A SELF-INSTRUCTIONAL TEACHING UNIT:

THE MECHANICS OF RESPIRATION

by

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CHAPTER I

INTRODUCTION

Each student enters into the nursing program with a variety of past learning experiences and knowledge. No two students are alike, nor have the exact same educational needs. With large groups of students it is often difficult for the teacher to individualize instruction by using the traditional lecture method. For some students the set pace of the classroom lecture may be too slow, and the student may become bored and lose interest. For others the set pace of the lecture may be too fast for them to comprehend with the students becoming frustrated and discouraged. All students should be given the opportunity and encouraged to seek knowledge in their own unique way. In order to meet these individual needs of the students a variety of teaching methods should be provided for the students' use. The self-instructional teaching unit with the use of multimedia is one approach in providing the student with an alternative or supplement to the traditional classroom lecture. Self-instructional teaching units allow the student to proceed at his own rate, and to repeat the information as often as he feels is necessary.

The Statement of the Problem

Research indicates that multimedia, self-instructional teaching units are a viable alternative and/or supplement to traditional teaching methods in nursing. Since each school has different needs for individualized methods of teaching, it would be logical for each school to develop some of its own self-instructional teaching units to meet those needs.

Many concepts that are difficult to comprehend, such as the mechanics of respiration, may benefit from a self-instructional approach. This writer believes that a self-instructional teaching unit using visual aids would be an appropriate method to help the student understand this area of respiratory physiology.

Significance of Problem

Walla Walla College School of Nursing is in the process of developing a Learning Resource Center where self-instructional material will be available to the students. It is a belief of the nursing faculty that the use of self-instructional teaching units will allow the students to supplement and expand their knowledge outside the traditional classroom. The writer is employed at Walla Walla College School of Nursing and is interested in the production of self-instructional teaching units that will benefit the students.

Purpose of the Study

The purposes of this study are as follows:

1. To demonstrate how a multimedia, self-instructional teaching unit in a selected area of respiratory physiology can be produced for the purpose of nursing education.

2. To produce a multimedia, self-instructional teaching unit in respiratory physiology that can be used by nursing students in a baccalaureate nursing program.

3. To test whether the self-instructional teaching unit would be a useful teaching tool on the mechanics of respiration.

CHAPTER II

REVIEW OF LITERATURE

Since all students are not alike, one method of instruction should not be expected to accommodate every student's needs. Many times the fact is overlooked that the student is an individual and has his own needs. Learning should be student centered, and teachers should provide an environment in which the students can achieve maximum learning. If instruction is student centered and individualized, information will be presented in a variety of teaching methods (Deegan, 1970; Husband, 1970; Jenkins & Russell, 1971).

One such teaching method is individualized self-instruction. Although the premise of individualized self-instruction is not basically different from other modern methods of instruction, self-instruction does provide the teacher and student with a different format of instruction. As with other methods, the student is responsible for his own learning. He will spend time pursuing a topic in some depth in conjunction with a course or as a complete course in itself.

The focus of self-instruction is on the individual performance and not on the class norm (Davidson, 1972). It is flexible enough to fit the individual student's needs. The student has access to the materials and can proceed at his own rate. The student is free to decide how much time he will spend working on the material and how much information he can absorb at one time (Bavin, 1973; Deegan, 1970; Husband, 1970). The student may review and repeat the material as often as he wishes until he feels he has mastered it. The flexibility of the self-instructional approach spares the student the embarrassment of learning too slowly or the boredom of repetitious teaching (Deegan, 1970; Fiel & Ways, 1972; Holcomb, 1972; Mundt, 1969; Postlethwait, 1970; Thornton & Brown, 1968).

Because of the flexibility all students do not have to be working on the same material at one time (Sather & Sleight, 1971). Students may work on material that is relevant and useful to them. They may learn basic information from the self-instruction and then work with the teacher to help them beyond their present knowledge (Holcomb, 1972). Through this individualization the student may find learning more stimulating (Bavin, 1973). It requires active participation from the student and provides a variety of learning opportunities. As with other methods of instruction the student is presented with the opportunity, but he must supply the motivation and be responsible for his learning (Beyers, Diekelmann & Thompson, 1972; Thornton & Brown, 1968). Because more responsibility is placed upon the student for his learning, the use of self-instructional materials frees the teacher from the routine instructional responsibilities (Carnegie Commission on Higher Education, 1972). The teacher is then free to spend time with the individual students helping them develop concepts, attitudes, and application of knowledge to clinical areas (Holcomb, 1972; Thornton & Brown, 1968; Wittkopt, 1972). In addition, more time is available for planning, co-ordinating, and evaluating student learning (Sather & Sleight, 1971).

Along with the advantages, individualized instruction also has its disadvantages. Some teachers feel they may lose their personal relationship with the students through the use of self-instructional materials (Koch, 1975; Poshek, 1972). Other teachers have become disenchanted with the use of instructional technology because studies have shown no significant difference in learning from the traditional methods (Carnegie Commission on Higher Education, 1972).

Because the interdigitation of hardware and software has not been standardized, hardware produced by one company may not be compatible with the software produced by a different company (Carnegie Commission on Higher Education, 1972; Holcomb, 1972). This lack of standardization may limit the materials available or create a need for more hardware or software. The hardware is expensive, and the budget may not be sufficient to provide the additional needed equipment for a particular, but necessary, program.

Additionally, the production of software has not kept up with the development of hardware, creating a lack of good instructional programs (Holcomb, 1972). Often the appropriate software is not available to accommodate the needs of the student. It is then the responsibility of the faculty to identify the needs and develop programs to meet them (Sather & Sleight, 1971). Many nursing schools have been encouraging their faculties to develop programs that can be used as self-instructional material (Davidson, 1972; Sartain, 1973; Wittkopt, 1972). Production of software that can be used on available equipment often meets needs not met by producers of commercial software. There is flexibility in that materials produced can be revised and improved. When necessary, additions and deletions can be made to adjust to the needs of the students (Holcomb, 1972; Langhoff, 1972). The disadvantages of producing one's own software are that a great deal of time and effort is expended, and those who do the production are not always properly rewarded for their work (Carnegie Commission on Higher Education, 1972).

Even though there are disadvantages to individualized self-instruction, it has become a popular method of teaching during the past few years. Lysaught (1969) states that even though there has not been much controlled experimentation on the self-instructional method for learning, there are small studies that have found it to be effective.

