University of Nevada, Reno

The Effectiveness of Case-Based Learning in Facilitating Clinical Reasoning Skills in Undergraduate Anatomy and Physiology Instruction

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Abstract

Case-based learning (CBL) is an approach that uses clinical case activities in the classroom to engage students and encourage a deeper understanding of scientific concepts. Anatomy and Physiology (A&P) is a course that many students take as a prerequisite for admission to professional health schools. This study investigated the effect of CBL in facilitating clinical reasoning skills (CRS) in undergraduate A&P instruction. Undergraduate students from two classes taught by the same instructor participated in the study. One class (experimental group, $n = 24$) was taught with the CBL approach, and the other class (control group, $n = 24$) was taught without CBL. Quantitative data collected for this study were scores on the pretest and posttest clinical reasoning problem (CRP) instrument about the central nervous system, autonomic nervous system, and special senses. A 2 × 2 (CBL vs. No CBL × Pre-Posttest) mixed-model analysis of variance (ANOVA) was performed for each of the three systems with the scores on CRP as a dependent variable. Nine students were selected for interviews from the control and experimental groups based on their CRP assessments. Interviews were conducted after the completion of each CRP assessment, and content analysis was performed for the interview data.

Analysis of the quantitative data revealed an increase in mean scores from pretest to posttest for those in the experimental group but a decrease in mean scores from pretest to posttest for those in the control group. Scores on special senses revealed a significant group × time interaction effect. Analysis of the interviews revealed that students in the experimental group utilized A&P concepts while reasoning through the CRP assessments. These results suggest that CBL may help facilitate CRS.

Keywords: anatomy and physiology (A&P), central nervous system (CNS), autonomic nervous system (ANS), special senses (SS), clinical reasoning skills (CRS), case-based learning (CBL)

Dedication

This dissertation is dedicated to my world, my love, my mother, Anita Sehwani, who has been by my side from Day 1. We have had some bumps in the roads with a lot of laughter and happy tears, and I cannot express how much your support and guidance meant to me. You gave me the courage to continue, and I would not be where I am today without you by my side. I will always be here for you, just like I know you will for me. I love you.

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Chapter I

Introduction

Lecturing is the principal mode of instruction in undergraduate science courses at many colleges and universities (Brockliss, 1996). However, as education evolves, educators have learned more about how students learn. Learning is a process that involves students actively making a connection between knowledge and experience (National Research Council, 1996). However, in traditional undergraduate science instruction, students are positioned as passive learners, and rote memorization is not an effective learning method for students. According to Freeman et al. (2014), passive learners are 1.5 times more likely to fail than those developing deeper conceptual understanding. Students who enroll in rigorous science courses suffer due to passive learning, which may result in a limited understanding of scientific concepts as the role of the student is to absorb knowledge instead of being actively involved in their learning process (Bohlscheid & Davis, 2012). A passive learner is defined as an individual who relies on the teacher as an information feeder. These students are not actively involved in their learning process in ways such as asking questions. Instead, they rely on repetition and applying what they have learned with little connection between skill and knowledge (Petress, 2008). Although the traditional way of learning is not considered harmful, students are less able to grasp a full understanding of scientific concepts making their application to real-world problems and situations limited.

Undergraduate science courses should be geared toward balancing instructional approaches. Passive lecturing can provide students with fundamental science concepts while active learning strategies may enable students to apply concepts to real-world situations and offer students the ability to develop a better understanding of scientific concepts. According to the National Academies of Science, Engineering, and Medicine (2018), expert and novice learners are separated by their understanding of concepts and their ability to apply that knowledge. Expert learners can apply their knowledge, recognize patterns, and solve complex problems. In undergraduate science instruction, many higher-level educators focus predominantly on content, ensuring that students receive adequate information yet provide very little support on how they should apply their knowledge or scientific concepts, which generates more novice, rather than expert, learners (Kelly, 2019). Instructors tend to forget about incorporating different ways of teaching to aid students' understanding of scientific concepts and acquisition of reasoning skills essential for success in science courses (Garcia et al., 2011; Hanson, 2006).

There have been multiple calls for education reform, as the approach for learning in undergraduate science does not always provide opportunities for students to make connections across scientific concepts (American Association for the Advancement of Science [AAAS], 2009). Science education should empower students to think, investigate, debate, make connections between concepts, and understand how the world functions (DeBoer, 1991). Instructors may alleviate some of the issues in undergraduate science instruction by using pedagogical approaches such as active learning strategies. Active learning entails engaging students through activities and allowing students to play an active role in their learning process (Passmore et al., 2014; Prince et al., 2006). Many universities have embraced peer interaction and engagement in the classroom (Bonwell & Eison, 1991). However, too many undergraduate science courses still rely upon traditional learning methods rather than encouraging active learning in the classroom (Dolan et al., 2015).

Thus, the purpose of this study was to investigate how case-based learning (CBL) can facilitate student CRS utilizing concepts central to undergraduate anatomy and physiology (A&P) instruction. CBL is an approach that uses clinical case activities in the classroom to engage students and, at the same time, encourage a deeper understanding of scientific concepts. A&P is a course that many students take as a prerequisite for admission to professional health schools. A&P is a challenging course in which many students struggle and rely heavily on traditional learning strategies such as memorization. To investigate the effectiveness of CBL, I used a pre-posttest clinical reasoning assessment and conducted semistructured interviews to examine the impact of CBL on students' understanding of A&P concepts.

Anatomy and Physiology

A&P is one of the first and quintessential classes that exposes students to the form and three-dimensional relationship of structures in the human body. A science course such as A&P is meant to encourage students to learn about the human body's intricacy (Martini et al., 2012). Learning anatomy is about recognizing structures while physiology is understanding the function of these anatomical structures (Martini et al.,1998). For example, when learning about the skeletal system, it is not simply about knowing the parts, but also understanding why they are structured and shaped a certain way in relation to muscle. However, many students struggle to learn these structures and functional relationships because they rely heavily on 2D images, PowerPoint lectures, and textbooks with little connection between the systems or applications to their career (Gultice et al., 2015). Instructors need to teach our students to tap into concepts any time, rather than memorizing information for a test and then forgetting about the material afterward (Miller et al., 2002). Traditionally, students rely upon memorization more to get through a challenging course like A&P without understanding the how and why. It is important that students reason through A&P concepts by demonstrating their understanding, and doing so by using their knowledge of the human body, rather than relying on memorization to get through the course. It is essential to integrate both knowledge and application of that knowledge, giving students multiple opportunities to learn A&P concepts through the use of case studies (McLean, 2016; Tubbs et al., 2014). Facilitating reasoning skills is encouraged as these skills are not only applicable in heath professional schools but other careers as well.

Case-Based Learning as a Pedagogical Approach

The case-based approach was utilized first at Harvard Law School and eventually spread to the health professional field and Johns Hopkins University (McNergney et al., 1999). CBL uses clinical cases to bridge classroom learning and real-world problems. Real-world experience means providing students with the opportunity to experience a situation in the classroom that they may encounter in real life (Aldridge, 1994; Bonwell & Eison, 1991; Chapman & Martin, 1996).

When implementing CBL in health professional programs, clinical cases are used to tap into human body concepts to reason through specific patient information such as symptoms, history, and laboratory results, which provide students with the opportunity to learn skills to adapt to different clinical situations (McLean, 2016; Thistlethwaite et al., 2012; Williams, 2005). Students are immersed in clinical case activities by making sense of the scenario, interacting with peers, and working with their instructors. Through active engagement with these cases, CBL may provide students the opportunity to develop clinical reasoning skills (CRS) and a better understanding of the structure and function of the human body, both of which are key components to learning A&P concepts (Gade & Chari, 2013). A CBL approach addresses this capacity through case-based reasoning (CBR) and hypo-deductive reasoning, teaching students to solve cases by reinforcing concepts and allowing them to deduce diagnoses through the application of those concepts.

CBL addresses the issues that arise when teaching and learning A&P concepts in traditional undergraduate science courses, such as the sole use of rote memorization, lack of interaction with peers, and lack of developing deeper conceptual understanding of the human body. CBL can also enhance teacher-student interactions since instructors are present and actively engaging with students during the learning process. Using cases in the classroom offers an alternative way for students to learn aside from passive learning. Using cases may encourage knowledge integration, which is defined as making connections between concepts (Esposito & Bauer, 2017). CBL instructors encourage students to dive deeper and understand the connections between A&P concepts and their application to real-world scenarios.

Purpose of the Study

In this study, I evaluated the effectiveness of implementing CBL to facilitate CRS in undergraduate A&P instruction of the following systems: the central nervous system (CNS), autonomic nervous system (ANS), and special senses (SS). I or We selected these systems based on pilot data from a survey conducted in October 2020. These data showed that students struggled to understand the CNS, ANS, and SS. The goal of this study was for students to apply their knowledge of A&P to cases by focusing on a whole-system approach rather than smaller concepts within an anatomical system. Also, the goal was not to clear misconceptions or close the gap in existing research but to add knowledge and understand ways instructors can improve students' understanding of A&P concepts.

To accomplish the goal of this study, I used an explanatory sequential study design with a convenience sample of undergraduate A&P I students enrolled at Western Community College. Using an explanatory sequential design enabled the qualitative data to be used to explore the findings from the quantitative data. I used the following measures to answer the research questions: a pre-posttest assessment using an established instrument called a clinical reasoning problem (CRP) which are mini case studies used to assess students reasoning skills and semistructured interviews. The quantitative portion of this study was analyzed using a 2 × 2 mixed ANOVA, and the qualitative portion was analyzed using content analysis approach to gain a better understanding of how the CBL teaching method supports the application of A&P content using cases. Groves et al. (2002) developed the CRP, which evaluates students' CRS by allowing them to select up to two diagnoses and critical features from the case to support their choice. The qualitative data, which entailed semistructured interviews, was designed, conducted, and used as additional support to determine the effects of CBL in facilitating CRS in undergraduate A&P instruction.

Research Questions

RQ1: What is the effect of case-based learning on the clinical reasoning skills of undergraduate anatomy and physiology students for the central nervous system, autonomic nervous system, and special senses?

RQ2: How does case-based learning support student application of anatomy and physiology concepts to cases that involve clinical reasoning?

Researcher Positionality

My interest in studying the effects of CBL on student learning stems from her experience as an A&P instructor and her study of related literature. As an instructor, she seeks to help students develop a better understanding of A&P concepts and be more engaged in their learning process. She has encountered numerous students who have grappled with A&P and struggled to understand why they must learn about histological tissues, parts of the bones, how muscles contract, how the brain and spinal cord function, and how individuals use their five senses. These concepts are intertwined with real-world applications that CBL currently offers. Multiple factors impact these novice learners' success, including but not limited to, a copious amount of content that must be learned in a short period of time, utilizing only rote memorization learning, and the use of anatomical models. These modes of learning result in little comprehension of how the information is essential to understanding A&P concepts and how to use their knowledge beyond the classroom. With various issues relating to how students learn and the struggle they often encounter in A&P, instructors should offer additional supplemental resources that can aid students' understanding of A&P concepts.

Significance of the Study

By completing this study, I worked toward implementing CBL may impact students, instructors, and other stakeholders as there is resistance to adopting new pedagogical methods in the classroom due to limited resources and the pressure to emphasize research over instruction. This study provides educators an opportunity to learn how they can easily incorporate CBL into the classroom without comprising their expectations. For these reasons, I sought to implement an alternate approach to teaching using CBL to understand if this method is effective in facilitating reasoning skills in undergraduate A&P instruction.

Definitions of Terms

The terms defined in this section were used in this study, and the contextual definitions can aid in understanding of this research report.

Undergraduate anatomy and physiology (A&P) at Western Community College: Anatomy is the study of the structure, and physiology is the study of function. A&P courses consist of teaching students about the body systems (Martini et al., 1988). When a student enrolls in this course, they will learn about the basic function and organization of the human body.

Anatomical systems taught at Western Community College: The anatomical systems covered in undergraduate A&P are histology, integumentary, skeletal, muscular, central nervous system (CNS), autonomic nervous system (ANS), special senses (SS), respiratory, cardiovascular, urinary, reproductive, lymphatic, endocrine, and digestive systems.

Case-based learning (CBL): Through this approach, students can apply their knowledge to real-world clinical practice, which is an important component for those entering allied health professional schools. This is also important to teach students about their own body, whether they wish to pursue matriculation at a health professional school or not. Students will receive cases portraying a patient history and symptoms, which will allow them to diagnose and treat patients (Mclean, 2016).

Case-based reasoning (CBR): CBR represents what clinicians may experience daily, thus enabling retrieval of past information with constant adjustments made based on new experiences with patients (Hmelo, 1995). Eventually, the problem or case is stored, retrieved, reused, revised, and retained (de Mantaras et al., 2005).

Clinical reasoning skills (CRS): CRS are skills that health professionals use to make decisions about a patient. These skills encompass CBR and hypo-deductive skills, which consist of health professionals' abilities to retrieve, reuse, and restore nonanalytical and analytical skills to assess patients and clinical problems that may arise (Barrows & Feltovich, 1987; de Mantaras et al., 2005; Eva, 2005; Khatami & MacEntee, 2011; Rochmawati & Wiechula, 2010).

Hypo-deductive skills: Hypo-deductive skills entail a student using nonanalytical and analytical skills to deduce a diagnosis and treatment (Pelaccia et al., 2011). For this study recognizing patterns based on non-analytical, analytical processes, and diagnosis was the focus

Summary

This chapter discussed a synopsis of how students learn about science in an undergraduate setting, CBL—a pedagogical approach that may help students gain a better understanding of scientific concepts—and how I conducted this study to determine CBL's effectiveness, focusing on three difficult anatomical systems. Finally, a review of definitions utilized throughout this study was presented. The next chapter presents a literature review on the vast applications of CBL.

Chapter II

Literature Review

In this study, I proposed to investigate the effectiveness of CBL as an instructional approach to improve student learning in undergraduate A&P courses. In this chapter, existing literature is reviewed regarding the implementation of CBL in health professional schools, how CBL may be operationalized in the real world, and a comparison of active learning pedagogies. Finally, "I" or "the researcher" discusses how the literature informed this study.

Active Learning

Active learning methods ensure that "science for all" is achieved by providing students opportunities to learn science using different pedagogical approaches so that they may develop a deeper understanding of the concepts aside from traditional tools such as textbooks (AAAS, 1998). Active learning is an instructional model that offers a way for instructors and students to learn in the classroom through engagement. As noted by Estes (2004), active learning is when a student becomes part of their learning process through sense-making, reconstructing new knowledge from existing knowledge, reasoning, putting information together, allowing students to learn skills they can use when they step into their profession, and adapting to different situations rather than the instructor feeding content to the students (Kember, 1997; Spronken-Smith, 2012). CBL offers some of the characteristics of active learning because it allows an instructor to present a case to the student with the goal of constructing meaning to determine a diagnosis, which entails students making sense of what they are learning, building a connection between the knowledge they know with new knowledge. For example, when scientific concepts are explained to students, they use cases to connect their knowledge of the body with new concepts they learn when reasoning through the problem. Furthermore, they are constructing meaning without being given the correct response; instead, students are working through the processes and exploring (National Academies Press, 2000).

It is important that instructors try to bridge the gap between theory and practice, which allows a student to step into the shoes of their desired profession and experience it in the classroom. The National Science Board (1986) outlined that science teachers should promote student engagement with and understanding of concepts through inquiry, cooperative learning, and small group interaction. Additionally, teachers can promote lifelong learning to build knowledge using students' prior knowledge of a concept and adopting a spirit of science for all (National Research Council, 1996; Shamos, 1995; Siebert & McIntosh, 2001). Importantly, these standards suggested that learning should no longer rely on rote memorization. These reforms are important because they provided insight into how undergraduate biology education can be reformed, and these suggestions were guided not only by stakeholders(e.g., instructors, department leads)but, most importantly, from undergraduate biology students from various STEM-related fields, indicating the collaboration of ideas and strategies from all, which provided a better understanding of the reforms (Vasaly et al., 2014).

The consensus of many educational reformers indicates that active learning may be difficult to implement in higher education because of a lack of time, understanding about active learning, and supplemental information about active learning for instructors (Blumberg et al., 2011; C. Henderson et al., 2011; Henrick et al., 2016). However, CBL may alleviate some of these issues as it does not force instructors to change their curriculum but instead add it as a new learning support. The current study provides valuable information to instructors and stakeholders on how they might incorporate CBL into their classrooms through professional development, divisional meetings, and departmental meetings, which can help develop new learning supports for students. CBL allows for activities in the classroom and provides students with hands-on, real-world experiences by using cases to gain a better understanding of scientific concepts (Aldridge, 1994; Bonwell & Eison, 1991; Chapman & Martin, 1996; Siebert & McIntosh, 2001; Thistlethwaite et al., 2012).

Features of Active Learning

In an active learning environment, students are the focal point while instructors act as facilitators (Kember, 1997). Active learning is a personalized process, one that ensures that students' learning needs, cultural backgrounds, and personal interests are taken into account (Brush & Saye, 2000; Harden & Crosby, 2000; Harden et al., 2000; National Academies of Science, Engineering, and Medicine, 2018). Through this method, the instructor facilitates learning through reasoning and conversations among and with students in the classroom (Hoidn, 2016; Nair, 2019). For these authentic interactions to occur, the teacher must provide a supportive classroom environment where students' opinions are listened to and taken into account. One way this valuation can be achieved is for instructors to repeat what they are hearing their students say to ensure clarity and accuracy. Land and Hannafin (1996) noted that active learning in science courses entails students participating in sense-making, encouraging deeper conceptual understanding of scientific concepts, making connections across concepts, understanding scientific concepts that can be built from previous knowledge, and exploring concepts.

Outcomes of Active Learning

Implementation of active learning offers several positive outcomes. This method was shown to be effective in challenging students and initiating student discussion, as it goes beyond direct instruction (Haak et al., 2011). Eddy et al. (2014) found that students who engaged in an active learning environment failed less often and that there is a 10% to 12% gain in performance. These findings were attributed to an increase in students' curiosity and reasoning skills elicited by active learning.

When focusing on the use of active learning in undergraduate science courses, particularly those geared toward people entering health professional schools, active learning supports students by encouraging them to *do* rather than memorize (Prince, 2004). CBL, as a form of active learning, provides an opportunity to support future health professionals and also students who are pursuing other careers and interested in understanding their health as they develop their abilities to understand the body through clinical reasoning. Students are encouraged to participate in clinical decision making by analyzing, interpreting, recognizing patterns, and deducing a decision using case stories (Jones, 1992). CBL offers students the ability to learn before stepping into the real world where they are unsupervised and making decisions independently (Tolsgaard, 2013).

Instructors can support learners through the implementation of CBL, as this is something currently missing in undergraduate instructions geared toward allied health professions. CBL may provide undergraduate students opportunities to learn more about the human body, step into the shoes of clinicians in the classroom, and develop CRS, all of which will be necessary when they enter their desired health careers.

Active Learning Approaches in Health Professional Schools

Many health professional schools currently implement different pedagogical approaches to elicit a deeper conceptual understanding of the human body including CBL along with process-oriented guided inquiry learning (POGIL) and problem-based learning (PBL; Eberlein et al., 2008; Jensen, 2016; Hopper, 2018). See Table 1 for an overview of these approaches. I has focused on CBL because undergraduate A&P instructors have depended on direct instruction as the main method of delivering information to students for a very long time. CBL is used in many health professional schools to teach students how to develop case-based reasoning and hypo-deductive skills that they will later depend upon when interacting with patients. Incorporating an approach like CBL early on to help student understand A&P concepts can be beneficial. CBL may be a vehicle to give students the necessary skills to succeed as they transition into health professional schools and learn more about their health McLean, 2016). To fully understand why I found CBL to be the best method of active learning for A&P instruction, a brief explanation of other pedagogical approaches is necessary.

