Abstract

The Effect of Concept Mapping on Student Understanding and Correlation with Student Learning Styles

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This study investigated the use of concept mapping as a pedagogical strategy to promote change in the learning styles of pre-nursing students. Students' individual learning styles revealed two subsets of students; those who demonstrated a learning style that favors abstract conceptualization and those who demonstrated a learning style that favors concrete experience. Students in the experimental groups performed concept mapping activities designed to facilitate an integrative understanding of interactions between various organ systems of the body while the control group received a traditional didactic instruction without performing concept mapping activities. Both qualitative and quantitative data were collected in order to measure differences in student achievement. Analysis of the quantitative data revealed no significant change in the learning styles of students in either the control or experimental groups. Learning style groups were analyzed qualitatively for recurring or emergent themes that students identified as facilitating their learning. An analysis of qualitative data revealed that most students in the pre-nursing program were able to identify concepts within the class based upon visual cues, and a majority of these students exhibited the learning style of abstract conceptualization. As the laboratory experience for the course involves an examination of the anatomical structures of the human body, a visual identification of these structures seemed to be the most logical method to measure students' ability to identify anatomical structures.

The Effect of Concept Mapping on Student Understanding and Correlation with Student Learning Styles

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The Effect of Concept Mapping on Student Understanding and Correlation with Student Learning Styles

Despite educators' efforts to carefully plan and implement instruction, it is a common occurrence that not all students will develop a rich understanding of scientific concepts introduced in university classrooms. When students are not successful in learning course curriculum, the difficulty may be attributed to factors associated with the students, the instructor, and/or the content. This study seeks to evaluate the use of concept mapping as a pedagogical strategy to enhance student achievement. In doing so, this study also seeks to evaluate if concept mapping is more effective for students of a particular learning style, as measured by the Kolb Learning Style Inventory. Specifically, student responses to the Kolb Learning Style Inventory were evaluated to determine if a student was closer to being identified as an abstract or concrete learning style student.

A study by Binder, Westbury, McKiernan, Possing, and Medler (2005) indicated there are distinct brain regions that are activated during concrete word processing that are less active during the processing of abstract concepts. These findings indicate that there are biological differences in the thought processes of abstract and concrete learners. Some learners may be more capable of thinking of concrete or abstract terms because of increased activity, usage, or development of particular region of the brain.

A meta-study by Hartman (2001) indicated that many students have difficulty learning the health sciences because the discipline requires students to incorporate discreet concepts into a holistic conceptual framework. The findings of the meta-study encourage metacognitive strategies, like concept mapping, to enhance teaching practices and student learning, with particular regard to the acquisition of concepts and the relationships between them.

Concept mapping can address the problem of discrepancies in abstract versus concrete learning and logical disconnects in course material by facilitating the integration of concrete concepts into an abstract framework, therefore benefitting both types of students. A study by Karns (2006) indicated that active learning strategies are effective for students of all learning styles. A study by Harpaz, Balik, and Ehrenfield (2004) reported that both students and instructors indicated that concept mapping had a positive effect on student learning outcomes by helping students to organize concepts in a theoretical framework, changing students into active rather than passive learners, and in helping students find connections between concepts. Concept mapping can not only function as an active learning tool but also serves to visually illustrate student conceptions (Novak and Gowan, 1984). Bandura (1989) also found that concept mapping facilitates student learning and performance by promoting encoding of information from short term memory to long term memory.

The purpose of this study is to determine if concept mapping, regardless of student learning style, is a constructive instructional strategy to address the problem of poor student performance in developing an understanding of the relationships between biological concepts. Professors and teaching assistants in the Department of Biology of a medium-sized southeastern university have observed that relatively few students perform well (having a grade of 90 or higher) in both the first and second sections of a two semester sequence course in anatomy and physiology laboratory.

The few students who perform well in both sections tend to be very high achievers with an overall average of 95% or greater. However, some students perform well in the first section of the course but perform poorly in the second section of the course, while others perform well in the second section of the course but perform poorly in the first section. This discrepancy in student performance may be attributable to the fact that much of the material covered in the first section of the course is highly concrete in nature and focuses on the identification of anatomical structures, whereas the material covered in the second course is relatively more abstract and involves an understanding of the human body as a holistic system with complex interacting subsystems that maintain homeostasis.

For students studying the health sciences, a basic, concrete-level understanding of the anatomical structures and their corresponding physiological functions is insufficient for the level of care they are expected to provide their future patients, just as understanding a general overview of how organ systems interact but having no knowledge of the structures involved is insufficient. Without an understanding of the organ systems of the body, the structures that comprise them, and the functions of those structures, a student in the health sciences program will be unable to operate successfully in a clinical or laboratory setting.

When this discrepancy in student understanding was discovered by the investigator, a pilot study was launched in the spring of 2011 to determine the learning styles of students who perform well in both courses and students who perform well in one section of the course but not the other (see Table 1). The results of the pilot study indicated that those students who perform well in the first section of the course have a predominantly concrete learning style. Students who have a concrete learning style are characterized by their ability to readily memorize, identify, and describe concepts. The results of the pilot study also indicated that those students who perform well in the second section of the course frequently have a more abstract learning style. Students exhibiting an abstract learning style are characterized by their ability to readily delineate relationships, develop hierarchies, and understand the interrelations between concepts. Interestingly, those students who perform well in both sections of the course tended to not only be very high-performing students, but also exhibited characteristics of both learning styles, that is hereafter referred to as a median learning style (Mosley, 2011).

Table 1. Comparisons of Student Performance in 2141 and 2151 with Learning Style

Student	2141 Grade	2151 Grade	Learning Style
TC	84	91	Abstract
EF	96	96	Median
HL	96	89	Concrete
AW	93	92	Concrete
EW	94	80	Concrete
SE	84	93	Median
JF	90	87	Concrete
BH	73	75	Concrete
EK	97	95	Median
AK	85	83	Concrete
AP	88	86	Concrete
TP	89	93	Concrete
MS	76	78	Concrete
LW	79	72	Concrete
AW	80	87	Abstract

The pilot study was conducted in order to identify a potential rationale for the discrepancy in student achievement and to suggest a manner to improve instruction to alleviate the discrepancy in achievement between the two courses. The discrepancy in student performance was confirmed by the achievement level of students who exhibit grade inconsistencies between the first section of the course and the second section of the course (or vice-versa). The fact that this tendency is exhibited by many students indicates a problem with the course material, the instructor, or other factors.

The discrepancy in student performance is a significant issue because health science students must understand concrete anatomical structures and their corresponding functions as well as have an abstract understanding of the interactions between the various anatomical structures in the human body. The hypothesis of the study speculates that the arising problem is reflected by a disconnect in the flow of ideas between the two courses. The disconnect occurs when a student with a primarily concrete learning style is challenged with learning abstract concepts such as the interactions between organ systems of the body. A disconnect also occurs when a student with a primarily abstract learning style is asked to group concrete concepts within their existing abstract framework.

The hypothesis of this study is that despite predominant learning styles, anatomy and physiology students who use concept mapping as an instructional tool will have higher achievement on course measures than their counterparts who do not. If so, then students who engage in concept mapping as a learning tool should assume a more median learning style that will facilitate their understanding of both concrete concepts and the relationships between those concepts in an abstract framework.

The implications of this study are twofold. First, as this study will examine the effectiveness of a specific instructional strategy on student achievement within an anatomy & physiology laboratory course, any findings on the effectiveness of this strategy could be applied to other science courses. Findings many also apply to any number of courses that require students to integrate concrete scientific concepts within an abstract framework. Second, this study will examine if a student's learning style can be modified by the use of concept mapping as an instructional strategy. If it is found to be so, then this study may challenge the notion that learning styles can be changed only over extended periods of time.

The research questions addressed in this study are: 1.Does concept mapping increase student achievement on understanding concrete concepts in abstract-learning style students; 2.Does concept mapping increase student achievement on understanding abstract concepts in concrete-learning style students; and 3.Does the use of concept mapping change students' learning style over a relatively short period of time?

To address the research questions, the population of students enrolled in the anatomy & physiology laboratory course had to be divided into sample groups. There were three control groups and three experimental groups. Data were collected in the form of unit surveys that were used to determine student understanding of abstract and concrete concepts relating to the course material, student self-reported learning style as determined by the Kolb Learning Style Inventory, student grades on formative assessments as well as overall student grade, work samples, and interviews. Students in the experimental groups also used a concept mapping routine developed by the researcher which was designed to holistically integrate concepts from various lessons. Those concept maps were scored and examined by the researcher for various themes.

Review of Literature

A pilot study was launched to determine the learning styles of students who perform well in both courses, students who perform well in the first section to perform poorly in the second section, and students who perform well in the second section but perform poorly in the first section. The results of this pilot study indicated that those students who performed well in the first section of the course have a concrete learning style. A concrete learning style is defined as a learning style that can readily memorize, identify, and describe concepts. The results of this pilot study also indicated that those students who perform well in the second section of the course frequently have a more abstract learning style. An abstract learning style is defined as a learning style that can readily delineate relationships, develop hierarchies, and understand the interrelations between concepts. Those students whom performed well in both sections of the course were found to not only be very high-performing students, but also exhibited characteristics of both learning styles, that is referred to as a median learning style (Mosley 2011).

In the review of literature, findings indicate that a student's learning style can influence their ability to learn and acquire concepts. There are various methods facilitating categorization of student learning styles, but each has its own advantages. Kolb's model of learning styles is used as a diagnostic instrument in this study because it fits closely with the abstract vs. concrete thinking spectrum addressed in this study. There is a biological distinction in the processing of abstract and concrete words and concepts and that biological difference provides evidence that student thinking patterns are an inherent trait (Binder et. Al, 2005). In order for students to acquire and categories concepts with that they are unfamiliar or uncomfortable, they must be aware of their thinking. Student awareness of their own thinking patterns is important in order to evoke change in those thinking patterns. In order for those thinking patterns to change, learning should be made meaningful. Concept mapping is an instructional tool that has been shown to promote meaningful learning. Concept mapping benefits students by encouraging them to find the connections between concepts and encouraging them to participate in active rather than passive learning (Novak & Gowan, 1984). Concept mapping is beneficial to instructors because it can serve as a diagnostic assessment for students, an illustration of student thinking patterns, and serves as a powerful instructional tool (Clayton, 2006). It is the one of the hypotheses of this study that concept mapping will facilitate changes in student learning style.

Tsai and Thomas (2011) indicated that student's learning style (whether concrete or abstract) and their critical thinking skills can influence their ability to recall information, especially if that information is presented in a coherent manner. They found that concrete learners attribute equal importance to all information acquired rather than prioritizing the relative importance of the information. In contrast, abstract learners place primary importance on central concepts, and attribute importance to secondary concepts if the students' judgment determined them to be significantly important. These results are applicable to this study because the results delineate the reasons as to why abstract and concrete learners place the relative importance on concepts taught in a typical lesson.

Abstract and concrete learners exhibit distinct thinking patterns and indeed use discreet regions of their brain for processing. Binder et. Al (2005) found that while both concrete and abstract words activate an area of the brain associated with linguistic processing, concrete words activate the angular gyrus and dorsal portion of the prefrontal lobe in both hemispheres.

Interestingly, abstract words activate only the left hemisphere's inferior frontal lobe regions associated with linguistic working memory. This study asserts that there are distinct modes of thinking activated in processing concrete and abstract words and provides a neurological basis for distinguishing concrete and abstract thinking processes.

There are various methods of attempting to categorize learning styles including, but not limited to: Kolb's model of learning styles (1984); the well-known Fleming VARK (Visual, Auditory, Read-write, and Kinesthetic) model (Fleming and Mills 1992); and Honey and Mumford's model (1982). These three models of learning styles are the most common in use today and each has its advantages. Kolb's model asks the person of interest to rate the methods in that they learn best; requiring a degree of understanding of one's thinking processes. Kolb's model was further refined by Honey and Mumford to survey the behaviors exhibited by the person of interest rather than by asking them how they best learn. By far the most common learning style model is Fleming's VARK model. Fleming's VARK model is commonly used because of the ease of administration of a diagnostic survey to students.

Out of all learning style inventories, Kolb's model of learning information on an abstract conceptualization to a concrete experience spectrum is unique and was selected for the study as an instrument to determine the students who have an abstract learning style or a concrete learning style. Kolb's model of learning styles was developed in 1982 and asserts that there are four distinct modes of thinking: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). The learning style of an individual is determined by the extent to that they rely on each of the four modes of thinking, with generally two modes being dominate, leading to a distinct learning style: converger (AC-AE), diverger

(CE - RO), assimilator (AC-RO), and accommodator (CE-AE). Convergers are able to find the practical applications for abstract concepts. Divergers are able to see multiple points of view in concrete experiences. Assimilators prefer to take abstract ideas and arrange them into logical forms. Accommodators learn best thorough doing, rather than thinking (Kolb, 1984). Kolb's learning style inventory is relevant to this study because it will help to classify students as one of four types of learners and student scores on the Learning style Inventory will be correlated with a student's learning style being either abstract or concrete.

Metacognition plays a minute role in the study because in order for an individual to understand their own concrete and abstract modes of thinking, they must be able to understand the methods in that they process information. This process is referred to by many as metacognition. Metacognition allows a student to develop an awareness of their thinking and learning processes and to become an active, rather than passive, learner. Hartman (2001) examined the effect of metacognitive strategies in the enhancement of instruction and learning in science courses. Hartman found that metacognition by the learner allows the development of learning strategies effective for the student to understand difficult concepts. One such metacognitive strategy explored was concept mapping. Hartman found that concept mapping promotes meaningful learning by understanding the hierarchical organization of concepts.

Concept mapping has its roots in constructivism, which is the epistemological theory that postulates learning is a student-centered active process of knowledge construction. Constructivism began as a psychological theory by Vygotsky, who proposed that an individual's understanding of the world is framed by their experiences. Constructivism was expanded in the work of Jean Piaget, a Swiss developmental psychologist whose theories on cognitive development led to the espousal of various epistemological theories on learning and understanding (Piaget, 1977). The work of Piaget is pertinent because it characterizes the cognitive processes that students experience during acquisition of new concepts.

Following Piaget, there were many epistemologists to embrace his works and evolve his propositions into various theories. One such philosopher was David Ausabel, who developed a cognitive learning theory that postulated that learning only occurs when it is made meaningful to the learner. Meaningful learning is defined as a student integrating new concepts into what the student already knows, thereby incorporating the new information into their existing conceptions (Ausabel, 1962). It has been found that students in a constructivist, theory-based learning environment are more aware of their role as a learner and therefore have greater motivation to understand essential concepts than students in a conventional learning environment (Gijbels et. Al, 2006). The work of Ausabel and Gijbels informs the study because it concluded that there are pedagogical methods that can enhance student learning.

Novak and Gowan (1984) applied the theories of Ausabel to education in their development of concept mapping. Concept mapping is a pedagogical and learning method that allows a learner to create a visual representation of new information in an attempt to integrate that information into their knowledge structures. Concept mapping as a learning strategy involves creating relationships between concepts proceeding from a general, broad abstraction to how specific, tangible concepts are interrelated with those abstractions. This allows for meaningful learning to occur as a student attempts to integrate new, unknown concepts in a broad, general hierarchy generated from their prior understanding of the topic (Akinsanya & Williams, 2004).

Bandura (1989) found that concept mapping facilitates student learning and performance due to the vast amount of concepts covered in the traditional classroom that must be encoded in order for learning to take place. Bandura's findings are important to the study because they suggest a mechanism through that concept mapping can facilitate learning. He proposed that concept mapping facilitates learning outcomes by promoting encoding of information from short term memory to long term memory. According to Bandura's social cognitive theory, this encoding is accomplished by making the information significant in a cognitive representation rather than the information itself.

In a study by Harpaz (2004), the perceived effects of concept mapping were examined from both student and instructor viewpoints. They found that:

> Students report that concept mapping "encourages them to think independently, increased orientation in knowledge and in finding connections between the different areas, (and) gave them more confidence in implementing their knowledge in clinical work" (Harpaz, 2004, p.30).
>
> Teachers report that concept mapping "helped organize the theoretical material in an integrative way, changed the student from a passive learner to an active one, enabled evaluation of a students' knowledge, (and) improved evaluation of the student's safety in the clinical environment" (Harpaz, 2004, p.30).

While it may be intuitively plausible, there have been no specific studies on the use of concept mapping on the development of specific abstract and concrete learning skills. There have been several studies that measure the effect of concept mapping on student performance. In a 2006 meta-analysis of concept mapping studies, Clayton concluded that there were three major themes that were prevalent in the literature: "1.Concept mapping results in generally positive effects on academic performance; 2. Concept mapping improves students' critical thinking abilities; 3. Concept mapping serves as an appropriate teaching method." In a meta-analysis by Daley and Torre (2010), they found that concept mapping functioned to enhance student learning in four ways: I. by promotion of student learning; II. By providing a resource for learning; III. by enabling instructors to provide feedback, and IV. by conducting assessment. Most studies conclude that concept mapping is not only an effective tool in enhancing student learning, but it can also serve as a valuable diagnostic tool for instructors to explore students' understanding of concepts.

In a study that explored concept mapping as a tool for illustrating students' developing conceptions of course material, Kinchin, Hay, and Adams (2000) had middle grades science students construct concept maps of scientific concepts relating to plant ecology. In their analysis of student concept maps, they distinguished between three main types of concept maps: spoke, chain, and net styles. The spoke style of concept map has concepts linked to a central concept but with little or no linkages between peripheral concepts, that indicates an incomplete understanding of the relationships between the subject matter concepts. The chain style of concept map is a characteristic linear map with a logical sequence that demonstrates an ordinal approach to understanding of the concepts rather than a hierarchical understanding. The net style of concept mapping is the most cognitively sophisticated and implies that a student has a thorough understanding of concepts, the hierarchical relationships between them, as well as the interconnectedness of the concepts through a variety of cross-links. These results are appropriate for the study because they indicate that the visual representation of a student's concept map can provide insight into the student's knowledge structure.

While concept mapping has been shown to be effective as an instructional and assessment tool, there have been studies that indicate that a student's ability to construct a concept map is not correlated with any particular learning style. The findings of a meta-study by Laight (2004) indicate that there is no preference between a student's use of concept mapping and the student's learning style. However, according to Laight: "The findings of this study support the conclusion that a complex learning strategy, such as concept mapping, can be effective for students with all kinds of learning style preferences" (p.230). This is applicable to the study at hand because it indicates that all students, regardless of preferred learning style, could potentially find concept mapping to be beneficial in instruction.

The use of concept mapping to modify or enhance student learning style (i.e. to help both concrete and abstract learners develop their weaker spectrum of learning style), has not been explored. Studies have explored the possibility that student learning styles may change over time. Rakoczy and Money (1995) examined learning styles of nursing students and the change in those learning styles over a three year period. Overall, the majority of students tested annually were assimilators, and that pattern remained consistent throughout the three-year period of the study. There was a slight change, but the difference was insignificant.

The problem at the center of the study is a discrepancy in student knowledge structure of concepts covered in the first and second sections of a course of anatomy and physiology laboratory. A pilot study determined the discrepancy in student knowledge structure to be the result of concept acquisition and understanding. Results of the pilot study indicated that those students who performed well in the first section of the course have a predominantly concrete learning style and those students who perform well in the second section of the course frequently have a more abstract learning style. Those students who performed well in both sections of the course were found not only be very high-performing students, but also exhibited characteristics of both learning styles, that is referred to as a medium learning style (Mosley 2011). There are various methods of attempting to categorize learning styles, but Kolb's model is the most commonly used with four distinct learning styles: converger, diverger, assimilator, and accommodator (Kolb, 1984). Each learning style has various strengths and weaknesses, with some learning styles being more adept at the acquisition of concrete concepts and other learning styles being more adept at the acquisition of abstract concepts. In the processing of abstract and concrete words, neurological studies have shown that differing brain regions are activated, providing a physiological basis for the distinction between abstract and concrete thinking. To promote changes in student thinking and encourage active learning, strategies such as concept mapping have been explored as an instructional tool to promote metacognition. Metacognition encourages students to examine their thinking processes as an introductory step in a sequence of processes designed to promote changes in student thinking. Concept mapping may facilitate changes in thinking processes because it not only assists in the encoding of information from short-term memory to long-term memory (Bandura 1989) but also facilitates student learning by encouraging the student to assign meaning and value to concepts and to organize those concepts into a theoretical framework.