In 1961 at Purdue University a self-instructional approach was developed by the Department of Biological Sciences to assist the students in a course in introductory botany. A learning center was set up containing the hardware and the software necessary for self-instruction. There was an instructor available at the learning center at all times to assist the student. The student could study at his convenience for as long as he wished. He could progress at his own pace and repeat materials until he felt confident to proceed (Husband, 1970; Postlethwait, 1970). The learning center was only a part of the total plan. The students met for general assemblies. These assemblies were not planned to be strictly lecture sessions, but were designed for activities that lent themselves to large groups such as films and guest lecturers. A quiz session was held weekly, where small groups of students met to present and discuss topics from the week. Other activities were planned as they were needed to complement the students' learning (Postlethwait, 1970).

There have been positive results from the self-instructional approach to learning used at Purdue University (Thornton & Brown, 1968). Husband (1970) states that it was possible to accommodate more students in less space, and include 50 percent more subject matter. Thornton and Brown (1968) believe that better instruction was given with equal or fewer staff than traditional methods, while personal contact between teacher and student was enhanced. They also found that student interest and grades improved. Many universities, colleges, and junior colleges have followed the basic format established at Purdue. Each has modified certain aspects of the program to meet individual needs. They have had positive feedback from faculty and students alike.

Schools of nursing are also using the self-instructional approach to learning including the use of multimedia materials. In a controlled experiment done by Stein, Steele, Fuller, and Langhoff (1972) a multi-media, self-instructional approach was used. Out of 120 sophomore baccalaureate nursing students, sixty were matched by the use of several tests and a questionnaire. Thirty students were assigned to the experimental group and another thirty students to the control group. Those in the experimental group were allowed to work at their own pace and had available to them modern audiovisual materials. This group's learning was also supplemented by class assemblies. The control group was taught by traditional classroom-laboratory-clinic method.

The students in the experimental group voiced their approval of the self-instructional and audiovisual method of learning, and expressed a desire to continue with the program in their junior year. Although there was no significant difference in the examination scores of the two groups, the experimental group interacted more with the faculty.

In a study presented by Langford (1972) the null hypothesis stated there would be no significant difference between nursing students taught in the traditional manner and those utilizing the self-instructional approach. Thirty-nine students were assigned at random to experimental and control groups. In the experimental group each was allowed to learn at his own rate. He was responsible for his own choice of learning activities and the method of learning. A list of learning activities was available for him including lectures. The control group was expected to attend classes weekly and be prepared to discuss specific topics.

The experimental group scored higher on the mid-semester exam and the final exam, while the control group scored higher on the term papers. Because none of the differences was statistically significant, the results of the study supported the null hypothesis. There were, however, some interesting findings. A teacher was able to supervise a larger group of students when they were self-instructed. It was also possible to allow for differences in students' modes and rates of learning and still have the same level of learning as those students taught in the traditional method.

Thompson (1972) compared the self-instructional approach to nursing with the traditional approach. The second year medical-surgical nursing course was divided into three modules, and combined the use of multimedia including slide-tape presentations, videotape, 16 mm films, and programmed instruction. Each module was then divided into smaller sub-modules. Each module could be approached independently, and the students had a choice as to the order in which the sub-modules could be taken.

The experimental group included 40 students registered for the class. The control group of 35 students consisted of the class from the previous year, who were taught in the traditional method. Both groups were taught by the same faculty members. The null hypothesis stated there would be no significant difference between those students taught with the traditional method and those students using the self-instructional method.

Faculty impressions were obtained informally. The instructors believed there was more flexibility and creativity when using the self-instructional method of teaching. They felt there was an increase in personalization and rapport with the students. Teachers were able to increase the number of students under their supervision by use of self-instruction. Students were asked to complete a questionnaire. The reactions were mixed. Initially the students' reactions to self-instruction were negative, but by the end of the semester most of the reactions became positive. Out of 37 questionnaires returned, 55 percent of the students preferred the self-instructional approach to learning, 14 percent preferred the traditional approach, and 31 percent had no preference. Retention of information was tested after one year, and there were no significant differences between the two groups.

In the previous three studies, self-instructional methods did not produce significantly different learning from traditional methods, but both faculty and students believed the self-instructional method to be useful and enjoyable. Although self-instruction is not necessarily better than the traditional methods, it has its advantages and appears to be a valid approach to learning. The role of the teacher in the future may be that of educational planner, organizer, and manipulator of learning experiences and methods. He will be able to provide the environment in which individual students can best learn (Husband, 1970; Koch, 1975).

CHAPTER III

METHODOLOGY

In an unpublished study by McClurg (1974) a self-instructional teaching unit was produced on the topic of hemodynamics. The unit contained 35 mm slides and a narrative script. Using the approach presented in McClurg's study, the writer has developed a unit on the mechanics of respiration.

As in McClurg's teaching unit the multimedia approach selected for this self-instructional program on the mechanics of respiration was 35 mm color slides synchronized with a written narrative. In order for the writer to develop the unit it was necessary to have the assistance of the professor of physiology for both undergraduate and graduate nursing students and the aid of the Medical Graphics department at the University of Oregon Health Sciences Center.

The first step was to formulate an outline of the content to be presented in the unit (Appendix A). The writer then took each section of the outline individually and prepared the narrative. As each section of the narrative was completed, it was evaluated and revised.

As the narrative was being compiled, the writer briefly sketched ideas of the visuals to correspond to the narrative. The sketches were done on 8 1/2 x 11 inch plain paper in black and white. Each visual was evaluated for its appropriateness to the program. When the sketches had been approved, colors were selected for use in preparing the slides. A variety of materials was needed to produce the slides. Appendix B is a listing of the materials that were used.

The completed slides and the narrative were evaluated as a total unit. Necessary revisions were made to insure that the visuals and narrative presented a logical flow of ideas, and that the intended message was clearly presented.

In order to validate the self-instructional teaching unit a pilot test was conducted on the Portland Campus of Walla Walla College School of Nursing during the winter quarter of 1977. The Dean of the school of nursing was contacted and permission was obtained to conduct the testing (Appendix C). Walla Walla College is a private institution operated by the Seventh-day Adventist church. The main campus is located at College Place, Washington, where the nursing students receive their basic arts and science courses. The upper division nursing courses are taught on the Portland Campus, affiliated with Portland Adventist Medical Center and other local medical facilities.