Table 1

Overview of Active Learning Methods

Characteristics	POGIL	PBL	CBL
Purpose	Relies on need-to-know concepts	Relies on need-to-know concepts	Elicits discussion, & exploration of various clinical cases
Theoretical foundation	Constructivism	Constructivism	Constructivism
Student preparation	No prior knowledge	No prior knowledge	Prior knowledge needed
Faculty role	Facilitator	Peer facilitator	Facilitator/guide

Note. POGIL = process-oriented guided inquiry learning. PBL = problem-based learning. CBL = case-based learning.

Process-Oriented Guided Inquiry Learning

POGIL is an active learning approach focused on group-learning strategies, guided inquiry exercises, and improved learning by focusing on need-to-know content (POGIL, 2012; Walker & Warfa, 2017). POGIL is best defined as an approach that involves the elimination or replacement of lectures and incorporates a self-teaching environment for students when working through problems (Eberlein et al., 2008; Hu & Shepherd, 2013; Moog & Spencer, 2008). The fundamental principles behind POGIL and the development of critical thinking and problem-solving skills are based on the learning cycle approach (Hanson, 2006; Pienta et al., 2009). Student activities are generated using the learning cycle paradigm that was developed by Jean Piaget (Shadle et al., 2018). The learning cycle consists of the following phases: exploration, invention, and application. The exploration phase uses visual data gathering, such as watching videos or laboratory demonstrations, graphs, and tables. Students make observations and use the data they gather from the first phase to help decipher the next phase of the learning cycle by testing and formulating hypotheses. In the second stage, invention, critical thinking questions are used, and students formulate ideas based on the data gathered. In the last phase of application, students reinforce and review what they learned through problem sets or laboratory exercises and explain their ideas using the data (Farrell et al., 1999; Lawson, 1995; Pienta et al., 2009).

When utilizing the POGIL approach, it is important to note that what makes POGIL a form of active learning is that it uses cooperative learning. Students work in teams of three or four and construct an understanding of a specific topic while the instructor or peers act as a facilitator during the activities (Hanson, 2006; Moog & Spencer, 2008). Problem activities are created, and students use the scientific method to arrive at a conclusion. Within each group, students are assigned roles as manager, spokesperson, recorder, or reflector (POGIL, 2012). Teams discuss findings, reflect on the activity with the class, and review possible solutions that provide evidence for their answer. At the end of group activities, students are given homework, such as reading from a textbook, to help develop a more profound understanding of concepts (Eberlein et al., 2008). Overall, students who use POGIL take ownership of their learning process using the learning cycle paradigm.

CBL offers a bit more instructor-student interaction when compared to POGIL. When CBL is implemented, the facilitator plays an active role, ensuring their presence is known. The facilitator balances a dual role through which they provide guidance while, at the same time, allowing students to interact with one other to discover the concepts. CBL does not focus on need-to-know concept as POGIL does, or ask students to read from a textbook. Students may, of course, read from their texts, but in CBL, the instructor provides students with the fundamental knowledge to help them understand and work through the cases they are given. CBL provides students with direction and enables them to step into the shoes of clinicians, which POGIL does not do. CBL features may be used to fill the gaps that POGIL does not provide.

Problem-Based Learning

Another approach often compared to CBL is PBL. This is a student-led process which enables them to construct ideas through self-directed and cooperative learning (Glaser & Bassok, 1989; Palincsar, 1998; Tarnvik, 2007). According to Barrow (1987), PBL may be achieved through lecture-based cases in which students are given a quick example and then complete a problem-solving activity using closed-loop PBL. Closed-loop indicates that students are relying heavily on their own feedback on how they may improve their decision when working with a given problem set. Furthermore, in closed-loop, the facilitator helps the student remember prior knowledge (Walker & Leary, 2009).

It should be noted that PBL is a type of self-directed learning in which students may be given minimal to no additional resources to help solve problems (Barrows, 1968). The goal of PBL is to encourage the development of problem-solving skills, self-directed learning, cooperative learning skills, and motivation (Dolmans et al., 2005). It is one of the many approaches utilized within various health fields to enhance student skills using authentic, real-world situations (Barrows, 1968; Boud & Feletti, 1997). However, this method relies heavily on self-directed learning, which entails students being left to their own accord to figure out concepts, with minimal to no assistance or guidance. CBL, on the other hand, allows the students to work through cases with the support of a facilitator nearby. Instructors can guide students and provide directional support to ensure they are not left to fall into a rabbit hole. CBL provides support for students, which is important in gateway courses so that students feel reassured that they are not alone.

In a tutorial style PBL, students receive a specific problem scenario from facilitators or peer tutors, or in some cases, groups may determine their own problem for solving (Barrows, 2000). Students identify facts, formulate a hypothesis, identify issues, reflect on the knowledge gained, and apply new knowledge (Barrows, 2000; Hmelo-Silver, 2004; Schmidt & Moust, 2000). Throughout the process, students are practicing student-direct learning as PBL leaves students to their own devices while the instructor does not provide any information before starting the problem-solving activities (Barrows, 2000).

In the PBL approach, students form teams with four to five peers, and the team leaders may act as facilitators to help guide the group through solving closed-ended complex problems (White & Ousey, 2010). The instructor or student can occasionally generate the problems, but facilitators should ensure that students can investigate, provide an explanation, and formulate a solution (Torp & Sage, 1998). Problems are designed for students to make connections between in-classroom concepts and real-world contexts that may or may not be related. Success of this method is highly dependent upon the instructor's needs and expectations of the course and students (Eberlein et al., 2008; White & Ousey, 2010).

Srinivasan et al. (2007) noted that PBL is often associated with CBL. However, CBL offers an advantage that PBL does not, which is not relying heavily on students working independently to search for the problem to be addressed. Instead, CBL involves more structure through which the facilitator presents the cases to students that they, in turn, can investigate individually. With CBL, the facilitators are more present in the discussion giving students the confidence that they are not alone in their learning processes. Furthermore, CBL is geared to build upon prior knowledge, merging science concepts with clinical cases, which allows for the connection of knowledge to application. CBL can fill the gaps that may not be seen in PBL or POGIL. Lastly, CBL is an approach that is used widely in health professional schools, and it may be beneficial to use this approach in undergraduate science instruction as well.

Case-Based Learning

CBL is used widely in various health professional schools. However, this approach is not used as commonly in undergraduate health program courses, which are often prerequisite courses and key to student success in professional schools.

CBL is an approach that focuses on merging basic science concepts with clinical science (Kaur & Sharma, 2021). Integrating the two using case studies to tap into students' prior knowledge, allowing them to make connections between that existing knowledge and the real world. By making sense of different patient scenarios that may be encountered in their careers, students build reasoning skills and learn to adapt in the midst of decision making. Working through cases presented in CBL may also teach students more about their own health (Anderson, 2010; National Academies of Science, Engineering, and Medicine, 2018).

CBL provides an efficient framework for students to learn about the real world through narratives that combine science and real-world patient data to engender student learning, sense-making, and exploration under the guidance of a facilitator (Slavin et al., 1995; Thistlethwaite et al., 2012; Williams, 2005). These narratives might include a patient's background, medical history, and current symptoms (Malau-Aduli et al., 2013; Williams, 2005). Most, if not all, CBL pedagogical approaches reflect situations that clinicians may experience in their day-to-day work lives as students must prepare in advance and interact with others to solve problems. Still, instructors are present to provide structure and guidance throughout the learning process (Srinivasan et al., 2007).

This section discusses three pedological approaches used in higher education. CBL is the method that is most closely related to the training of health professionals. CBL may be used to facilitate CRS and operationalized in the classroom and in the real word.

Clinical Reasoning Skills

The goal of clinical reasoning is for students to think like clinicians, which entails making decisions based on a set of problems presented when interacting with a patient (Higgs et al., 2008). Decision making starts when clinicians interact and converse with patients. It then progresses to a higher level, such as ordering appropriate tests and interpreting the results. Generally speaking, clinicians utilize their CRS to diagnose and treat patients (Kassirer, 2010).

CRS include the CBR cycle and the hypo-deductive reasoning model, summaries of which can be seen in Table 2 (Feltovich et al., 1987). The CBR cycle represents what clinicians may experience daily, thus enabling the retrieval of past information with constant adjusting based on new experiences with patients (Hmelo, 1995). Eventually, the problem or case is stored, retrieved, reused, revised, and retained (de Mantaras et al., 2005). In the CBR cycle, a person sorts through clusters of information, retrieves information stored from previous patient encounters, justifies the reasons for determining a specific diagnosis based on current patients, stores new information, and is able to retrieve information again. The overall approach of the CBR cycle is to store cases and adapt the acquired knowledge to conform to new scenarios. This cycle helps clinicians recognize patterns across similar situations (Eva, 2005; Khatami & MacEntee, 2011). CBR and hypo-deductive skills are the goals of CRS and therefore the goal of educators. Health professional instructors should help students develop CRS, giving each individual the ability to experience what clinicians experience on a daily basis but incorporated into the classroom.

Table 2

Overall Features of Clinical Reasoning Skills

Type of reasoning	Feature
Case-based reasoning cycle	Ability to store, revise, retrieve, & retain information
	Make connections from one clinical encounter to the next
Hypo-deductive reasoning	Recognize patterns based on nonanalytical & analytical processes

The hypo-deductive reasoning approach entails an individual having the ability to store and reuse information through pattern recognition. In this approach, a clinician would need to shift between nonanalytical and analytical solutions. The nonanalytical task is the clinician's first impression of patients (e.g., an initial visit, a checkup, and medical history provided by the patient). Only then does the analytical solution take place.

Thus, the hypo-deductive reasoning model allows clinicians to generate a hypothesis, develop ways to prove or disprove a diagnosis, evaluate results obtained to identify problems associated with the results, and present a final diagnostic decision (Barrows & Feltovich, 1987; Eva, 2005; Khatami & MacEntee, 2011). Using hypo-deductive reasoning occurs once a clinician retrieves information and patterns from the past to establish a diagnosis (Eva, 2005; Goldszmidt et al., 2013).

CBL addresses the goals of clinical reasoning because it enables students to grasp scientific concepts and acquire social, communication, and reasoning proficiency skills (Hmelo, 1995; Kulak & Newton, 2015). CBL enables reconstructing from previous knowledge, engaging in real-world situations, and tapping into A&P concepts to reason through specific patient information such as symptoms, history, and laboratory results, while providing students the skills to adapt to different clinical situations (McLean, 2016; Thistlethwaite et al., 2012; Tiwale et al., 2019; Williams, 2005).

Instructors are present during their students' learning process, encouraging and guiding them to make sense of what is occurring. This structure may alleviate some of the negative emotions that arise from an active learning environment such as pressure, insecurity, and a lack of confidence associated with learning scientific concepts (Abdel & Collins, 2017; Felder & Brent, 2004). When instructors are involved in the learning process, it can elicit a feeling of safety, support, and assurance (Seidel & Tanner, 2013). Another significant aspect of CBL is that it enables students to learn critical information prior to in-class activities (Sirinivasan et al., 2007). Thus, the focus of CBL is to provide students with CRS by solving problems related to a disease or problem. In addition, students are expected to be active participants and to synthesize real-world clinical cases while the teacher's role is to guide student discussion by rendering themselves as facilitators (McLean, 2016; Williams, 2005).

In summary, CBL has the capacity to offer a variety of features that may be beneficial for undergraduate A&P students to by allowing them to step into the shoes of clinicians and experience the thought processes that go into assessing patients. By implementing CBL in undergraduate instruction, we may better prepare these students to succeed once they enter their desired health professional school by instilling skills that they can carry with them and also helping them gain a better understanding of the human body.

Teaching Methods to Facilitate Clinical Reasoning Skills

Instructors employ various methods of teaching CRS, including the lecture method, directed cases, small group interactions, or a combination of these methods (Herreid, 2007). The role of the instructor is to guide students and take an active role during activities by encouraging class discussion on topics that have already been covered in the course. Instructors also emphasize concepts to further ensure that any misunderstandings may be amended (Hay & Katsikitis, 2001; Herreid, 1997; Srinivasan et al., 2007). Other duties of CBL instructors include ensuring that student-peer and teacher-student discussions are facilitated. Some ways to accomplish this are through group interactions and whole-group discussions. For example, an instructor might walk around the room, engage in conversation with students, and encourage them to voice their opinions. During the class discussion, the instructor may call on a group of students to express their thoughts on the case and explain their decision making. If a student feels comfortable speaking in front of a class, they are encouraged to do so. Instructors can also provide extra time for students to think about and discuss ideas with their peers. Instructors can help refocus students' understanding, take notes using tools such as a whiteboard or computer program, and help lead an overall wrap-up discussion. Instructors may also repeat main points from each clinical case that has been discussed in a group. Staging debates or role-playing case scenarios are additional strategies that can be used (Herreid, 1997).

Another important role of the facilitator is to generate clinical scenarios that act as a vehicle to bridge the gap between theory and practice (Edelbring et al., 2011; McGinty & Smyth, 2000; Thistlethwaite et al., 2012). The format of clinical cases should be direct or open-ended. While the direct format results in one answer, the open-ended format may have a variety of options geared toward understanding students' thought processes when analyzing cases (Herreid, 1997). In addition, each case generated should allow students to transfer knowledge and skills by solving additional case scenarios that may be given (Cliff & Wright, 1996; Kolodner, 1993; Kolodner & Guzdial, 2000).

Even though implementing CBL may be new and uncomfortable for some instructors, it is still important. Instructors should find ways to not only provide students with the foundational knowledge of A&P concepts, but also incorporate some case studies into their course to offer a different perspective to learning. An adequate amount of information can be provided via CBL through an example of how to assess and deduce a patient's clinical scenario before starting the in-class activities (Kunselman & Johnson, 2004; McKeachie & Svinicki, 2006). Instructors are encouraged to provide feedback, keep class discussions open so that students can sort through multiple solutions, hear and address opinions, and use materials such as whiteboards or posters to keep track of discussions, students thoughts, and responses (Austin & Packard, 2009; Barnes et al., 1994; Herreid, 1997; Kim et al., 2006; Moust et al., 2005; Rosenstiel et al., 2003). Additionally, the facilitator of CBL must determine how they will evaluate the effectiveness of CBL in promoting a deeper understanding of scientific concepts. This study provides an understanding of how CBL can be a tool to help non-clinician instructors incorporate case studies into their classrooms.

Implementing Case-Based Learning in Health Professional Schools

Pursuing a career in the health field is an enormous investment for both the student and the school. This pursuit requires abundant dedication, and while a professional health career may be rewarding, it comes with its share of challenges, high expectations, and academic rigor (Doroghazi & Alpert, 2014; Jackson et al., 2016; Rotenstein et al., 2016). According to Boudoulas (2005), health professional schools should help shape students to become well-rounded clinicians who are able to assess, diagnose, and treat patients with minimal reliance on others or technology. They should also be trained to acknowledge mistakes, rectify them, and minimize their reoccurrences (Rencic et al., 2017). To achieve this goal, however, there must be a balance between the scientific knowledge acquired in the classroom and the practical knowledge acquired through practice, or in the case future clinicians, interaction with patients (Boudoulas, 2005). The balancing of both helps students understand how the two complement one another. For example, to understand a disease such as Parkinson’s, it is essential to understand how the nervous system functions and what happens when the physiological aspect of brain function changes. Therefore, in this case, it is essential to understand the relationship between nerve damage and dopamine levels as a way to predict clinical symptoms that can, in turn, fuel the search for diagnosis and therapeutics associated with a disease like Parkinson's (Schor, 2013).

Health professional students are expected to learn every facet of the human body and its function. Thus, the coursework knowledge that is gained, and the opportunity to practice in the real world, are important for developing CRS (Ryan & Higgs, 2008). CRS are critical to learning because health professionals use these skills to make decisions about diagnosing and treating patients (Pelaccia et al., 2011). CRS encompass CBR and hypo-deductive skills, which consist of health professionals' abilities to retrieve, store, and use both nonanalytical and analytical tools to assess clinical problems as they arise (Barrows, & Feltovich, 1987; de Mantaras et al., 2005; Eva, 2005; Khatami & MacEntee, 2011; Rochmawati & Wiechula, 2010).

Given that health professional students are preparing to interact with patients upon entering their desired career and because they are no longer being supported by their peers or instructors after leaving the classroom, these schools want to ensure that students are well prepared. In fact, they now deal with the real world and the expectation that they can use the skills learned in the classroom to help take care of patients. For these reasons, it may be beneficial to implement CBL in undergraduate courses such as A&P. Additionally, incoming health professional students are required to take prerequisites courses to aid in their understanding of the human body, such as general biology, biochemistry, and A&P. Using CBL early on in their schooling may help bridge the gap between these undergraduate courses and the expectations health professional have for their students. CBL could provide students with fundamental skills that they can carry forward when transitioning as well as the ability to explore correlations between science concepts and clinical expectations. Furthermore, using CBL in undergraduate A&P instruction would not only prepare students who plan to enter into health professional school but also help students learn more about their own body and how it functions (Miller et al., 2002).

Health professional students are occasionally? often? thrown into clinical practice without adequate preparation from their didactic lectures and with a lack of cross-connection between health topics, which is not helpful in preparing for their future career as a clinician (Einstein et al., 2015). The strategies that students use to learn about the human body are constantly evolving, and health professional schools are recognizing the importance of moving away from didactic lectures and toward active ways to engage students in learning about the human body (King, 1993). Health professional schools are adapting ways to help their students intertwine lectures and clinical work. In fact, numerous health professional schools have moved toward implementing CBL into their didactic lectures (McLean, 2016). Applying theory to practice may help students integrate their understanding of the human body, a skill that all health professionals need to succeed in the long-run. In fact, when health professional students were asked what form of learning improvement they felt they would benefit from, many responded that it would be beneficial to have courses incorporating clinical work (Staśkiewicz et al., 2007). Thus, CBL is implemented in various fields such as general medicine, dentistry, pharmacology, nursing, and various other health professions.

Such training programs have incorporated CBL with positive outcomes. Several studies have discussed the development of in-depth knowledge of clinical situations, diagnosing, treating patients, reasoning skills, and communication skills when CBL is implemented (Bonney, 2015; Gade & Chari, 2013; Keeve et al., 2012; Khan et al., 2015; Nordquist et al., 2012; Singh & Bhatt, 2011; Tathe & Singh, 2014).

Tathe and Singh (2014) conducted a study comparing CBL to traditional lectures. In their study, second year medical students were given pre and posttests to determine the significant effect of CBL. The results showed that students exposed to CBL had significantly higher postscores compared to those who were exclusively exposed to traditional lectures. CBL also enabled those students to be engaged in a lecture format course. Another study by Palter et al. (2013) implemented CBL in a surgical rotation in which students learned to use laparoscopic techniques. Students were evaluated and scored based on how they handled their patients and the associated complications. Results showed that CBL improved medical students' clinical knowledge and helped them adapt to changes and complications easily.