Methodology

The focus of this study is the discrepancy in student performance in laboratory courses of human anatomy and physiology. In an attempt to reduce that discrepancy in performance, concept mapping was explored as a pedagogical method to enhance student understanding and achievement. The study's purpose was to determine the effects of the concept mapping activities on students' learning of concepts in the anatomy & physiology laboratory. The research design incorporates a pragmatic parallel mixed-methods approach (Mertens, 2010). A pragmatic parallel mixed-methods approach was chosen for this study because data were collected through both quantitative and qualitative methodologies at three time points during the semester.

The research questions to be addressed were threefold:

1. Does the use of a concept mapping routine increase concrete concept acquisition in students identified as having an abstract learning style?
2. Does the use of a concept mapping routine increase abstract concept acquisition in students identified as having a concrete learning style?
3. Does the use of a concept mapping routine change student learning styles?

Answering the research questions involved the creation of groups from amongst a sample of students. The sample for this study included students enrolled in an Anatomy & Physiology Laboratory course during the fall semester of 2011 at a medium sized university in the southeastern United States. This sample is a convenience sample because it consists of those students who consented to participate. The typical student is a female undergraduate, health professions major (although there are exceptions) in her sophomore year at twenty years of age.

The Anatomy & Physiology Laboratory course had seven sections consisting of a maximum of 24 students each. The sample was then divided into control and experimental course sections in order to determine the effects of experimental treatments. There were three course sections in the control group and three course sections in the experimental group. One section was not used for the study as there was no baseline for the graduate teaching assistant's performance as an instructor. The remaining six sections consisted of a total of 129 students, with 63 students in the control group and 66 students in the experimental group. The treatments applied were concept mapping activities.

As the university assigns instructors to course sections, it is not in the investigator's power to assign students or instructors to particular groups. Control groups were assigned to a single graduate teaching assistant who instructed all three groups. The three experimental groups were assigned to two instructors, with one section being taught by the investigator, and two sections being taught by a graduate teaching assistant. Those instructors that were chosen for the study were chosen because of prior teaching experience with this class, acceptable student opinion of instruction data, and a consistent distribution of student grades.

In order to insure consistency in course content between different sections, lesson plans included a diagnostic assessment at the beginning of the lesson to determine the student's pre-existing knowledge, a common lecture PowerPoint, extension activities for each lesson (including concept mapping activities for experimental groups and self-study times for control groups), as well as a common quiz used as a formative assessment administered at the end of every lesson. Lesson plans were developed for every lesson. An example lesson plan is included as Appendix A. In order to minimize variability in grading, the researcher was responsible for grading all assignments of all students enrolled in the course. To ensure fidelity in the delivery of the lesson plan, the lectures were recorded with an audio device and then screened by the researcher with an observation protocol to verify that all activities were completed.

In order to conduct this study, approval of the University Institutional Review Board (IRB) was received on October 11, 2011. The research study was eligible for expedited review because the collection of data from voice, video, digital, or image recording made for research purposes and research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, and quality assurance methodologies. The chairperson of the IRB deemed this unfunded study presented no more than minimal risk requiring a continuing review at 12 months. Changes to this approved research could not be initiated without IRB approval except when necessary to eliminate an apparent immediate hazard to the participant. All anticipated problems involving risks to participants and others were promptly reported to the IRB, but no such problems were incurred. The investigator must submit a continuing review\closure application to the University institutional review board prior to the date of study expiration. The chairperson of the IRB does not have a potential for conflict of interest on this study.

Table 2. Timeline of Data Collection and Instrument Administration

Week / Group	Oct. 12 – Oct. 14	Oct. 17 – Oct. 21	Oct. 31 – Nov. 4	Nov. 7 – Nov. 11	Nov. 14 – Nov. 18	Nov. 28 – Dec. 2	Dec. 5 – Dec. 9
Control Group	-Consent Forms -U1 Content Survey -P1LSI -Intro Concept Mapping Activity	-U1 Content Survey Interviews	-U2 Content Survey	-U2 Content Survey Interviews		-U3 Content Survey -P2LSI	-U3 Content Survey Interviews
Experime-ntal Group	-Consent Forms -U1 Content Survey -P1LSI -Intro Concept Mapping Activity	-U1 Content Survey Interviews	-U2 Content Survey -First Concept Mapping Activity	-U2 Content Survey Interviews -Second Concept Mapping Activity	-Third Concept Mapping Activity	-U3 Content Survey -P2LSI	-U3 Content Survey Interviews

An informed consent form for the study (Appendix B) was distributed to all students who were present during the week of October 12-14 (see table 2). Students were instructed to sign the first signature line to signify they were aware the study was occurring. Students were then instructed to only sign the second signature line to signify their consent and willingness to participate in the study. Students who consented agreed to participate in the study, to have their completed class work and grades submitted as data, and consented to complete the surveys that measure their understanding of abstract and concrete concepts delivered in the course of instruction. Students who did not consent were not included in the study and were allowed to leave the classroom before administration of the group surveys. If students were enrolled in course sections that had been assigned as experimental groups and did not consent, during the concept mapping activities those students were moved to a different classroom and allowed to self-study using anatomical diagrams and models (similar to the control groups).

Data were collected in the form of surveys that were used to determine student understanding of concrete and abstract concepts relating to the course material (surveys), student self-reported learning style as determined by the Kolb Learning style Inventory (LSI) version 3.1, student grades on formative assessments as well as overall student grade, work samples, and interviews. Student grades were used as measures of concept acquisition by the students. To minimize intergroup variability in grades, the researcher was responsible for grading all work of all students in all sections. Student work samples were selected by the researcher exemplifying particular learning styles and traits.

The surveys were developed by the researcher to measure student acquisition of both abstract and concrete concepts relating to the course material. All surveys were administered under the supervision of the researcher with the exception of the unit 2 content survey that was administered to Section 006, one of the sections of the control group. Students were given one minute to answer each question and at the completion of the 10-minute time frame, students were required to hand in all materials. Each survey had a corresponding PowerPoint presentation that contained images or information used in the identification of concrete concepts relating to the course material. To minimize variability, the researcher created a grading rubric and took responsibility for scoring all surveys with one point being given for each correct answer. Odd-numbered questions on the survey asked students to name structures or identify functions of anatomical features, requiring the student to understand concrete concepts. This data should be considered a measure of student acquisition of concrete concepts. Even-numbered questions asked students to identify how one particular system, structure, component, or pathology of the human body interacts with another system, structure, component, or pathology requiring the student to understand the interconnectedness of concepts. This data should be considered a measure of student acquisition of abstract, holistic concepts. Scoring rubrics for each of the surveys are attached as Appendices C-E.

The Kolb LSI version 3.1 was administered under group conditions in the classroom under the supervision of the researcher. The survey of Kolb's LSI was used with the permission of Experience-Based Learning Systems, Incorporated. Permission to use the survey was granted on September 28, 2011. The Kolb LSI was administered at two time points: a phase I LSI (P1LSI) was administered at the beginning of the study, and a phase II LSI (P2LSI) was administered at the end of the study. Student learning styles were identified according to Kolb's model. Student scores on two categories of the Kolb LSI will be recorded and used to determine student learning style. The two categories to be scored are abstract conceptualization (to determine the degree that a student is an abstract thinker) and concrete experimentation (to determine the degree that a student is a concrete thinker). In Kolb's model, abstact conceptualization is defined as a logical analysis of concepts and ideas and the framing of those ideas within a larger hierarchy. Concrete experience is defined as learning through experiences and feelings. The P1LSI and P2LSI were identical; therefore, any changes in student self-reported learning style were due to the student's perceptions. Student scores were calculated using a scoring sheet provided by the Hay group.

Interviews with students were conducted in the classroom on a scheduled basis. Students who were chosen for interview were required to sign an additional consent form allowing for the recording of their interview sessions so that a transcript could be produced (Appendix F). Students who did not sign the interview consent form were not interviewed. Students who agreed to participate in interviews received a $10 Subway™ gift card for their time and participation. Students were selected for interviews via deliberate sampling in order to identify the learning styles and thinking processes that occur in each type of student, whether concrete or abstract and high-, medium-, or low-performing. High-performing students are identified as having an A average. Average-performing students are identified as having a B average. Low-performing students are identified as having a C average or lower. By characterizing each type of student, the researcher was able to identify characteristics of the type of learning style a student exhibits, as well as identify an ideal learning style of a student who performs well as indicated by overall grade. In order to maintain consistency between interviews, an interview protocol (Appendices G-I) as well as a scoring rubric (Appendices C-E) was developed for each of the interviews that contained specific instructions to the student as to the purpose of the interview, the questions to be asked during the interview, and any additional follow-up questions that could be asked to further elucidate the thinking processes of the student. The interviews were conducted one week after the administration of the surveys. In the interviews, the students were expected to state their answer(s) to a question on the survey, then to explain their thinking process. Intervews were recorded and transcribed verbatim. Appropriate punction was used to signify pauses made by the student. When the student paused for less than five seconds, the symbol "…" was used. When a student paused for greater than five seconds, the designation "(long pause)" was used in the transcript. In the vignettes, comments made by the researcher are signified with "R" in the transcripts, while comments and explanations made by the student are signified with their assigned psuedonym.

The independent variable, the use of concept mapping as a teaching/learning tool, was applied to the experimental groups on a regular basis. The dependent variables included student achievement on formative assessments, overall grade in the course, and student self-reported learning style as determined by Kolb's LSI version 3.1. The control and experimental groups were both introduced to concept mapping as a learning tool, however, only the experimental group performed concept mapping on a regular basis.

An introductory activity (Appendix J) was developed that explained the theory supporting concept maps, how to construct them, sample concept maps, as well as a concept mapping activity that asked students to visually represent the effects of the sympathetic nervous system on the respiratory, digestive, and reproductive systems. Both the control and experimental groups were instructed in the construction and theory of concept maps to maintain fairness in the sense that both groups were exposed to appropriate learning styles interventions. Only those students who consented to participate in the study and who were in the experimental group completed the remaining concept mapping activities. Concept mapping activity 1 (Appendix K) consisted of a researcher constructed concept map with preexisting nodes, crosslinks, and prepositions linking some nodes. Concept mapping activity 1 was intended to instruct students in the use of concept maps to link what may have seemed to some students as disconnected concepts that were from various organ systems. Concept mapping activity 2 (Appendix L) consisted of a researcher constructed concept map with preexisting nodes, crosslinks, and prepositions linking some nodes. Concept mapping activity 2 was intended to instruct students in the use of concept maps to delineate hierarchical relationships within organ systems. Students were still encouraged to insert their own cross-links that would link seemingly disconnected concepts from differing organ systems. The final concept mapping activity (Appendix M) consisted of a researcher-developed PowerPoint presentation that instructed students to create a concept map on one or all of a selected group of organ systems that were covered during instruction as a part of the lesson. Students were given a list of terms that should be included for each organ system covered; therefore, this was a closed-ended concept mapping activity. However, students were allowed to construct their concept maps from that list of terms.

Analysis. The study sought to determine if concept mapping was effective in increasing the acquisition of concrete concepts in students with abstract learning styles. To determine if the data supported that proposal, students' learning styles were determined by analyzing the results of both the P1LSI and P2LSI. In order to determine if a student was a predominantly abstract or concrete learner according to the LSI, the difference in scores on the Abstract Conceptualization (AC) subsection and the Concrete Experience (CE) subsection were compared. The average of the difference between those scores for all students was calculated, and analyzed for standard error. Students were classified as having an abstract learning style if their scores on the AC subsection exceeded their scores on the CE subsection by more than the standard error. Only those students who were identified as having a learning style dominated by Abstact Conceptualization on both the P1LSI and P2LSI were evaluated for their ability to acquire concrete concepts. Their ability to acquire concrete concepts over the course of the semester was calculated by determining the difference in scores of the concrete subsections of the unit three content survey (that was administered at the end of the semester) and the unit one content survey (that was administered at the beginning of the semester).

Second, the study sought to determine if concept mapping was effective in increasing the acquisition of abstract concepts in students with a concrete learning style. To determine if the data supported that proposal, students' learning styles were determined by analyzing the results of both the P1LSI and P2LSI. In order to determine if a student was a predominantly abstract or concrete learner according to the LSI, the difference in scores on the Abstract Conceptualization (AC) subsection and the Concrete Experience (CE) subsection were compared. The average of the difference between those scores for all students was calculated, and analyzed for standard error. Students were classified as having a concrete learning style if their scores on the CE subsection exceeded their scores on the AC subsection by more than the standard error. Only those students who were identified as having a learning style dominated by Concrete Experience on both the P1LSI and P2LSI were evaluated for their ability to acquire abstract concepts. Their ability to acquire abstract concepts over the course of the semester was calculated by determining the difference in scores of the abstract subsections of the unit three content survey (that was administered at the end of the semester) and the unit one content survey (that was administered at the end of the semester).

Finally, the study sought to determine if concept mapping was effective in changing student learning styles over the course of the study. In order to determine if a change in student learning style occurred, the difference in student scores on subsections on the P2LSI and the P1LSI was calculated. Any potential changes in learning style were analyzed for correlation with a student being a part of the control or experimental group.

To establish the validity of the surveys in measuring student achievement on abstract and concrete concepts, student scores on the surveys were first correlated with grades to assess the ability of the surveys to measure student achievement via an f-test. Student scores within the abstract and concrete subsections of the surveys were then correlated with the degree to which the students rely on Abstract Conceptualization or Concrete Experimentation as their dominant mode of thinking using an ANOVA analysis.

Interviews with students were analyzed for recurring themes in students' descriptions of their understanding of concepts or a lack thereof. These recurring themes were then examined for trends found within low-, average-, and high-performing students as well as trends found within students who rely on Abstract Conceptualization or Concrete Experimentation as their dominant mode of thinking.

Concept maps will be scored according to a scoring method provided by Novak and Gowin (1984). This scoring model involves giving one point for meaningful, valid propositions, five points for each level of valid hierarchical organization, ten points for each meaningful cross-link used, and one point for each valid example given of a concept.

Results

Validity of Instruments. In order to assess the validity of the researcher-developed surveys in measuring student achievement within the course, students' total scores on the abstract and concrete subsections (30 points total) for each survey were combined to obtain a total score out of 90 possible points. This score was then converted to a percentage of correct responses on the surveys. Each student's percentage of correct responses on the surveys was compared to their overall grade and analyzed via an f-test to determine significance. The resulting value of the f-test was 0.0034, indicating that students' performance on the survey is correlated with their achievement in the classroom as determined by overall grade. These findings indicate that the surveys are a valid measure of student achievement.

The first research question asks "does concept mapping increase student achievement on understanding concrete concepts in abstract-learning style students." In order to assess the validity of the researcher-developed surveys as a measure of concrete concepts within the course, the scores on the concrete subsection of the surveys were correlated with student learning style. According to Kolb, Concrete Experience is the acquisition of concepts through experiences and feelings. On the opposite end of Kolb's spectrum is Abstract Conceptualization, which is the ability to logically organize acquired concepts into a hierarchy. It would be expected that students who fall predominantly on the Concrete Experience end of the spectrum (thus having a higher CE score) would also have a higher score on the concrete subsections of the surveys.

To calculate the percentage of correct responses on the concrete subsections of the surveys, each student's survey was scored according to the rubric. Once each student's survey had been scored, their percentages of correct responses on the concrete subsections were calculated. The number of correct responses within the concrete subsection of each unit survey was calculated by dividing by 15 (the total number of possible correct responses on the concrete subsection).

On each learning style inventory, there are a total of 120 possible points that are divided amongst each of the four modes of thinking. To determine the percentage of points that were devoted to Concrete Experience, each student's learning style inventory was scored according to a rubric provided by the Hay Group. The number of points calculated in the concrete subsection of each student's learning style inventory was divided by 120 to calculate the percentage of points to indicate the degree that a student is a concrete learner.

To determine if there is a correlation between the percentage of correct responses on the concrete subsections of the surveys and the percentage of points devoted to Concrete Experience on the learning style inventories, a five sample, correlated, standard weighted-means ANOVA analysis was performed with each student's percentage of correct responses on the concrete subsections of all three unit surveys with the percentage of the Concrete Experience subsection scores on both the P1LSI and P2LSI. An overall analysis revealed a p value of less than 0.0001 (see Table 4). The Tukey HSD Analysis indicates a strong correlation between student scores on the Concrete Experience subsections of the LSIs with each student's respective score on the concrete questions of the surveys (see Table 5). This indicates that the higher a student's score on the Concrete Experience subsection, the higher their score on the concrete subsection of the surveys. Based on all the aforementioned analyses, it can be concluded that the surveys are a valid measure of student acquisition of concrete concepts.

Table 3. Data Summary of ANOVA Analysis of Concrete Subsections of LSIs and Surveys

	P1LSI-CE %	P2LSI-CE %	Unit 1 Concrete %	Unit 2 Concrete %	Unit 3 Concrete %
N	74	74	74	74	74
Σx	14.348	14.178	41.065	45.001	45.935
Mean	0.194	0.192	0.555	0.608	0.621
Σx^2	2.89	2.84	24.93	29.44	30.75
Variance	0.00152	0.00164	0.0294	0.0284	0.0307
Std. Dev.	0.039	0.0404	0.171	0.168	0.175
Std. Err.	0.00453	0.0047	0.0199	0.0196	0.0204

Table 4. Summary of ANOVA Analysis of Concrete Subsections of LSIs and Surveys

Source	SS	df	MS	F	P
Treatment	14.521	4	3.63	234.21	<0.0001
Error	4.51	292	0.0155		
SS/Bl	2.169	73			
Total	21.204	369			

Table 5. Tukey HSD Analysis of ANOVA Analysis of Concrete Subsections of LSIs and Surveys

P1LSI-CE% - P2LSI-CE%	nonsignificant
P1LSI-CE% - Unit 1 Concrete	P<0.01
P1LSI-CE% - Unit 2 Concrete	P<0.01
P1LSI-CE% - Unit 3 Concrete	P<0.01
P2LSI-CE % - Unit 1 Concrete	P<0.01
P2LSI-CE % - Unit 2 Concrete	P<0.01
P2LSI-CE % - Unit 3 Concrete	P<0.01
Unit 1 Concrete - Unit 2 Concrete	nonsignificant
Unit 1 Concrete - Unit 3 Concrete	P<0.05

The second research question asks "does concept mapping increase student achievement on understanding abstract concepts in concrete-learning style students." In order to assess the validity of the researcher-developed surveys as a measure of abstract concepts within the course, the scores on the abstract subsection of the surveys were correlated with student learning style. It would be expected that students who fall predominantly on the Abstract Conceptualization end of the spectrum (thus having a higher AC score) would also have a higher score on the abstract subsections of the surveys.

To calculate the percentage of correct responses on the abstract subsections of the surveys, each student's survey was scored according to the rubric. Once each student's survey had been scored, their percentages of correct responses on the abstract subsections were calculated. To calculate their percentage, the number of correct responses within the abstract subsection of each unit survey was calculated by dividing by 15 (the total number of possible correct responses on the abstract subsection of each unit survey).

On each learning style inventory, there are a total of 120 possible points that are divided among each of the four modes of thinking. To determine the percentage of points that were devoted to the abstract subsection, each student's learning style inventory was scored according to a rubric provided by the Hay Group. The number of points obtained in the abstract subsection of each student's learning style inventory was divided by 120 to calculate the percentage of points to indicate the degree that a student is an abstract learner.