Permission to participate in the study was obtained from forty junior nursing students in the baccalaureate program (Appendix D). One student requested to be dropped from the study, leaving thirty-nine who participated in the study. The junior students were divided into two classes. Group I contained twenty-one students who were required to take the self-instructional unit. The eighteen students in Group II were not exposed in any formal way to the content presented in the unit or given any specific instructions to follow. Group II acted as the control group for the study.

Both groups were told that they would be taking three tests. They were not told the three tests would be identical. A pretest was given to both groups at a prearranged time. After the pretest, the students in Group I were given the instructions concerning the use of the self-instructional unit. No record was kept of which students in Group I actually completed the teaching unit. The students were given one week in which to complete the unit and review the material as they felt necessary. The slides, the narrative script, and a projector were placed in the school's library for the students' use. The librarian was given a list of those students in Group I, and instructed to sign out the unit to only those students whose names appeared on the list.

At the end of the week, both groups were given the posttest. Six weeks from that date a retention test was administered to both groups. The six-week time period was chosen because it would allow the students sufficient time to become involved in other content areas. All three tests (pretest, posttest, and retention test) were composed of the same questions and were presented to the groups in the same sequence (Appendix E).

During the time of the study both groups were in the medical and/or surgical areas for their laboratory experiences. Since all three tests were identical, Group II was used to determine if the students were able to significantly improve their test scores by taking the tests without being exposed to the material presented in the unit. Using a t-test, comparison of test scores was made to determine the effectiveness of the self-instructional teaching unit.

THE SELF-INSTRUCTIONAL TEACHING UNIT

The self-instructional teaching unit includes the content narrative, The Mechanics of Respiration, and a set of 35mm slides.

The following are prerequisites for the unit on the mechanics of respiration:

1. A basis course in anatomy and physiology
2. An understanding of the terms:

   cephalad

   caudally

   tidal volume

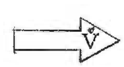
   functional residual capacity

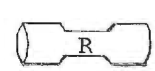
THE MECHANICS OF RESPIRATION
(Slide A)

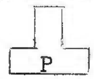
I. INTRODUCTION

A. DEFINITIONS

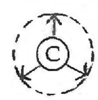
This unit on the mechanics of respiration focuses on ventilation and the mechanical factors that influence ventilation. Mechanical factors include: the muscles of respiration, pressure differences generated during the respiratory cycle, and the concept of dead space. In addition, emphasis is given to the static mechanical factors, compliance and surface tension, that influence ventilation. Finally, dynamic properties of breathing are discussed. These include flow and the resistance to flow. Before we continue further, it is necessary to define some terms and symbols that will be used throughout the discussion.

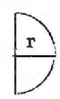
(Slide 1) 1) Flow is the change in volume per unit time. The symbol  or $\dot{V}$ is used for air or gas flow. The units for flow are usually liters per minute or milliliters per minute.

(Slide 2) 2) Resistance is the impediment to air or gas flow ($\dot{V}$) through an airway. The symbol  or R is used to indicate resistance.

(Slide 3) 3) Pressure is defined as force per unit area and can be expressed in terms of the height of a column of liquid above an arbitrary reference point. The symbol  or P is used for pressure. The units of pressure are generally centimeters of water or millimeters of mercury (torr).

(Slide 4) 4) <u>Difference</u> between two quantities is indicated by the Greek letter delta, symbolized here by the sign Δ.

(Slide 5) 5) <u>Compliance</u> is the volume change produced by a unit of pressure change, measured under static conditions. The symbol  or C is used for compliance.

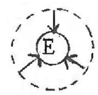
(Slide 6) 6) <u>Radius</u> and <u>length</u> are physical dimensions of airways. The symbols  or r are used for radius and  or L for length.

(When L appears as a subscript it refers to lung.)

(Slide 7) 7) <u>Viscosity</u> is the internal friction of a gas that tends to retard flow ($\dot{V}$), and thus, is one of the components of resistance. The symbol  or η, the Greek letter eta, is used for viscosity.

(Slide 8) 8) <u>Tension</u> is defined as units of force per unit of length. The symbol T is used for tension.

(Slide 9) 9) <u>Elasticity</u> or elastance is a physical property of tissue which causes the tissue to return to its resting shape after deformation by some external force.

The symbol  or E is used for elasticity. Elastance is the reciprocal of compliance (i. e., E = 1/C).

(Slide 10) 10) Work of breathing is directly related to the pressure difference (ΔP) and the change in volume (ΔV) produced by the pressure difference. The symbol W will be used for work.

B. A PREVIEW OF THE MECHANICAL EVENTS OF THE RESPIRATORY CYCLE

(Slide 11) For an individual to maintain life it is essential that he continually supply his cells with oxygen and remove carbon dioxide from his system. Oxygen is brought into the lungs from the atmosphere during inspiration, and carbon dioxide is removed from the lungs during expiration. Ventilation, the flow of gases from the atmosphere to the alveoli (inspiration) and from the alveoli back to the atmosphere (expiration), is brought about by changes in pressure within the lungs.

Gases, like fluids, flow from an area of higher pressure to an area of lower pressure. At sea level the atmospheric pressure is 760 torr. In order for inspiration and expiration to occur, the pressure within the lungs must alternately be less than and greater than atmospheric pressure.

(Slide 12) In a normal person at rest the respiratory muscles are relaxed at the end of expiration. The pressure in the alveoli of the lungs is equal to the atmospheric pressure, and there is no flow of air. As the muscles of inspiration contract, the volume of the thoracic cage enlarges. The lungs follow the outward movement of the thoracic cage, and the pressure within the lungs becomes less than atmospheric pressure (subatmospheric). Because of the pressure difference, air then flows into the lungs from the atmosphere.

During inspiration the elastic tissues in the lungs are stretched as the lung and chest expand. At the end of inspiration the muscles relax and the elastic tissue recoils back to its original size. The recoil of the elastic tissue in the lungs compresses air within the alveoli and increases the pressure to values greater than atmospheric pressure. The gases now flow from the alveoli through the airways out into the atmosphere.

C. THE MUSCLES OF RESPIRATION

1. The Diaphragm

Inspiration is an active process that requires work from the inspiratory muscles. (Slide 13) The principal muscle of inspiration is the diaphragm. This dome-shaped muscle, and its tendon, separate the thoracic cavity from the abdominal cavity. As the diaphragm contracts, it becomes flattened and moves downward. This downward movement increases thoracic volume.