Geriatric medicine is another field in which CBL is used. A study conducted by Struck and Teasdale (2008) offered students who were in their geriatric clerkship a combination of clinical activities and clinical rotations. The clinical activities consisted of learning how to assess, diagnose, treat, and assist geriatric patients suffering from muscle ?? strains/tears and hip fractures, ulcers, pancreatic cancer, and neurological issues. Students worked on three longitudinal cases, and at the end of the case studies, they were evaluated using a seven-point Likert scale along with open-ended questions about their experiences with CBL. The results showed that 92% of students found CBL to be an effective way of learning about geriatric medicine, and 88% of the students indicated that CBL was an effective pedagogical approach used during their rotation.

With that being said, many undergraduate science courses are seeing high attrition rates due to the size of the classes, the need to cover all materials in a given time, and even pedagogical approaches that are not in sync with what students may encounter in the work force (Rhodes et al., 2020). Implementing CBL in difficult courses may improve student outcomes in tough subjects such as A&P. Furthermore, by using this approach in undergraduate science instruction, instructors can instill reasoning skills and deeper understanding of the human body for students entering the work field as well as teach students about their bodies and how to advocate for themselves within the public health system.

Anatomy and Physiology Concepts Applied to a Case Using Clinical Reasoning Skills

Rather than maintaining an environment in which the teacher transmits knowledge to the student, CBL allows students to actively engage with content, make sense of what they are learning, and use effective reasoning skills to help solve clinical practice scenarios. CBL is a preferred pedagogical method because it can be used to reinforce CRS, in turn, create lifelong learners with the ability to change and adapt as the world evolves. In a CBL learning environment, students use the knowledge they learn to help evaluate different scenarios (Miller et al., 2002).

> For instance, a clinical case scenario given to students might state,
> A 65-year-old female patient walks into the emergency room and complains of the following symptoms: shortness of breath, fatigue, inability to eat or concentrate, and slight swelling in her legs. Her medical history indicates she suffers from high blood pressure and high cholesterol. During the examination, an EKG, chest x-ray, complete blood count (CBC), and echocardiography was conducted. The examination results showed fluid leaking into the tissues (indicating constricted blood flow), a heart murmur was detected, and a blood pressure level of 138 mmHg/80 mmHg was recorded.

In a case such as this, the facilitator would ensure that students have the foundational knowledge of how blood flows through the body and how the heart pumps blood through the chambers and valves. Students would then need to use A&P concepts relating to the heart and be able to distinguish between normal and abnormal heart functions. From their knowledge about the heart structure and function, students would formulate a diagnosis by analyzing and evaluating the patient's symptoms and examination results while listing features from the case that support their diagnosis. Through this implementation of CBL, students would utilize A&P concepts and utilize CRS when solving a problem.

CBL is designed to relate concepts learned to what clinicians may experience when interacting with patients. Using cases in the classroom not only bridges the gap between the workforce and the classroom but also provides opportunities for applying scientific concepts. The previous case example is just one example of how CBL enables students to apply their knowledge of the human body by using CRS.

Parallels Between Case-Based Learning and the Importance of Learning Anatomy and Physiology

A&P is the study of structure and function of the human body (Martini et al., 2012). Moreover, A&P is a gateway course for those wishing to pursue careers in the health sciences (Entezari & Javdan, 2016; S. J. Henderson & Orr, 1989; McLachlan & De Bere, 2004) because these courses require students to learn complex and intricate concepts (Sawant & Rizvi, 2015).

Aside from just learning the core concepts of anatomical and physiological systems, a deeper understanding of the structure of the human body and its function is essential for future clinicians (Collins, 2008; Older, 2004). According to Collins (2008), the primary goal of learning about the human body is for students to understand the difference between how typical and abnormal tissues and organs function. Students who wish to pursue careers in the health field may greatly benefit from CBL in their A&P courses as they will encounter scenarios that may not be considered normal. Understanding the difference between typical and abnormal structures and functions will provide the foundational knowledge that students need to use reasoning and hypo-deductive skills in order to diagnose and treat patients (Barrows & Feltovich, 1987; Collins, 2008; Eva, 2005; Khatami & MacEntee, 2011; Turney, 2007).

Instructors of A&P are important as they are the ones who equip students to enter health professional schools with the knowledge needed to succeed. Students take the knowledge acquired and integrate it when they enter health professional schools. Currently, lower-level A&P courses are missing a valuable aspect in the classroom, which is the facilitation of CRS.

Summary

This chapter presents the literature surrounding educational reforms, types of pedagogical approaches used, and how CBL is an approach that can be applied in undergraduate science courses. The information pertains to the current study as the goal is to help students gain a better understanding of A&P concepts by implementing CBL. The literature informed this study because it allowed me to provide students with additional learning support in the classroom as undergraduate science instruction relies heavily on didactic lecture and having to remember copious amounts of information to learn; because of this, students are relying on rote-memorization rather than understanding what they are learning. According to Ryan and Higgsm(2008), the knowledge students learn in the classroom, and having an opportunity to utilize it, is important for CRS development. I wanted to implement CBL as a way to encourage students to apply the concepts they learn in my classroom to real-world decisions. In summary, this chapter details how students learn, what active learning is, ways in which is it used, and its connection to A&P instruction. Chapter III discusses participants and how data were collected and analyzed.

Chapter III

Methodology

Chapter I focused on providing a background and reasoning for the need to examine the effectiveness of CBL in undergraduate A&P instruction. Chapter II was an overview of the literature regarding CBL, how it is operationalized, its comparison to other pedagogical approaches, and the importance of using CBL in A&P instruction. The current chapter provides a description of the rationale for the chosen design, the school setting, participant information, sampling procedures, data collection, study procedures, and the limitations for this research.

This study assessed the effectiveness of CBL in aiding students' understanding of concepts in two sections of undergraduate A&P. Students in both the control and experimental groups were tested on their CRS before and after the intervention. The pretest and posttest were administered to both groups by the primary researcher, who is the instructor of the class. The assessments were distributed through Canvas Learning Management Software (2022), and students were only able to access the pretest before starting a lesson on an anatomical system and after concluding the chapter. The sample was selected out of convenience as the primary researcher is a biology instructor who was teaching A&P at the local community college at the time. Two sections of Biology 223 (A&P) participated and were randomly assigned to the experimental or control conditions.

Research Questions

Two steps were taken to assess for CRS. First, the CRP instrument for three anatomical systems (CNS, ANS, and SS) was used to compare mean differences between groups, and to understand two-way interaction within-subject and between-subject factors, on the dependent variable. Second, a qualitative element consisting of semistructured interviews further aided in understanding how students used the cases to grasp A&P concepts. These assessments were analyzed to answer the research questions for this study, which are as follows:

RQ1: What is the effect of case-based learning on the CRS of undergraduate anatomy and physiology students for the central nervous system, autonomic nervous system, and special senses?

RQ2: How does case-based learning support student application of anatomy and physiology concepts to cases that involve clinical reasoning?

Participants and Setting

An a priori power analysis was conducted to determine desired sample size using G*Power with an ANOVA within-between interaction design and the following input parameters: effect size of 0.25, alpha error of 0.05, power of 0.95, two groups, two measurements, and nonsphericity correction of one. These parameters were used to determine the number of participants required to achieve statistical significance (Faul et al., 2007). The G*Power analysis generated a sample size of 54 participants. However, when reaching the end of data collection, only 48 participants participated in this study due to withdrawal from the course or not completing CRP assessments.

I recruited participants for this study from a community college in the Western United States. The demographics for students enrolled at the time were as follows: 1% American Indian, 7% Asian, 3% Black/African American, 0% Native Hawaiian/Pacific Islander, 31% Hispanic/Latino, 51% White, 5% Two or more races, 2% Unknown; 43%

male, 57% female. For the purpose of this study, undergraduate A&P students enrolled in Anatomy & Physiology I for the fall 2021 semester were the targeted population. I purposely selected students enrolled in A&P I for this study because the research questions focused on undergraduate students in a community college setting. Typically, there are approximately 26 to 28 students enrolled in A&P courses. Western College offers a total of 11 sections of A&P I during the fall semester.

I taught two A&P I courses in the Fall of 2021, and randomly assigned either as the control or experimental group. The control group initially consisted of 27 students; however, two participants from the control group withdrew from the course before the assessments began, and one did not complete the assessments. The experimental group consisted of 28 students originally, but four participants did not complete the CRP assessments and were eliminated from the study. A total of 48 students completed all CRP assessments, and a total of 18 students were preselected for the interview from both the control and experimental groups. Data collection and analysis is discussed further in this chapter.

Detailed information regarding all students' professional majors and the number of times they had taken A&P I was obtained from the Community College research department. According to Ritchey (2008), percentages and frequencies are the appropriate descriptive statistics to report for categorical variables. The information was then entered into SPSS, and percentages and frequencies were calculated for all categorical variables for the group as a whole, the experimental group, and the control group.

As represented in Table 3, the sample of the experimental group consisted of 24 participants. For the experimental group, the number of times a student had taken Biology 223 was the following: never: 40 (83.3.0%), one time: 6 (12.5%), two times: 2 (4.2%), three times: 1 (1.8%). Students' professional majors are as follows: AA: 1 (4.2%), biology-AS: 3 (12.5%), CHS-kinesiology: 1 (4.2%), CHS-pre-nursing track: 7 (29.2%), dietician-AS: 1 (4.2%), science-AS: 11 (45.8%).

Table 3

Percentages and Frequencies of Categorical Variables for Experimental Group (n = 24)

Variable	Frequency	Percent
Number of times taken A&P I		
0	21	87.5
1	2	8.3
2	1	4.2
Professional major		
Associate of Arts	1	4.2
Biology-Associate of Arts	3	12.5
CHS-kinesiology - Associate of Arts	1	4.2
CHS-pre-nursing track-Associate of Science	7	29.2
Dietetic-Associate of Science	1	4.2
Associate of Science	11	45.8
n	24	100.0

As seen in Table 4, there was a total of 24 participants in the control group. The number of times a student has taken Biology 223 was the following: never: 19 (79.2%), one time: 4 (16.7%), two times: 1 (4.2%). Students' professional majors are as follows: CHS-kinesiology: 3 (12.5%), CHS-pre professional track: 8 (33.3%), CHS-pre-nursing track: 8 (33.3%) and Associate of Science: 11 (45.8%). A comparison of the experimental and control groups is presented in Table 5.

Table 4

Percentages and Frequencies of Categorical Variables for Control Group (n = 24)

Variable	Frequency	Percent
Number of times taken A&P I		
0	19	79.2
1	4	16.7
2	1	4.2
Professional major		
CHS-kinesiology-Associate of Arts	3	12.5
CHS-pre-professional track-Associate of Science	2	8.3
CHS-pre-nursing track-Associate of Science	8	33.3
Associate of Science	11	45.8
n	24	100.0

Design

The study was an explanatory sequential mixed method design (DeCuir-Gunby & Schutz, 2018). The greatest advantage of this design is the ability to use the qualitative data to explore the findings from the quantitative portion. The quantitative data is collected and analyzed, and those results are then used to collect the qualitative data portion (DeCuir-Gunby & Schutz, 2018). A 2 × 2 mixed ANOVA was used to examine the between groups factor of the treatment condition and the within group factor of time. For this study, the within group variables were no CBL (control group) and CBL (experimental group), the independent between groups variable was time (pre and posttest), and the dependent variable was CRS using the established instrument of CRP (Groves et al., 2002).

Table 5

Percentages and Frequencies of Categorical Variables for Control vs. Experimental

		Experimental Group(N=24)		Control Group(N=24)	
		Freq	%	Freq	%
# of times take A&P I	0	21	87.5	19	79.2
	1	2	8.3	4	16.7
	2	1	4.2	1	4.2
Professional major	CHS Kinesiology	1	4.2	3	12.5
	CHS-Pre professional			2	8.3
	CHS-Pre-Nursing	7	29.2	8	33.3
	Associate of Science	11	45.8	11	45.8
	Dietetic-Associate of Science	1	4.2		
	Biology-Associate of Arts	3	12.5		
	Associates of Arts	1	4.2		

Study Procedure

This study was conducted via Canvas because A&P lecture course was held online asynchronously for the fall semester. To maintain consistency, I delivered CBL online as she is an A&P instructor and both familiar and well-versed in facilitating CBL. In addition, she informed participants that working through the cases would be part of their in-class participation grade for the course. The participation grade accounts for 10% of their overall grade. Each student in my class completed the CRP; however, the CRPs of those who did not wish to participate in the study have not been included in this research report.

When implementing CBL, I chunked the process into the following segments to ensure content was given and students could apply their knowledge: first assessment (CRP pretest), lecture video, directed case method (practice case), case study video examples, and final assessment (CRP posttest). The control group was not exposed to CBL during class instruction. Students in this group only completed a pretest and posttest. For the purpose of this study, I focused on the three body systems of CNS, ANS, and SS. The reason for focusing on these three anatomical systems is because students have a difficult time understanding concepts in each of these systems based on a previous survey analysis I conducted in 2020. The survey focused on students' perception of A&P and which anatomical system they found difficult. The survey analysis revealed CNS and ANS as very difficult and SS as somewhat difficult by twenty five students who have previously taken A&P.

For the experimental group, students completed a pretest CRP assessment before starting with the lecture videos. Next, they were given lecture videos on the anatomical systems and asked to watch a mini case study video I created for the students to help them work through the exercise. The videos walk students through the process of analyzing a practice case for the three anatomical systems. During this process, students also completed practice case stories in which they generated a hypothesis, developed strategies to evaluate the patient's problem, assessed the given situation, utilized A&P concepts, and came to a diagnostic decision. Each of the practice cases was submitted and looked at by the instructor, and feedback was provided to help students understand the case and areas in which they could improve. The directed case method entailed students receiving a practice case after watching the lecture videos through Canvas. Within 1 to 2 days after completing the lecture videos, CBL videos, and practice case studies, students were assessed through a posttest CRP. Again, I only collected data from the units covering CNS, ANS, and SS for the purposes of this study.

For the control group, students were given a pretest and posttest assessment on the three anatomical systems of CNS, ANS, and SS. These assessments were the exact same as those given to the experimental group. The only difference was in the instruction; no case studies and practices were provided to the control group. Students in the control group completed the pretest prior to starting a system and again upon completion of the unit of study. See Tables 6 and 7 for a brief outline of the intervention protocols for each group.

Table 6

Overview of Intervention Protocol for Experimental Group

Protocol overview	Synopsis of each activity piece
Assessment 1	CRP pretest via Canvas prior to starting a system & prior to watching the lecture videos
Lecture videos	Students watch lecture videos on important anatomical concepts & how to assess cases
Mini-case study videos	Students watch videos demonstrating how to work through a case step-by-step & practice assignments
Directed case method via Canvas	Students are given a practice clinical case
Assessment 2	CRP posttest via Canvas within 1 to 2 days

Note. CBL = case-based learning. CRP = clinical reasoning problem.

Table 7

Overview of Intervention Protocol for Control Group

Protocol overview	Synopsis of each activity piece
Assessment 1	CRP pretest via Canvas prior to starting a system & prior to watching the lecture videos
Lecture videos	Students watch lecture videos on important anatomical concepts
Assessment 2	CRP posttest via Canvas within 1 to 2 days of watching lecture videos

Note. CRP = clinical reasoning problem

Instrument

During the pretest and posttest time periods, I assessed students using an established instrument called the CRP. She generated cases for the pretest and posttest assessments according to the steps as indicated by Groves et al. (2002). Case studies topics and ideas were selected by searching through established cases (citations); however, modifications were made (see Appendix A). There was a total of six CRP cases for the anatomical systems: two for the ANS, two for the CNS, and two for the SS. The pretest and posttest assessment were slightly different; however, the cases stayed consistent, and only the final diagnosis changed between the pretest and posttest. I analyzed the assessments only after submitting the students' grades. The data collection and analysis processes are discussed later in this chapter.

The assessment is called CRP and has a Cronbach's alpha reliability range between 0.70 and 0.87 and a satisfactory construct and external validity (Custers et al., 2017; Groves et al., 2002). In addition, other researchers have implemented CRP and revealed that it has a Cronbach's alpha range between 0.61 and 0.91 (Amini et al., 2011; Custers et al., 2017; Derakhshandeh et al., 2018; Groves et al., 2002). The alpha levels mentioned by these scholars in their publications generally fall within the acceptable range of 0.70 to 0.95, with anything below this range indicating an inadequate number of questions posed or possible interreliability issues between items (Tavakol & Dennick, 2011). Regardless, most alphas in prior research projects attest to the CRP instrument's reliability.

The CRP cases contained the following information: patient name, reason for visit, patient history, symptoms (i.e., length of time, where, when, what), and results from a physical examination of the patient (i.e., blood pressure, temperature, and respiratory rate). In addition, the critical features are a list of possible symptoms associated with that particular diagnosis. Each student was asked to generate a plausible diagnosis and identify the critical features that aided in their choice and rate how important each of those factors was in leading to the diagnosis (see Appendix A). The instrument helped assess students' CRS by using these established instruments with slight modifications focusing on each anatomical system.

To generate the CRP cases, I sought examples of case studies and modified the content to fit my A&P course. I collaborated with an anatomist, to review the materials. I ensured that the clinical cases contained information that the targeted participants could answer, which also assessed the CRPs' face validities. The reason for using an expert collaborator in the field of anatomy was to ensure the cases' content information was accurate.

For the qualitative portion of this study, an interview protocol was created considering students' experiences with CBL and A&P concepts that were valuable. Toward the end of the semester, students were asked to participate in a 10-minute interview, which would be used to answer RQ2 and help provide a robust understanding of CBL.

The Clinical Reasoning Problem's Scoring Mechanism

The CRP's scoring mechanism followed Groves et al.'s (2002) method to ensure that the instrument was used correctly. Groves et al. (2002) generated the total scores based on the critical features and first and second top diagnoses. For example, if there is a total of 12 critical features, each feature is scored with a maximum of 3 points, making 12 x 3 = 36 points for the critical feature. With that said, the feature's point total depended upon the number of critical features provided by the expert. In addition, the expert provided their top two diagnoses along with the clinical features associated with each diagnosis.

The anatomist and I calculated the score for each of the CRPs generated. The scoring entailed weighting the averages of each critical feature. The reason for having a reference weight was so that students' scores could be compared to those of the expert. This process was then used to give students points for each critical feature that they entered. Again, the total amount of points depends on the number of critical features developed (see above example for when the number of critical features fluctuates). In addition, if a student missed a critical feature, they received a negative mark in accordance with the average weighted score that the expert gave. For example, if a patient is diagnosed with conjunctivitis and the average point score the expert had given for a critical feature (such as discharge) is 2.5 points and the student omits this feature, they will receive a score of -2.5 points. For this study, each CRP pretest and posttest was tallied to determine total possible points.

Once the Institutional Review Board (IRB) approved this study approved, I implemented the intervention and collected the data between October and December year. The data were analyzed after each CRP submission. The upcoming sections discuss the data collection and analysis processes for this study.

Data Collection

First and foremost, permission to conduct this study was obtained from the Western Community College registrar, Biology Department Chair, Director of Registrar, and the IRB. Students enrolled in A&P I were sent an email of consent for collecting CRP assessments and participating in a semistructured interview. Students were provided with a link that contained a brief description of the study, the principal investigator’s contact information, and the option to opt out at any time during this study. Students’ demographic information, along with the number of times they had taken A&P I and their professional majors were obtained directly from the Director of Institutional Research. The information obtained from the Director of Institutional Research at the Western Community College was used to explain student demographics and is provided in the participants section of this study.