To determine if there is a correlation between the percentage of correct responses on the abstract subsections of the surveys and the percentage of points devoted to Abstract Conceptualization on the learning style inventories, a five sample, correlated, standard weighted-means ANOVA analysis was performed with each student's percentage of correct responses on the abstract subsections of all three unit surveys with the percentage of the Abstract Conceptualization subsection scores on both the P1LSI and P2LSI. An overall analysis revealed a p value of less than 0.0001 (see Table 7). The Tukey HSD Analysis indicates a strong correlation between student scores on the Abstract Conceptualization subsections of the LSIs with each student's respective score on the abstract questions of the surveys (see Table 8). This indicates that the higher a student's score on the Abstract Conceptualization subsection, the higher their score on the abstract subsection of the surveys. Based on all the aforementioned analyses, it can thus be concluded that the surveys are a valid measure of student acquisition of abstract concepts.

Table 6. Data Summary of ANOVA Analysis of Abstract Subsections of LSIs and Surveys

	P1LSI-AC %	P2LSI-AC %	Unit 1 Abstract %	Unit 2 Abstract %	Unit 3 Abstract %
N	74	74	74	74	74
Σx	17.542	17.873	14.138	11.933	9.67
Mean	0.237	0.242	0.191	0.161	0.131
Σx^2	4.35	4.53	4.8	2.87	2.17
Variance	0.00257	0.00292	0.0288	0.0129	0.0124
Std. Dev.	0.0507	0.054	0.17	0.114	0.111
Std. Err.	0.00589	0.00628	0.0197	0.0132	0.0129

Table 7. Summary of ANOVA Analysis of Abstract Subsections of LSIs and Surveys

Source	SS	df	MS	F	P
Treatment	0.68	4	0.17	19.1	<0.0001
Error	2.59	292	0.0089		
SS/Bl	1.75	73			
Total	5.02	369			

Table 8. Tukey HSD Analysis of ANOVA Analysis of Abstract Subsections of LSIs and Surveys

P1LSI-AC % - P2LSI-AC %	nonsignificant
P1LSI-AC% - Unit 1 Abstract	P<0.05
P1LSI-AC% - Unit 2 Abstract	P<0.01
P1LSI-AC% - Unit 3 Abstract	P<0.01
P2LSI-AC % - Unit 1 Abstract	P<0.01
P2LSI-AC% - Unit 2 Abstract	P<0.01
P2LSI-AC % - Unit 3 Abstract	P<0.01
Unit 1 Abstract - Unit 2 Abstract	nonsignificant
Unit 1 Abstract - Unit 3 Abstract	P<0.01

Research Questions. The first research question asks: "Does concept mapping increase student achievement on understanding concrete concepts in abstract-learning style students?" In order to answer that question, student scores on the P1LSI and P2LSI were analyzed to determine which students used Abstract Conceptualization as a dominant mode of learning. In order for a student to be considered an abstract learner, their scores on the Abstract Conceptualization subsection of the LSI must exceed their scores on the Concrete Experimentation section by the standard error of the overall difference between those scores, which was determined to be plus or minus 1 unit. Only those students considered to be abstract learners on both the P1LSI and P2LSI were examined. Within the experimental group, there were 25 students who were considered to be abstract learners. Within the control group, there were 14 students who were considered to be abstract learners.

To determine student achievement on understanding concrete concepts, student scores on the concrete questions of the unit 3 content survey were compared to their respective scores on the concrete questions of the unit 2 content survey to determine if their score had improved. The results of these analyses are shown in tables 9 and 10. The p-value of 0.78 indicates that there is no significant difference between the control and experimental groups when comparing student scores on the concrete subsections of the unit 3 and unit 2 content surveys.

Table 9. Data Summary of Comparisons of Abstract Conceptualizers

	U3-U2 Concrete of Experimental Group	U3-U2 Concrete of Control Group
n	25	14
Σx	16	13
Σx^2	272	125
SS	261.76	112.93
Mean	0.64	0.929

Table 10. T-Test of Comparisons of Abstract Conceptualizers Assuming Unequal Sample Variances

Difference between Means	t	df	P-value
-0.289	-0.28	29.74	0.78

The second research question asks: "Does concept mapping increase student achievement on understanding abstract concepts in concrete-learning style students?" In order to answer that question, student scores on the P1LSI and P2LSI were analyzed to determine which students used Concrete Experimentation as a dominant mode of learning. In order for a student to be considered a concrete learner, their scores on the Concrete Experimentation subsection of the LSI must exceed their scores on the Abstract Conceptualization section by the standard error of the overall difference between those scores, which was determined to be plus or minus 1 unit. Only those students considered to be concrete learners on both the P1LSI and P2LSI were examined. Within the experimental group, there were only 3 students who were considered to be concrete learners. Within the control group, there was only 1 student who was considered to be a concrete learner.

To determine student achievement on understanding abstract concepts, student scores on the abstract questions of the unit 3 content survey were compared to their respective scores on the abstract questions of the unit 2 content survey to determine if their score had improved. With such a small sample size, conducting a valid analysis is not possible. Due to an unknown factor, there were very few students who rely on Concrete Experimentation as a dominant mode of thinking within the Anatomy & Physiology Laboratory course. Speculations on the possible reasons for this outcome are presented within the discussion chapter.

The third research question asks: “Does concept mapping change student learning style?” To determine if that is the case, differences in student scores on the Abstract Conceptualization subsection of the P1LSI and P2LSI were calculated. Student score differences in the Concrete Experimentation subsection of the P1LSI and P2LSI were also calculated. The score differences between control and experimental groups were then compared and analyzed via a t-test to determine if there was a significant difference. As seen in table 11, there is no significant difference between the control and experimental groups with respect to changes in the Abstract Conceptualization subsection of the LSIs.

Table 11. Differenences of Scores on the Abstract Conceptualization Subsection between Groups

	P2LSIAC-P1LSIAC Experimental	P2LSIAC-P1LSIAC Control
n	47	28
mean	-0.213	1.93
p (two-tailed)	0.114	

As seen in table 12, there is no significant difference between the control and experimental groups with respect to changes in the Concrete Experimentation subsection of the LSIs. Taken as a whole, this data suggests that using concept mapping as a teaching and learning tool does not change learning styles.

Table 12. Differences of Scores on the Concrete Experimentation Subsection between Groups

	P2LSICE-P1LSICE Experimental	P2LSICE-P1LSICE Control
n	47	28
mean	-0.298	-0.464
p (two-tailed)	0.897	

Interview Results. In an effort to provide a broad analysis of the types of students who chose to take an undergraduate pre-nursing anatomy and physiology laboratory course, I purposefully selected students for interviews that exemplified low, average, and high achievers within predominant learning styles as determined by the Kolb LSI. When chosing students for interviews based on achievement, selection was based on three categories: high-performing (A average), average performing (B average), and low-performing students (C average or lower). Within those performance groups, students were further identified as having an abstract learning style, a concrete learning style, or a median learning style. Either due to the small sample size or an unknown factor, students of all learning styles were not found in all performance groups.

Interviews were conducted on an individual basis in the classroom setting where students were to reiterate their responses to the surveys as well as explain their thinking processes as they formulated their answers. This was done in an effort to identify recurring themes in the students' thinking processes as they described their understanding of concepts as well as the areas where their understanding was inadequate. Following are the results of those interviews:

Interview with High-Performing, Abstract-Learning style Student from Experimental Group. The first student chosen, known as "Ashley", was a 20 year old undergraduate female with an A average, therefore she is considered to be a high-performing student and was a member of the experimental group. Ashley's scores on the PILSI were higher on Abstract Conceptualization than on Concrete Experience; therefore, her dominant mode of learning is through Abstract Conceptualization. Her scores were similar on the P2LSI. Below is an example of Ashley's explanations:

> R: Okay question two says identify the endocrine glands shown on the projector. So what is structure a?
>
> Ashley: Thymus.
>
> R: And how you know that?
>
> Ashley: No wait that is the thyroid.
>
> R: How do you know that?
>
> Ashley: Because that's what it is, because it is in the neck, and the thymus should be in the chest.

R: So you know it because of location?

Ashley: Yes

R: Are there any other factors that help you to identify it?

Ashley: No.

R: Okay, what about structure B?

Ashley: It is the adrenal gland.

R: And how do you know that?

Ashley: Because it is on top of the kidneys.

R: So how were you able to identify that properly?

Ashley: Because of its location.

R: Okay, what about structure C?

Ashley: That is the hypothalamus.

R: And how do you know that?

Ashley: Because it is above the pituitary gland.

R: So again you know that because of location?

Ashley: Yes.

When analyzing the recurring themes to that she attributes her understanding, the most common explanations are visual cues (11), usually based upon location, attributing importance to concepts (5), and a hierarchical understanding (3). The fact that she attributes importance to concepts that faciliates her understanding is consistent with prior studies on abstract learning style students as examined by Tsai and Thomas (2011). When analyzing the recurring themes to that she attributes a lack of understanding, the most common explanations are an absence of details (6) and a lack of studying (4).

Interview with Average-Performing, Abstract-Learning style Student from Experimental Group. The second student chosen for interviews, Brittany, was a 20 year old undergraduate female with a B average; therefore, she is considered to be an average-performing student. Brittany's scores on the PILSI were higher in Abstract Conceptualization than in Concrete Experience, therefore, her dominant mode of learning is through Abstract Conceptualization. Her dominant mode of thinking did not change as evidenced by her subsection scores on the P2LSI. Brittany was part of the experimental group.

> R: Question one says explain the process by which aldosterone increases blood pressure.
>
> Brittany: (Long pause) Aldosterone is from the pituitary and that is all I can give you right now.
>
> R: Why do you remember that?
>
> Brittany: Mainly from pictures in the lab manual.
>
> R: Okay, so when you say you remember the pictures in the lab manual, what are you remembering about them?
>
> Brittany: Just the diagrams and not so much the reading, but the diagrams and explanations on the diagrams.

When analyzing the recurring themes she describes in her understanding, the most common explanations are visual cues (18), usually based upon image recognition, a hierarchical understanding (4), personal experience (3), prior knowledge from other classes (3), and auditory cues (3). This student is a highly visual learner as evidenced by her explanations. When analyzing the recurring themes to that she attributes a lack of understanding, the most common explanations are a lack of prior knowledge (5) and a lack of studying (4).

Interview with High-Performing, Abstract-Thinking Student from Control Group Exhibiting a Transition to Median-Thinking. The third student chosen for interviews was a 19-year old undergraduate female, Chelsea, from the control group. Chelsea had an A average; therefore, she is considered to be a high-performing student. Chelsea's scores on the phase I LSI was significantly higher in the Abstract Conceptualization subsection (28) than in the Concrete Experimentation subsection (19), indicating her dominant mode of learning is through Abstract Conceptualization. Interestingly, her scores on the phase II LSI exhibited a significant change. Chelsea's scores within the Abstract Conceptualization subsection was slightly lower at 36 than her score of 37 on the Concrete Experimentation subsection, implying that she has experienced a transition to a median learning style centered on the continuum from Abstract Conceptualization to Concrete Experimentation.

R: Question one says explain the process by which aldosterone increases blood pressure.

Chelsea: Okay, aldosterone is the hormone that…um, keeps… They keep sodium in the blood which increases the pressure inside the arteries and causes the blood to push on artery walls more.

R: How do you know that?

Chelsea: Um…for me, it is kind of like a photographic type of memory kind of thing. I would study for the final exam and I am one of the people that would write out all the notes in the lecture and writing it out helps me to remember and to recall which one aldosterone was compared to the other hormones. I like picture my notes that I wrote out my head and where it was on the page and like if it was in the lecture notes… I think it was like a little arrow and I remember it said for one of them about raising blood pressure… the long-term regulation of raising the blood pressure renin is released. It does like the angiotensin and angiotensin can regulate it directly or it would go the other arrow side but something about aldosterone being released from the kidney? I don't know. I just did it based on photographic I guess.

R: So you picture the words in your head?

Chelsea: Yes.

R: So when you picture the words in your head are you picturing your notes of the notes of the lecture?

Chelsea: My notes.

When analyzing the recurring themes in her understanding, the most common explanations are visual cues (21), 12 of which were due to shape or location while nine of which were due to visualization of her handwritten notes. Other common explanations were word associations (5) and prior classroom exposure (3). This student is also a highly visual learner as evidenced by her explanations. When analyzing the recurring themes to that she attributes a lack of understanding, the most common explanations are a lack of studying (7) and non-translation to long-term memory (4).

Interview with Average-Performing, Abstract-Thinking Student from Experimental Group. The fourth student chosen for interviews from the experimental group is Derrick, a 41-year old undergraduate male. Derrick has a B average; therefore, he is considered to be an average-performing student. Derrick's scores on the phase I LSI were higher in the Abstract Conceptualization subsection (27) than in the Concrete Experimentation subsection (16), indicating that his dominant mode of learning is through Abstract Conceptualization. Interestingly, his scores on the phase II LSI exhibited a significant change. Derrick's scores within the Abstract Conceptualization subsection were higher at 34 than his score of 15 on the

Concrete Experimentation subsection, implying that his learning style has become even more dependent upon Abstract Conceptualization.

R: Excellent, question number two says identify the endocrine glands shown on the projector. What is structure A?

Derrick: That is the thyroid.

R: How do you know that?

Derrick: I remember from studying the lab manual and it is pure memorization.

R: Okay, when you remember it, is that words or pictures? What is it about that that clues you in that that structure is the thyroid?

Derrick: The pictures.

R: What about the picture are you remembering? What led you to associate this picture with thyroid?

Derrick: Well, in studying the lab manual, I noted that it is in the head it is on the neck.

R: So location is one thing. Any other factors?

Derrick: It just has that same picture that would be in the book. It has the texture in the color in that sort of stands out.

R: How about structure B?

Derrick: That is the…um... Adrenaline… Gland.

R: Okay, how did you know what you did?

Derrick: Well it is on top of the kidney, and I know that the gland on top of the kidney releases adrenaline and some other substance.

R: How did you know that it produces adrenaline but not remember the name of the gland?

Derrick: (Long pause)…

R: Is it something that was emphasized enough in the class or was that something you didn't study enough?

Derrick: Well, it is just repetition. I have to go through repetition and studying. I made an association with the kidney and the organ on top and the other materials that we covered. I know that on top of the kidney lies the adrenal gland or whatever it is… and that is where adrenaline essentially comes from. So, it is a combination of looking at the materials in the lab manual…the pictures… as well as the lecture notes from the course where you learn to associate the hormones and such.

R: What about structure C?

Derrick: The pituitary gland.

R: How do you know that?

Derrick: How do I know that… (Long pause)… Studying the pictures in the lab manual.

R: Now when you say you know it from the pictures the lab manual, what do you do? Do you look at them and cover them up? What strategy do you use?

Derrick: For me it is kind of scanning the picture in associating what is around it. In this case it is a little piece shaped at the tip. If it had been pointing to another part, it would've been difficult to remember, but because that stands out a little more, I am able to remember the picture.

When analyzing the recurring themes in his understanding, the most common explanation is visual cues (27), 20 of that were due to some type of visual recollection while 4 of that were due to location and 3 being due to shape. Other common explanations were recall of notes (9), word associations (3), personal experience (3) and auditory recall of the lecture (3). This student is also a highly visual learner as evidenced by his explanations. There are no consistently recurring themes to which this student attributes a lack of understanding.

Interview with Abstract-Learning style, Low-Performing Student from Experimental Group. The fifth student chosen for interviews was Emily, a 20-year old undergraduate female who was in the experimental group. Emily had a C average; therefore, she is considered to be a low-performing student. Emily's scores on the phase I LSI were higher in the Abstract Conceptualization subsection (34) than in the Concrete Experimentation subsection (20), indicating that her dominant mode of learning is through Abstract Conceptualization. Interestingly, her scores on the phase II LSI exhibited a change: her scores within the Abstract Conceptualization subsection were higher at 26 than her score of 19 on the Concrete Experimentation subsection, implying that her learning style has become slightly more median, but she is still considered to be an Abstract Conceptualizer.

R: Question number three says why does exogenous testosterone, in other words anabolic steroids, cause gynecomastia?

Emily: Because the hormones are out of balance.

R: Okay, how were you able to remember that?

Emily: (Long pause)… I mean… just because of basic knowledge of steroids. The purpose of them is to… well… like… if you are using them for… like… performance purposes… just basic knowledge about them I guess.

R: Where did you get that basic knowledge from?

Emily: Probably from high school.

R: Okay, so previous experience?

Emily: Yeah. How like baseball players and stuff would get caught.

When analyzing the recurring themes in her understanding, the most common explanation is visual cues (20), 12 of that were due to shape or while 8 of that were due to location. Another common explanation was personal experience (8). This student is also a highly visual learner as evidenced by her explanations. When analyzing the recurring themes to that she attributes a lack of understanding, the most common explanations are a lack of studying (3), a lack of prior exposure (3) and the complex nature of the concepts (3).

Interview with Abstract-Learning style, Average-Performing Student from Control Group. The sixth student chosen for interviews was a 20-year old undergraduate female from the control group known as Farrah. Farrah had a B average; therefore, she is considered to be an average-performing student. Farrah’s scores on the PILSI were only slightly higher in the Abstract Conceptualization subsection (24) than in the Concrete Experimentation subsection (21), indicating that she is skewed towards Abstract Conceptualization. Interestingly, Farrah’s scores on the P2LSI exhibited a significant change. Farrah’s scores within the Abstract Conceptualization subsection were significantly higher at 43 than her score of 19 on the Concrete Experimentation subsection, implying that her learning style has become more dependent on Abstract Conceptualization.

> R: Okay, let's go to question number two. Question number two says identify the male reproductive structures shown on the projector. What is structure A?
>
> Farrah: I think that is like, epididymis. I don't remember how to say it.
>
> R: Okay you know that?
>
> Farrah: It was on the test and I just remembered that the sequence… I don't know if you would call it sequence… but the route, I guess, and where the sperm goes from that one there to there.

R: What about structure B?

Farrah: B starts with an a-… It's like albumin something.

R: Okay how do you know that?

Farrah: I remember it from the PowerPoint. I can see the words but I don't know exactly what it is. I know it starts within a-.

R: Okay, what about structure C?

Farrah: C…um… that's the spongy… I want to say… no… yeah… that is the…um…gosh… I think it's like, cavernosa spongy something.

R: How do you know that?

Farrah: I remember seeing it on the slides and I remember our TA talking about that.

When analyzing the recurring themes in her understanding, the most common explanation is visual cues (31), 14 of those were due to location while 13 were due to shape. Four responses were also attributed to visual cues, but it is unclear as to the nature of the association. Other common explanations were a hierarchal understanding (5), word associations (5), and rote memorization (3). This student is also a highly visual learner as evidenced by her explanations. When analyzing the recurring themes to that she attributes a lack of understanding, the most common explanation is a lack of prior exposure (3).

Interview with Abstract-Learning style, High-Performing Student from Control Group. The seventh student chosen for interviews was a 20-year old undergraduate female from the control group known as Gwyn. Gywn had an A average; therefore, she is considered to be a high-performing student. Gwyn's scores on the phase I LSI were only slightly higher in the Abstract Conceptualization subsection (29) than in the Concrete Experimentation subsection (23), indicating that her dominant mode of learning is Abstract Conceptualization. Gwyn's scores on the phase II LSI exhibited little change. Her scores within the Abstract Conceptualization subsection were higher at 27 than her score of 20 on the Concrete Experimentation subsection, implying that her learning style has remained constant.

R: What about question number eight? It says identify the embryonic structures shown on the projector. Structure A is pointing to a germ layer. What is that germ layer?

Gwyn: Okay… gosh… hold on a second… I think that is the… the… it's like… I want to say like endo-germ or meso- germ. I remember the three germ layers… I can't remember the order.