2. The Intercostal Muscles

(Slide 14) Thoracic volume may be increased when the anterior ends of the ribs are elevated. Contraction of the external intercostal muscles increases thoracic volume by elevating the anterior end of each rib (Slide 15). This action of the external intercostal muscles causes the anterior aspect of the rib cage to be moved cephalad thereby enlarging thoracic volume. These muscles are not essential for inspiration as long as the diaphragm functions properly. However, contraction of the external intercostal muscles tenses the tissues in the intercostal spaces and prevents these tissues from bulging in during inspiration.

(Slide 16) The internal intercostal muscles move the ribs caudally and inward thereby reducing thoracic volume. Those muscles also stiffen the intercostal space and thus limit outward bulging of tissues between the ribs during expiration. (Slide 17) Note in this figure the anatomical orientation of the intercostal muscles. The external intercostal muscles are shown as thicker lines and slope downward toward the anterior aspect of the lower rib. The internal intercostal muscles are shown as thinner lines that slant upward toward the anterior aspect of the upper rib. (Slide 18) This slide summarizes the actions of the internal and external intercostal muscles. Note the opposing actions of the two muscle groups.

3. Accessory Muscles of Respiration

In normal people at rest the accessory muscles are not used in breathing. However, during exercise or maximal voluntary ventilation all of these muscles may be used. The accessory muscles for inspiration include the scalenes, the sternocleidomastoids, trapezius, and muscles of the back.

Expiration in quiet breathing, at rest, is passive. During inspiration the lungs and thorax are expanded and like a spring, the lungs store energy. When inspiration ceases the energy is released and the lungs and thorax passively return to their former positions. Under conditions of high rates of ventilation or obstruction of airways expiratory muscles are used. The most important muscles of expiration are the abdominal muscles. This group includes the external oblique, rectus abdominis, internal oblique, and transversus abdominis. Contraction of these muscles depresses the lower ribs and compresses the abdominal viscera. This latter action increases intra-abdominal pressure which pushes up against the diaphragm forcing it cephalad thereby decreasing thoracic volume.

II. DEAD SPACE

A. ANATOMIC DEAD SPACE

(Slide 19) In order for atmospheric air to reach the alveoli it must first flow through the conducting airways which consist of the nose, mouth, pharynx, larynx, trachea, bronchi, and bronchioles. (Slide 20) In adults the volume of the conducting airways is approximately 150 milliliters. No significant exchange of O_2 and CO_2 with the blood takes place across the walls of the conducting airways. (Slide 21) For this reason the volume of the conducting airways is termed anatomic dead space.

(Slide 22) During expiration approximately 500 milliliters of gases are exhaled from the pulmonary system. Of this 500 milliliters, approximately 350 milliliters of the gas comes from the alveolar space, and 150 milliliters are from the anatomical dead space. One hundred and fifty milliliters of alveolar air remain in the conducting airways or dead space at the end of expiration. (Slide 23) During the following inspiration 500 milliliters of air flow into the alveoli, but the first 150 milliliters of this air consist of the air that remained in the dead space from the previous expiration. (Slide 24) At the end of inspiration what are the components of the lung volume? (Slide 25) There are three components which are mixed in the alveolar space. These are: 1) 150 milliliters of dead space air which was left in the conducting airways from the previous breath (shown as diagonal lines in the figure), 2) a volume of alveolar air equal to the functional residual capacity minus anatomical dead space volume and 3) 350 milliliters of fresh air from the atmosphere (shown as dots). Note that the dead space now contains 150 milliliters of fresh air. (Slide 26) At the end of the next expiration 500 milliliters of air will be exhaled leaving 150 milliliters of alveolar air in the dead space. Thus, keep in mind that while the volume of air entering the lungs during inspiration is equal to the tidal volume, the actual volume of fresh air entering alveoli will be about 150 milliliters less than tidal volume.

B. PHYSIOLOGIC DEAD SPACE

(Slide 27) Even though inspired air reaches the alveoli, it may not participate in effective gas exchange with the blood. For various reasons the alveoli may not receive adequate blood flow. The reduced blood flow does not allow effective gas exchange to take place. The portion of the tidal volume reaching the alveoli that does not participate in gas exchange with the blood is termed physiologic dead space. Physiologic dead space is a calculated value and can be determined if one knows the concentrations of gases in mixed expired air and arterial blood.

III. PRESSURE DIFFERENCE DURING BREATHING

A. PRESSURE IN THE INTRAPLEURAL SPACE

(Slide 28) The inner surface of the thoracic cage is covered with a thin sheet or layer of epithelial cells called the parietal pleura. The parietal pleural is in intimate contact with the visceral pleura, a thin sheet of epithelium that covers the outer surface of the lungs. Between these two pleural surfaces there is a potential space that is normally occupied only by a thin film of fluid. The film of fluid acts as a linkage between the pleural surfaces, keeping them in contact with each other. The film also acts as a lubricant allowing the two surfaces to slide easily upon each other.

When the lungs are inflated they are forced to follow the movements of the thoracic cage and the lung tissue is stretched. (Slide 29) Like a stretched rubber band the lung tissue tries to return to its original position. (Slide 30) At the end of expiration the lungs and the thoracic cage are exerting equal but opposing forces upon each other, the lungs pulling inward and the thoracic cage pulling outward. (Slide 31) These two opposing forces create a subatmospheric pressure within the intrapleural space.

B. PRESSURE DIFFERENCE ACROSS THE LUNG WALL

Since the alveoli are open to the atmosphere through the conducting airways, pressure within alveoli or alveolar pressure is equal to atmospheric pressure at end expiration. (Slide 32) The pressure outside of the alveoli (intrapleural pressure) is subatmospheric. Hence, there is a pressure difference across the alveolar wall which maintains inflation of alveoli at the end of expiration. This pressure difference across the lung wall (ΔP_L) is equal to the difference between pressure in the alveoli (P_A), and intrapleural space pressure (P_{IPS}). The elastic recoil or stretching of the lung tissue opposes the pressure difference across the alveolar wall (ΔP_L). It is this pressure difference across the alveolar (lung) wall that prevents the lungs from complete collapse at the end of expiration.

C. PRESSURE DIFFERENCE ACROSS THE CHEST WALL

(Slide 33) There is also a pressure difference across the chest wall, ΔP_C. The pressure on the outside of the chest is at atmospheric pressure while pressure in the intrapleural space is subatmospheric. The pressure difference across the chest wall is equal to the difference between the pressure in the intrapleural space (P_{IPS}) and atmosperhic pressure outside the chest (P_{ATM}). Hence $\Delta P_C = P_{IPS} - P_{ATM}$. This pressure difference tends to compress the chest wall inward preventing the chest from assuming its most expanded position.