The quantitative data were collected first to capture the effectiveness of CBL in facilitating CRS using the CRP pretest and posttest assessments. CRPs for each anatomical system were created prior to the beginning of the semester. Each CRP was scored independently by the collaborator and I to ensure content accuracy. The scores were averaged, and a scoring sheet was kept for each CRP to compare when grading commenced. I collected all participant CRPs between Weeks 9 and 15 of the semester. I administered CRP pretest and posttest assessments using the Canvas platform before and after each of the three systems (CNS, ANS, and SS) for both the control and experimental groups. I administered the pretest and posttest assessments because, as an instructor at the Western Community College, she is the only individual with access to these students due to FERPA.

I kept all CRP data on the Canvas platform, which is a secure place, and was only the primary researcher who had access to it due to FERPA regulations. The information remained confidential. The timeline for collecting the data from beginning to end was approximately 8 to 10 weeks because I began collecting data when she started the CNS, which was first week of November, and concluded with the SS system.

In addition, I conducted semistructured interviews with students from the control and experimental groups after their submission of the CRP assessments. Permission to participate was obtained via Qualtrics from selected students. According to Downe-Wamboldt (1992), planning should be conducted before written, verbal, or observational data are collected. The research process involves planning and deciding who can best answer the question that I was seeking (Downe-Wamboldt, 1992). The planning portion of a study entails asking my selves what the aim of the study is (Bengtsson, 2016). Furthermore, I should select their ideal sample size to answer the research question (Krippendorff, 2018; Patton, 2014).

For this study, the planning portion included selecting students for interviews based on their CNS CRP results. Student selection occurred after grading the CNS pretests and posttests and differences between those assessments had been determined. From there, a total of nine students from the control group and nine students from the experimental group were selected for each category: top three, middle three, and bottom three. The following criteria were used to determine which category a student fell into. Top scores were determined if there was a large positive change such as a pretest score of 32 and posttest score of 40, giving a difference of 8 points. Scores were considered middle if there was a small change in scores; for example, a pretest score of 29 and posttest score of 30 would provide a difference of 1 point. Finally, bottom scores were those with a large negative change between the pretest and posttest scores, as in a pretest score of 30 and posttest of 12, giving a difference of -18 points. The secondary consideration for selection was students who ended up with a particularly high score and those who began with a noticeably low or high score.

The quantitative results were analyzed leading to the collection of the qualitative data. A total of 54 semistructured interviews were conducted, as each student was interviewed three times, once after each unit of study (CNS, ANS, and SS). According to Bengtsson (2016), because these data were analyzed using content analysis, there was no ideal size or number of subjects required; in fact, the number of participants selected for interviews is ideal when it is sufficient to provide the researcher the ability to answer the research questions. For this study, all interviews were held via Zoom and audio recorded. Students' faces were not shown; only voices were recorded to protect students' identities. The questions were prepared and vetted before the interviews and related to each of the three anatomical CRP case studies (Appendix B).

SPSS software V28.0.1 was used to conduct a 2 × 2 mixed ANOVA analysis, and TranscribeME software was used to transcribe the 54 semistructured interviews. All quantitative data were stored in a password protected Canvas module to ensure that FERPA requirements were met. Interview transcripts were stored on a password protected computer that could only be accessed by me The upcoming section provides further elaboration on the data analysis.

Data Analysis

I analyzed by the data to ensure that FERPA requirements were followed. Firstly, a descriptive statistical analysis was done on the number of times students took Biology 223 and their professional majors. The information for this was used to provide an understanding of the targeted population. This information can be found in the participants section of Chapter III. Secondly, to answer RQ1, a two-way mixed ANOVA was conducted using SPSS software to compare mean differences between groups, and to understand the two-way interaction within-subjects factor and between-subjects factor. The two-way interaction between-subjects factor was the treatment condition (no CBL versus CBL) and the within-subjects factor was time (pretest and posttest). The dependent variable was clinical reasoning as determined by the CRP assessment scores?. The CNS CRP assessments were extracted at the beginning of November and scored to determine interview selection in the beginning, before scoring the CRP assessments on the ANS and SS.

After the first CNS assessments were submitted, I scored the CNS pretests and posttests following the criteria generated first by Groves et al. (2012). The reason the first CRP assessments were scored immediately was to preselect students for the interview portion of this study. The interviews would be used to answer Research Question 2 of how students applied A&P concepts when solving case studies. A descriptive statistic was conducted to determine if there was any increase between the control group and experimental group. In addition, I followed the guidelines described in the data collection section to select students. Furthermore, scoring was also conducted after the submission of the ANS and SS pretests and posttests. However, a statistical analysis using a two-way mixed ANOVA was only conducted at the end of the semester.

Thirdly, the semistructured interview data were analyzed using a content analysis approach. All interviews were conducted via Zoom. I served as the only coder. Using content analysis provides knowledge and understanding to a specific study (Downe-Wamboldt, 1992). Content analysis is a qualitative approach widely used by scholars in health studies, thus making it an appropriate approach for this study (Hsieh & Shannon, 2005). Discussed below is how the interview for this study was analyzed.

Following content analysis methods, preplanning was conducted during the data collection. For the analysis portion, the data were first deidentified by assigning pseudonyms to each student. Once deidentification took place, each set of interviews was uploaded to the TranscribeME software for transcription. Afterwards, I reviewed each transcript to ensure accuracy and stored them on a password protected computer. All audio was stored on my personal password protected computer and deleted once transcribing was completed to protect the anonymity of the participants. Next, the data were interpreted using latent analysis. Latent analysis involves finding out the underlying meaning behind the words and what the participants is talking about on a deeper level and discover the meaning of the participants experience (Berg & Lune, 2012; Catanzaro, 1988; Downe-Wamboldt, 1992).

All transcript responses were read multiple times in an effort to gain a thorough understanding and complete picture of the interview. The next step was to determine the meaning behind the participants' responses by highlighting what appeared to describe how CBL aided the students' reasoning skills using A&P concepts when solving case studies. Four themes developed throughout the analysis: *utilizing A&P concepts facilitating CRS*, *resources employed*, and *application to the real world*. Key terminologies relating to the three systems were highlighted. For example, if a student described the physiology of the ANS system by describing terminologies associated with this system such as pre-ganglionic, post-ganglionic, types of hormones, and the overall function of the ANS divisions while they were working through the CRPs . . . then what? In addition, themes that overlapped between interviews were noted to ensure that participants' voices were being heard. For example, for the theme, application to real-world, if the participants from either the control and experimental group mentioned using the information they learned from the CRP assessments in a clinical setting, or if there was an overlap in describing personal experience these were highlighted, and noted that both groups were similar in expressing their ideas. Another example was highlighting terminologies and concepts associated with how students reasoned during the CRP assessments. For example, the interviewer was looking for how students reason through the CRP and if any CRS concepts such as mentioning what was normal versus abnormal and detecting nonanalytical (initial examination) and analytical skills (symptoms, examination, test results) were discussed.

Once the themes emerged, I created a list detailing the themes with examples from the interviews. The themes and interviews were shared with each participant to ensure accuracy. The participants were asked to provide feedback and any corrections within 5 days of receiving the data. Once the interview was analyzed, the participants from each group, control and experimental, were placed into three categories for the first two themes as seen in Tables 12-14. The categories for the first theme, utilizing A&P, were utilizing A&P *very well*, *well*, and *not able* to utilize A&P concepts. The categories for the second theme, facilitating CRS, were facilitating CRS *very well*, *well*, and *not able* to facilitate CRS. The last two themes were resources employed and application to the real world.

The current chapter provides an overview of the methodology utilized to conduct and analyze the data from this study. I provided a description of the quantitative portion of the research, the 2 × 2 mixed ANOVA, and the use of content analysis for the semistructured interview. A description of the procedures, participant recruitment, demographics, data collection, and data analysis procedures have also been provided in this chapter. Chapter IV discusses the quantitative results from this study, and the themes that were developed from the interviews to provide additional understanding on the effectiveness of CBL.

Chapter IV

Results

Chapter I focuses on the rationale for using CBL and its effectiveness in facilitating CRS in undergraduate science instruction. Chapter II describes the literature base for CBL, how it is used, and the comparison of CBL to other pedological approaches. Chapter III provides a description of the methodology utilized in this study, which was an explanatory sequential mixed method design that employed a 2 × 2 mixed ANOVA along with semi-structured interviews that were analyzed to provide additional support to the quantitative data. The current chapter provides an overview of the results of the study, including the quantitative data and themes developed using content analysis of the interviews. A discussion of each theme will be supported with quotes from the participant interviews as a means to provide additional context for the quantitative results.

Quantitative Findings

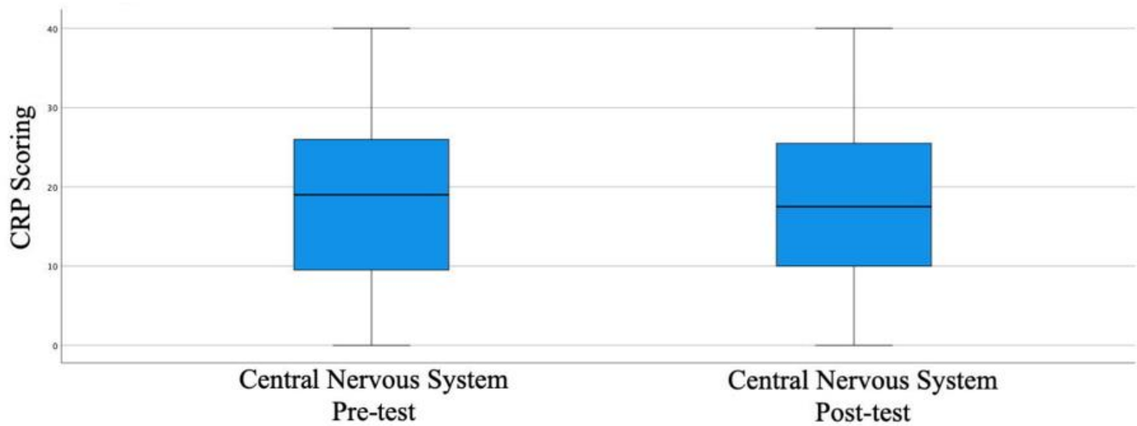
To address the quantitative portion of the study, CRP assessments were administered to 48 students enrolled into A&P I during the fall semester of 2021 semester. The CRP was administered through a pretest and posttest for each of the three anatomical systems, CNS, ANS, and SS, from October of 2021 to December 2021. Tables 3 through 5 offer complete demographic breakdowns of the students who participated in this study. Baseline and assumption assessments ensured the data did not violate any of the ANOVA assumptions, and a 2 × 2 mixed ANOVA was conducted afterwards. After the completion of each CRP (pre and post) assessment, semistructured interviews were conducted and analyzed using content analysis. The following research questions guided this portion of the study: What is the effect of CBL on CRS of undergraduate anatomy and physiology students for the central nervous system, autonomic nervous system, and special senses? How does CBL support student application of A&P concepts to cases that involve clinical reasoning?

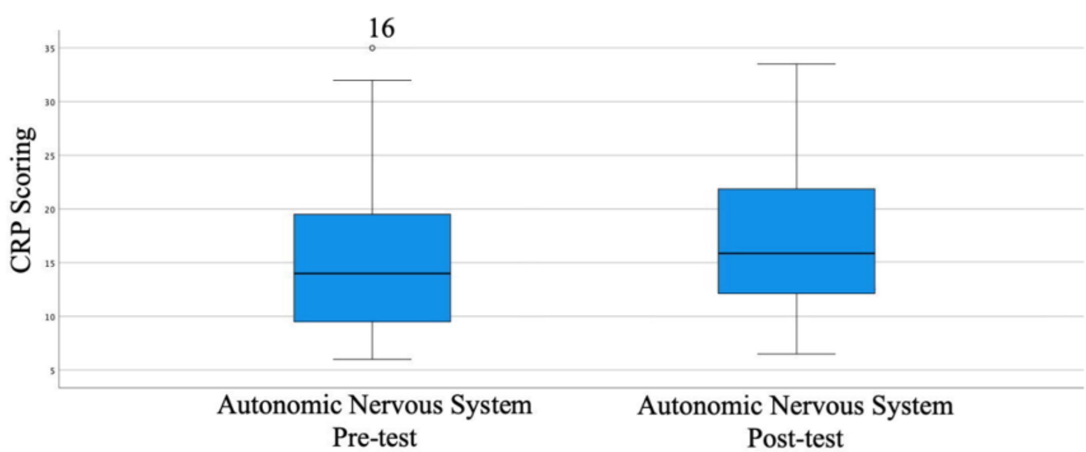
Assessments Conducted

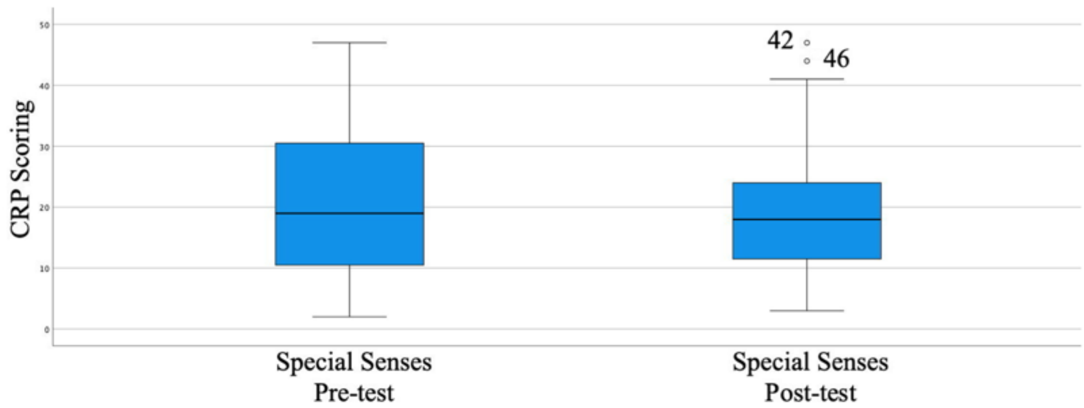
The data was analyzed prior to performing a 2 × 2 mixed ANOVA to ensure that the first condition was met, which is having one dependent variable that is measured at the continuous level. For this study, this condition was met because the dependent variable, CRS, was a continuous measure. The next condition entails having one between-subjects factor that is categorical with two or more categories. This condition was also met because the independent variables have at least two categories, as the two independent variables are pre-test and post-test (i.e., Time 1 and Time 2) and group (experimental versus control). Next, normality was assessed. A box and whisker plot calculation was performed to detect the presence of outliers in the data. A outlier is any observed abnormal distance seen in the values in the population. A single outlier was detected for the ANS pretest, and two outliers were detected in the SS posttest scores. See Figure 1 for the box and whisker plots CNS, ANS and SS. The normal procedure to address the outliers would be to delete them from the dataset (Sheskin, 2010). However, the deletion of outliers in a relatively small dataset would alter the distribution of the data, resulting in new cases being classified as outliers when running updated box and whisker plots. This pattern was seen when the original three outliers were deleted from the dataset, and the pattern only resolved when approximately 40% of the existing data were deleted. For this reason, it was decided to retain the three outlying cases because their retention ran the risk of altering the mean and variance of the variables in question (Sheskin, 2010)

Figure 1

Box and Whisker Plots CNS, ANS, SS







Further evidence in favor of the retention of the outliers can be found in the skew and kurtosis values of each variable. As Green and Mallery (2020) noted, skew and kurtosis values between +2.0 and -2.0 indicate normally distributed data. All skew and kurtosis values for this study are below an absolute value of 1.0 (see Table 8). In addition, ANOVA is robust to violations of normality (Green & Salkind, 2014), and given that all skew and kurtosis values are within tolerance, no data transformation was needed.

Table 8

Skew and Kurtosis Values

Variable	Skew	Kurtosis
CNS pretest	0.25	-0.87
CNS posttest	0.35	-0.49
ANS pretest	0.97	0.37
ANS posttest	0.72	-0.44
SS pretest	0.36	-0.87
SS posttest	0.90	0.69

Note. $N = 48$.

Analysis of Central Nervous System, Autonomic Nervous System, and Special Senses

A 2 × 2 Mixed ANOVA was conducted for the CNS, ANS, and SS. Table 9 presents the means and standard deviations of the pretest and posttest scores on CNS, ANS, and SS for the experimental and control groups. The mean score differences showed an increase for those participants in the experimental group and a decrease in mean scores for those in the control group between CRP pretest and posttest assessments. The means for the participants in the experimental group showed an increase on CNS from pretest ($M = 18.54$) to posttest ($M = 19.58$) while the control group showed a decrease in means ($M = 18.04$; $M = 16.79$). Similar difference was seen for the last two systems, ANS and SS. For ANS, the experimental group showed a mean of 15.04 for the pretest and 18.67 for the posttest while the control group showed a decrease in means: $M = 16.04$ for the pretest and $M = 14.88$ for the posttest. Finally, for the SS anatomical system, those in the experimental group showed an increase between pretest and posttest with a mean of 20.92 to a mean of 22.21. However, the means for the participants in the control group showed a decrease between pretest and posttest with a mean of 21.79 to a mean of 15.54.

Table 9

Means and Standard Deviations on Clinical Reasoning Problem Assessments (N = 48)

Group	Pretest		Posttest	
	M	*SD*	*M*	*SD*
CNS				
Experimental	18.54	10.47	19.58	11.05
Control	18.04	8.15	16.79	9.69
ANS				
Experimental	15.04	7.34	18.67	10.68
Control	16.04	7.43	14.88	9.19
SS				
Experimental	20.92	12.72	22.21	10.35
Control	21.79	13.03	15.54	9.25

ANOVA Results on Central Nervous System

Levene's test of equality of variances based on the mean was statistically nonsignificant at Time 1 ($F = 3.056$, $df = 1, 46$, $p = .087$) and Time 2 ($F = 1.428$, $df = 1, 46$, $p = .238$), suggesting that the data were homoscedastic, which indicated that the groups under examination have equal variance patterns in terms of standard deviation being the same or roughly the same. Mauchly's test of sphericity was not computed as there were only two groups under investigation.

The main effect of time was statistically nonsignificant as indicated by Wilk's lambda (Λ = 1.00) and the *F*-test (*F* = 0.005, *df* = 1, 46, *p* = .941, η^2 = .0001). The η^2 of .0001 indicated a less than small effect size based on Cohen(1998, p.284-288). The main effect of group was statistically nonsignificant *F*-test (*F* = .437, *df* = 1, 46, *p* = .512, η^2 = .009). The η^2 of .009 indicated a less than small effect size based on Cohen(1998, p.284-488).The interaction effect of time x group was also statistically nonsignificant as indicated by Wilk's lambda (Λ = .986) and the *F*-test (*F* = 0.663, *df* = 1, 46, *p* = .420, η^2 =.014). Yet the η^2 of .014 indicated a small-to-medium effect based on Cohen (1998).

ANOVA Results on Autonomic Nervous System

Levene's test of equality of variances based on the mean was statistically nonsignificant at Time 1 (*F* = 0.019, *df* = 1, 46, *p* = .892) and Time 2 (*F* = 1.430, *df* = 1, 46, *p* = .238), suggesting that the data were homoscedastic. Mauchly's test of sphericity was not computed as there were only two groups under investigation.