R: Why do you think that doesn't stand out to you?

Gwyn: The picture that I remember seeing was a little different, but I don't know specifically why. I just remember the three layers I can't remember what order they were in though.

R: What about structure B? This is pointing to the maternal portion of the placenta.

Gwyn: Okay… I remember this… I remember seeing the exact structure… but I can't remember the exact name of that.

R: Why not?

Gwyn: Um…. I don't know. It didn't stick very well… I don't know.

R: Okay, structure C, while there is no picture, asks for the embryonic stage at which neuralation occurs.

Gwyn: I have no idea.

R: Why do you think you don't know that?

Gwyn: I just can't remember to be honest.

When analyzing the recurring themes in her understanding, the most common explanation is visual cues (15), 11 of that were due to recollection of a diagram while 3 of that were due to location (1 is due to shape). Other common explanations were recollection of the powerpoint (10), auditory recall of the lecture (8) and emphasis placed on the concept by the teaching assistant (4). This student is a highly visual learner as evidenced by her explanations, but also recalls a great deal of information in an auditory fashion. There are no significant recurring themes to which she attributes a lack of understanding.

Interview Themes. Themes and their respective frequencies to which students attributed their understanding as well as themes to which students attributed a lack of understanding were tabulated among high-, average-, and low-performing students as presented within table 13.

Table 13. Frequencies of Themes that Students Attributed Their Understanding or a Lack of Understanding Grouped by Achievement Level

High Performing (A average)	Average Performing (B average)	Low Performing (C Average or lower)
Visual Cues (47) Lack of studying (11) Recall of Powerpoint (10) Auditory Cues (8) Absence of details (6) Attributing Importance (5) Word Associations (5) Non-translation to long-term memory (4) Hierarchical Understanding (3) Prior knowledge (3)	Visual Cues (76) Recall of Notes (9) Hierarchical Understanding (9) Word Associations (8) Lack of Prior Knowledge (8) Personal Experience (6) Auditory Cues (6) Prior Knowledge (3) Rote Memorization (3)	Visual Cues (20) Personal Experience (8) Lack of studying (3) Lack of Prior knowledge (3) Complex Nature of Concepts (3)

Analysis of Student Samples of Concept Maps. An analysis of a sample of student concept maps is presented in the following section. The method of analysis is concordant with the scoring rubric provided by Novak and Gowin (1984). This scoring model involves assigning one point for meaningful, valid propositions and relationships, five points for each level of valid hierarchical organization, ten points for each meaningful cross-link used, and one point for each valid example given of a concept. A similar analysis of student concept mapping will be presented.

In the introductory concept mapping activity, students were asked to create a concept map with the effects of the sympathetic nervous system on the organ systems under study at that particular time within the laboratory classroom. Those organ systems were the digestive, urinary, and the respiratory systems.

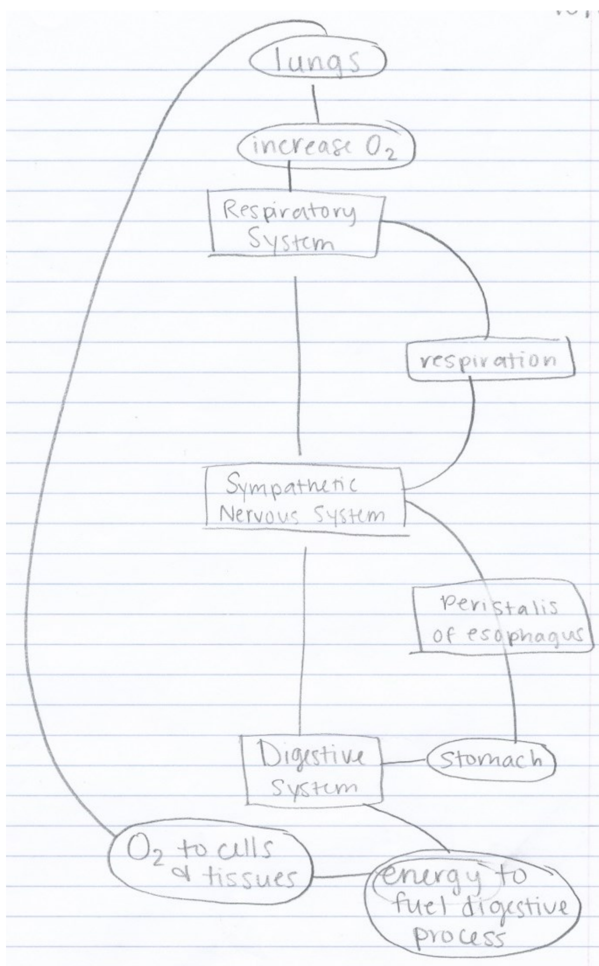

Figure 1. Introductory Concept Mapping Activity Student Work Sample of Average-Performing, Abstract Conceptualization Student

The student who submitted this work sample had a B average in the class and is therefore considered to be an average-performing student. This student had a learning style favoring abstract-conceptualization. This style of concept map demonstrates an ordinal approach to the understanding of the concepts. This student only connected the actions of the sympathetic nervous system to the respiratory and digestive systems, implying an incomplete understanding of the effects of the sympathetic nervous system on the various organ systems of the body. Due to the fact there are no linking words, this student receives a 0 for propositions. The hierarchy is somewhat difficult to understand, but the student has created a hierarchy of systems to substructures of those systems, so this student has two levels of hierarchy and receives 10 points. There is one valid cross-link which shows the respiratory system providing oxygen to cells to fuel digestive processes; therefore, this student receives 10 points. This student has given two valid examples, one of stomach, and one of the lungs for a total of 2 points. The overall score for this student's concept map is 22 points.

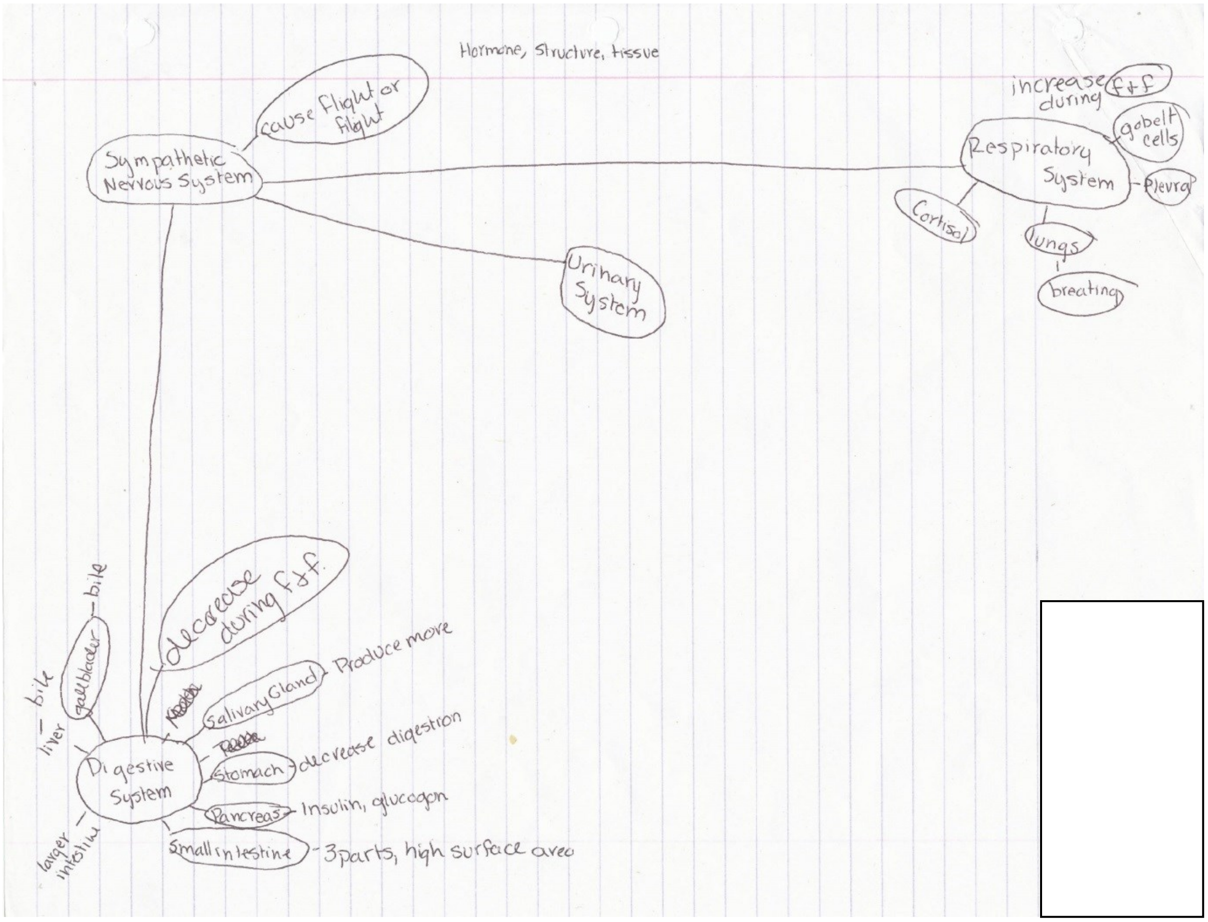

Figure 2. Introductory Concept Mapping Activity Student Work Sample of High-Performing, Abstract Conceptualization Student

The student who submitted this work sample had an A average in the class and is therefore considered to be a high-performing student favoring Abstract Conceptualization. The student connected the actions of the sympathetic nervous system to the respiratory and digestive systems extensively, and while she did include the urinary system in their map, she didn't delineate the effects of the sympathetic nervous system on the anatomical structures of the urinary system, implying an incomplete understanding of the effects of the sympathetic nervous system on the various organ systems of the body. This student has a valid proposition in that the sympathetic nervous system encourages fight or flight, as well as having the stomach decrease digestion; therefore, she receives two points for propositions. This student demonstrates two levels of hierarchy with organ systems and substructures; therefore, she receives 10 points for hierarchy. This student has made no cross-links and thus receives 0 points. She has given 10 examples of substructures and receives one point for each. The total number of points on this concept map is 22.

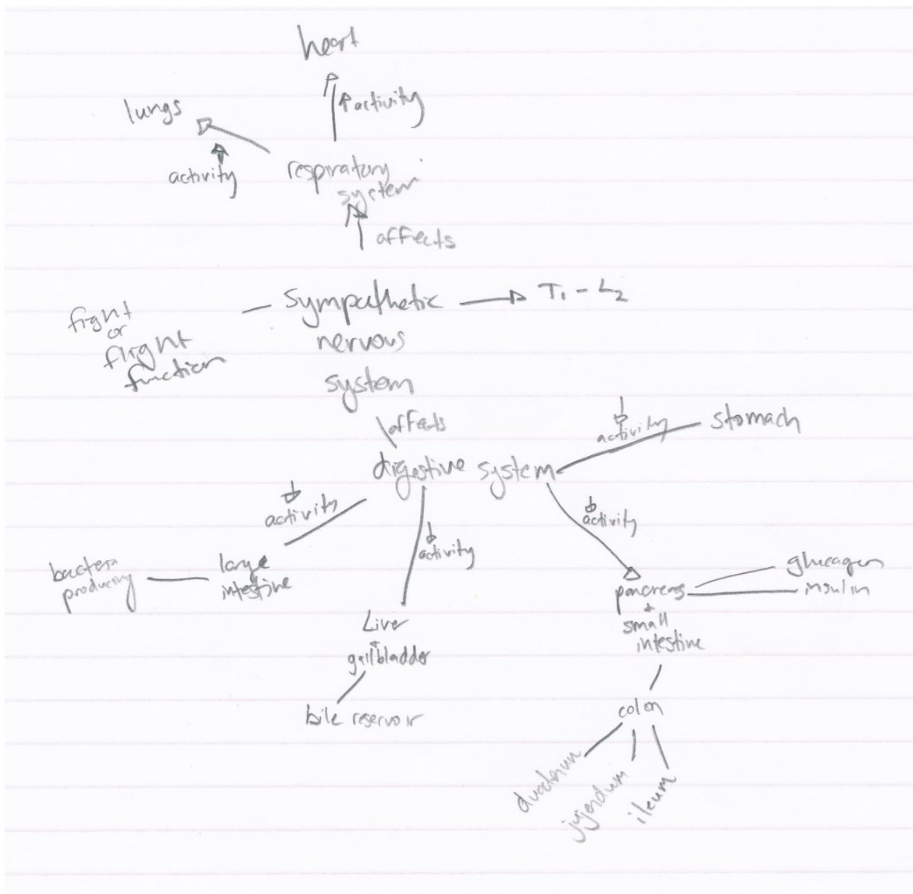

Figure 3. Introductory Concept Mapping Activity Student Work Sample of High-Performing, Median Learning style Student

The student who submitted this work sample had an A average in the class and had a median learning style. This style of concept map demonstrates an understanding of the basic concepts and is unable to link seemingly disconnected concepts. This student only connected the actions of the sympathetic nervous system to the respiratory and digestive systems, implying an incomplete understanding of the effects of the sympathetic nervous system on the various organ systems of the body. She has seven correct propositions and receives 7 points. This student has two levels of hierarchy consisting of the organ systems and their respective substructures for 10 points. She has no cross-links. This student has given 10 correct examples for a total of 10 points. This concept map receives 27 points.

The first concept mapping activity was a pre-constructed concept map that related the functions of the Endocrine, Urinary, and Reproductive Systems with concepts related to components of the blood. As this concept map was pre-constructed, it was only necessary for students to insert new structures within new nodes, create cross-links between nodes that relate concepts, and insert prepositional phrases linking subsequent nodes to one another. The analyses of these concept maps are based upon new material that the students added to the pre-constructed map.

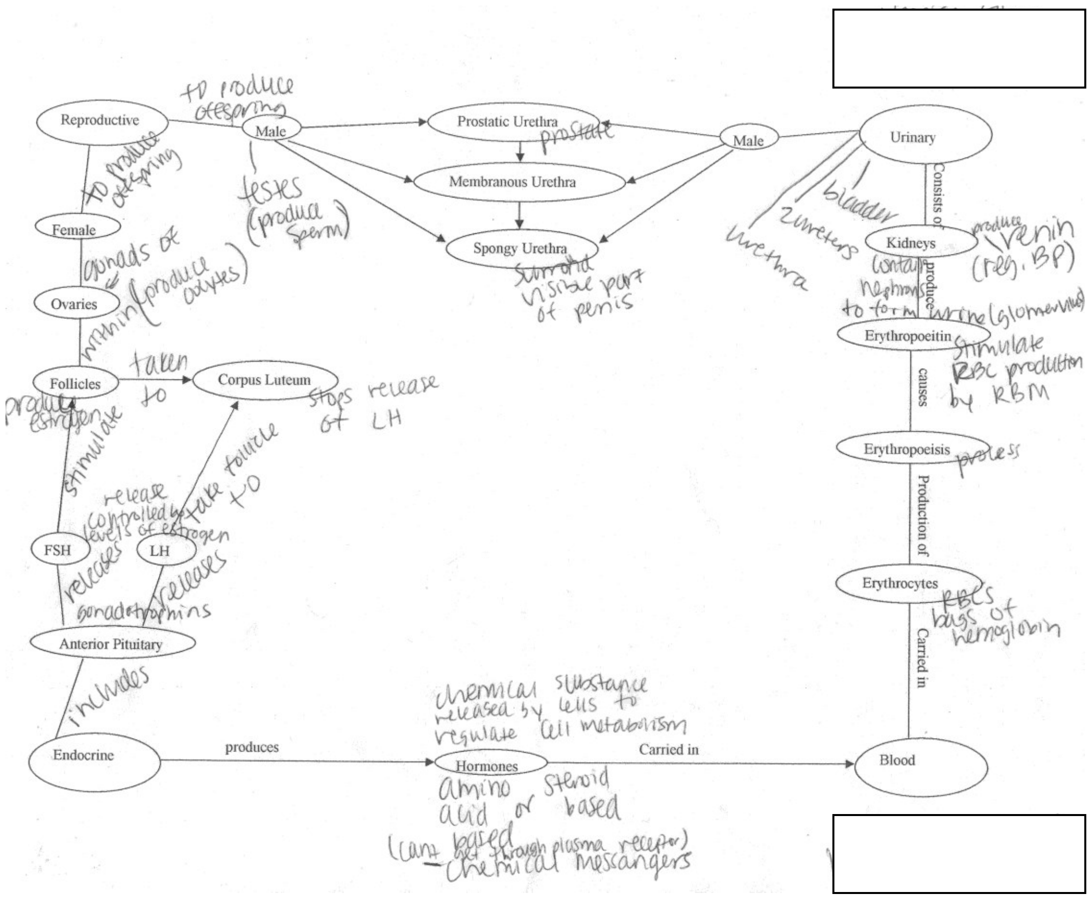

Figure 4. First Concept Mapping Activity Student Work Sample of Low-Performing, Abstract Conceptualization Student

This student had a C average and had a learning style favoring abstract conceptualization. This concept map has several features that distinguish it as being cognitively unsophisticated. The new nodes of anatomical structures that this student has chosen to write in are only connected to a larger nodes that represent the organ system under study. New nodes have no cross-links. The propositions used to link the nodes are relatively simple words such as “produces”, “includes”, and “taken to” but there are 9 introduced propositions for 9 points. This student has added no additional levels of hierarchy and thus receives 0 points. There are no cross-links. This student has written in some personal notes and examples that relate to surrounding nodes of concepts, however, those notes have not been linked to other topics.

Despite that, she still has a total of 10 correct examples and thus receives 10 points. This concept map receives a total of 19 points.

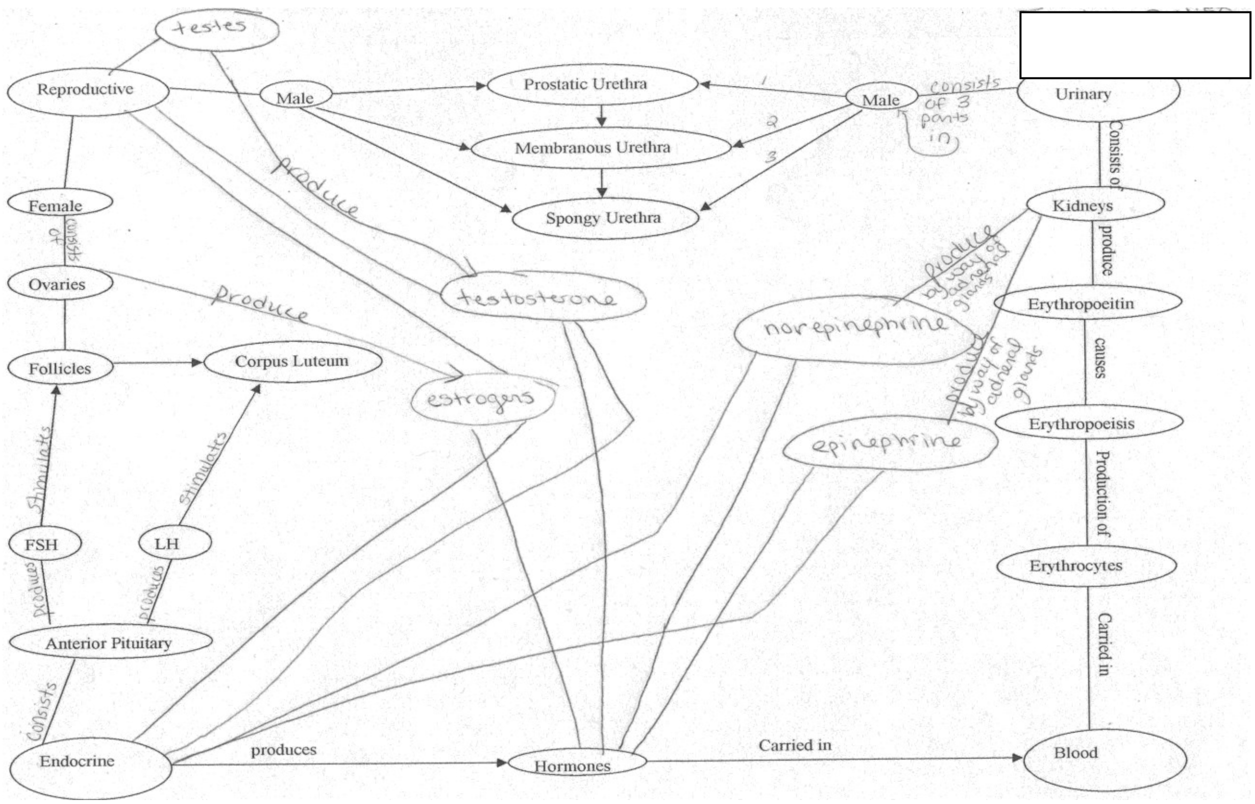

Figure 5. First Concept Mapping Activity Student Work Sample of Average-Performing, Abstract Conceptualization Student

This student had a B average with an Abstract Conceptualization learning style. The concept map has several features that identify it as being a map of intermediate cognitive sophistication. The new nodes of anatomical structures that this student has chosen to write in are not only connected to a larger nodes that represent the organ system under study, but also to other nodes, demonstrating a basic understanding of the interactions between these systems. Due to the fact that the student has chosen to write in new nodes, they have introduced an additional level of hierarchy and thus receive 5 points. This student actually uses too many cross-links; therefore, it shows that while the basic understanding is present, a hierarchical organization of the concepts is absent. There are seven valid cross-links for a total of 14 points. The propositions that link the nodes are relatively simple words such as “produces”, but she interestingly used notes to describe (albeit incorrectly) interactions between the kidneys and the endocrine system. Due to the correct usage of 12 propositions, this student receives 12 points. There are five valid examples for an additional 5 points, yielding a grand total of 36 points.

