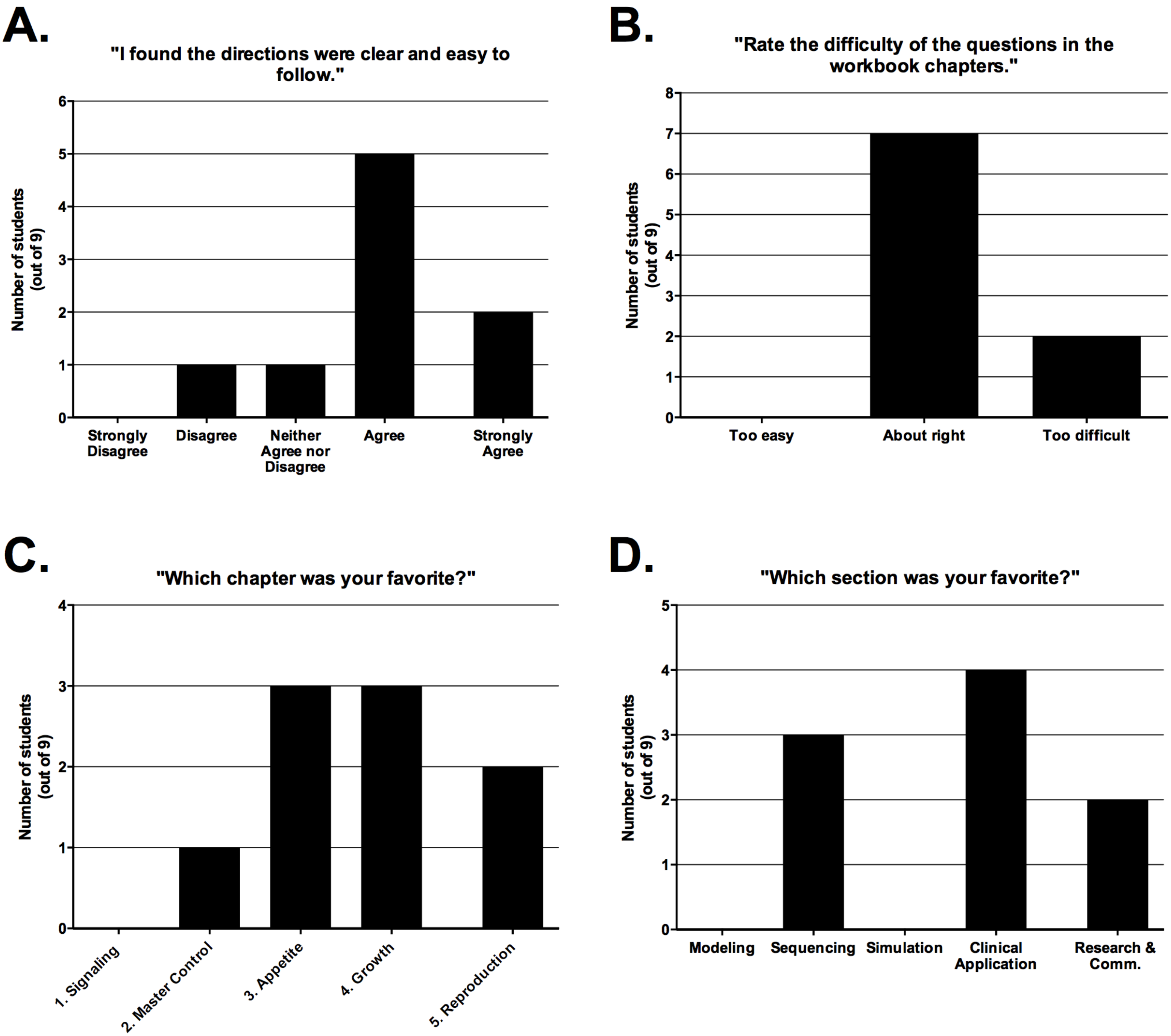

Core Concept
Structure/Function
Information Flow
Homeostasis/Systems
Scientific Reasoning
Learning Goals
Students will evaluate how its form determines the function of a cell, tissue or organ.
Students will discover how the biological organisms maintain homeostasis through integration and flow of external and internal information.
Students will discover the coordinated functioning that exists amongst different organ systems.
Students will model scientific thinking.
Learning Objectives
Students will be able to describe how major gross and microscopic anatomical components of the endocrine system dictate their respective roles in communication, control and integration.
Students will be able to describe the functional-anatomical relationship that exists between the hypothalamus and pituitary gland.
Students will be able to explain the mechanisms of hormonal action.
Students will be able to generate endocrine axes and feedback mechanisms.
Students will explain how hormones act upon their respective target organs/tissues.
Students will describe the collective actions of various organs and organ systems in maintaining homeostasis.
Students will be able to predict physiological consequences of alterations to the hypothalamic-pituitary axis and explain the rationale behind their predictions.
Students will be able to predict how variables regulated by the endocrine system will change if hormonal feedbacks are blocked.
Students will be able to determine the site of dysfunction given a set of pathophysiological signs and symptoms.

Figure 1.



55
50
45
40
Score (points)
1. Signaling
2. Master Control
3. Appetite
4. Growth
5. Reproduction
Chapter


A.
"I found the directions were clear and easy to follow."
Number of students (out of 9)
0
1
2
3
4
5
6
Strongly Disagree
Disagree
Neither Agree nor Disagree
Agree
Strongly Agree
B.
"Rate the difficulty of the questions in the workbook chapters."
Number of students (out of 9)
0
1
2
3
4
5
6
7
8
Too easy
About right
Too difficult
C.
"Which chapter was your favorite?"
Number of students (out of 9)
0
1
2
3
4
1. Signaling
2. Master Control
3. Appetite
4. Growth
5. Reproduction
D.
"Which section was your favorite?"
Number of students (out of 9)
0
1
2
3
4
5
Modeling
Sequencing
Simulation
Clinical Application
Research & Comm.