The main effect of time was statistically nonsignificant as indicated by Wilk's lambda (Λ = .981) and the *F*-test (*F* = 0.875, *df* = 1, 46, *p* = .354, η^2 =.019). The main effect of group was statistically nonsignificant *F*-test (*F* = .416, *df* = 1, 46, *p* = .522, η^2 =.009). The η^2 of .009 indicated a less than small effect size based on Cohen(1998, p.284-488).The interaction effect of time and experimental versus control group was also statistically nonsignificant as indicated by Wilk's lambda (Λ = .933) and the *F*-test (*F* = 3.324, *df* = 1, 46, η^2 =.067). Yet the η^2 of .067 indicated a small-to-medium effect based on Cohen (1998).

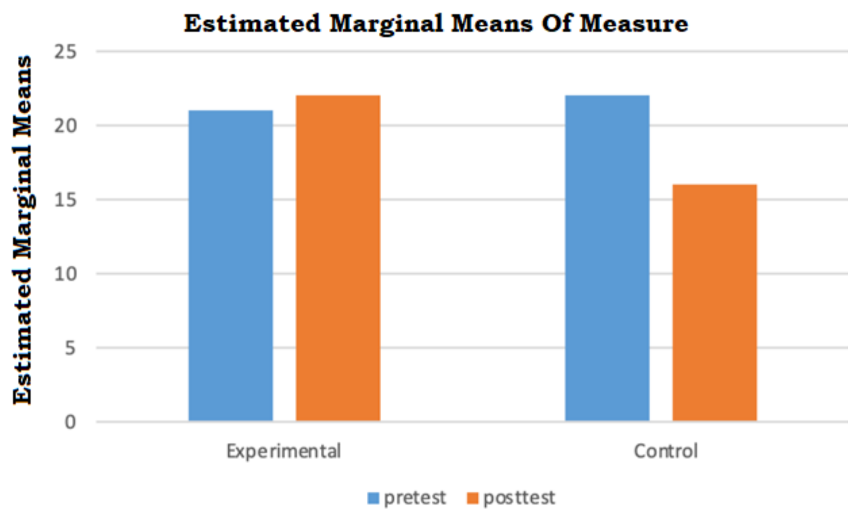
ANOVA Results on Special Senses Anatomical System

Levene's test of equality of variances based on the mean was statistically nonsignificant at Time 1 (F = 0.423, df = 1, 46, p = .519) and Time 2 (F = 0.262, df = 1, 46, p = .611), suggesting that the data were homoscedastic. Mauchly's test of sphericity was not computed as there were only two groups under investigation, which is why the value of Mauchly's W is 1.0 for this investigation.

The main effect of time was statistically nonsignificant as indicated by Wilk's lambda (Λ = .956) and the F-test (F = 2.139, df = 1, 46, p = .150, η^2 =.044). The main effect of group F-test (F = 1.042, df = 1, 46, p = .313, η^2 =.022).The interaction effect of time and experimental versus control group was statistically significant as indicated by Wilk's lambda (Λ = .903) and the F-test (F = 4.948, df = 1, 46, p = .03, η^2 =.097). In addition, the η^2 of .097 indicated a small-to-medium effect based on Cohen (1998). Figure 2 presents visualization of the interaction effect. Given these findings, conducting post-hoc t-tests was required (Green & Salkind, 2014).

Figure 2

Interaction of Time by Group on Special Senses System



A paired samples *t*-test was computed to see if significant changes existed in SS scores between the pretest and the posttest (i.e., Time 1 and Time 2) within the experimental group and the control group. As Ritchey (2008) noted, a paired samples *t*-test is the appropriate statistic to compute when a single continuous variable is measured at two time points for the same subjects. This criterion was met for the current analysis scenario.

Results of the paired samples *t*-test suggest that there was a difference in SS scores between Time 1 (M = 21.78, SD = 13.03) and Time 2 (M = 15.54, SD = 9.25; t = 2.624 df = 23, p = .015, η^2 =.536.) for the control group. There was no difference in SS scores between Time 1 (M = 20.92, SD = 12.72) and Time 2 (M = 22.21, SD = 10.35; t = -0.535 df = 23, p = .598, η^2 =.107) for the experimental group.

Descriptive statistics showed a mean score from increase between pretest to posttest for those in the experimental group and a decrease in mean scores for participants from pretest to posttest in the control group. only the interaction effect of time x group was seen for the SS system, and the paired-sample t-test revealed no statistical difference between pre-test and post-test (i.e., Time 1 and Time 2) for experimental group, and a statistical difference was seen between pre-test and post-test (i.e., Time 1 and Time 2) for experimental group. This result indicates the participants in the experimental group who were exposed to CBL did not significantly do better than those in the control group.

Qualitative Findings

This section will review the qualitative findings from the interviews conducted after participants' completion of CRP assessments to understand how CBL supported students' applications of A&P concepts to cases involving clinical reasoning. The quantitative data resources from Research Question 1 were used to answer the second research question for this study. The results from the CNS CRP assessments were used to select the interviewee. A total of 18 students, nine from the experimental group and nine from the control group, were selected to participate in the interview. For each of the groups, the CRP pre-posttest for the CNS system was scored and inputted into an Excel spreadsheet. Next, score trends were examined to look for students who had an increase from pretest to posttest, stayed the same, or a slight decrease. The last trend was the decrease of scores from pretest to posttest. Students were then placed into three categories: top three, middle three, and bottom three. If a student chose not to participate in the interview, I used the next corresponding student in the list and their designated student name. See Table 10 for the final selected interviewees in each group.

Three interviews per student for each of the three anatomical systems occurred during the semester between November and December. A total of 54 interviews were conducted. A total of four themes materialized from the qualitative data analysis: *utilizing A&P concepts, facilitating CRS, resources employed*, and *application to the real world*. See Table 11 for an overview of themes and supporting quotes.

Table 10

Names of Interviewees

Placement Range	Control Group	Experimental Group
High	Akimi	Claire
	Bianca	Valeria
	Jessica	Emma
Medium	Kate	Daniela
	Matthew	Olivia
	Ashley	Victoria

Low	Kim Camilla Isabella	Mia Bryan Lindsey

Utilizing Anatomy and Physiology Concepts

It was important to support student learning when enrolled in A&P by applying their knowledge of the human body to support understanding. All participants discussed utilizing A&P concepts during each of the three systems (CNS, ANS, and SS). However, there was an overall difference between how students described which concepts they utilized from the control and experimental groups. The experimental group discussed specific terminologies and cross-connecting concepts, whereas the control group discussed generalized concepts and their struggles to interpret A&P concepts. The following section outlines concepts from the CNS, ANS, and SS portion of the interview

Table 11

Utilization and Understanding of Central Nervous System Concepts

Level	Concepts	Participants	Description of application	Example quote
Apply concepts very well	Spinal cord (plexuses) Reflexes proprioception	Control Bianca Akimi Experimental Lindsey Olivia Claire Emma Bryan Victoria Mia	Participants described the role of the plexus (cervical & lumbar), understanding the correlation to the case.	"Reflexes and more specifically patellar reflex arc are absent, plexuses supplying from lumbar and sacral regions and down the lower body were affected, like nerve into the groin, around the hips and legs, for example the sciatica nerve, but nothing from the upper body, and decrease sensation occurring." (Lindsey)
Apply concepts well		Control Kim Experimental Daniela	Participants mentioned a few generalized concepts but couldn't pinpoint specific concepts or elaborate further on the topic.	"Just knowing that like obviously like different things affect your upper and lower limbs, I don`t know the word, just like loss of sensation to the lower limbs versus the upper limbs were fine and how that could maybe be spinal cord injury." (Kim)
Not able to apply concepts		Control Kate Camilla Ashley Isabella Jessica Matthew Experimental Valeria	Participants struggled to discuss or explain how they utilized their concepts, instead they generalized the terms such as "back."	"Knowing the back were the concepts I utilized here, so just what happening in the back in general." (Camilla)

Central Nervous System

For CNS, the A&P concepts students were expected to understand included the role of the spinal cord and its associated structures: plexuses, reflexes, and proprioception. As seen in Table 11 for the CNS, content analysis showed that the CBL approach enabled students to apply their knowledge and understanding of A&P concepts when working through the case studies. Analyzing the control and experimental groups, 7 of the 9 participants in the experimental group and 2 out of the 9 participants in the control group performed well when conversing about the concepts for that chapter. The participants used specific terminologies such as "nerve plexus" associated with the cervical and lumbar and "proprioception of limbs" and how these concepts played a role in understanding patient symptoms. For example, Lindsey stated,

> Reflexes and more specifically patellar reflex arc are absent, plexuses supplying from lumbar and sacral regions and down the lower body were affected, like nerve into the groin, around the hips and legs, the sciatica nerve, but nothing from the upper body, and decrease sensation occurring.

For each group, 1 of the 9 participants were classified as intermediate, meaning that student applied some concepts *well*; however, the same student displayed minimal use of specific terminologies. These participants made diagnostic assumptions by understanding that everything was normal except for the lumbar region. For example, Kim said,

> Just knowing that like obviously like different things affect your upper and lower limbs, I do not know the word, just like the loss of sensation to the lower limbs versus the upper limbs were fine and how that could maybe be spinal cord injury.

While Daniela indicated that she used minimal A&P concepts and went straight to symptoms and correlating that to the information she learned. She said, "There were a bit A&P concepts I utilized, like the spinal cord, but yeah I just picked up on how to analyze the case from the CBL videos and that was it."

Finally, 5 of the 9 participants from the control and 1of the 9 participants in the experimental group were classified at the lowest level of *not able to apply A&P concepts*.

Participants in this category used generalized terminology, much of which was not related to CNS concepts at all. For example, Camilla used the term “back” rather than pinpointing the nerves that play a role within the spinal cord. She stated, “Knowing the back were the concepts I utilized here, so just what was happening in the back in general.” One participant from the experimental group indicated not utilizing A&P concepts and going straight to test results within the case by stating, “The CT scan was important and correlated her symptom of feeling dizzy. So yeah, the dizziness and then rolling over in the bed and stuff like that causing spinning of the room.”

Overall, data from the CNS interviews indicated that CBL was effective in facilitating clinical reasoning as 7 of the 9 participants in the experimental group and 2 of the 9 participants from the control group analyzed the case by applying A&P concepts *very well* and using the expected terminologies associated with this system. In contrast, 6 of the 9 participants in the control group were unable to apply the ideal A&P concepts expected for this system while only 1 of the 9 participants from the experimental group fell into this category. Furthermore, the groups were the same in applying concepts as they were ranked as intermediate because 1 or 2 concepts were briefly mentioned when conversing with these participants.

Autonomic Nervous System

For ANS, students were expected to utilize and understand the A&P concepts of the fight or flight response in the body, the role of hormones and neurotransmitters, and fibers/tracts (preganglionic and postganglionic). As seen in Table 12, data analysis showed that the CBL approach enabled students to apply their knowledge and understanding of A&P concepts when working through the case studies. Analyzing both

Table 12

Utilization and Understanding of Autonomic Nervous System Concepts

Level	Concepts	Participants	Description of application	Example quote
Apply concepts very well	Fight/flight rest/digest roles role of hormones & neurotransmitters, within/inside the effectors & fibers/tracts (preganglionic & postganglionic)	Control Bianca Experimental Daniella Mia Olivia Claire Emma Victoria	Participants described the role of the sympathetic division & what the pre/post ganglionic releases (hormones, NT) & the main effector that played a role here.	"For me, what was important is understanding which division was important here because of the catecholamines, two main ones, norepinephrine and epinephrine, and the adrenal medulla, and that these can act as hormones released into the blood stream especially when thinking about sympathetic like what the prereleases and post releasing norepinephrine, so these were a lot in her urine." (Claire)
Apply concepts well		Control Isabella Experimental Valeria Bryan	Participants mentioned a brief understanding of the adrenal medulla, along with the hormones that play a role.	"Looking here, I was focused on the adrenal medulla since that was something from the sympathetic and the hormones like the elevated catecholamines which are norepinephrine and epinephrine." (Isabella)
Not able to apply concepts		Control Kim Camilla Akimi, Jessica Matthew Ashley Kate Experimental Lindsey	Participants did not discuss the ideal concepts for this system as there was no specific mention of hormones or understanding the division.	"Like having the tumor in the adrenal medulla and like how that is going to affect how things are secreted in your urine and its kinds of affects your part of the body." (Ashley)

groups, 6 of the 9 experimental participants and 1 of the 9 control participants were able to describe the ANS concepts that they utilized while working through the case. They were able to explain their understanding of the two divisions of the ANS system (sympathetic and parasympathetic), which hormones or neurotransmitter, such as epinephrine and norepinephrine, and associated these with preganglionic and postganglionic fibers. Furthermore, they correctly associated epinephrine and norepinephrine with the adrenal medulla. For example, Claire stated,

> For me, what was important is understanding which division was important here because of the catecholamines, two main ones, norepinephrine and epinephrine, and the adrenal medulla, and that these can act as hormones released into the blood stream especially when thinking about sympathetic like what the prereleases and post releasing norepinephrine, so these were a lot in her urine.

Two of the 9 participants from the experimental group and 1 participant from the control group were able to utilize and apply some concepts *well*; however, their explanations were brief and missed some of the ideal concepts such as understanding the two ANS divisions and associated structures. For example, Isabelle stated, “Looking here, I was focused on the adrenal medulla since that was something from the sympathetic and the hormones like the elevated catecholamines which are norepinephrine and epinephrine.” Valeria and Bryan were able to express some understanding, but with difficulties. For example, Valeria stated, “The catecholamines were important here for understanding the two division because of ACH and norepinephrine/epinephrine as these can act as hormones and neurotransmitters.” However, nothing more was offered in terms of discussing which division played an important role with these neurotransmitters/hormones. Similarly, Bryan stated, “The catecholamines and how that correlates to with the adrenal medulla which is part of the ANS, and that hormones norepinephrine and epinephrine increase in the urine.”

Finally, analyzing the participants who fell into the category of *unable to apply concepts*, 7 of the 9 participants from the control group and 1 of the 9 participants in the experimental group could not apply A&P concepts. Students in this category could not discuss the ideal concepts for this system, instead terms were generalized rather than being correlated back to the ANS division, showing inaccuracy of concepts. For example, Ashley stated, “Like having the tumor in the adrenal medulla and like how that is going to affect how things are secreted in your urine and its kinds of affects your part of the body.” Another example was from Kim, who stated, “The adrenal medulla, and ACH. And the parasympathetic had to do with rest and digest, and that informs the ANS, and that is when your body needs to be consuming stuff and not getting correct information.”

Overall, analysis from the ANS interviews indicated that CBL was effective in facilitating clinical reasoning because 6 of the 9 participants in the experimental group and 1 of the 9 in the control group utilized and understood ANS concepts *very well* when applying them to the case studies. In contrast, 7 of the 9 participants from the control group were unable to apply and utilize the ideal ANS concepts for this system while only 1 of the 9 participants from the experimental group fell into this category. Furthermore, 2 of the 9 from the experimental group were categorized as applying ANS concepts *well* while only 1 of the 9 participants from the control group fell into this category.

Special Senses System

For SS, students were expected to master the A&P concepts related to the eyes and ears, both anatomically and physiologically. They were responsible for understanding and utilizing knowledge of the structures and functions of all parts of the eyes and ears, including middle and inner components such as muscles of the eye, vestibule, semicircular canals, and auditory ossicles. As seen in Table 13, data analysis showed that the CBL approach enabled students to apply their knowledge and understanding of SS concepts when working through the case studies. Looking at both groups, 7 of the 9 participants in the experimental group were able to apply their understanding of SS concepts *very well*. Individuals in this group discussed main components of the middle to inner ear, which plays a role in hearing and balance, along with other vital anatomical functions like the fluid found within the inner ear and the role of the extraocular muscles in eye movement. They were also successful in correlating this knowledge to some of the patient symptoms. For example, Claire stated,

> Like when we're talking about the different nerves, and how the muscles of the eye plays a role in eye movement. Like rectus and oblique, looking up, and down. Also, the dizziness, talking about the ear, more specifically, the different semicircular canals, how each one has a role when you move your head. The fluid in the ear such as perilymph and endolymph. The inner ear plays a big role, because that is where balance and hearing plays a role.

On the other hand, when assessing the control group, there were no participants who could apply the concepts *very well*.

One of the 9 participants from each group fell into the intermediate category, understanding the A&P concepts of the SS *well*. These participants were able to describe some of the terminologies but lacked thorough explanations of the function and structures of the eye and ear and their roles. For example, Bianca said, "Like jerky eye movement, that the part the kind of made me go back to the special senses, also, the inner ear like the vestibule and the function of these so like balance." Struggling similarly Lindsey stated, "Ummm so like vestibule and like umm, inner ear, like the semicircular canals, for example, lateral semicircular canals." Lindsey was able to grasp some concepts but still offered little information on the structures or explanation of the functions.

Table 13

Utilization and Understanding of Special Senses Concepts

Level	Concepts	Participants	Description of application	Example quote
Apply concepts very well	Eyes & ears anatomically & physiologically, including anatomical parts, & function of these parts (e.g., semicircular canals, auditory ossicles, & balance)	Experimental Claire Valeria Olivia Bryan Emma Daniela Victoria	Participants described the role by explaining the specific anatomy & functions of the ear & eye.	"Like when we`re talking about the different nerves, and how the muscles of the eye plays a role in eye movement. Like rectus and oblique, looking up, and down. Also, the dizziness, talking about the ear, more specifically, the different semicircular canals, how each one has a role when you move your head. The fluid in the ear such as perilymph and endolymph. The inner ear plays a big role, because that is where balance and hearing plays a role." (Claire)
Apply concepts well		Control Bianca Experimental Lindsey	Participants mentioned a brief understanding of eye and ear, but without mentioning specific anatomical parts of the ear that plays a role here.	"Like jerky eye movement, that the part the kind of made me go back to the special senses, also, the inner ear like the vestibule and the function of these so like balance." (Bianca)
Not able to apply concepts		Control Matthew Kate Kim Akimi Jessica Ashley Isabella Camilla Experimental Mia	Participants did not discuss the ideal concepts for this system as there was no specific mention of specific parts and function excepts for one or two terms within these structures.	"I remember the labyrinth, and was able to remember stuff from the notes and thinking about that." (Matthew)

Finally, analyzing the last category for those participants who were not able to apply SS concepts, 8 of the 9 participants from the control group were unable to apply concepts while only 1 of the 9 from the experimental group were unable to apply SS concepts from this system when working through the case studies. The participants struggled to elaborate on anatomical or physiological concepts during the discussion; in fact, terms were generalized. For example, Matthew stated, "I remember the labyrinth, and was able to remember stuff from the notes and thinking about that." Mia only mentioned the broader concepts by providing the name of the system when she noted, "So like the sensory system and like the eyes, and hearing, that kind of stuff." There was a lack of SS application during the case studies.

Overall, analysis of the SS interviews indicated that 7 of the 9 participants in the experimental group were able to apply the SS concepts *well* and being able to articulate their understanding during the interview. However, 8 of the 9 participants in the control group were unable to apply SS concepts to the case studies and when articulating their understanding, were vague in describing the system. Also, notably, these students used phrases such as "stuff like that" instead of appropriate terminology. Furthermore, both groups were the same in the number of participants who fell into the middle category for this system, because based on the quotes, they were able to pick up on a few concepts *well*.