The second concept mapping activity was a pre-constructed concept map that related the functions of the Digestive, Circulatory, and Respiratory Systems with that of concepts on Embryonic Development. As this concept map was pre-constructed, it was only necessary for students to insert any new structures within new nodes, create cross-links between nodes that relate concepts, and insert prepositional phrases linking subsequent nodes to one another. The analyses of these concept maps are based upon any new material that the students added to the pre-constructed map.

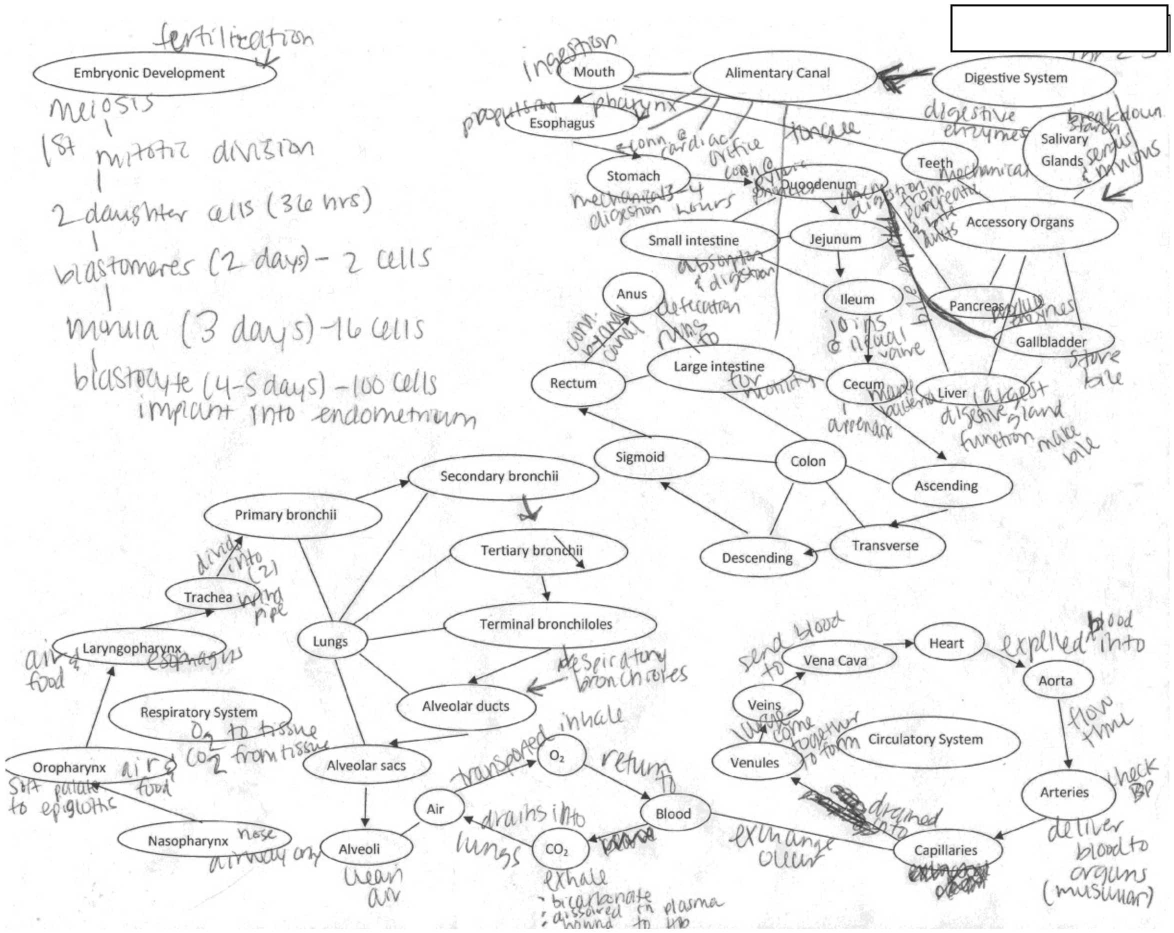

Figure 6. Second Concept Mapping Activity Student Work Sample of High-Performing, Abstract Conceptualization Student

This student had an A average with an Abstract Conceptualization learning style. This student has only added a few new nodes and not properly defined them as nodes by enclosing them in circles. Therefore, there are no additional levels of hierarchy. The examples added to embryonic development reflect an ordinal understanding of the stages of embryonic development, but there are no cross-links to other concepts. Regardless, this student receives 7 points for valid examples. A great deal of propositions were added to the existing nodes, as no propositions were included in this concept map. This student's propositions reflect that she is attempting to integrate the physiological functions of various anatomical structures to one another. The total number of correct propositions are 17. There are many crosslinks within the digestive system, implying that she has a thorough understanding of the anatomy involved. There are no crosslinks added to the respiratory or circulatory systems, implying that her knowledge of the interactions within the systems is largely incomplete. Due to four valid cross-links within the digestive system, this student receives 8 points, bringing the total score for this concept map to 32 points.

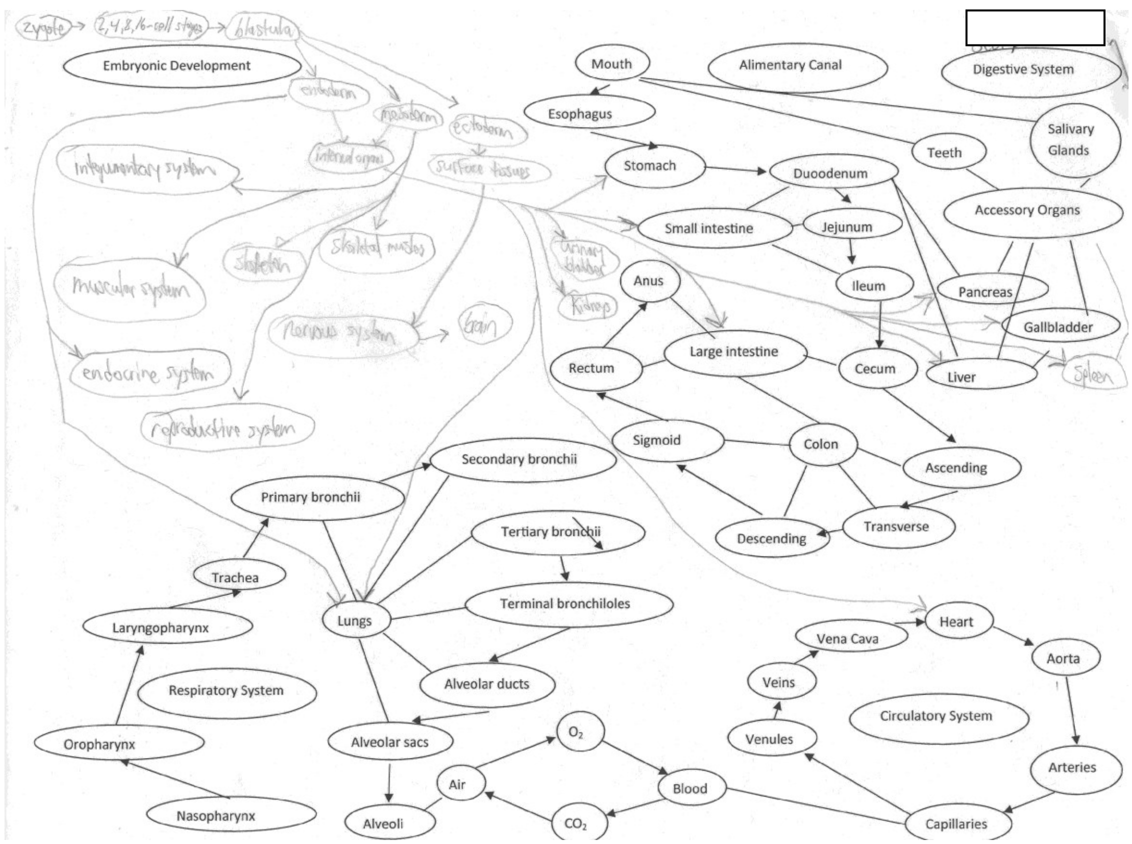

Figure 7. Second Concept Mapping Activity Student Work Sample of Average-Performing, Abstract Conceptualization Student

This student had a B average and has an Abstract Conceptualization learning style. There are several new nodes which are properly defined as nodes by being enclosed in circles. As this student has introduced an additional level of hierarchy, he receives 5 points. The concepts added to embryonic development reflect an ordinal understanding of the stages of embryonic development, and while there are cross-links to other concepts, all of those crosslinks lack joining propositions. There are no crosslinks added to the respiratory or circulatory systems, implying that his knowledge of the interactions within the systems is largely incomplete. The number of valid cross-links are six; therefore, this student receives 12 points. No propositions have been added to the existing nodes, and there is little evidence that this student understands the interactions between concepts. As there are no propositions, he receives no points. This student has provided five relevant examples of stages of embryonic development, and thus receives 5 points. The total number of points for this concept map is 22.

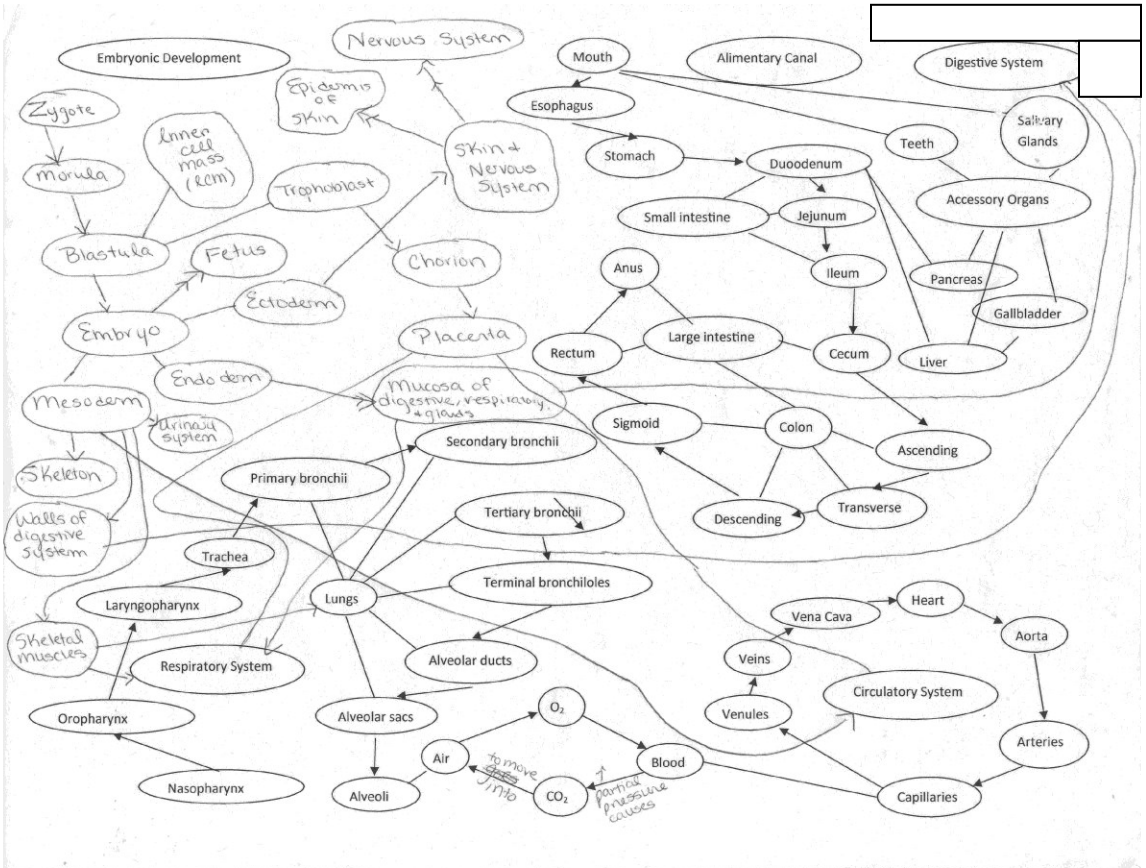

Figure 8. Second Concept Mapping Activity Student Work Sample of High-Performing, Median Learning style Student

This student had an A average and had a learning style centered on the Abstract Conceptualization to Concrete Experience spectrum (defined as a median learning style). Several new nodes have been added and are properly defined as nodes by being enclosed them in circles; therefore, due to the introduction of an additional level of hierarchy, this concept map receives 5 points. The concepts added to embryonic development reflect an ordinal understanding of the stages of embryonic development, as well as a hierarchical understanding of the structures that develop. This student has added only two propositions to the existing nodes and thus receives 2 points. The lack of propositions could reflect that she doesn't understand how to integrate the physiological functions of various anatomical structures to one another. There are many crosslinks of embryonic development to other concepts, implying that she has a thorough understanding of embryonic development. Due to the five relevant cross-links, she receives 10 points. Due to the addition of 20 relevant examples, this student receives 20 additional points for a total of 37 points.

The final concept mapping activity was a closed-ended concept map activity where students had their choice of creating a concept map on concepts of the Reproductive System, Embryonic Development, or Principles of Genetics. The students were given a minimal list of terms that were expected to be diagrammed within nodes on the concept map. There was no predefined structure for the student to follow; therefore, the arrangement of the concept map was dependent on the student's understanding of the topic as well as their ability to organize their understanding and communicate it effectively. Students could also create a composite concept map that integrated concepts from all possible closed-ended lists.

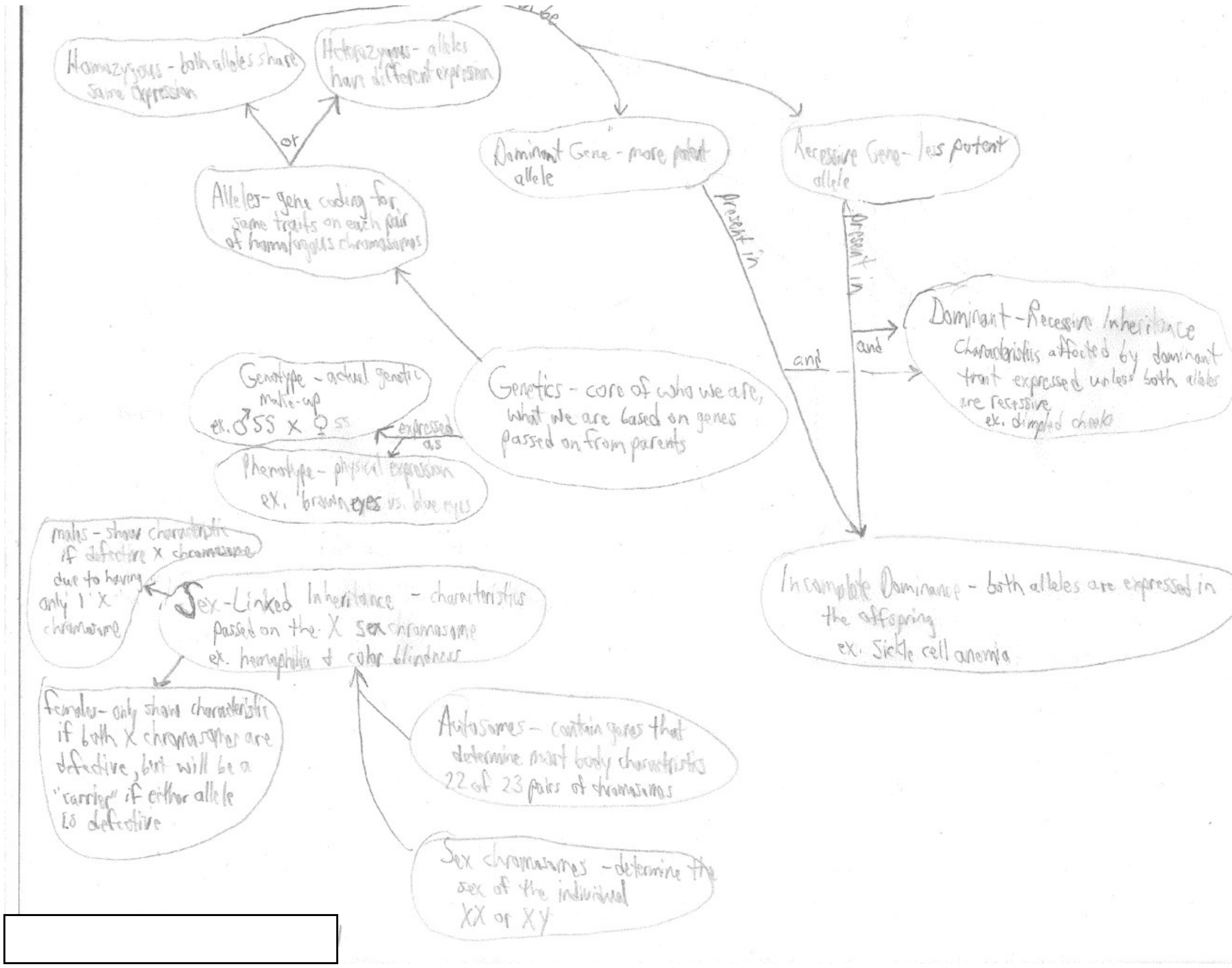

Figure 9. Final Concept Mapping Activity Student Work Sample of Average-Performing, Abstract Conceptualization Student

This student had a B average and had a learning style favoring Abstract Conceptualization, which on the P2LSI became even more strongly in favor of Abstract Conceptualization. She has chosen to complete a concept map on the Principles of Genetics unit. There are only two discernible levels of hierarchy, and receives 10 points. With only four simple propositions correctly placed, this student receives only 4 points. There are no valid cross-links. There are 15 related examples and therefore, 15 additional points. The total score for this concept map is 29 points.