As long as the intrapleural space is not open to the atmosphere, there will be a pressure difference across the wall of the lung. (Slide 34) If the thoracic cage is opened (e.g., via trauma), the higher atmospheric pressure forces air into the intrapleural space. Then the pressure within the intrapleural space becomes equal to atmospheric pressure. As a result the recoiling forces of the lung no longer oppose the expanding force of the thoracic cage and the thorax expands outward. The pressure difference across the lung wall has also been lost and the lungs collapse since there is no force opposing elastic recoil.

D. CHANGES IN ALVEOLAR AND INTRAPLEURAL PRESSURES DURING THE RESPIRATORY CYCLE

(Slide 35) At the end of expiration, for a person at rest, the respiratory muscles are relaxed; there is no air flow. Pressure within the alveolar space is atmospheric, and the opposing forces of the lung and the thoracic cage are equal but opposite in direction. Under these circumstances the lungs and the thoracic cage are said to be at resting mid-position. (Slide 36) As the inspiratory muscles contract, the thoracic volume is enlarged and the intrapleural pressure becomes more subatmospheric. Hence, there is now a greater pressure difference across the wall of the lungs. (Slide 37) The lung wall is pushed outward (inflation) by the increased pressure difference across the alveolar wall. With the increase in volume, pressure within the lung (alveolar pressure) falls below that of atmospheric pressure. Air then flows in through the conducting airways along the pressure gradient until the alveolar pressure again becomes equal to atmospheric pressure (Slide 38).

During inspiration the lungs have been stretched. The more they are stretched the more they try to recoil and return to the resting mid-position. At the end of inspiration the inspiratory muscles begin to relax. (Slide 39) Then the elastic recoil force in the lungs becomes greater than those forces trying to expand the lungs. As the lungs recoil, alveolar pressure becomes greater than atmospheric pressure. Air now flows out through the conducting airways, and the lung volume decreases. (Slide 40) Expiration ceases when alveolar pressure again equals atmospheric pressure.

E. EFFECTS OF PRESSURE DIFFERENCES ON AIRWAYS IN THE LUNGS

1. Definition of Transmural Pressure

(Slide 41) Respiratory airways are not rigid tubes. Their diameters are determined by the pressure difference across their walls. The pressure difference across the airway wall, luminal pressure minus intrapleural pressure, is called transmural pressure. When the intrapleural pressure is less than the luminal pressure, there is a positive transmural pressure difference. (Slide 42) A negative transmural pressure difference occurs when the intrapleural pressure is greater than luminal pressure. At negative transmural pressure differences the airways tend to be compressed. Under these conditions the lumen is narrowed or even closed.

2. Regional Variations in Transmural Pressure

(Slide 43) The transmural pressure varies in different regions of the lungs. When a person is sitting or standing the transmural pressure at the apices is more positive than at the bases of the lungs. The reason for this apical-basal gradient in transmural pressure is as follows. When a person is standing or sitting upright the fluid in the intrapleural (and interstitial) space of the lung tissue is greater at the bases of the lungs than at the apices. The fluid accumulates in the bases of the lungs due to the effects of gravity. The accumulation of the fluid increases intrapleural pressure i.e., the greater the amount of fluid, the greater or the more positive the intrapleural pressure. Due to this difference in distribution of fluid, the intrapleural pressure tends to compress airways and alveoli in the lung bases. On the other hand airways and alveoli in the apices of the lungs are expanded relatively more than those in the basal regions. Thus airways in the bases of the lungs tend to collapse while those in the apices tend to be more dilated or open.

3. Changes in Transmural Pressure During Expiration (Slide 44) At the end of inspiration the respiratory muscles relax, the lungs begin to recoil, and pressure within the alveoli increases. The increased alveolar pressure is due to the elastic recoil of the lungs tending to compress the alveoli. The pressure in the lumen of the alveoli is greater than the pressure in the intrapleural space. This positive transmural pressure prevents the alveoli from collapsing. In healthy lungs during nonforced expiration there is a positive pressure gradient from alveoli to upper trachea. Air flows along

this gradient. However, during forced expiration intrapleural pressure is increased and may become greater than airway pressure. In this situation the transmural pressure across subsegmental bronchi becomes negative, tending to collapse these segments. However, these larger airways are supported by strong, cartilaginous connective tissue that resists compression and collapse.

In the normal person as well as in the patient with emphysema when expiration is forced, the intrapleural pressure will become positive. There is a greater pressure in the intrapleural space than within the airways, and hence the transmural pressure now becomes negative. Airways with limited structural support collapse, and air is trapped in the alveoli. The emphsematous patient must force expiration because normal recoil of the lung tissue is reduced. (Slide 45) In the emphysematous patient, the structural support, connective tissue, of the larger airways is also partially destroyed. During forced expiration the transmural pressure becomes negative as in the normal lung. The intrapleural pressure is greater than airway pressure and the airways are compressed. The structural support of larger airways has been weakened and cannot oppose the compressing force generated during expiration. As a result the airways become narrow or collapse causing increased resistance and obstruction to the flow of air. The patient with pulmonary disease of this sort must learn to create a higher pressure within his airways to keep them patent. During expiration the emphysematous patient purses his lips. Some investigators believe this act increases the pressure in the airways which helps to maintain a positive transmural pressure, and therefore reduces the degree of collapse of the airways during expiration.

IV. FACTORS THAT AFFECT THE DISTENSIBILITY OF THE LUNGS

There are two major factors that affect distensibility of the lungs: elasticity and surface tension. Elasticity and the reciprocal of elasticity, compliance, is discussed first and then surface tension follows.

A. COMPLIANCE AND ELASTICITY

(Slide 46) Hooke's law states that when a perfectly elastic body is acted on by one unit of force it will stretch in length by one unit. Because a portion of the force applied to cause an object to be stretched is used to overcome internal friction, a perfectly elastic body does not exist except in theory. A rubber band, although it does not have perfect elasticity, can be used to demonstrate Hooke's law. If we take the rubber band and pull on it using one unit of force, the rubber band will respond by stretching one unit of length. If two units of force are used, the rubber band will stretch two units of length, and so on.