Summary of Utilizing Anatomy and Physiology Concepts

The theme of utilizing A&P concepts was present in both groups, but a difference was seen between participants in the experimental and control groups (Table 14). When analyzing the interview data for the CNS system, in the experimental group, 7 of the 9 participants were able to apply concepts *very well* while 1 was able to apply concepts *well*, and 1 was *not able to apply* concepts for this system. Participants in the control group struggled to apply and understand A&P concepts within each anatomical system as there were 2 of the 9 participants who applied concepts *very well*, 1 who applied concepts *well*, and 6 were *not able to apply* CNS concepts. When gathering the final numbers for the ANS system, 6 of the 9 participants were able to apply concepts *very well* while 2 applied concepts *well*, and only 1 was *not able to apply* concepts for those in the experimental group. However, when considering the control group, 7 of the 9 were *not able to apply* concepts, and only 2 participants either applied concept *very well* or *well*.

Finally, for the last system, SS, the data showed that 7 of the 9 participants were able to apply SS concepts *very well* when compared to the control group, which consisted of 8 students *not able to apply* concepts. Furthermore, 2 participants from the experimental group either applied concepts *well* or were *not able to apply*, and there were no participants from the control group who could apply concepts *very well*.

Table 14

Summary of Utilizing Anatomy and Physiology Concepts

	CNS		ANS		SS	
Treatment group	Control	Exper.	Control	Exper.	Control	Exper.
Apply concepts very well	2	7	1	6	0	7
Apply concepts well	1	1	1	2	1	1
Not able to apply concepts	6	1	7	1	8	1

Facilitating Clinical Reasoning Skills

The theme of facilitating CRS examined how the participants analyzed the case studies. When participants looked through each case, they were expected to break down the information given about the patient. In addition, participants were expected to sort through the information using hypo-deductive reasoning, which entailed sorting through the case to distinguish nonanalytical (e.g., initial check-up, vitals) from analytical data (e.g., symptoms, test results, if any) features.

As seen in Table 15, analysis of the experimental group showed 5 of the 9 participants were able to apply CRS *very well* when analyzing a patient while 3 of the 9 were able to apply CRS *well*. Those who used CRS *very well* were able to do so, because it entailed working line-by-line and separating what was considered normal and abnormal. By doing this, the participants were then able to focus on what was abnormal and formulate an understanding of what to look for in a patient. For example, Bryan discussed step-by-step how he was able to work through the case. He started by saying,

> The patient was pretty healthy overall. His BP beating 128/76 , temp was 98.6 when it comes to his temperature, it was normal. Then I looked at the next piece of information since I knew those were normal. When it comes to his ability to flex his muscle he is able to extend and flex his upper body. When it reaches his bottom part it’s not as flexible. And that lets me realize that it must be something wrong with his spinal cord or part of his spine just because he is able to do everything on top and when it goes down lower it gets more physical.

The participants who were able to apply CRS *well* discussed how they studied the cases, recognized what was important, and extracted this information for the purpose of diagnosing the patient. The slight difference for this group that put them in this category was not discussing vitals or other information provided by the patient. For example, Victoria went straight to mentioning that she looked for the abnormal:

> I saw he’s normal, like strengthening, flexing and extending elbows and the wrist. But then I was looking at the area involving the patella and ankle were absent. And that tied that it could be more of his lower back.

Table 15

Analysis of Facilitating Clinical Reasoning Skills

Level	Concepts	Participants	Description of application	Example quote
Apply concepts very well	Identifying nonanalytical (check-up, vitals) & analytical data (symptoms, test results abnormal vs normal) Reusing & revising diagnosis	Control Akimi, Ashley Experimental Claire Olivia Valeria Bryan Daniela	Participants described step-by-step how they analyzed the case by separating out line-by-line the nonanalytical & analytical signs & deduced diagnosis based on what was out of the ordinary.	"He was pretty healthy. his bp beating 128/76, temp was 98.6 when it comes to his temperature was normal. When it comes to his ability to flex his muscle he is able to extend and flex his upper body. Then I looked at the next piece of information since I knew those were normal When it reaches his bottom part it's not as flexible. And that lets me realize that it must be something wrong with his spinal cord or part of his spine just because he is able to do everything on top and when it goes down lower it gets more physical. (Bryan)
Apply concepts well		Experimental Victoria Mia Emma	Participants were able to describe analytical information and recognize abnormal symptoms, however, there was lack of explaining the nonanalytical symptoms (Basic initial check-up results BP, temperature). Some information was ignored when assessing the patient.	"I saw he's normal, like strengthening, flexing, and extending elbows and the wrist. But then I was looking at the area involving the patella and ankle were absent. And that tied that it could be more of his lower back." (Victoria)
Not able to apply concepts		Control Kate Kim Camilla Jessica Matthew Isabella Bianca Experimental Lindsey	Participants did not discuss the ideal concepts for this system as there was no specific mention of specific parts and function excepts for one or two terms within these structures.	"Yeah, I read it first, how old the guy or person is. Then I asked myself Is it a guy or female and then if he has a fever. Linking those symptoms to the body like the back, hips and reflexes. That is pretty much how I do it." (Camilla)

When analyzing the participants from the control group, 2of the 9 were able to apply CRS, while 7 were *unable to apply* CRS to the case studies. Students who applied CRS *very well* discussed step-by-step how the case studies were looked at. This was done by going line-by-line and extracting nonanalytical and analytical information so that they did not miss any key information. For example, Akimi, stated,

> I just went to the case and line-by-line so I made sure not to miss anything. I highlighted the important stuff. Jason being 32 years old is a decent age where he is active but there seems to be a little issue with his back and his muscle. So, sport accidents seem to be a little bit more common towards this age. His BP is normal, and his temperature is normal as well, no neurological issues. The strength and flexing and extending his elbow and his middle finger were normal, I took this as his upper body was not the problem. To me then it made me think his mid to lower had something going on as he didn't exhibit no movement when the physician tests his ability to flex his hips and extending his knees then I used Googled.

Participants who were *not able to apply* CRS did not focus on analyzing the case by considering the information provided by the patient. Instead, they focused on gender and, at times, went straight to the test results rather than working through the case. For example, Camilla stated,

> Yeah, I read it first, how old the guy or person is. Then I asked myself Is it a guy or female and then if he has a fever. Linking those symptoms to the body like the back, hips, and reflexes. That is pretty much how I do it.

Another example of skipping patient information was provided by Kim who said, "I researched a lot about test results, catecholamines increase, the symptoms vomiting, and nauseas can be something like a common cold, so I was not concerned about these."

Resources Employed

The resources employed differed between the two groups. Experimental participants received the following: lecture videos, videos depicting a case study and how to formulate a diagnosis, lecture PowerPoints, and multiple practices with feedback. The control group received lecture videos and lecture PowerPoints only.

Some experimental group participants indicated a great deal of the terminologies for the pretest assessment were new to them, and they needed to utilize search engines to explore diagnosis possibilities. Many struggled and indicated going down a rabbit hole. For example, Ashley indicated struggling:

> I definitely Googled a bunched of the symptoms and I was talking with other classmates about this and going down a rabbit hole a little bit. I definitely will go down a rabbit hole and I`m like this is not what I am asking, and then I have to just keep adjusting, and adjusting until I get the right one.

Camilla also indicated something similar when stating, “So I just kind of went through everything and plugged it into Googled. Something like different types of parasites came up and I also utilized the cheat sheet below.”

For the experimental group, students indicated watching the lecture videos first, followed by the CRP videos, and then doing the practices. Emma stated the following:

> I thought the videos and practices were beneficial. I like how you would explain things and then I was like okay underline everything that seems to play a role in the cases, so that is what I did, as I underlined, and also work through each sentence and recognize what was important and underline it, That’s what I did. I used the same when I did the practice. I got the hang of it”

Daniela indicated the videos helped them assess the case studies piece-by-piece:

> Oh yeah absolutely, it just helps looking at the process of it and being able to understand piece by piece by understanding and breaking it into parts. Like looking at the physical, what was abnormal and not normal. Little things like that were you were able to, like the way you explained it.

A few participants from the experimental group also indicated they watched the first example of CRP videos but wanted to try doing the assessments on their own. For example, Lindsey stated,

> To be quite honest, I only watched the first one and I wrote down everything you did and wanted to try it out on my own moving forward, plus the practices we did helped me because I got used to it. After the video, I was like ohhhh.

Claire followed similar techniques as Lindsey. She wanted to learn to assess the case moving forward on her own. She said,

> So, I watched the video to get an idea of what to look for, but since then, I have not watched the video to be honest, I wanted to challenge myself, I used the video to understand the pattern and how to do it.

When analyzing the theme of resources used between the two groups, the participants in the control group were not able to extract information for diagnosing. Instead, it was through the processes of elimination, resulting in struggles even for those who did well on the assessments. Another issue that arose was the participants found it difficult to diagnose the patient. At this point, limited to no CRS was facilitated from participants in the control group as they were not able to isolate symptoms to support a diagnosis. For the experimental group, the videos and practices were beneficial because they aided the participants' understanding of how to analyze the case, knowing which information to extract from a patient, drawing from A&P concepts to understand the information, and formulating a diagnosis closely relating to the anatomical system. With practice, the participants in the experimental group were able to identify key features from the case, making it easier and instinctual for them as they moved from case-to-case.

Application to the Real World

The theme of application to the real world was present across all participants, regardless of group. According to the participants, the case studies were valuable because they allowed the students to take a peek into the real world and what a student may encounter when interacting with patients, regardless of their pursuit of a career in the health field. Claire stated the following:

> A lot of people that are going through the CNS chapter would find this beneficial. I am someone who never been in a health care setting at all or familiar with like body parts and function, like the brain, you know, those kinds of things. So for me, I think it`s beneficial, even if it just a refresher for some. I mean like, Okay, I`ve heard that before, like looking back on it again, just to remember, like , I mean, for example, when moving a patient, and they just had hip surgery, how those nerves are affected the individual gives us insight on how to care and understand these patients. It is a good habit to have, rather than just saying I need to get through this course, it`s a good thing, especially, if you're going to use it. You don't want the information you learned to go to waste.

Emma stressed the importance of how she was able to interact with clinicians:

> I think it helped. Sometimes I would call my aunt who is a clinician, I bounce ideas and discuss with her these case studies, just to gain a sense of how she thought. She be like, oh my gosh, it's so good that you guys are doing this, so it`s been so helpful for me because it`s real-world experience that help you put what you are learning into like real-world practices.

A few participants discussed how the case studies applied in a hospital setting. For example, Bryan stated,

> Understanding the different diagnosis is what doctors have to go through for the most part, especially, like the ER. They are kind of looking at everything randomly, you never know what we're going to get. It did help encourage me to want to learn it, especially, considering I want to do rest of my life. It does help encourage me to understanding how it is and how things are developed and how we are able to understand it. And pretty much understand every single part of interacting with a patient and understanding how the patient may have sustained an injury by understanding the parts of the body and correlating it to assessing patients. A lot of students say what is the point of learning anatomy, these case studies are great examples of why we are learning this stuff.

Kate emphasized learning to assess patients and how they will encounter something similar in a real-world setting:

> Yes, because in the real world you are going to have somebody come into the ER like complaining of a back pain or anything, like I cannot move my ankle, or move an arm, stuff like that. And then you are like, okay, I have to figure out what is going on because sometimes patient can't tell us much either. This is a

> good way to just have some foundation to help us when we do interact with patient in the real-world. You have that information, and it teaches you for the future. Like oh my gosh, I learned this. This could be exactly what that it.

Victoria indicated how the case studies provided valuable information in terms of learning key words such as types of x-rays and blood work, which can be valuable when assessing a patient and knowing what to do. She shared,

> Just like last time, if a patient would come in with similar symptoms, I probably will know what to ask and run, like CBC, and other blood panel. I think it does help for real-world clinician situation if someone came into the hospital, this is what they would do, and I would know where and how to start as.

Akimi detailed how the information from the case studies is utilized in her profession as a dialysis technician. Terminologies and assessing patients were helpful to see in the classroom and applying it. She said,

> One of my patients explained to me he was cramping at home and hungry. I'm like okay I can be a clinician and asses this patient in the clinic and maybe guide this individual. I started using some of the information from the case studies in assessment. I am like, okay let's take your weight if you have been consuming more food than normal. Let's talk to the nurse, let's talk to the doctor, and I'll explain to the patient what is going, so we can figure it out. I think it's so beneficial learning how to assess a patient what all the diagnosing tools do, especially when taking physiology courses and going into the medical field. This is going to help me in my future. Assessing the case, made me assess my patient in the dialysis patient and I was trying to figure out things as I would with the case studies.

Aside from real-world clinical settings, participants also discussed how the case studies applied to those individuals not seeking to become health professionals, but understanding real world health issues and advocating for their own health by knowing what is happening to them. For example, Kim stated, "I feel like when you go to the doctor, like, they take your blood pressure, your temperature and all that. So, I feel like it kind of helps you understand what is normal and what is irregular."

Bianca mentioned how the case studies teach people how to detect when something is abnormal in their own body and learning would help them understand when interacting with a doctor as a patient. She said,

> These cases are very realistic, it helps connect some more abstract things. I feel like we are learning real-life purposes, especially, nowadays. I feel like every single one of us google all our symptoms, if something is wrong, before we even go to the doctors. I feel it's good to learn these things in the classroom because then when you`re googling your symptoms, you're not like, "Oh, it`s cancer," or like, "Oh, I am going to have my left leg amputated." You're more like, "Okay, I recognize these symptoms. We encountered it. I might just have some back issue like a pinched nerve." Something you came across in the class and now actually experiencing it, something more realistic. And now when we go to the doctor's office, you aren't panicking.

Finally, Ashley expressed how the case studies are beneficial for beginners and directing non-clinician as well as future clinicians on where to begin. She stated,

> I think the case studies was a great way to look at concepts together, especially, those working towards allied health programs. I think these allow you to kind of see what is normal and what is not normal, and kind of what to look out for when you are interacting with patients. I actually was thinking, like, I know what a normal blood pressure and normal pulse is, but if someone didn't, this would help get them started, like know where to begin and what should be done first. Also, for an individual who doesn't pursue a career in the health field, at least they understand their body, like if they take their blood pressure for example, they will know if something is wrong.

Application to the real world was present among all participants. Applying theory to practice was beneficial as it gave the participants an opportunity to visualize scientific concepts in the workforce and taught them about their own health. The stories aided the participants' understanding of the human body, not just anatomically, but physiologically as well. The case studies provided an opportunity for all individuals—regardless of career path—to learn how to assess, recognize abnormal from normal, and advocate for their patients or themselves.

The four emergent themes gathered from the qualitative data suggest the students in both groups responded to how CBL supported their application of A&P concepts to the CRP that involved clinical reasoning in different ways. For others in the experimental group, they were able to articulate how they utilize A&P to reason through the CRP assessments by conversing specific A&P terminologies associated with each system. Furthermore, the students were able to reason through the CRP assessments using CRS, recognizing nonanalytical vs. analytical, and being able to retrieve and reuse the information they learned from one assessment to the next, but not necessarily for all students in this group. Looking at the students in the control group, there were difficulties in explaining the A&P concepts they utilized and how they reason through the CRP assessments. Specific terminologies and using CRS to work through the story was difficult for students in this group, but not necessarily for all students in this group. Finally, both groups did indicate the benefits of the CRP assessment to its application to the real-world and how it teaches them about their body, but also providing an insight into becoming a health professional.

Summary

This chapter provided analysis of the quantitative and qualitative data results to answer Research Questions 1 and 2. Although the experimental group showed a significant difference (versus the control group) for the dependent variable of CRS when analyzed using a 2 × 2 mixed ANOVA, there was an increase in mean score pretest to posttest compared to the mean score of pretest to posttest for the control group (see Table 9). When looking at the qualitative data, the themes of facilitating CRS and utilizing A&P concepts indicate that students from the experimental group were able to learn from the CBL videos that I created, which modeled how they should reason through the CRP assessments, indicating that there are some benefits of CBL in facilitating students' CRS. Lastly, the theme of application to the real world overlapped between the two groups, and the CRPs gave students an opportunity to experience what it may be like to be in a healthcare setting interacting with patients but also learning about their bodies.

Chapter V

Discussion

The purpose of this research was to identify the effectiveness of CBL in facilitating CRS in undergraduate A&P instruction. I worked to understand the implementation of case studies, planning a CBL experience, carrying out CBL learning experiences, and discovering how students apply their knowledge of the human body. I was interested in understanding CBL effectiveness, specifically, undergraduate science students in a community college setting. More specifically, students who enroll in A&P I. Students taking A&P I enter with the idea that rote-memorization is the key to success in A&P, and relying heavily on textbooks and other resources was the way to approach this course. Getting a good grade is important, but what when taking A&P I, it is important to understand the concepts and be able to apply what they learned in the classroom. I was interested in how students evaluated the CRP assessments given for each of the three anatomical systems, students struggled in when taking A&P. The following research questions guided this study:

RQ1: What is the effect of case-based learning on the CRS of undergraduate anatomy and physiology students for the central nervous system, autonomic nervous system, and special senses?

RQ2: How does case-based learning support student application of anatomy and physiology concepts to cases that involve clinical reasoning?

To answer these questions, I performed an explanatory sequential mixed method study to determine the effectiveness of CBL in facilitating CRS using an existing instrument called the CRP. Furthermore, to expand the understanding of CBL facilitating

CRS, semistructured interviews were conducted to evaluate how students used A&P concepts when reasoning through case studies as a means to provide understanding to the quantitative results.

In total, 48 students participated in this study. They were given a pretest and posttest CRP assessment for each of three anatomical systems: CNS, ANS, and SS. Twenty-five students were interviewed at the end of each assessment. The CRPs were made prior to the beginning of the study and vetted while interview protocols for both the control and experimental groups were created prompting specific questions geared toward each CRP. Data collection began immediately after the first CRP assessment and continued up to the second week of December. The first CRP was graded to preselect students for interviews; however, all other CRP assessments were analyzed after the completion of the interviews. In performing the data analysis, I conducted a 2 × 2 mixed ANOVA and content analysis for the transcribed interviews. A total of four themes were generated from the interviews: utilizing A&P concepts, facilitating CRS, resources employed, and application to the real world. This chapter provides a discussion of the findings, limitations of the study, and implications for instructors.

Discussion of Findings

Case-Based Learning Facilitating Student Clinical Reasoning Skills Utilizing Anatomy and Physiology Concepts

The first area focused on the effect of CBL on facilitating CRS for the CNS, ANS, and SS. Even though the results showed that differences did not reach statistical significance for any of the participants in the experimental group in CNS or ANS, the results did show that the control group had decreased mean scores from pretest to posttest compared to the experimental group. The decrease seen in the control group, even after given the lecture material, could be due to the resources the two groups employed on the assessment. There may be several reasons for these results. One possible explanation may be due to participants in the experimental group engaging with the CBL videos that I created, which was a critical part for facilitating CRS and doing so utilizing A&P concepts. Some students in the control group, as indicated by the interviews, appeared to be confused on how to evaluate the CRP assessments they received. Students in the control group used their lecture notes and relied heavily on Google to determine their diagnoses through the process of elimination. These participants were less astute in distinguishing between normal and abnormal symptoms or understand how to examine the case and make the connection to the anatomical systems under investigation.