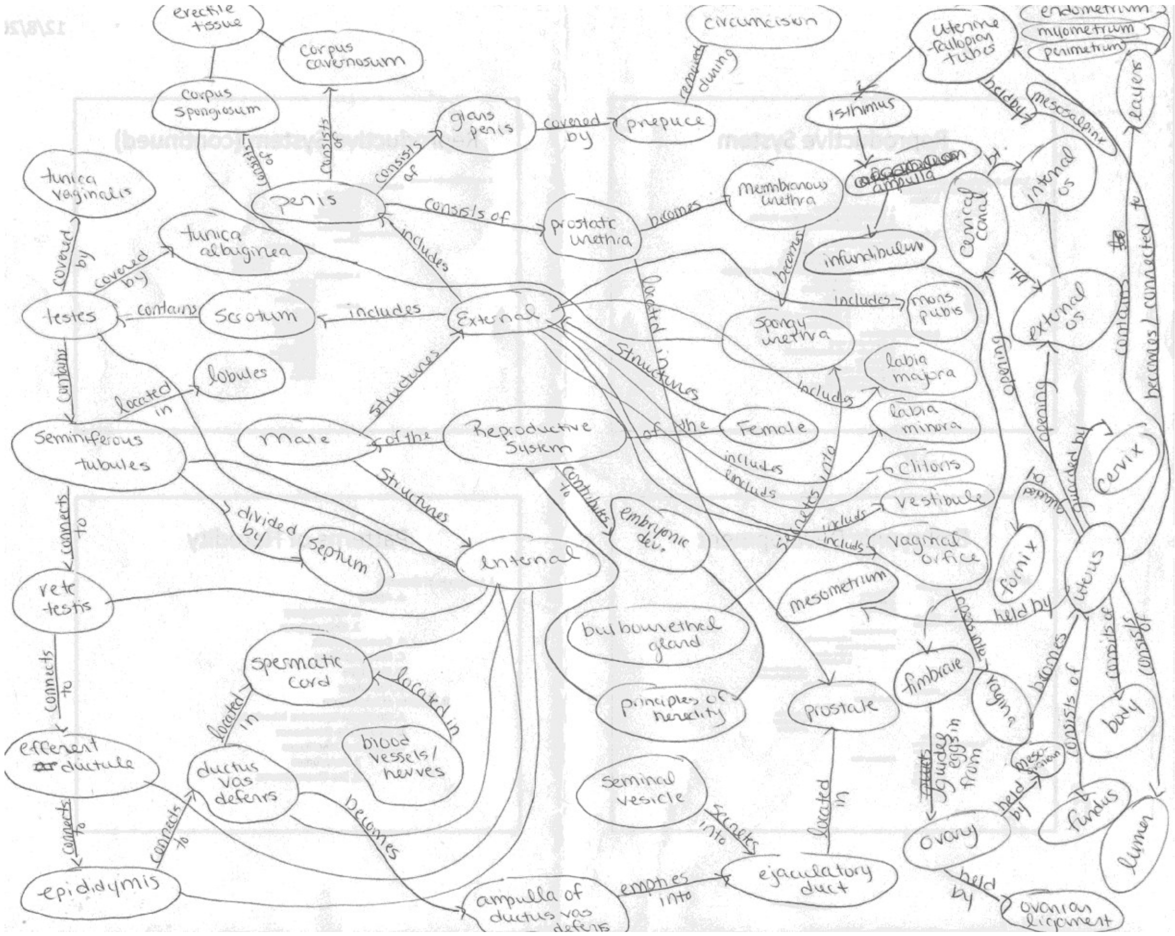

Figure 10. Final Concept Mapping Activity Student Work Sample of High Performing, Median Learning style Student

This student had an A average with a median learning style centered on the spectrum from Abstract Conceptualization to Concrete Experience. This concept map focused on the reproductive system. There is an abundance of nodes, crosslinks, and propositions implying a thorough understanding of the reproductive system. There are two discernible levels of hierarchy created by dividing the reproductive system into male and female then internal and external parts and therefore, receives 10 points. This student has 52 valid propositions and receives 52 points. There are only two valid cross-links for 4 additional points. This student has given 62 examples for a total score of 128 points.

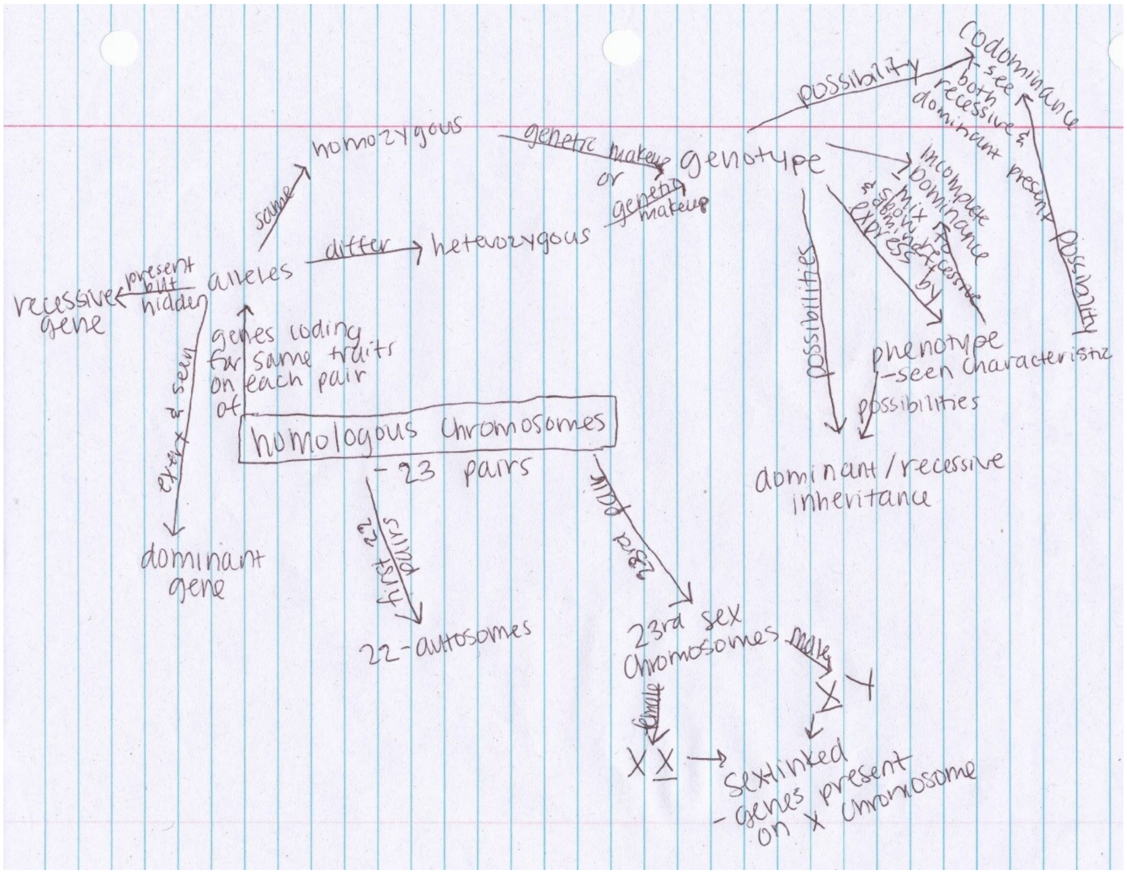

Figure 11. Final Concept Mapping Activity Student Work Sample of Low Performing, Abstract Conceptualization Student

This student had a C average with a learning style strongly favoring Abstract Conceptualization. She has chosen to complete a concept map on the Principles of Genetics unit. All necessary nodes have been included, but there no valid cross-links between concepts. There are no discernible levels of hierarchy present. The propositions used to link concepts are relatively simplistic, but accurate for a total of 10 points. The student has included 10 relative examples for a total score of 20 points on this concept map.

Discussion

Research Questions. The first research question addressed by this study is: "Does concept mapping increase student achievement on concrete concepts in abstract learning style students?" Due to the fact that the differences in scores on the concrete subsections of the third and second survey was insignificant between Abstract Conceptualizers in both control and experimental groups,it cannot be concluded that concept mapping increases student achievement on concrete concepts in abstract learning style students. In examining the data, I was also intrigued as to whether concept mapping would increase student achievement on concrete concepts in students who were classified as concrete or median learners. Due to the fact that there were only three concrete learning style students in the experimental group and one in the control group, an analysis of these students would have such limited generalizability as to make it ineffectual. In addition, due to the fact that there was only one student within the experimental group whose scores on both the P1LSI and P2LSI were indicative of median thinkers, an analysis could not be performed as to the effects of concept mapping on median thinkers.

The second research question addressed by this study is: "Does concept mapping increase student achievement on abstract concepts in concrete learning style students?" Due to unknown factors, there was an extremely small number of students who rely on Concrete Experience and an analysis of those students would be ineffectual. In contemplating this issue, I reflected on Kolb's definition of Concrete Experience as learning concepts through experiences and feelings. According to research by Tsai and Thomas (2011), students with a concrete learning style attribute equal importance to all information acquired rather than prioritizing the relative importance of the information. I believe that students who rely on Concrete Experience as a learning style are rarely able to progress to such high level classes as Anatomy & Physiology because of their inability to organize the overwhelming amount of information into a hierarchy. Interestingly, of the three students who relied on Concrete Experience in the experimental group, two of them had an A average and the other had a B average. The single student who relied on Concrete Experience in the Control group had an A average. As the overall grade within the course is mainly determined by practical exams (85% of overall grade), these students must have attributed significance to most concrete concepts covered within the class and have been able to organize those concepts into some type of hierarchical understanding. Since practical exams were centered around identification of anatomical structures, it is possible that these students are better able to distinguish between significant concrete concepts than their peers.

In examining the data, I was also curious as to whether concept mapping increased student achievement on abstract concepts in abstract learning style students. Only students who were classified as having an abstract learning style were used to perform this analysis. To determine student achievement on understanding abstract concepts, student scores on the abstract questions of the unit 3 content survey were compared to their respective scores on the abstract questions of the unit 2 content survey to determine if their score had improved. The results of the independent sample t-test gave a p-value of 0.452, indicating that there is no significant difference between the experimental and control groups. Due to this result, it cannot be concluded that concept mapping increases student achievement on abstract concepts in abstract learning style students.

The third research question asks “does the use of a concept mapping routine change learning style?” When comparing changes in Abstract Conceptualization between the control and experimental group, a p-value of 0.114 was obtained for the difference in the subsection scores on the LSIs. While this p-value is not significant, with a larger sample size, a change in learning style may be seen. However, the experimental group which engaged in concept mapping had a mean decrease in Abstract Conceptualization subsection scores of -0.213 units. The control group which did not engage in concept mapping had a mean increase of 1.93 units. With a larger sample size, it may be possible to see that concept mapping actually decreases a student's dependence on Abstract Conceptualization. When comparing changes in Concrete Experience between the control and experimental group, a p-value of 0.897 was obtained for the difference in the subsection scores on the LSIs. This indicates that concept mapping does not change a student's dependence on Concrete Experience.

As an extended analysis, I wanted to look at those students whose learning style did change and those whose learning style did not change. Within the experimental group, there were 25 Abstract Conceptualization students, 3 Concrete Experience students, and 1 median-thinking student who had a constant learning style on both the P1LSI and P2LSI. Within the control group, there were 14 Abstract Conceptualization students, 1 Concrete Experience student, and 0 median-thinking students who had a constant learning style on both the P1LSI and the P2LSI. However, there were students whose learning style did exhibit a change from the P1LSI to the P2LSI. In order to determine if concept mapping had any effect on these students, I first performed a t-test of unequal variances between student overall grades in the students whose learning style did change. When comparing the control and experimental groups, a p-value of 0.91 was obtained, indicating that there is no significant difference when comparing overall grades of students whose learning style did exhibit a change over the course of the study. This could indicate that those students who exhibit a change in learning style do not also exhibit increased achievement within the course.

It was then my intent to determine if concept mapping increased student performance on concrete concepts in those students who did exhibit a change in learning style. In order to do so, differences in scores on the concrete subsections between the unit 3 content survey and unit 2 content survey were calculated for each student. When comparing control and experimental groups with a t-test of unequal variances, a p-value of 0.219 was obtained, indicating that there is no significant difference when comparing concrete concept acquisition in students whose learning style exhibited a change over the course of the study. It was also necessary to determine if concept mapping increased student performance on abstract concepts in those students who exhibited a change in learning style. In order to do so, the differences in scores on the abstract subsections between the unit 3 content survey and the unit 2 content survey were calculated for each student. When comparing control and experimental groups with a t-test of unequal variances, a p-value of 0.801 was obtained, indicating that there is no significant difference when comparing abstract concept acquisition in students whose learning style exhibited a change over the course of the study.

In order to present the changes in learning style that occurred during the course of the study, a quantitative variable in the form of their subsection scores on the LSIs was transformed to a qualitative variable by labeling them as an Abstract Conceptualizer (signified by the letter A), Concrete Experiencer (signified by the letter C), or median-thinking student (signified by the letter M). Table 14 is a frequency table which contains the changes in learning styles in the control and experimental groups. Due to the extremely small sample size, no viable conclusions should be made as to the causes for the observed changes in learning style.

Table 14. Comparison of Learning Style Changes Observed in Control and Experimental Groups

	Experimental Frequency	Experimental RF	Control Frequency	Control RF
A to C	3	0.167	2	0.154
A to M	4	0.222	2	0.154
C to A	3	0.167	4	0.308
C to M	2	0.111	1	0.077
M to A	2	0.111	3	0.231
M to C	4	0.222	1	0.077
Total	18	1	13	1

Discussion of Student Interviews. Due to the extremely small sample size of students who agreed to be interviewed, a qualitative analysis of interviews has limited generalizability. In analyzing the frequency of the themes to which students attribute their understaning or lack of understanding, an overarching trend was observed. The vast majority of explanations that students contributed indicated that their understanding is dependent on visual cues. Since the laboratory portion involves examination of anatomy, it is evident that a great many students will be able to identify structures based upon visual cues.

When grouping the themes by student achievement level, several trends were observed. High performing students were the only students to mention that they had attributed importance to the concept, admitted they possessed a lack of details when they could not answer a question, and also recognized that while they had learned a concept for the practical, the transition to long-term memory did not occur. Average performing students were the only students to mention that they used rote memorization to acquire a concept. Low performing students were the only students to recognize that the complex nature of the concepts interfered with their ability to understand the information at hand. Interestingly, low- and average-performing abstract students were the only students to mention personal experience and personal interest as an explanation for their responses. This is in accordance with earlier studies by Tsai and Thomas (2011) in which they found that abstract learners place primary importance on central concepts and only attribute importance to secondary concepts if the students' judgement determines those concepts to be significant.

Discussion of Concept Maps. With a few exceptions, high-performing students often created concept maps that received high marks and illustrated a thorough understanding of the course content. These concept maps had an abundance of cross-links, examples, and propositions. Over time, these concept maps became progressively more intricate. For example, the same high performing student only scored 22 points on the introductory concept mapping activity, but then later scored 128 points on the final concept mapping activity. Low-performaning students often created concept maps that were essentially incomplete. Most concept maps created by low-performing students contained few prepostions, cross-links, or any additional nodes that could reflect a hierarchical understanding of the interconnectedness of concepts. Low-performing students submitted concept maps whose scores were never above 20 points.

Conclusions

In this study, concept mapping was explored as a metacognitive strategy to facilitate the acquisition of concrete concepts in abstract-learning style students as well as assist in the acquisition of abstract concepts in concrete-learning style students. It was also a goal of this study to determine if concept mapping had any influence in changing student learning styles over time. An analysis of the quantitative data reveals that there were no significant differences between the control and experimental groups on the instruments used. There was no statistically significant difference in the changes observed in student self-reported learning style between the control and experimental groups; therefore, it cannot be concluded that concept mapping facilitates changes in learning style over a relatively short period of time. However, a few students did exhibit a change in learning style over the course of the study.

While concept mapping was not found to have any effect on learning style as determined by the instrument used in this study, concept mapping as an instructional strategy still enables students to see the hierarchical organization of complex concepts, such as those presented in Anatomy & Physiology. While I find concordance with the meta-study of Laight (2004) which found that complex instructional tools are effective with students of all learning styles, due to the evidence presented within this manuscript, it can also be concluded that no single instructional tool is sufficient to increase student performance or acquisition of concepts. The logical extension of that conclusion is that a variety of instructional tools should be used over a course of a semester to facilitate student performance and acquisition of concepts.

In examining the recurring themes that students identified as facilitating their understanding, all students interviewed from all performance levels mentioned visual cues as a primary explanation for their understanding. This leads me to believe that concept mapping, as a teaching and learning tool, is useful in facilitating visual representations of scientific concepts. In a class such as Anatomy & Physiology, where anatomical structures are identified by visual cues, concept mapping could prove highly useful.

Potential limitations of this study include a small sample size and problems with compliance. The small sample size can be attributed to the maximal section class size of 24 students. As only six sections were chosen for the study, there was a maximal number of 144 students who could be involved in the study. Many students chose not to consent, and some students who did consent were noncompliant. Compliance issues ranged from students improperly responding to surveys (therefore making an analysis of that survey impossible) to non-attendance of scheduled interview sessions. In addition, there were a great deal of compliance issues and protocol violations caused by the instructor of the three control group sections. Despite being trained and instructed in proper protocol, this teaching assistant repeatedly violated protocols (see appendix N).

In order to effectively implement this study, there would need to be one instructor of all course sections to minimize the variability between different course sections. Even with the same instructor, there is variability observed in virtually all sections, so it is essentially impossible to eliminate inter-group variability. Even if inter-group variability is minimized, there will still be serious issues with student compliance. In order to increase student compliance, pertinent directions would need to be underlined and highlighted, students would need reminders to attend scheduled meetings, and incentives would need to be offered to encourage student participation.

Opportunities for further study include examining other teaching and learning strategies as methods of inciting change in student learning style and/or increasing student performance and achievement as measured by overall grade within the course. It is also an implied conclusion of this study that visual instructional strategies facilitated the acquisition of visual concepts of students of all performance levels and learning styles. Whether that is indeed the case is a valid point for further study.

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Appendices

Appendix A – Lesson plan for Endocrine/Blood

Endocrine and Blood Lesson Plan
Week of 8/29/2011

I. Materials

Endocrine Models
Endocrine Diagrams
Blood Diagrams
Blood Typing Kit

II. SCOS/NSES Objectives

III. Central Concepts

1. Hormones
   A. steroid-based hormones
   B. amino acid-based hormones
   C. tropic hormones
2. pituitary gland (hypophysis)
   A. anterior pituitary (adenohypophysis)
   B. posterior pituitary (neurohypophysis)
   C. infundibulum (stalk)-connects to hypothalamus
3. pineal gland
4. thyroid gland
5. parathyroid glands
6. thymus
7. adrenal glands
8. pancreas
9. gonads

IV. Engaging Preconceptions (10 minutes)

Students will engage their preconceptions by taking a diagnostic assessment to determine their knowledge in various aspects pertaining to the endocrine system and blood components. The diagnostic assessment will be divided into four sections: endocrine system anatomy and physiology, endocrine system abnormalities, blood anatomy and physiology, and blood abnormalities. At the completion of the diagnostic assessment, student scores in each subsection will be tabulated to yield a percentage. The subsection with the highest score will be the subsection at that the student will begin during review stations. The student will then move through subsequent review stations according to their score. If students have equal scores across some or all of the subsections, then students are encouraged to wait and see how many other students will be at that station during the time that they could go to that station. If the station is crowded, students should be encouraged to attend another station.

V. Explain (Teacher-Led Instruction) (80 minutes)

The teacher led instruction will consist of a PowerPoint presentation on the endocrine system and blood.

VI. Explore (30 minutes)

In the exploration section of the lesson plan, students will be allowed to go to one of four separate stations: a station on endocrine system anatomy and physiology, blood abnormalities, blood components, and endocrine system abnormalities. Students will rotate through each station according to their scores obtained on the diagnostic assessment. Students will spend the least amount of time at the station in that they have the most knowledge, and the most amount of time in the station at that they have the least knowledge, with intermediate times spent at the intermediate station. The times are as follows:

first station - 5 min.
second station - 6:30 min.
third station - 8:30 min.
fourth station - 10 min.