This can be continued until the rubber band reaches its limit of elasticity. At this point further force will not increase the length. When the force is removed, the rubber band will recoil to its original position. (Slide 47) Plotting the relationship between force and length on a graph shows that there is a linear relationship between the two variables. The slope of this line is a measure of how easy (or difficult) it is to stretch the rubber band. The distensibility or the compliance for the rubber band is defined as the change in length produced by a unit change of force or $C = \frac{\Delta L}{\Delta F}$. (Slide 48) Elasticity is the reciprocal of compliance, hence $E = \frac{1}{C}$. Thus if compliance is increased the elasticity is necessarily decreased and vice versa.

Like the rubber band, the lungs and the thoracic cage are not perfectly elastic, but Hooke's law can be applied to describe their elastic properties. During inspiration the respiratory muscles exert a force on the thoracic cage, causing expansion of the thorax and lungs. The greater the force applied to the thoracic cage the more the tissues are stretched and the greater the change in volume of both lungs and thorax. When the muscles relax, the lungs and the thoracic cage recoil to their resting mid-positions. (Slide 49) Compliance for the lungs and thoracic cage is defined as the volume change produced by a unit of pressure change, measured under static conditions (no air flow) $C = \frac{\Delta V}{\Delta P}$. Unlike the relationship between force and length with the rubber band, the relationship between force per unit area (pressure or P) exerted on the lungs and the resulting change in volume is not a linear relationship.

(Slide 50) As you look at the graph relating pressure and volume, note the slopes of the lines. When the slope of the line is steep, as shown in the top or left line, the compliance is high. When the slope is flatter, as is the case with the lower or right line, the lungs and thoracic cage are stiffer--i.e., less compliant--and require a greater pressure change to obtain a given volume. The slope of the curve is used as a measure of the compliance of the lungs and thoracic cage.

(Slide 51) When the lungs have a decreased compliance (increased elasticity), they become stiffer. A greater pressure is needed to inflate the lungs to their normal volume. A decrease in compliance may occur in diseases, such as pleural fibrosis and tuberculosis, where the normal elastic lung tissue is replaced by fibrous tissue that is not easily stretched. As the compliance decreases, a greater pressure must be generated to inflate the lungs to a normal tidal volume, and the work of breathing is increased.

(Slide 52) When there is an increase in the compliance of the lungs, decreased elastic recoil, less pressure is required to expand the lungs to a specific volume. In emphysema the elastic lung tissue has been partially destroyed, but it is not replaced by fibrous tissue.

The lungs are easily inflated during inspiration, but do not have normal recoil due to the loss of elastic tissues.

(Slide 53) In addition, with the decrease in the elastic recoil of the lungs, there is a decrease in the compressive forces exerted upon the thoracic cage. The thoracic cage now expands outward toward its resting position, the position the thoracic cage would assume if there were no opposing forces exerted upon it by the lungs, and thoracic volume is increased. This increase in volume accounts for the "barrel chest" appearance observed in many emphysema patients.

(Slide 54) As the thoracic cage expands outward, the lungs follow, due to the pressure difference across the lung wall. When the lungs again exert an equal and opposite force against the thoracic cage, a new resting mid-position is established. At the new resting mid-position the lungs have an increased volume, and there is an increase in functional residual capacity.

B. SURFACE TENSION

(Slide 55) Surface tension is caused by the attracting forces that molecules or atoms have for one another. The molecules in a drop of water are continuously pulling on each other. A molecule in the middle of the drop is being pulled equally in all directions, but this is not true for a molecule that is on the surface of the water. There are fewer water molecules in the air to exert a pulling force on the water molecules in the liquid. The water molecules on the surface of the liquid are pulled to each side and downward by the other water molecules. The unequal attractive forces of the air and water molecules acting on each other cause the surface of the water to shrink to the smallest possible area. The molecular attracting forces on the surface at the air-water interface is referred to as surface tension. The surface tension is determined by the composition of the materials making up the interface and the absolute temperature.

(Slide 56) Since each alveolus is lined with a thin layer of fluid, there is a liquid-gas interface in the alveolus. The molecules in the fluid act upon each other in the same manner as described above for the drop of water. The surface tension (T) increases alveolar recoil. In order to prevent collapse, the recoil must be opposed by an equal pressure (P) within the alveoli. (Slide 57) The law of Laplace states that the pressure within an alveolus is directly proportional to the surface tension and inversely proportional to the radius of the alveolus. The equation $P = \frac{2T}{r}$ expresses these relationships for an alveolus (assuming the alveolus is spherical in shape). If the surface tension remains constant, a change in the radius (r) of the alveolus affects the pressure needed for inflation. Because the pressure is inversely proportional to the radius, if the radius is increased the pressure needed to maintain the inflation of the alveolus is decreased. If the radius is decreased, a larger pressure is needed for inflation.

(Slide 58) For example, if two soap bubbles with different radii but equal surface tensions are connected, the bubble with the smaller radius has the higher pressure and air will empty from the smaller bubble into the larger bubble.

The same situation described for the soap bubbles applies to the alveoli in the lungs. If we assume that the surface tension of all alveoli is the same, then the pressure required to inflate a small alveolus is greater than that for a large alveolus. However, all alveoli are connected through the distributing airways. At end inspiration or end expiration, small alveoli are exposed to the same inflation pressures as larger alveoli. It follows, that during inspiration large alveoli would tend to become even larger, while the small alveoli would tend to collapse as the air from them flows into the larger alveoli. Since we know that this is not the case, something must influence the surface tension of the alveoli as the radius changes during inflation and deflation of the lungs.

The lungs produce a substance that becomes part of the fluid lining of the alveoli. This substance is called pulmonary surfactant. (Slide 59) The surfactant molecules have a lower attraction for water molecules than water molecules have for each other. Surfactant accumulates on the surface of the fluid lining the alveoli. It dilutes the water molecules at the air-liquid interface and reduces the attracting forces between water molecules, thus decreasing surface tension.

As the surface area of the alveolus increases during inspiration, the number of surfactant molecules per unit area decreases. As the surfactant molecules are spread further apart, the ability of surfactant to lower surface tension decreases. The resulting increase in surface tension makes further inflation more difficult. During expiration the surface area of the alveolus decreases, and the number of surfactant molecules per unit area is increased. The surfactant molecules are now closer together and surface tension is reduced. With the decrease in surface tension the alveoli become more compliant. The same pressure inflates both small and large alveoli and small alveoli tend not to collapse. Less pressure is required for inflation, and the lungs can be more evenly ventilated.