On the other hand, participants in the experimental group were given CBL videos that modeled how students should reason through the assessments. Modeling enables students to visualize what is occurring and focus on the processes rather than the end results (Hamilton et al., 2008). Furthermore, I was modeling real-life cases that would be relatable for students and give them an opportunity to make the connection to their personal lives. Through the CBL modeling videos, students were able to learn patterns, important concepts, and reasoning strategies that can be applied to different patient scenarios. Utilizing CBL online seemed to give students an opportunity to facilitate CRS. The CRP videos were created by the instructor modeling how to assess a case when looking at a patient, rather than jumping in and not having a direction. The videos modeled how to highlight key terms and look at the nonanalytical information first and how the information supported the need for a specific diagnostic. Participants found these resources beneficial as they were taught how to structure and break down the CRP assessments into smaller pieces. For example, the video showed students how to separate nonanalytical from analytical information, which they were able to visualize and mimic when working from case to case. Participants learned to understand and visualize the terminologies and their correlations to each anatomical system and how to cope with the ambiguities from case to case. The exercise CRPs that participants received supported students by providing guided work to help them practice and apply what they learned after watching the videos, which is an important part of implementing CBL (Williams, 2005).

Facilitating Clinical Reasoning Skills

The quantitative data indicated that the experimental group did not perform statistically better than the control group. A possible explanation may be due to the workload and time required in an online A&P course. A&P is a course that requires copious amounts of information to be learned, a lab component, exams, and quizzes, and students may not have adequate time to complete the CRPs, or it might be their first time taking an online science course. Secondly, the participants from both groups could have had prior personal exposure to the patient story depicted in the CRPs. Some participants may have experienced acute otitis, spinal injury, or vertigo, and it would be difficult to tailor the CRPs to ensure that it is something new for them. In addition, a large sample size might be needed to reach statistical significance.

The mean increase shown in Table 9 does support the assertion that CBL was effective in facilitating CRS. It appeared that, based on the qualitative data, the participants in the experimental group were better able to facilitate CRS when CBL was implemented. Participants from the experimental group discussed how they assessed the CRPs by analyzing the patient story line-by-line, pinpointing and recognizing what was considered nonanalytical, such as blood pressure, temperature, and weight, and distinguishing abnormalities using hypo-deductive skills (symptoms and test results). However, when analyzing the control group for comparison, a majority of participants struggled to differentiate nonanalytical and analytical information along with deducing what was considered normal and abnormal.

The participants in the experimental group were able to carry forward CRS as they moved from case-to-case, applying the same method when analyzing a patient. The data appears to support the idea that CBL can be used to facilitate CRS in the classroom. This group was able to apply CBR and hypo-deductive reasoning when processing the case studies, which is consistent with the findings from Hmelo (1998), indicating that utilizing CBL gave students the opportunity to solve problems and utilize hypo-deductive reasoning compared to solely relying on lecture materials. The resources I provided for the participants in the experimental group offered multiple opportunities for them to become comfortable moving from case-to-case and doing so at times by not watching the CBL videos I provided. Students learned and became accustomed to applying CRS and hypo-deductive skills. Furthermore, the data may indicate that students learned to understand their decisions using information from the CBL videos and knowing what information was valuable, which played a crucial role in their conclusion.

Utilizing Anatomy and Physiology

The second area of focus that I sought to understand through Research Question 2 was how CBL supported students' applications of A&P concepts to cases (CRPs) that involved reasoning. Looking at the interview transcripts, students from the experimental group were able to articulate the A&P concepts that they utilized when working through the CRP assessments compared to the control group. In fact, students used generalized terms such as *back*, *secretion*, *things*, among others. These results suggest that the participants from the control group struggled to understand the A&P concepts and how to apply them as they were not given CBL videos in which I modeled the processes. This indicates that CBL instruction and videos provided in this study may be helpful for studying moderately difficult to difficult anatomical systems.

Furthermore, allowing students to visualize what was being done may have helped them understand the connection between the CRPs and their understanding of the systems. In addition, the participants in the experimental group were given personal feedback during the practice CRPs, which is important when an instructor models CBL (Wilson et al., 2020). By providing individualized feedback and practices, I was able to build on student knowledge and help them acquire skills that I taught during the CBL video so they could use it as a guide while they moved from one CRP to the next, indicating the importance of modeling CBL (Hobbs et al., 2013). The CBL videos guided students in understanding how the CRPs can help them understand structure-function relationships for the three systems supporting CBL effectiveness in facilitating CRS. A&P is about building knowledge and knowing how to apply it, understanding how the A&P concepts intertwined with the CRP assessments, and moving toward a richer understanding of A&P rather than solely relying on rote-memorization, which the participants in the experimental group exhibited.

The results from this theme support the idea about CBL and the importance of the facilitator. The role of the facilitator is to guide students, provide feedback, and to try to rectify any misunderstanding (Srinivasan et al.,2007). CBL encourages students to explore possible diagnosis, make clinical decisions, and provide a structured learning environment, which is important as it keeps students focused and able to become accustomed to how they should go about reasoning through each case (DeSanto-Madeya, 2007; Murad et al.,2010; Srinivasan et al., 2007). Furthermore, this theme supports the idea that CBL can help students understand A&P concepts (Cliff, 2006).

Enhancing Students' Applications to the Real World

The third area focuses on the application to real-world, a realistic experience for the learners in both groups. Application to real-world is important, as it is important to train students to have the skills they can successfully apply (Burkhardt, 2006). Utilizing case studies better prepares students for entering the work force. Herreid (1994) and Thistlethwaite et al. (2012) supported this idea of creating case stories for the real world. According to Herreid (1997), using realistic case stories can enhance students' understanding of a subject matter by enabling them to apply their knowledge of basic science concepts and clinical sciences in the classroom. In creating the CBL experiences, I worked to create realistic case stories that students might encounter in the workforce. By creating a realistic experience for students, they become interested in understanding the reason behind the learning about the physiological and anatomical functions of the human body. Students in both groups were able to express their appreciation for the case stories as they provided each participant a view into a healthcare setting as well as an understanding of their own health.

Students explained the value of the case studies further by expressing how important it is to understand the diagnostic tools that can be used to assess patients, such as bloodwork, x-rays, and physical examinations. Understanding when and how to run specific tests was important as it gave students the skills to know where to start when they encounter their first patient. Furthermore, understanding one's body is crucial as many individuals use Google to search for medical diagnoses if they are suffering from an illness. By giving them a fundamental understanding, individuals will not go into panic mode; instead, they can go to the doctor and understand the terminologies that their medical professionals use. Similar findings were seen in making the CBL experience more realistic (Aldridge, 1994; Bonwell & Eison, 1991; Chapman & Martin, 1996; Siebert & McIntosh, 2001; Thistlethwaite et al., 2012). Furthermore, CBL enables students to learn in the classroom before entering the workforce where they may be unsupervised and deciding how to treat a patient (Tolsgaard, 2013). The participants in both groups reported that they were able to understand the perspective of a clinician and that they might encounter scenarios similar to the case studies. The CRPs helped students link practice to theory and increased their depth of understanding for the purpose of learning, which supports the literature. For example, O'Neill et al. (2000) and Hayward and Cairns (1998) conducted a survey about the use and perception of CBL for students in their clinical clerkships and found that the students felt it allowed them to connect clinical experience with scientific knowledge, and it gave purpose to learning. CBL enabled students to see the importance of understanding body concepts and how this knowledge relates to real-world practices (Aldridge, 1994; Bonwell & Eison, 1991).

These findings support the current literature of how students should learn about science and how CBL facilitates students' CRS by incorporating CBR and hypo-deductive skills. Science should be taught to actively engage students—allowing them to investigate and practice situations—and describe how modeling can help them visualize scientific concepts (National Academies Press, 2001). When instructors use CBL as a tool for learning A&P concepts, students learn to visualize how to investigate a problem, the processes involved in the case, and how they can apply this learning to solve a story (Herreid, 1994; National Academies of Science, Engineering and Medicine, 2018). The practice supports the finding that science is about sharing ideas with others; it is about interacting and model-building and allowing students to ask questions and defend their choices (National Academies of Science, Engineering, and Medicine, 2018).

In addition, CBL was deemed an effective method for students to understand the world of a health professional, but also learning about their own health. Mclean (2016) and Thistlethwaite et al. (2012) proposed that CBL is a method used to prepare students when entering clinicals by working through case studies in the classroom, which can connect theory to practice. Furthermore, using CBL, as indicated by Srinivasan et al. (2007), enables educators to prepare students and guide them when working through the case studies. The findings of this study provide support for the benefits of CBL and evidence that this mode of instruction may enhance the educational preparation for undergraduate A&P students entering health professional schools by offering advantages to learning how the body functions and its correlation to interacting with patients.

Summary of the Findings

To understand how the quantitative and qualitative data provided more clarity to this study, firstly, it provided the significance of including a qualitative portion to illuminate the findings of the quantitative results. The data highlighted that even though the experimental group who was exposed to CBL did not statistically perform better than those in the control group, facilitating CRS can be valuable to students' understanding of A&P concepts and learning to understand the connection between the knowledge they gain in the classroom and it application to the real world. These data are significant as they portray the type of environment needed in an A&P course that may support students' understanding of concepts and why they are learning about the intricacies of the body. The results is a learning environment that is conducive to engaging students in reasoning and learning how to apply theory to practice (Mclean, 2012; Thistlethwaite et al., 2012).

Limitations of the Present Study

Most, if not all, research will have limitations when working with human subjects. One of the major limitations of this study dealt with the sample size, as this study encountered students withdrawing, auditing, and not completing CRP pretest and posttest assessments, which resulted in a possible Type II error for the quantitative portion of this study. Secondly, this study employed a pre-posttest assessment of students' CRS using the CRP instrument. Posttests are used commonly in educational research and are evaluated as a means to investigate the effects of an intervention where a mean increase is typically seen. However, this study was able to offer a qualitative portion to provide insight into exactly how students were reasoning through the CRP`s assessment rather than solely focusing on the numbers given. Secondly, the school and population were selected purposefully based on their willingness to participate, and my role in the college as an instructor, which leads to the next limitation. This study dealt with my own subjectivity as I was the instructor, as it was beneficial for someone who has CBL experience to implement this study. I was involved in an effort to expand the use of CBL into other interdisciplinary courses. Furthermore, she is an advocate for implementing and using CBL in the classroom as a means to help students understand scientific concepts. During this study, she strived to be objective in the data collection and analysis by distancing herself from the analysis and focusing on the raw data as a means to explain the effectiveness of CBL in facilitating CRS in undergraduate A&P instruction. During the data analysis, I ensured the participants' thoughts and ideas were understood correctly by restating what the students were describing during their interview for accuracy.

Additionally, due to the COVID pandemic, all of the students participated in this study using Canvas as an online platform to complete the CRP assessments and video conferences for the interviews. Utilizing online platforms may have caused the participants to be guarded during the interviews or feel the need to complete the interview rapidly due to other commitments, possibly omitting important information and preventing them from discussing the case in much depth. Furthermore, it was difficult to accommodate everyone's schedules after every CRP assessment, which led to some participants forgetting the information from the case and needing to refresh their memory before the interview could begin. Another limitation of this study is that the results may differ with a different student population, for example, in another science related course.

Also, results may differ if CBL was implemented throughout the semester, focusing on other A&P systems such as histology or the muscular or skeletal system.

Implications for Instructors

This study sought to understand the effectiveness of CBL in facilitating CRS. CBL is a tool that can not only be used in medical, engineering, business, or other professions, but can be used in undergraduate settings, which may have a greater impact on student learning. Undergraduate instructors can easily integrate CBL into their classroom using a variety of methods such as directed case studies, such as were implemented in this study, modeling CBL using videos, small group methods, or computer simulation cases, as indicated by Herreid (1997). CBL is not about replacing the traditional way of how students learn in a science classroom, because it is still important for students to receive the fundamental science concepts, but rather enhancing a student's learning environment that can instill a deeper understanding of science concepts by allowing them to apply their knowledge and make the connection between basic and clinical science. Faculty can use case studies in an in-person, large classroom environment or online instead of solely relying on exams or quizzes as a means of assessing students' knowledge. Every instructor can choose their own technique that seems appropriate for their classroom environment, and this study offers instructors and full time and adjunct professors another way of teaching A&P to their students that keeps them actively engaged. A&P courses are commonly held in a traditional didactic format; however, instructors can open up a world for students in the classroom and depict the purpose of learning this concept not just for those wishing to pursue a health professional carrier, but also those learning about their own health.

The findings in this study highlight the importance of CBL and how it can be used in the classroom, which not only acts as a resource for an instructor, but also showed the effect CBL can have on aiding students' understanding of scientific concepts. As discussed before, higher education instruction is gradually shifting toward engaging students in the classroom, and this study provides an opportunity to learn about the various ways educators can do so, especially in undergraduate science instruction where many students struggle. It is also important to help students with public health advocacy by helping them understand the A&P functions of their bodies, research their own health, understand when a medical professional is conversing with them, and teaching them to not be afraid to ask questions. Furthermore, the literature and current study have shown the benefits of CBL in the classroom and its impact on instructors and benefits to students. Finally, implementing CBL in the classroom in a small way can be impactful. This study provided insight into how students can take the knowledge they learn and apply it.

Future Research Directions

There are many possible areas for future research that can be identified. Because this study focused on A&P instruction, it would be interesting to broaden the scope of the participants to interdisciplinary courses such as radiology, nursing, dental, and other science course that are not utilizing CBL in their curricula. If possible, a longitudinal study could be conducted to assess the effect of CBL in these different interdisciplinary courses as some of them incorporate student learning in a clinical setting. Another possible research direction is working with faculty members to portray the benefits of CBL and collaborate together and write new case stories that meet different instructors' needs. These can be shared with faculty members from other universities and community colleges. Finally, further research may be performed on how CBL is implemented; for example, students can complete practice assignments for their classmates to peer review. This process may enable further learning and illuminate how others reasoned through the case studies. It provides an alternative perspective, which is what clinicians do occasionally, bouncing ideas off of other practitioners.

Conclusion

The purpose of this study was to evaluate the effectiveness of CBL in facilitating CRS in undergraduate A&P instruction. Participants from two A&P I course were part of this study due to convivence sampling. Data sources included the CRP pre-test and post-test which was used to identify if CBL facilitated CRS. Interviews were semistructured to allow the participants to express how they utilize A&P concepts when reasoning through the CRP assessments. Through the analysis of quantitative data, there was no statistical significance found for the CNS, ANS and SS when compared to the control group. However, for all three anatomical systems, CNS, ANS, and SS, there was a mean increase from the pretests and posttests for those in the experimental group compared to the control group (see Table 9). In addition, the semistructured interviews depicted four themes: facilitating CRS, utilizing A&P, resources employed, and application to the real-world. Specifically, students in the experimental group were able to articulate the A&P concepts they utilized by using specific terminologies correlating to each of the three anatomical systems. Participants in the experimental group indicated that the CBL videos enabled students to visualize what they needed to do when assessing each case and its connection to the concepts. Furthermore, both groups indicated that the CRPs helped them understand their bodies, but also look into the world of a health professional.

A few barriers may have limited the CBL implementation's effectiveness, such as population size and the COVID pandemic. The COVID pandemic has affected enrollment and students completing the course. In this study, there were a few students who withdrew and some who did not complete the assessments due to time constraints with learning A&P online. Furthermore, CBL was implemented in an online setting, limiting interaction between student and instructor. On the other hand, multiple factors may have positively influenced the CBL implementation's effectiveness, such as multiple practices and CBL videos, which modeled how students may go about working through the case and applying the A&P concepts they learned. This study intended not only to fill a gap in the research but also to facilitate students' understanding and application of A&P concepts and provide an opportunity for students to learn how to facilitate CRS in the classroom and take these developed skills with them into the real world.

As an instructor, I was very interested to see the impact of CBL, and this study provided valuable information on implementing pedagogical approaches such as CBL in undergraduate science instruction to elicit reasoning skills and the understanding of scientific concepts. I have personally experienced students who enter A&P I relying on rote-memorization, rather than trying to understand the connection between the knowledge gained and how it can apply not only in the real world as health professional, but also in understanding one's own health. It is important to note that focusing on the concepts on a need-to-know-basis is beneficial, but being able to put what they have learned into practice is even more important. By exploring CBL in my classes, I was able to teach students to visualize and learn the importance of A&P through CBL. As a result, students may look at anatomy in a different light, more than just terminologies, but as concepts instead that can give more insight into the human body and how it functions. Implementing CBL, I was able to learn more about my role as an instructor and the impact that all instructors can have in the classroom in helping students gain knowledge. I was also able to provide one-on-one valuable feedback about the concepts they understood, which allowed me to cater to students' learning needs in the classroom, and thereby, the students gained a sense of proficiency on reasoning processes. CBL may have helped students understand the content and see its usability, but it also provided an insight into how I can better myself as a teacher. The benefits of this study have pushed me to continue using CBL approaches not only in my A&P course, but with my non-science major courses as well, as it is important for instructors to teach students to be prepared for the workforce.

Implementing CBL in undergraduate A&P instruction can address the changes needed in preparing students for higher order of thinking, and providing the fundamental skills they need to be successful. Finally, this study gave me an opportunity to see that I as an instructors needed an approach like CBL that can help me identify skills that my students are developing and using to better support their understanding of the human body.

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Appendix A

CNS pretest *(Modified from Texas A&M Health Science Center College)*

Bianca Salvador is a 35-year-old nurse. Bianca arrived four months ago from South Africa where she was part of the Peace Corps volunteering with the Red Cross. About 8 weeks after arriving home, Bianca begins experiencing headaches. The headaches progressively increased over the next four weeks. The headaches were joined by occasional nausea. While at work she all of sudden experienced a seizure and was admitted to the ER.

In the ER, her vital signs were 120/80 with a temperature of 98.3 F. Her temporal arteries are not thickened or tender, ruling out giant cell arteritis. The physician asked Bianca if she had any recently travel abroad. She did not seem to experience muscle stiffness, and her Brudzinski's sign was negative. The nurse also describe other symptoms such as abdominal pain, loss of appetite, and weight loss to the attending physician before Bianca suffers yet another generalized seizure. The ER doctor orders a CT scan of Bianca's brain and the imaging shows multiple hypodense lesions. The ER doctor noticed subcutaneous nodules across her head and arms while conducting a physical examination. A stool sample was also taken from Bianca. The findings from the stool sample reveal parasitic eggs. The doctor prescribe praziquantel(10mg)

Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each

Features	Support(+) or Opposes(-)	Weighting 1. Slightly relevant 2. Somewhat relevant 3. Very relevant

If the diagnosis above is proved incorrect, what would your next choice be? Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each

Features	Support(+) or Opposes(-)	Weighting 1. Slightly relevant 2. Somewhat relevant 3. Very relevant

Brain:

- The central nervous system is composed of the brain and spinal cord.
- The spinal cord serves as a middleman between the brain and the rest of the body. It control musculoskeletal reflexes without the need of the brain
- The brain integrate sensory information and coordinates body function.
- The CNS is cushioned/protected by cerebrospinal fluid(CSF).

Blood pressure range:

Blood pressure category	Systolic(upper #)		Diastolic(lower #)
Normal	Less than 120	and	Less than 90
Elevated	120-129	and	Less than 80
High blood pressure stage 1	130-139	or	80-89
High blood pressure stage 2	140 or higher	or	90 or higher
Hypertensive crisis	Higher than 180	And/or	Higher than 120

NOTE: https://www.webmd.com/hypertension-high-blood-pressure/guide/diastolic-and-systolic-blood-pressure-know-your-numbers

Temperature:

^{0}F	0-2 years	3-10 years	11-65 years	>65 years
Core	97.5-100	97.5-100	98.2-100.2	96.6-98.8

Terminologies:

CT Scan: Computerized tomography which creates cross-sectional images of the brain, bones, and other soft tissues.
Hypodense lesion: Structures appear darker and benign (non-cancerous)
Brudzinski's test: A test used to determine if a patient has meningitis, subarachnoid hemorrhage or encephalitis's.