Table A1. Exploration groups and themes of study

Station/Group	Endocrine A&P	Endocrine Abnormalities	Blood A&P	Blood Abnormalities
First Group	Thyroid	Thyroid Disorders	Erythrocytes	Atherosclerosis
Second Group	Pancreas	Acromegaly	Platelets	Eosinophilia
Third Group	Adrenal Glands	Steroid Use	Agranulocytes	Sickle-cell anemia
Fourth Group	Pituitary	Diabetes	Granulocytes	Hemophilia

At the station involving examination of endocrine anatomy and physiology, students in each group should be able to identify the location of the endocrine organ, the hormones it produces, the target organs of those hormones, and the physiological effects of those hormones. At the station involving examination of endocrine abnormalities, students in each group should be able to identify the causes and risk factors attributing to the disorder, the effects the disorder has upon the body, the treatment for the disorder (if any), and the long-term effects on the body if the disorder goes untreated. At the station involving examination of blood anatomy and physiology, students in each group should be able to identify the characteristics of the blood cells, the location of their production, the cause and process of their production, and the physiological functions of the blood cells. At the station involving examination the blood abnormalities, students in each group should be able to identify the causes and risk factors attributing to the disorder, the effects the disorder has upon the body, the treatment for the disorder (if any), and the long-term effects on the body if the disorder goes untreated.

VII. Elaborate (40 minutes)

For the elaboration section of the lesson plan, each group will be called up to present their findings to the class in 2 min. intervals, until all groups have presented their information.

VIII. Evaluate (10 minutes)

The evaluation section of the lesson plan consists of a 10 question quiz.

IX. Dissection (30 minutes)

Students should dissect the heart along a frontal plane, dividing the heart into two portions, so that a view of the heart can be obtained and internal structures can be examined. Then, have students present their dissected heart to the remainder of their table.

X. Homework

- Exercise 27-functional anatomy of the endocrine glands-pages 411 - 413, questions 1 - 11
- Exercise 29A-blood-pages 437-441, questions 1-4, 6-10 (with the exception of student test results), 11-20, 22-23

XI. Lesson Reflection

1. To identify and name the major endocrine glands and tissues of the body when provided with an appropriate diagram.
2. To list the hormones produced by the endocrine glands and discuss the general function of each.
3. To indicate the means by that hormones contribute to the body homeostasis by giving appropriate examples of hormonal actions.
4. To cite mechanisms by that the endocrine glands are stimulated to release their hormones.
5. To describe the structural and functional relationship between the hypothalamus and pituitary.
6. To describe a major pathological consequence of hyper secretion and hypo secretion of several of the hormones considered.

Appendix B – IRB Approved Informed Consent Form for Study

Consent and Release Form

You are being invited to participate in a **research** study titled "Concept mapping & learning styles: Concept mapping as a method to increase student understanding and its correlation with Kolb's abstract vs. concrete cognitive model" being conducted by William G. Mosley, a graduate student in the Master of Arts in Science Education program at East Carolina University in the Education department. There are three 2151 class sections which have been selected as control groups. There are three 2151 class sections which have been selected as experimental groups. The goal is to survey 144 individuals in/at East Carolina University enrolled in Biology 2151 during the fall semester of 2011. The survey will take approximately 30 minutes to complete. It is hoped that this information will assist us to better understand if concept mapping is an effective technique of instruction in enhancing student understanding and addressing student weaknesses in thinking. The survey is asking you to provide identifying information, however, your responses will be kept confidential. No data will be released or used with your identification attached Your participation in the research is **voluntary**. You may choose not to answer any or all questions, and you may stop at any time. There is **no penalty for not taking part** in this research study. Please call William G. Mosley at (336) 414-9455 for any research related questions or the Office for Human Research Integrity (OHRI) at 252-744-2914 for questions about your rights as a research participant.

Signature of Participant: ______________________________ Date: ____________

I consent to allow William G. Mosley to use information gathered during instructional time, work samples, and grades in the study.

Signature of Participant: ______________________________ Date: ____________

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Appendix C – Unit One Content Survey Scoring Rubric

1. Explain the process by that aldosterone increases blood pressure.
-Increases Mineral absorption
-Increases osmosis of water from urine
-Increased fluid retention

2. Identify the endocrine glands shown on the projector.
   A. ________________Thyroid
   B. ________________Adrenal
   C. ________________Hypothalamus

3. Why would an individual with a parathyroid tumor suffer from osteoporosis?
-Increased PTH hormone secretion
-Increased bone breakdown
-Reduction of bone strength

4. Identify the Blood Vessels shown on the projector.
   A. ________________ Common Carotid Artery
   B. ________________ Abdominal Aorta
   C. ________________Femoral Artery

5. Why would a heart attack caused by a blockage in the left coronary arteries be more severe than a blockage in the right coronary arteries?
-Decreased blood supply to heart muscle
-Left side of heart supplies blood to body
- Right side of heart supplies blood to lungs

6. Identify the structures of the heart shown on the projector.
   A. ________________ Pulmonary Semilunar Valve
   B. ________________ Mitral (bicuspid) valve
   C. ________________ Pulmonary Veins

7. Why does the thoracic duct return lymph to the subclavian veins?
- Reduced Blood Pressure in veins
- Lymph flows passively due to skeletal muscle movement
-Lymph fluid has little pressure

8. Identify the blood cell types shown on the projector (be specific).
   A. ________________ Eosinophil
   B. ________________ Lymphocyte
   C. ________________ Thromobocytes

9. Why would a patient with kidney problems be anemic?
-Kidney produces erythropoietin
- Erythropoietin causes Erythropoesis (blood cell generation)
- No erythropoietin= no blood cells = anemia

10. Identify the structures shown on the projector.

A. _________________ Inguinal Lymph Nodes

B. _________________ Thymus

C. _________________ Cisterna Chylii

Appendix D – Unit Two Content Survey Scoring Rubric

1. Explain the process of pulmonary ventilation in terms of volume and pressure changes occurring within the thorax.
- increase volume, decrease pressure in inhalation
- air flows from area of high pressure to area of low pressure
- decrease volume, increase pressure in exhalation

2. Identify the respiratory structures shown on the projector
   A. ________________ (thyroid cartilage)
   B. ________________ (cardiac notch)
   C. ________________ (segmental bronchi)

3. Why does oxygen diffuse into the blood in the alveoli?
- air flows from area of high pressure to area of low pressure
- partial pressure of oxygen in the alveoli is higher than blood
- oxygen flows from alveoli into blood

4. List the three regions of the pharynx from most superior to most inferior
   A. ________________ (Nasopharynx)
   B. ________________ (Oropharynx)
   C. ________________ (Laryngopharynx)

5. Why would a person who has had their gallbladder removed have difficulty digesting fatty foods?
-gallbladder stores and concentrates bile
- bile emulsifies fats
- without gallbladder, fats pass undigested through GI tract

6. Identify the structures of the digestive system shown on the projector.
   A. ________________ (pancreatic duct)
   B. ________________ (cystic duct)
   C. ________________ (hepatopancreatic ampulla)

7. Why would a person not be able to survive without the pancreas?
-pancreas produces enzymes essential for digestion
-pancreas produces bicarbonate to neutralize chyme from stomach
- without pancreas digestion wouldn't occur and small intestine would be destroyed by acid

8. Identify the following cell types based upon their description.
   A. ________________ (secrete mucus) - goblet
   B. ________________ (produce HCl) - parietal
   C. ________________ (form the alveolar wall) - squamous alveolar

9. Most blood pressure drugs are diuretics. How do diuretics lower the blood pressure?
-diuretics increase mineral excretion

- increased rate of osmosis due to hypertonic urine
- increased fluid excretion lowers blood volume

10. Identify the urinary system structures shown on the projector.
A. Renal Pyramid
B. Bowman's/Glomerular Capsule
C. Urethra

Appendix E – Unit Three Content Survey Scoring Rubric

1. Explain the process of negative feedback of Inhibin on the production of gonadotropins.
-Inhibin is produced by the gonads to
-Stop the production of gonadotropins
-released from the anterior pituitary

2. Identify the male reproductive structures shown on the projector.
A. ________________ (Ductus (vas) deferens)
B. ________________ (Tunica albuginea)
C. ________________(Corpus Spongiosum)

3. Why does exogenous testosterone (i.e. anabolic steroids) cause gynecomastia?
-Exogenous testosterone causes the body to produce excess estrogen
-via conversion of the excess testosterone to estrogen via aromatase enzyme, that leads to
-development of breast tissue because of heightened estrogen levels

4. Identify the female reproductive structures shown on the projector
A. ________________(Fallopian (Uterine) tube)
B. ________________(Vagina (Vaginal) Canal)
C. ________________(Great vestibular gland)

5. Explain the process by that spina bifida occurs and how it can be prevented.
-Spina bifida is caused by incomplete closure of the caudal end of the neural tube, leading to
-Malformation of the spinal column during the process of neurulation in the neurula
-Can be prevented by pre-natal vitamin supplementation (specifically folate)

6. Identify the structures of the embryonic development structures shown on the projector.
A. ________________(Amnion(tic sac))
B. ________________(Yolk sac)
C. ________________(Blastula (cavity))

7. Why and how would an amniocentesis show genetic abnormalities?
-An amniocentesis is a sampling of amniotic fluid and cells, that are
-derived from the same cells as an embryo, from that
-genetic information can be obtained and tested for abnormalities

8. Identify the embryonic structures.
A. ________________ (germ layer)- ectoderm
B. ________________ (maternal portion of the placenta) - decidua basalis
C. ________________ (embryonic stage at that neurulation occurs) – neurula

9. How does the "morning after" pill (RU-486) prevent a pregnancy?
-The morning after pill prevents a pregnancy by blocking the action of progesterone, that
-makes the stratum functionalis of the uterus unsuitable for implantation by the
-blastocyst stage and the embryo passes out of the uterus

10. Identify the genetics structures shown on the projector.
A. Karyotype
B. Chiasma
C. Chromosome

Appendix F – Informed Consent Form for Interviews

Consent and Release Form for Interviews

You are being invited to participate in a **research** study titled "Concept mapping & learning styles: Concept mapping as a method to increase student understanding and its correlation with Kolb's abstract vs. concrete cognitive model" being conducted by William G. Mosley, a graduate student in the Master of Arts in Science Education program at East Carolina University in the Education department. There are three 2151 class sections which have been selected as control groups. There are three 2151 class sections which have been selected as experimental groups. The goal is to interview 12 individuals in/at East Carolina University enrolled in Biology 2151 during the fall semester of 2011, with six students from each group. It is hoped that this information will assist us to better understand if concept mapping is an effective technique of instruction in enhancing student understanding and addressing student weaknesses in thinking. The survey is asking you to provide identifying information, however, your responses will be kept confidential. No data will be released or used with your identification attached Your participation in the research is **voluntary**. You may choose not to answer any or all questions, and you may stop at any time. There is **no penalty for not taking part** in this research study. Please call William G. Mosley at (336) 414-9455 for any research related questions or the Office for Human Research Integrity (OHRI) at 252-744-2914 for questions about your rights as a research participant.

Signature of Participant: ______________________________ Date: _____________

I consent to allow William G. Mosley to use information gathered during instructional time, work samples, audio transcripts of interviews, and grades in the study.

Signature of Participant: ______________________________ Date: _____________

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Appendix G – Unit One Content Interview Protocol

General Directions

1. "Thank you for coming and agreeing to participate in these interviews. The purpose of these interviews will be to trace your thinking processes and the methods through that you answer a question. This material will not be graded and doesn't affect your grade in any manner."
2. Give student consent form for interview and audio recording. If student has any questions, answer them appropriately. If the student declines to sign interview consent form, then say, "well thank you for coming, but I cannot use the information garnered from this interview without your consent, I appreciate your willingness to assist me in my research goals", then dismiss student. If student understands and signs consent form, proceed to step 3.
3. Begin recording. "I will be recording these interviews so that I may understand and record your answers and your responses to how you trace those answers. Only the audio will be used from this recording and all identifying information will be removed. Are there any questions about privacy?" Answer student's questions appropriately.
4. "I will be asking you the same questions to that you responded during the group interview sessions, but you will have an unlimited time in that to answer them. After you have given your answer, please thoroughly explain how you arrived at that answer by tracing your thinking process. Are there any questions before we begin?" Answer student's questions appropriately.
5. "Let us begin with question 1."

1. Explain the process by that aldosterone increases blood pressure.
   A. After student's explanation, go to B.
   B. "Please trace the thinking process that you go through in order to answer that question."
   C. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

2. Identify the endocrine glands shown on the projector.
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)
      i. After student's explanation, go to ii.
      ii. "Please trace the thinking process that you go through in order to answer that question."
      iii. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

3. Why would an individual with a parathyroid tumor suffer from osteoporosis?
   A. After student's explanation, go to B.
   B. "Please trace the thinking process that you go through in order to answer that question."

C. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

4. Identify the Blood Vessels shown on the projector.
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)\
      i. After student's explanation, go to ii.
      ii. "Please trace the thinking process that you go through in order to answer that question."
      iii. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

5. Why would a heart attack caused by a blockage in the left coronary arteries be more severe than a blockage in the right coronary arteries?
   A. After student's explanation, go to B.
   B. "Please trace the thinking process that you go through in order to answer that question."
   C. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

6. Identify the structures of the heart shown on the projector.
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)
      i. After student's explanation, go to ii.
      ii. "Please trace the thinking process that you go through in order to answer that question."
      iii. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

7. Why does the thoracic duct return lymph to the subclavian veins?
   A. After student's explanation, go to B.
   B. "Please trace the thinking process that you go through in order to answer that question."
   C. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

8. Identify the blood cell types shown on the projector (be specific).
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)
      i. After student's explanation, go to ii.
      ii. "Please trace the thinking process that you go through in order to answer that question."

iii. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

9. Why would a patient with kidney problems be anemic?
   A. After student's explanation, go to B.
   B. "Please trace the thinking process that you go through in order to answer that question."
   C. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

10. Identify the structures shown on the projector.
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)
      i. After student's explanation, go to ii.
      ii. "Please trace the thinking process that you go through in order to answer that question."
      iii. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

Appendix H – Unit Two Content Interview Protocol

General Directions

1. "Thank you for coming and agreeing to participate in these interviews. The purpose of these interviews will be to trace your thinking processes and the methods through that you answer a question. This material will not be graded and doesn't affect your grade in any manner."
2. Give student consent form for interview and audio recording. If student has any questions, answer them appropriately. If the student declines to sign interview consent form, then say, "well thank you for coming, but I cannot use the information garnered from this interview without your consent, I appreciate your willingness to assist me in my research goals", then dismiss student. If student understands and signs consent form, proceed to step 3.
3. Begin recording. "I will be recording these interviews so that I may understand and record your answers and your responses to how you trace those answers. Only the audio will be used from this recording and all identifying information will be removed. Are there any questions about privacy?" Answer student's questions appropriately.
4. "I will be asking you the same questions to that you responded during the group interview sessions, but you will have an unlimited time in that to answer them. After you have given your answer, please thoroughly explain how you arrived at that answer by tracing your thinking process. Are there any questions before we begin?" Answer student's questions appropriately.
5. "Let us begin with question 1."

1. Explain the process of pulmonary ventilation in terms of volume and pressure changes occurring within the thorax?

A. After student's explanation, go to B.
D. "Please trace the thinking process that you go through in order to answer that question."
E. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

2. Identify the respiratory structures shown on the projector

A. ________________ (ask student to identify structure A on projector)
B. ________________ (ask student to identify structure B on projector)
C. ________________ (ask student to identify structure C on projector)
   i. After student's explanation, go to ii.
   iv. "Please trace the thinking process that you go through in order to answer that question."
   v. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

3. Why does oxygen diffuse into the blood in the alveoli?

A. After student's explanation, go to B.

D. "Please trace the thinking process that you go through in order to answer that question."
E. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

4. List the three regions of the pharynx from most superior to most inferior
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)\
      i. After student's explanation, go to ii.
      iv. "Please trace the thinking process that you go through in order to answer that question."
      v. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

5. Why would a person who has had their gallbladder removed have difficulty digesting fatty foods?
   A. After student's explanation, go to B.
   D. "Please trace the thinking process that you go through in order to answer that question."
   E. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

6. Identify the structures of the digestive system shown on the projector.
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)
      i. After student's explanation, go to ii.
      iv. "Please trace the thinking process that you go through in order to answer that question."
      v. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

7. Why would a person not be able to survive without the pancreas?
   A. After student's explanation, go to B.
   D. "Please trace the thinking process that you go through in order to answer that question."
   E. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

8. Identify the following cell types based upon their description.
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)
      i. After student's explanation, go to ii.

iv. “Please trace the thinking process that you go through in order to answer that question.”
v. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”

9. Most blood pressure drugs are diuretics. How do diuretics lower the blood pressure?
A. After student’s explanation, go to B.
D. “Please trace the thinking process that you go through in order to answer that question.”
E. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”

10. Identify the urinary system structures shown on the projector.
A. ________________ (ask student to identify structure A on projector)
B. ________________ (ask student to identify structure B on projector)
C. ________________ (ask student to identify structure C on projector)
i. After student’s explanation, go to ii.
iv. “Please trace the thinking process that you go through in order to answer that question.”
v. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”

Appendix I – Unit Three Content Interview Protocol

General Directions

1. "Thank you for coming and agreeing to participate in these interviews. The purpose of these interviews will be to trace your thinking processes and the methods through that you answer a question. This material will not be graded and doesn't affect your grade in any manner."
2. Give student consent form for interview and audio recording. If student has any questions, answer them appropriately. If the student declines to sign interview consent form, then say, "well thank you for coming, but I cannot use the information garnered from this interview without your consent, I appreciate your willingness to assist me in my research goals", then dismiss student. If student understands and signs consent form, proceed to step 3.
3. Begin recording. "I will be recording these interviews so that I may understand and record your answers and your responses to how you trace those answers. Only the audio will be used from this recording and all identifying information will be removed. Are there any questions about privacy?" Answer student's questions appropriately.
4. "I will be asking you the same questions to that you responded during the group interview sessions, but you will have an unlimited time in that to answer them. After you have given your answer, please thoroughly explain how you arrived at that answer by tracing your thinking process. Are there any questions before we begin?" Answer student's questions appropriately.
5. "Let us begin with question 1."

1. Explain the process of negative feedback of Inhibin on the production of gonadotropins.
   - A. After student's explanation, go to B.
   - F. "Please trace the thinking process that you go through in order to answer that question."
   - G. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

2. Identify the male reproductive structures shown on the projector.
   - A. ________________ (ask student to identify structure A on projector)
   - B. ________________ (ask student to identify structure B on projector)
   - C. ________________ (ask student to identify structure C on projector)
     - i. After student's explanation, go to ii.
     - vi. "Please trace the thinking process that you go through in order to answer that question."
     - vii. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

3. Why does exogenous testosterone (i.e. anabolic steroids) cause gynecomastia?
   - A. After student's explanation, go to B.
   - F. "Please trace the thinking process that you go through in order to answer that question."

G. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”

4. Identify the female reproductive structures shown on the projector
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)\
      i. After student’s explanation, go to ii.
      vi. “Please trace the thinking process that you go through in order to answer that question.”
      vii. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”

5. Explain the process by that spina bifida occurs and how it can be prevented.
   A. After student’s explanation, go to B.
   F. “Please trace the thinking process that you go through in order to answer that question.”
   G. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”

6. Identify the structures of the embryonic development structures shown on the projector.
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)
      i. After student’s explanation, go to ii.
      vi. “Please trace the thinking process that you go through in order to answer that question.”
      vii. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”
      viii.