Pulmonary surfactant is continuously being produced and destroyed in the alveoli. The production of surfactant requires an adequate supply of oxygen. When oxygen does not reach the alveoli, or alveolar P_{O_2} is significantly decreased, the production of surfactant is decreased. In some diseases, such as respiratory distress syndrome, cystic fibrosis, and adult shock lung, or when a patient is on cardio-pulmonary bypass, the production of surfactant is reduced. The decrease in surfactant allows surface tension to increase, and there is an increased work of breathing. The stabilizing effect of the surfactant on the surface of the alveolus is diminished, and there is a greater tendency for the alveolus to collapse. Once the alveolus is collapsed, greater pressure must be used to expand it during inspiration until the surfactant can be replaced.

V. RESISTANCE TO AIR FLOW

A. THE DEFINITION OF RESISTANCE

Most of the energy used in normal, quiet breathing is used to overcome the elastic recoil of the lungs and the thoracic cage, but some must be used to overcome the resistance to air flow. (Slide 60) As air is moved through the airways, the gas molecules come in contact with the walls of the airway causing friction. There is also an internal friction (viscosity) within the gas itself caused by the molecules moving about and colliding with each other. The friction causes a resistance to the flow of air. (Slide 61) Resistance (R) to air flow is the impediment to air or gas flow ($\dot{V}$) through an airway, and may be defined as the ratio of driving pressure to the resulting flow rate.

$$\text{(equation \#1)} \qquad R = \frac{\Delta P}{\dot{V}}$$

Resistance to air flow is an important component in the mechanics of respiration. Resistance to air flow changes in several respiratory diseases. Thus it is important for a nurse to have a knowledge of the factors that affect resistance to air flow.

B. COMPONENTS OF RESISTANCE

(Slide 62) Several factors determine resistance, and are expressed as follows:

$$\text{(equation \#2} \quad R = \frac{8\ \eta\ l}{\pi\ r^4}$$

Two of the factors, 8 and π (3.14) are constants. Resistance is directly proportional to the length (l) of the tube, the viscosity (η) of the material flowing through the tube, and inversely proportional to the radius (r) of the tube.

C. LAMINAR FLOW

(Slide 63) As air flows through a rigid, smooth tube of constant diameter at a low flow rate, a laminar flow pattern develops. In laminar flow the gas molecules flow through the tube in layers. Due to friction, the layer of gas molecules next to the wall of the tube has the lowest velocity of flow. The gas molecules in this outer layer are colliding and brushing against the next layer of gas molecules, causing an internal friction. The outer layer of gas molecules slows down the velocity of flow of the next inner layer of gas molecules. This internal friction slows the velocity of flow of each adjacent layer of gas molecules. Each layer of gas molecules has its own velocity of flow, the lowest velocity being nearest the walls of the tube, while the highest velocity of flow is at the center or axis of the tube.

D. POISEUILLE'S LAW

(Slide 64) Poiseuille's law for laminar flow states that in a rigid tube of constant dimensions the driving pressure necessary to produce a specific flow is directly proportional to the viscosity of the fluid or gas and the length of the tube, and inversely proportional to the fourth power of the radius.

As the viscosity of a fluid or gas increases, it is necessary to increase the driving pressure to assure a constant flow. When the tube is lengthened, the driving pressure must be increased proportionally to maintain a constant flow. If the radius is decreased the pressure must be increased significantly to maintain the same flow. A decrease in the radius has a profound effect on the flow ($\dot{V}$) of gases through a tube. Note in Poiseuille's law the radius is raised to the fourth power. Hence, if the radius is doubled from one unit to two units, and pressure remains constant, flow in the tube will increase sixteen fold.* (Slide 65) By combining the previous equations (# 1 and # 2) we can derive the equation for Poiseuille's law. Equation #1 may be rearranged to express the following:

$$\dot{V} = \frac{\Delta P}{R}$$

Equation # 2 may now be substituted for R, and the equation now shows

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*If r changes from one to two units, then r^4 changes from one to a value of sixteen (1 X 1 X 1 X 1 = 1 and 2 X 2 X 2 X 2 = 16) that

$$\dot{V} = \frac{\Delta P}{\frac{8 \eta l}{\pi r^4}}$$

By inverting the denominator and multiplying the equation becomes

$$\dot{V} = \frac{\pi r^4 \Delta P}{8 \eta l}$$

When applying Poiseuille's law for laminar flow, several assumptions are made. We assume that the tube through which the air or fluid flows is rigid and straight with a circular and smooth lumen of constant diameter. We assume that the physical dimensions of the tube do not change. While these assumptions are not met by the anatomical structure of the respiratory tree, the principles of Poiseuille's law still apply to air flow in the lungs of normal individuals and patients with respiratory diseases.

E. TURBULENT FLOW

(Slide 66) As driving pressure (i. e., ΔP) increases, the velocity of air flow increases, and laminar flow deteriorates. Eddy currents develop at high velocities of flow, and the flow becomes turbulent. As the velocity increases and turbulent flow develops, resistance increases and a greater driving pressure (ΔP) is necessary to obtain a specific flow. The work of breathing is increased when driving pressure must be increased.

In the normal, healthy individual at rest, there is a combination of laminar and turbulent air flow. Turbulent flow develops wherever the airway changes shape or bifurcates. However, normally the extra energy required for turbulent flow represents a small percentage of the total energy or work involved in breathing. During exercise, ventilation rate increases, the amount of turbulent flow increases, and therefore resistance to flow increases. To maintain a specific air flow in exercise a greater driving pressure is necessary to overcome the increased resistance due to turbulence. More energy and hence, work, is required to produce the necessary increase in driving pressure. The healthy individual is usually able to tolerate the increase in the work of breathing. However, people with respiratory disease may not be able to meet this increased demand in the work of breathing. For example, the emphysema patient has limited pulmonary function and spends a large percentage of his total energy just to breathe at rest. If work of breathing is increased for this patient, little or no extra energy may be left for other normal activities.

F. SMOOTH MUSCLE TONE AND RESISTANCE TO FLOW

Airway resistance is also influenced through the nervous system. Sympathetic and parasympathetic regulation of the smooth muscle in the wall of respiratory passages regulates their diameters. Impulses from sympathetic nerves cause the smooth muscle in the wall in the wall of the airways to relax; the diameter of the airways is increased, and resistance is lowered. In contrast, parasympathetic nerve impulses cause the smooth muscle to contract, thus decreasing the diameter of the airways. Resistance is increased, and the work of breathing is increased.