CNS posttest (Modified from National center for case study teaching: David F. Dean, Department of Biology, Spring Hill College)

Jason is 32 years old. Jason indicated he was involved in a sports accident when playing tennis this morning, but initially felt fine. However, he has since started experiencing excruciating pain in his back. Upon examination, his BP was 128/76 with a temp of 98.6 °F. A neurological exam was performed and showing the following:

Jason demonstrated normal strength in flexing and extending his elbows, extending his wrists, and when flexing his middle finger and abducting his little finger on both hands. However, he exhibited no movement when the physician tested his ability to flex his hips, and flex/extend his knees. Reflexes involving the following muscles: biceps, brachioradialis, and triceps muscles were found to be normal, while those involving the patella and ankle were absent. In addition, Jason add decreased temperature sensation but preserved proprioception, and light touch sensation in his lower limbs.

What do you think is the most likely diagnosis in this patient?

1. Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each

Features	Support(+) or Opposes(-)	Weighting 4. Slightly relevant 5. Somewhat relevant 6. Very relevant

7. If the diagnosis above is proved incorrect, what would your next choice be?

8. Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each

Features	Support(+) or Opposes(-)	Weighting 4. Slightly relevant 5. Somewhat relevant 6. Very relevant

Note: CASE Modified slightly from National center for case study teaching: David F. Dean, Department of Biology, Spring Hill College

- Proprioception: sense of body position (limbs and trunk), equilibrium, and balance. Receptors located in skin, muscle, and joints

-Spinal cord is a way for information to travel between the brain and the rest of the body. You have your white matter: contains sensory or motor and it encompasses the gray matter. The gray matter contain cell bodies of neurons.

-Dermatomes: nerves convey sensory information from skins to dermatomes and then sends information to motor impulses.

-Spinal reflex: involuntary response. Spinal reflex arc goes through the spinal cord(patellar reflex, withdraw reflex, as discussed in CNS chapters).

-Spinal nerves supplies the arms, neck, and legs

-General Pathways:

-Spinothalamic pathway/anterolateral: transmit proprioception, pain and temperature

-Spinocerebellar: involves the cerebellum, no third order neurons involved.

-medial lemniscus pathways: involves fine touch, vibration and pressure(discussed in CNS)

International standards for neurological classification C5 –

Elbow flexors (biceps, brachialis)

- C6 –

Wrist extensors (extensor carpi radialis longus and brevis)

- C7 –

Elbow extensors (triceps)

- C8 –

Finger flexors (flexor digitorum profundus) to the middle finger

- T1 –

Small finger abductors (abductor digiti minimi)
- L2 –

Hip flexors (iliopsoas)
- L3 –

Knee extensors (quadriceps)
- L4 –

Ankle dorsiflexors (tibialis anterior)
- L5 –
  Long toe extensors (extensor hallucis longus)
- S1 –

Ankle plantar flexors (gastrocnemius, soleus)

- The **L1** spinal nerves affect movement and sensation of the pelvic/hip region (and below). Bowel/bladder functions may also be disrupted.
- The **L2** spinal nerves affect the muscles that allow you to bend the hips (hip flexors) and sensation at the upper thighs (will present similarly to an L1 injury).
- The **L3** spinal nerves affect the ability to straighten the knees (knee extension) and sensation at the lower thighs and knees.
- The **L4** spinal nerves affect the ability to lift the foot upwards (ankle dorsiflexion) and sensation at the front and inner regions of the lower legs.
- The **L5** spinal nerves affect the ability to bend and straighten the big toe and sensation at the outer areas of the lower legs down to the big, second, and middle toes.
- **Cauda equina**: nerve roots that leave the spine and provide sensation and movement to the lower legs

Blood pressure range:

Blood pressure category	Systolic(upper #)		Diastolic(lower #)
Normal	Less than 120	and	Less than 90
Elevated	120-129	and	Less than 80
High blood pressure stage 1	130-139	or	80-89
High blood pressure stage 2	140 or higher	or	90 or higher
Hypertensive crisis	Higher than 180	And/or	Higher than 120

Note: https://www.webmd.com/hypertension-high-blood-pressure/guide/diastolic-and-systolic-blood-pressure-know-your-numbers

Temperature:

^{0}F	0-2 years	3-10 years	11-65 years	>65 years
Core	97.5-100	97.5-100	98.2-100.2	96.6-98.8

Note: https://www.zoeruth.com/blog/normal-body-temperature

ANS pretest

(Modified from National center for case study teaching: James A. Hewlett; Science and Technology Department Finger Lakes Community College, Buffalo NY)

Imani Morales is a 52-year-old individual who was rushed into the emergency department by his mother, Angela, after having dinner at a seafood restaurant. Angela indicated Imani is experiencing shortness of breath, muscle weakness, facial numbness, nausea, vomiting, abdominal pain, and a feeling of "floating". In addition, Imani mentions a metallic taste in his mouth. Imani blood pressure was within normal ranges and no severe cardiac or respiratory issues during his consultation. Imani has been experiencing these symptoms for the past 2 hours.

Imani's physical examination was conducted, and he had an average temperature of 37.7°C. His BP while in a supine position was 89/60. Imani also indicated he has coronary artery disease and his current heart rate of 55 beats per minute, during the ER examination, so, Atropine was given. In addition, physical examination showed numbness of the lips and tongue. CT and MRI scans of his brain were normal. Imani was also questioned regarding his meals over the past few hours, and he indicated he had a wide variety of seafood dishes which included a small portion of sea bass, mussels, and a delicacy, pufferfish.

1. What do you think is the most likely diagnosis in this patient?
2. Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign [positive(+) or negative(-)] and weighting to each

Features	Support(+) or Opposes(-)	Weighting 9. Slightly relevant 10. Somewhat relevant 11. Very relevant

3.If the diagnosis above is proved incorrect, what would your next choice be?
4.Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each

Features	Support(+) or Opposes(-)	Weighting 7. Slightly relevant 8. Somewhat relevant

		9. Very relevant

Note: Modified slightly from National center for case study teaching: James A. Hewlett; Science and Technology Department Finger Lakes Community College, Buffalo NY.

ANS:
-Autonomic Nervous System: Divided into parasympathetic and sympathetic nervous system.
-Sympathetic nervous system: fight or flight
-Parasympathetic: Rest and digest

Blood pressure category	Systolic(upper #)mm Hg		Diastolic(lower #)mmg Hg
Below normal: Hypotensive	Lower than 90	or	Lower than 60
Normal	Less than 120	and	Less than 90
Pre-Hypertension: Elevated	120-129	and	Less than 80
High blood pressure stage 1(High stage hypertension)	130-139	or	80-89
High blood pressure stage 2(High stage hypertension)	140 or higher	or	90 or higher
Hypertensive crisis	Higher than 180	And/or	Higher than 120

ANS posttest

Alice, a 44-year-old woman, visited her primary care physician for her annual physical. Alice indicated she is sporadically experiencing headache, heart palpitations, abdominal pain, nausea and vomiting. She indicated these symptoms have appeared over the past couple of months, but didn't pay attention to her issue until the nausea and vomiting started.

Alice`s vitals signs include a temperature is 97.6° F, a BP 120/75, and a pulse of 88. Alice is perfectly healthy with no previous health concerns. Upon weighing Alice, the physician also noticed a drop in her weight. Alice indicated she was not on any diet plans. In addition, Alice`s appeared pale and sweaty. Her physician ordered a urinalysis and CT scan of her abdomen. The urinalysis revealed the presence of elevated catecholamines and the CT scan confirmed the presence of a tumor in the adrenal medulla.

Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each

Features	Support(+) or Opposes(-)	Weighting 12. Slightly relevant 13. Somewhat relevant 14. Very relevant

If the diagnosis above is proved incorrect, what would your next choice be? Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each

Features	Support(+) or Opposes(-)	Weighting 10. Slightly relevant 11. Somewhat relevant 12. Very relevant

NOTE: Modified from national teaching center for case study: David F. Dean, Department of Biology, Spring Hill College

Blood pressure range:

Blood pressure category	Systolic(upper #)		Diastolic(lower #)
Normal	Less than 120	and	Less than 90
Elevated	120-129	and	Less than 80
High blood pressure stage 1	130-139	or	80-89
High blood pressure stage 2	140 or higher	or	90 or higher
Hypertensive crisis	Higher than 180	And/or	Higher than 120

https://www.webmd.com/hypertension-high-blood-pressure/guide/diastolic-and-systolic-blood-pressure-know-your-numbers

Temperature:

^{0}F	0-2 years	3-10 years	11-65 years	>65 years
Core	97.5-100	97.5-100	98.2-100.2	96.6-98.8

https://www.zoeruth.com/blog/normal-body-temperature

Autonomic Nervous System refresher:

Two division

- Sympathetic
    - Fight or flight When SNS is triggered
    - Prepares body for stress
    - Increases heart rate and blood pressure
    - Decreases digestions
    - Contains pre-post ganglionic fibers: releases ACH and Norepinephrine
    - Adrenal glands secrete hormones also known as adrenergic receptors (Catecholamines hormones: norepinephrine/epinephrine) directly into the blood stream
    - Leaves CNS from the thoracolumbar region
    - Alpha and beta receptors
- Parasympathetic
    - rest or digest
    - returns body to a calm state/homeostasis

- decreases heart rater/blood pressure
- Nicotinic and Muscarinic receptors
- contains pre-post ganglionic fibers: releases ACH
- Leaves CNS from the craniosacral region

Terminologies:
Computed Tomography(CT)-Abdomen and pelvis: A type of test used for diagnostic purposed. More importantly, a test used to detect any abnormalities of the small bowel, colon, and other internal organs found within the abdomen.
Urinalysis: used to test a sample of urine. A urinalysis can detect a wide range of disorders by checking appearance, concentration and the content of the urine. EX: detecting diabetes, or kidney diseases.
24- hour Urine Catecholamine testing: A test used to measure the amount of catecholamines present). Catecholamine: Proteins that are neurotransmitters such as dopamine, norepinephrine, and epinephrine.

SS Pretest:

Linda Hu is a 9-year-old individual brought into the ENT experiencing, ear pain, loss of balance, and limited hearing. Linda's mom also indicated that her daughter has trouble sleeping, eating, occasional vomiting, tinnitus (ringing in the ears), a fever of 101.2° F in the morning, and problems hearing.

Linda's temperature is 100.1° F, BP 120/75, and a pulse of 88. Linda is perfectly healthy with no previous health concerns. A pneumatic otoscope was used to examine Linda's ear canal to check for fluid. Moreover, a tympanometry was used to examine air pressure and sound tones. The otoscope examination showed that the tympanic membrane was slightly red and swollen(figure 1 below), with fluid trapped behind the eardrum. Furthermore, the tympanometry showed a flat line (O decapascals: unit of air pressure). What do you think is the most likely diagnosis in this patient?

Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign [positive(+) or negative(-)] and weighting to each.

Features	Support(+) or Opposes(-)	Weighting 15. Slightly relevant 16. Somewhat relevant 17. Very relevant

If the diagnosis above is proved incorrect, what would your next choice be? Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each.

Features	Support(+) or Opposes(-)	Weighting 13. Slightly relevant 14. Somewhat relevant 15. Very relevant

Note: modified from Hole's Human Anatomy & Physiology, 9/eDavid Shier

Blood pressure range:

Blood pressure category	Systolic(upper #)		Diastolic(lower #)
Normal	Less than 120	and	Less than 90
Elevated	120-129	and	Less than 80
High blood pressure stage 1	130-139	or	80-89
High blood pressure stage 2	140 or higher	or	90 or higher
Hypertensive crisis	Higher than 180	And/or	Higher than 120

https://www.webmd.com/hypertension-high-blood-pressure/guide/diastolic-and-systolic-blood-pressure-know-your-numbers

Temperature:

^{0}F	0-2 years	3-10 years	11-65 years	>65 years
Core	97.5-100	97.5-100	98.2-100.2	96.6-98.8

The ear is divided into three regions**: outer, middle and inner ear**. The middle ear contains the tympanic membrane, also referred to as the ear drum. The tympanic membrane vibrates when sounds is moving through the external auditory canal. The middle portion of the ear aids in ensuring vibration/soundwaves are sent into the inner ear.

Otoscope examination: A test used to assess the auditory canal and obtain a visual of the tympanic membrane. This test can be conducted by any doctor. The tool used is called an otoscope and it shines a beam of light into the ear. This will allow doctors to examine the ear for any infection. To perform an otoscope examination, the physician will use on hand to pull down on the ear lobe and gently slide the tip of the otoscope into the ear canal.

A **tympanometry test** is a test to determine how well the tympanic membrane moves, essentially determining how well sound is transmitted through the middle ear. The results will indicate the max pressure(daPa) of the ear. These numbers is crucial to distinguishing if an individual as hearing loos or other ear issue resulting from an infection. See below for daPa levels and the meaning behind the numbers.

SS posttest:

Aisha Klein is a 32-year-old who was admitted to the emergency room (ER) after experiencing a fall. Aisha complained of nausea and severe headache. A full work-up was done to ensure there was no other issues. Aisha's temperature was 98.1^0 F with a blood pressure level of 120/80. A CT scan was done to rule out any intracranial bleeding. After all the work-up, Aisha was released and instructed to get some rest, and to come back if she experienced any new symptoms.

After several days Aisha started experiencing dizziness. Sudden movements such as rolling over in bed or turning her head side to side caused her to feel as if the room was spinning for brief periods. She felt nauseated and had a dull ringing in her ears. Instead of going to the ER again, Aisha went to see a neurologist. The neurologist conducted head-impulse test (HIT) and noticed some involuntary jerking eye movement.

Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each.

Features	Support(+) or Opposes(-)	Weighting 18. Slightly relevant 19. Somewhat relevant 20. Very relevant

If the diagnosis above is proved incorrect, what would your next choice be? Please list the features of the case which you consider support your diagnosis and also those which oppose it, giving an appropriate sign[positive(+) or negative(-)] and weighting to each.

Features	Support(+) or Opposes(-)	Weighting 16. Slightly relevant 17. Somewhat relevant 18. Very relevant

Blood pressure range:

Blood pressure category	Systolic(upper #)		Diastolic(lower #)
Normal	Less than 120	and	Less than 90
Elevated	120-129	and	Less than 80
High blood pressure stage 1	130-139	or	80-89
High blood pressure stage 2	140 or higher	or	90 or higher
Hypertensive crisis	Higher than 180	And/or	Higher than 120

https://www.webmd.com/hypertension-high-blood-pressure/guide/diastolic-and-systolic-blood-pressure-know-your-numbers

Temperature:

^{0}F	0-2 years	3-10 years	11-65 years	>65 years
Core	97.5-100	97.5-100	98.2-100.2	96.6-98.8

https://www.zoeruth.com/blog/normal-body-temperature

Head-impulse testing: A test used to assess vestibulo-ocular reflex, but more so to assess the horizontal semicircular canals and peripheral vestibular nerve function. In patients with a positive HIT test (that's a bad thing), corrective "catch-up" saccades will be present. When using HIT we are trying to distinguish peripheral from central (cerebellar/brainstem) vestibular disfunction.

The two functional division of the vestibular apparatus are:

- The vestibular
- The semicircular canals

The two sensory receptors of the vestibule are:

- The Maculae - monitors the position of the head in space
- The Cristae Ampullae - the receptor for rotational acceleration

Appendix B

Interview protocol

Experimental group: How does CBL support students application of A&P concepts to cases that involve clinical reasoning?

Time of Interview__________
Place_________
Interviewee Name:_____________

Purpose of Interview: This interview purpose is to understand how a student reason through the case studies. There is no right or wrong response. Expected interview time is around 10 minutes.
Tools used: CRP Assessments will be shown via zoom/screen share. Only the interviewee and I will be able to see the assessment.

1) CNS
    - Could you walk me through your reasoning process through this case?
    - What additional information do you think you could use when solving this cases?
    - Were the CRP videos/practice CRP valuable, if so, why, if not why? So the videos were helpful in solving the cases?
    - Which A&P concepts were valuable and why? If you remember from spinal cord and brain, anything from these chapters?
    - And Did the cases aid your understanding of A&P concepts
    - Did this activity encourage you to develop or learn any skills? If so, what type of skill and how?
    - What was your overall opinion about this activity? Did the activity impact your view of how A&P should be learned? If so, How?
    - Did the cases aid its application to real-world clinical situation? If so, how? If no, why not? And also non-clinical situation, just people who want to learn about their body?
2) ANS
    - Could you walk me through the process of thinking through this case?
    - Which A&P concepts were valuable and why?
    - What additional information do you think you could use when solving this cases?
    - Did you feel the case stores was helpful in understanding A&P concepts, if so, why, if not, why not?
    - Did the activity encourage critical thinking/problem solving skills? If so, how?

A) What was your overall opinion about this activity? Did the activity impact your view of how science should be learned? If so, How?

3) SS
   - could you walk me through the process of thinking through this case?
   - Which A&P concepts were valuable and why?
   - What additional information do you think you could use when solving this cases?
   - Did you feel the case stores was helpful in understanding A&P concepts, if so, why, if not, why?
4) What was your overall opinion about the case studies?
5) Did the cases aid your understanding of A&P concepts and its application to real-world clinical situation? If so, how? If no, why not?
6) Did the activity encourage critical thinking/problem solving skills? If so, how?

B) What was your overall opinion about this activity? Did the activity impact your view of how A&P should be learned? If so, How?

Control group: How does CBL support students application of A&P concepts to cases that involve clinical reasoning

Time of Interview__________
Place_________
Interviewee:_____________

Purpose of Interview: This interview purpose is to understand how a student reason through the case studies. There is no right or wrong response. Expected interview time is around 10 minutes.
Tools used: CRP Assessments will be shown via zoom/screen share. Only the interviewee and I will be able to see the assessment.

1) CNS,
   - could you walk me through the process of thinking through the cases?
   - What additional information do you think you could use when solving this cases?
   - Which A&P concepts were valuable and why?
   - Did you feel the case stories was helpful in understanding A&P concepts, if so, why, if not, why
   - Did the cases aid your application to real-world clinical situation? If so, how? If no, why not?
   - What was your overall opinion about this activity? Did the activity impact your view of how A&P should be learned? If so, How?

2) ANS

- could you walk me through the process of thinking through the cases?
- What A&P concepts were valuable and why?
- What additional information do you think you could use when solving this cases?
- Did you feel the case stores was helpful in understanding A&P concepts, if so, why, if not, why
- Did the cases aid your understanding of A&P concepts and its application to real-world clinical situation? If so, how? If no, why not?
- What was your overall opinion about this activity? Did the activity impact your view of how A&P should be learned? If so, How?

3) SS

- could you walk me through the process of thinking through the cases?
- What A&P concepts were valuable and why?
- What additional information do you think you could use when solving this cases?
- Did you feel the case stores was helpful in understanding A&P concepts, if so, why, if not, why?

Did the cases aid your understanding of A&P concepts and its application to real-world clinical situation? If so, how? If no, why not?