7. Why and how would an amniocentesis show genetic abnormalities?
   A. After student’s explanation, go to B.
   F. “Please trace the thinking process that you go through in order to answer that question.”
   G. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”

8. Identify the embryonic structures.
   A. ________________ (ask student to identify structure A on projector)
   B. ________________ (ask student to identify structure B on projector)
   C. ________________ (ask student to identify structure C on projector)
      i. After student’s explanation, go to ii.
      vi. “Please trace the thinking process that you go through in order to answer that question.”
      vii. If student does not provide enough detail, say “Could you tell me more about how you were able to answer that question?”

9. How does the "morning after" pill (RU-486) prevent a pregnancy?

A. After student's explanation, go to B.

F. "Please trace the thinking process that you go through in order to answer that question."

G. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

10. Identify the genetics structures shown on the projector.

A. ________________ (ask student to identify structure A on projector)

B. ________________ (ask student to identify structure B on projector)

C. ________________ (ask student to identify structure C on projector)

i. After student's explanation, go to ii.

vi. "Please trace the thinking process that you go through in order to answer that question."

vii. If student does not provide enough detail, say "Could you tell me more about how you were able to answer that question?"

Appendix J – Introductory Concept Mapping Activity

Concept Maps

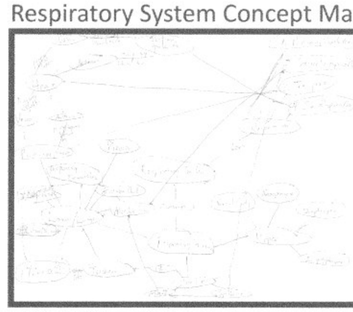
Concept Maps

- Concept maps are used to graphically represent concepts and information related to a learning objective or outcome.
- Concept maps serve to hierarchically delineate the relationships between concepts and terms within a lesson.

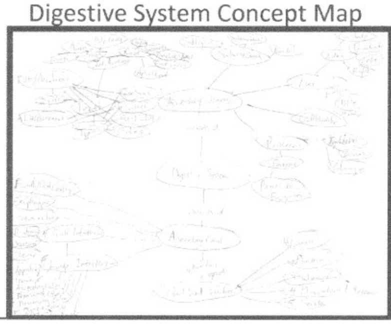
Concept Map Samples

- The items within circles are called nodes. They are often terms or concepts which you are studying.
- The nodes are linked together with lines, which may or may not be directional.
- Within the line, you will include a preposition that links the nodes (or concepts) together.

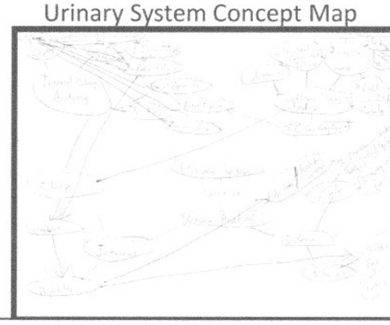
Respiratory System Concept Map



Digestive System Concept Map



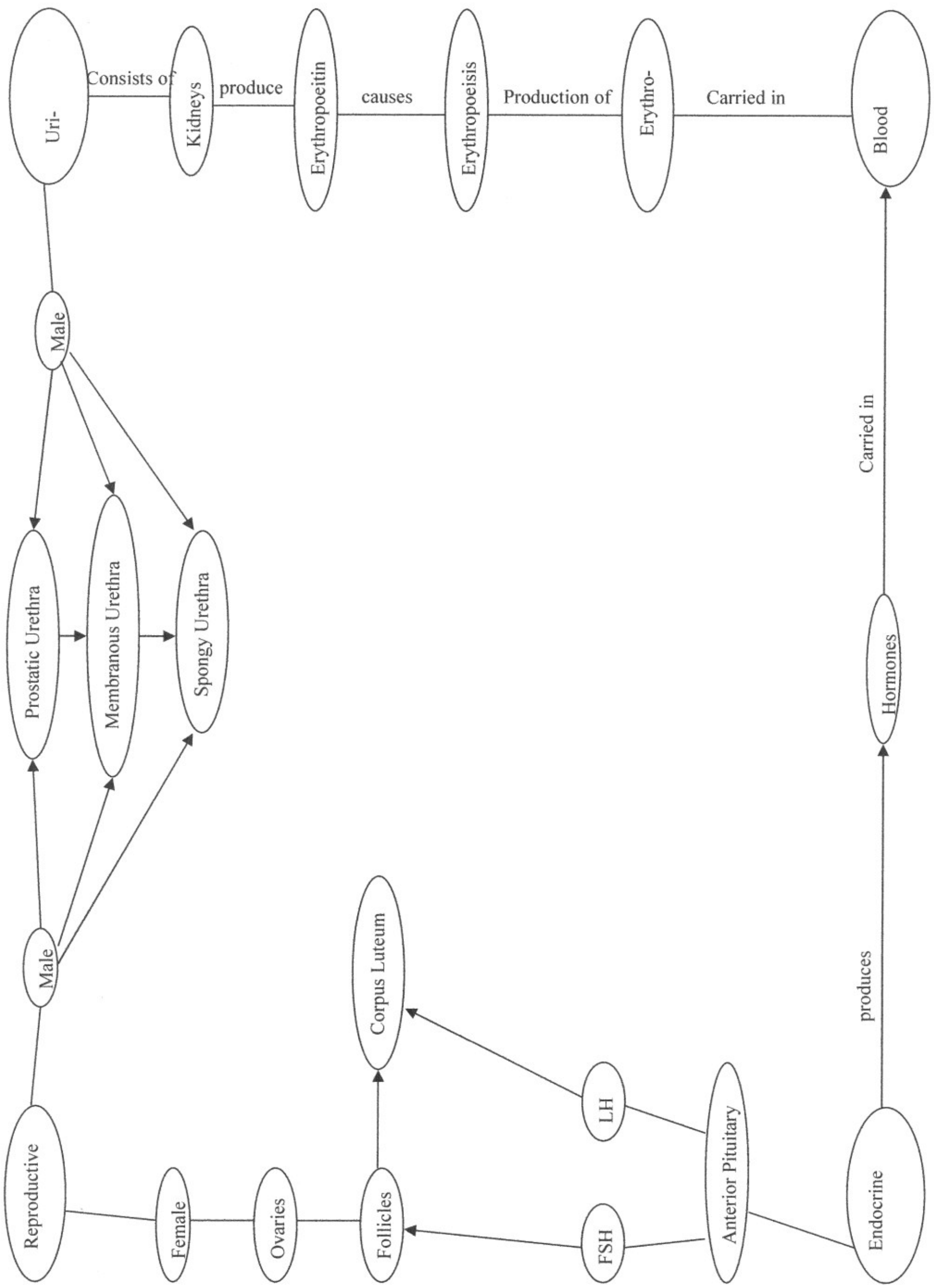
Urinary System Concept Map



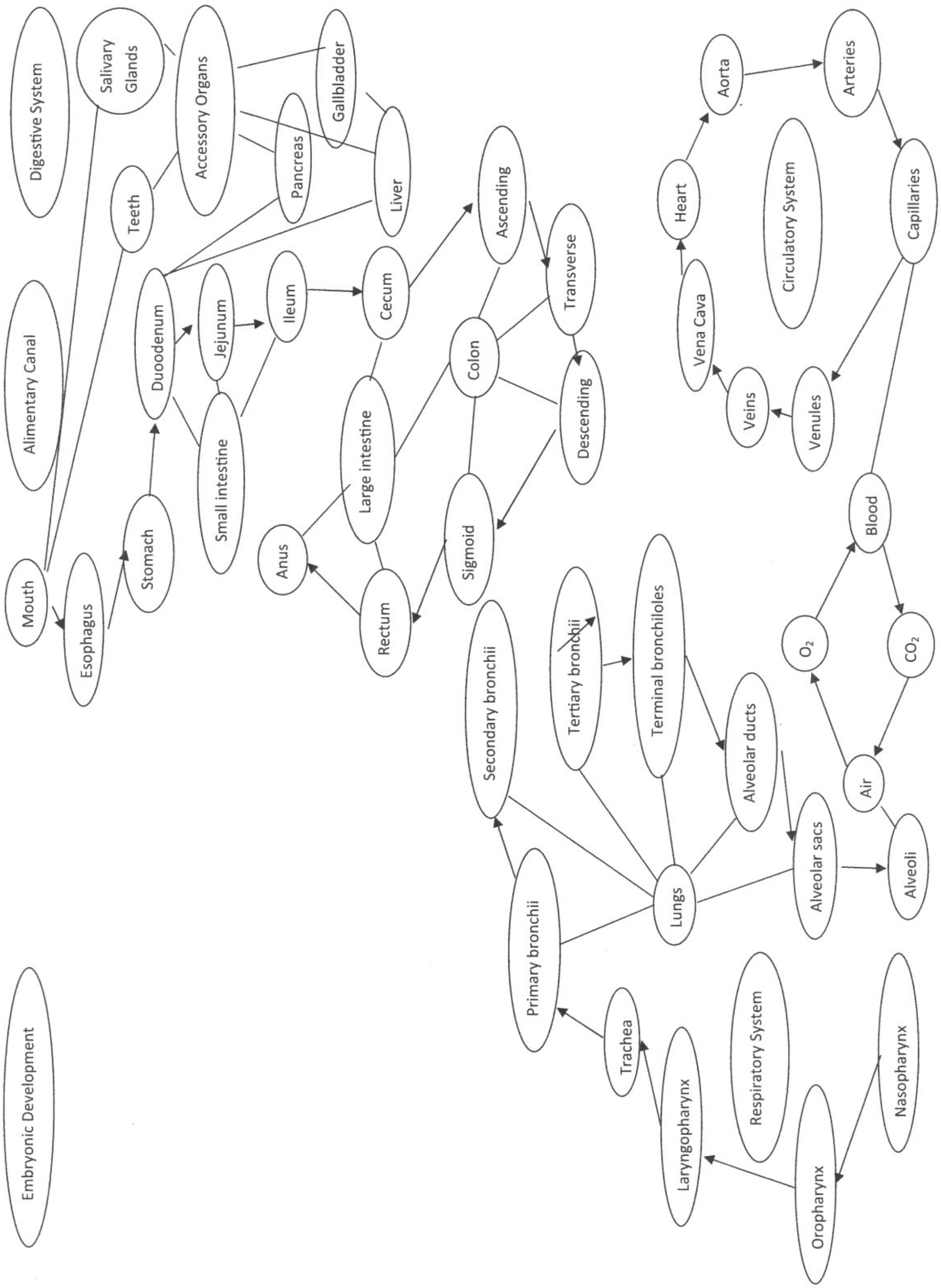
Assignment

- Create a concept map which defines the effects of the sympathetic nervous system on each of the systems we have studied.
- You must use at least four nodes: sympathetic nervous system, respiratory system, urinary system, and digestive system.
- Whenever possible, you should talk about the specific hormones, structures, and tissues involved.
- Look on page 325 to see some of the structures innervated by the sympathetic nervous system.

Appendix K – Concept Mapping Activity One



Appendix L – Concept Mapping Activity Two



Appendix M - Final Concept Mapping Activity Powerpoint

3/30/2012

Concept Mapping Activity

Why?

- This concept mapping activity will not only prepare you for your upcoming practical, it will also help to prepare you for your examinations in Bio 2150.

How?

- Create a concept map on one section, or multiple sections: Reproductive, Embryonic Development, and/or Patterns of Heredity.
- Use a central node to describe the system, then expand it by having various topics linked to it.
- Make sure to use a sentence linking those nodes to describe the relationship between them.

What?

- The terms which should be included in your concept map will be on the following slides.
- These terms are central and important ideas which will be tested in both a practical setting as well as in exams within the lecture.

Reproductive System

I. Male Reproductive Anatomy
A. External Structures
1. Penis
i. Corpus Cavernosum
ii. Corpus Spongiosum/Spongy Urethra
iii. Glans Penis/Foreskin
2. Testes in Scrotum
i. Internal Structures
a. Tunica vaginalis
b. Tunica albuginea
c. Seminiferous Tubules in Lobules
d. Septum
e. Rete Testis
ii. External Tubules
a. Epididymis
b. Ductus (vas) deferens
c. Spermatic cord
B. Internal Structures
1. Spermatic cord
2.Ampulla of ductus deferens
3. Prostate
4. Seminal vesicle
5. Ejaculatory duct
6. Balbourethral Gland

Reproductive System (continued)

II. Female Reproductive Anatomy
A. External Structures
1. Mons pubis
2. Labia majora
3. Labia minora
4. Clitoris(glans)
5. Urethral Orifice
6. Vestibule
7. Vaginal orifice
B. Internal Structures
1. Ovaries
i. Ovarian ligament
ii. Broad ligament
a. [illegible]
b. Mesovarium
c. Mesosalpinx
2. Fallopian tubes
i. Fimbriae
ii. Ampulla
iii. Isthmus
iv. Infundibulum
3. Uterus
i. Fundus
ii. Lumen
iii. Endometrium
iv. Myometrium
v. Perimetrium
vi. Body
vii. Internal Os
viii. Cervical canal
ix. External Os
x. Cervix
xi. Fornix
xii. Vagina

1

Embryonic Development

I. Embryonic Stages
- A. Zygote
  - 1. Fertilization
  - 2. Blastomeres
  - 3. Cleavage
- B. Morula
- C. Blastula
  - 1. Early Blastocyst
    - i. Blastocyst cavity
  - 2. Implanting Blastocyst
    - i. Inner cell mass
    - ii. Trophoblast
      - a. Decidua Basalis
      - b. Decidua Capsularis
    - iii. Blastocyst cavity
- D. Gastrula
  - 1. Early Gastrula
    - i. Gastrulation
      - a. Endoderm
      - b. Mesoderm
      - c. Ectoderm
- E. Fetus

II. Extraembryonic Structures
- A. Chorion
  - 1. Chorionic villus
- B. Amnion
- C. Yolk Sac
- D. Allantois

Patterns of Heredity

I. Language of Genetics
- A. Alleles
  - 1. Homozygous
  - 2. Heterozygous
- B. Dominant Gene
- C. Recessive Gene
- D. Genotype
- E. Phenotype

II. Patterns of Inheritance
- A. Dominant-Recessive Inheritance
- B. Incomplete Dominance
- C. Sex-linked Inheritance
  - 1. Autosomes
  - 2. Sex Chromosomes

When?

- Please complete this before the end of the course. This is an optional assignment: you do not have to complete it. If you do complete this assignment, it should help you to understand the central concepts important in the each chapter.

Appendix N – Protocol Violations

Protocol for Lesson Plan Validation
Anatomy of the Reproductive System
Section 006
October 17, 2011

I. Central Concepts

Were all central concepts mentioned within the lecture? Yes
If not, please note that concepts were not covered:

II. Engaging Preconceptions

Was the diagnostic assessment administered? No
Were the answers given after completion of the diagnostic assessment? No

III. Explain (Teacher-Led Instruction)

Was the lesson PowerPoint presented? Yes
What was the length of time spent on the lecture PowerPoint? 64 minutes

IV. Elaborate

Did students complete rotation through all stations? No

V. Explore

Did students present all information that they learned during the elaboration activity? No

VI. Evaluate

Was the quiz given after the elaboration activity? Yes

VII. Homework

Was the homework assignment for the week announced to the class in some form or fashion? Yes

VIII. Protocol Violations

Was any given protocol violated in any way? If so, how? Please list all steps taken to prevent further protocol violation.

Protocol was violated due the fact that neither the diagnostic assessment nor the unit two content survey was administered to the students. The teaching assistant asked the students "do you really want to do this or wait until next week?" The students as a whole responded "Let's wait until next week". The teaching assistant completely skipped administering the diagnostic assessment and at the completion of the lecture, a quiz was given and students were dismissed. Upon review of the recording, the researcher contacted the teaching assistant and informed him that he must follow protocol. To ensure that protocol was followed, the researcher attended the class section the following week.

Protocol for Lesson Plan Validation
Embryonic Development
Section 006
November 7, 2011

I. Central Concepts

Were all central concepts mentioned within the lecture? Yes
If not, please note that concepts were not covered:

II. Engaging Preconceptions

Was the diagnostic assessment administered? No
Were the answers given after completion of the diagnostic assessment? No

III. Explain (Teacher-Led Instruction)

Was the lesson PowerPoint presented? Yes
What was the length of time spent on the lecture PowerPoint? 47 minutes

IV. Elaborate

Did students complete rotation through all stations? No

V. Explore

Did students present all information that they learned during the elaboration activity? No

VI. Evaluate

Was the quiz given after the elaboration activity? Yes

VII. Homework

Was the homework assignment for the week announced to the class in some form or fashion? Yes

VIII. Protocol Violations

Was any given protocol violated in any way? If so, how? Please list all steps taken to prevent further protocol violation.

Protocol was violated due the fact that neither the diagnostic assessment nor the unit two content survey was administered to the students. The researcher attended to administer the unit two content survey, however, the eight students who consented to participate felt that they were inconveniencing the other members of the class, therefore, they declined to participate any further in the study. The students agreed to allow the researcher to use their grades for comparison. The researcher then left the classroom. Again, the teaching assistant completely skipped administering the diagnostic assessment and at the completion of the lecture, a quiz was given and students were dismissed. Upon review of the recording, the researcher contacted the teaching assistant and informed him that he must follow protocol. The teaching assistant's response was that he didn't feel as if he had to follow protocol as those students were no longer participating in the study. In order to maintain fairness between all course sections, it was explained to the teaching assistant that all students should have the same lesson.

Protocol for Lesson Plan Validation
Exam 3 Test Administration
Section 006
November 28, 2011

I. Central Concepts

Were all central concepts mentioned within the lecture? N/A
If not, please note that concepts were not covered:

II. Engaging Preconceptions

Was the diagnostic assessment administered? N/A
Were the answers given after completion of the diagnostic assessment? N/A

III. Explain (Teacher-Led Instruction)

Was the lesson PowerPoint presented? N/A
What was the length of time spent on the lecture PowerPoint? N/A

IV. Elaborate

Did students complete rotation through all stations? N/A

V. Explore

Did students present all information that they learned during the elaboration activity? N/A

VI. Evaluate

Was the quiz given after the elaboration activity? N/A

VII. Homework

Was the homework assignment for the week announced to the class in some form or fashion? N/A

VIII. Protocol Violations

Was any given protocol violated in any way? If so, how? Please list all steps taken to prevent further protocol violation.

Protocol was violated due the fact that the teaching assistant placed additional diagrams and pictures on only his sections administrations of Exam 3. This was discovered after the fact on November 29, 2011 when the teaching assistant was administering Exam 3 to section 005.

Protocol for Lesson Plan Validation
Exam 3 Test Administration
Section 005
November 29, 2011

I. Central Concepts

Were all central concepts mentioned within the lecture? N/A
If not, please note that concepts were not covered:

II. Engaging Preconceptions

Was the diagnostic assessment administered? N/A
Were the answers given after completion of the diagnostic assessment? N/A

III. Explain (Teacher-Led Instruction)

Was the lesson PowerPoint presented? N/A
What was the length of time spent on the lecture PowerPoint? N/A

IV. Elaborate

Did students complete rotation through all stations? N/A

V. Explore

Did students present all information that they learned during the elaboration activity? N/A

VI. Evaluate

Was the quiz given after the elaboration activity? N/A

VII. Homework

Was the homework assignment for the week announced to the class in some form or fashion? N/A

VIII. Protocol Violations

Was any given protocol violated in any way? If so, how? Please list all steps taken to prevent further protocol violation.

Protocol was violated due the fact that the teaching assistant placed additional diagrams and pictures on only his section's administrations of Exam 3. This was discovered on November 29, 2011 when the teaching assistant was administering Exam 3 to section 005. This was discovered prior to the administration of the exam. The teaching assistant was told to remove the images and the researcher stayed to verify that the teaching assistant didn't place the diagrams again. The researcher also attended the administration of that teaching assistant's Section 003 exam on Wednesday to verify that protocol was followed.