The airways may also become constricted in response to irritant compounds. Irritants such as dust, smoke, certain antigens, and some chemicals may cause the airways to constrict. Arterial hypoxemia and a decrease in arterial P_{CO_2} may also initiate a reflex which causes constriction of the airways. Bronchodilators such as isoproterenol and epinephrine act directly on the smooth muscle of the tracheobronchial tree causing smooth muscle relaxation and an increase in the diameter of the lumen of the airway.

(Slide 67) Regulation of smooth muscle tension (constriction or dilatation) of the airways affects resistance since the radius of the lumen changes with smooth muscle tone. As the smooth muscle contracts, the lumen of the airway is narrowed. With this decrease in the radius of the airway resistance to air flow is increased, and it is necessary to increase the driving pressure to maintain an adequate tidal volume. There is an increase in energy needed to maintain an increased driving pressure, and the work of breathing increases. The opposite effects occur when smooth muscle tone in the tracheobronchial tree decreases.

VI. SUMMARY

The purpose of this unit has been to identify and interrelate the various mechanical factors that influence ventilation. You should now have an understanding of the following:

1. the actions of the muscles of respiration
2. the concept of dead space
3. pressure difference during the respiratory cycle
4. the concepts of compliance and surface tension
5. air flow and the resistance to air flow

A posttest follows this unit. Review any sections that you wish before going on to the posttest..

CHAPTER IV

RESULTS AND DATA ANALYSIS

The sample consisted of thirty-nine junior students in a baccalaureate nursing program. Twenty-one students were in Group I, the study group, and eighteen students in Group II, the control group. The self-instructional teaching unit was presented to Group I, while Group II had no formal exposure to the content contained in the unit. Both groups took three tests (pretest, posttest, and retention test). Each consisted of forty-eight possible points.

The pretest scores for Group I ranged from 16 to 31 (33% - 64%). The mean score was 22.571 (47%). The posttest ranged from a low score of 29 (60%) to a high score of 46 (96%) with a mean of 37.048 (77%). The retention test scores ranged from 19 to 46 (40% - 96%). The mean was 35.667 (74%).

Group II's pretest scores ranged from 17 to 29 (35% - 60%). The mean was 22.556 (47%). The posttest ranged from 16 (33%) to 31 (64%) with a mean of 22.667 (47%). The retention test scores ranged from a score of 18 (38%) to a top of 33 (69%) with the mean score of 24.555 (51%) (Appendix F).

Inspection of the means and standard deviations (see Table 1) showed there was no difference between the two groups at the time of the pretest. Using t-tests, the means of the posttest and retention test scores were compared, between and within groups, to determine if the self-instructional teaching unit communicated a specified amount of content to the students.

Table 1. Score Summary on Pre, Post and Retention Tests for Study and Control Groups

	Pretest		Posttest		Retention Test	
	Mean	SD	Mean	SD	Mean	SD
Group I N = 21	22.571	4.00	37.048	5.14	35.667	7.42
Group II N = 18	22.556	3.73	22.667	4.19	24.555	4.93

The mean score on the posttest for Group I (37.048) was significantly higher than the mean score for Group II (22.667). The results of the t-test (9.460) for the posttest demonstrated that there was a significant difference between the two groups ($p < .01$). The mean score for the retention test was higher than for Group II (24.555). A t-test value of 5.560 showed that there was a significant difference between the two groups on the retention test ($p < .01$).

Within Group I there was a significant gain in the mean scores between pretest (22.571) and posttest (37.048) with a t-test value of 11.597 ($p < .01$). There was no significant difference of mean scores between posttest (37.048) and retention test (35.667). Group II showed no significant difference of mean scores between pretest/posttest, or posttest/retention test. The t-test (2.128) showed that there was significant difference between pretest (22.556) and retention test (24.555) ($p < .05$). However, the actual score difference was only two points. Thus, one should be careful in drawing any conclusions from interpretations of this difference.

Discussion

Students in Group I were able to learn from the self-instructional study unit as measured by the test developed for this unit. Although there was a decrease in the mean scores between posttest and retention test, the difference was not significant, demonstrating that students were able to retain the majority of the information presented in the unit. Group II showed significant gain in scores between pretest and retention test. Although there was a statistically significant increase in the mean score on the retention test in Group II, the increase is probably due to statistical artifact, e.g., sample size or to concomitant clinical experiences in which patients with respiratory disease were being cared for. Additionally, there was a seven-week period between pretest and retention test which would allow the students in both groups to explore areas of interest stimulated by the questions on the previous tests. There was also the possibility that the students learned from taking the same test three times.

By exposure to the content presented in the self-instructional teaching unit the students in Group I were able to significantly improve their test scores, while those students in Group II showed only a slight increase in test scores. It can be concluded that the teaching unit was able to communicate a specified amount of content to junior nursing students.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to demonstrate how a self-instructional teaching unit in the area of respiratory physiology could be developed and be used by nursing students in a baccalaureate nursing program.

The unit on the mechanics of respiration was developed and consisted of a narrative script and 35mm slides. A pilot test was conducted to determine the usefulness of the teaching unit. Data were collected on thirty-nine junior nursing students in a baccalaureate nursing program. The students were divided into two groups, the study group (Group I) and the control group (Group II). Each of the students was given a pretest, posttest, and retention test with a six-week time period between the posttest and the retention test.

Both groups had the same mean score on the pretest. There was a significant difference between the posttest and retention test. In the study group (Group I) posttest scores were significantly higher than pretest scores ($p < .01$), but there was no significant difference between the mean scores obtained from the posttest and retention test. In Group II there was no significant difference in mean scores between pretest and posttest. Statistically there was a significant difference between mean scores on pretest and retention test for Group II. This difference was probably due to statistical artifact or concomitant clinical experiences caring for patients with respiratory disease.

Conclusion

From the results of this study it may be concluded:

1. students were able to significantly improve their test scores by completing the content in the self-instructional teaching unit, and
2. students were able to retain a majority of the information learned for a period of six weeks.

Recommendations for further study:

1. Groups of students at different levels should be tested.
2. Students' attitude toward self-instructional teaching units should be evaluated.
3. A retention test that deals with application should be developed to test the students' understanding of the content.

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APPENDICES

APPENDIX A

OUTLINE FOR THE CONTENT OF THE TEACHING UNIT

OUTLINE FOR THE CONTENT OF THE TEACHING UNIT

THE MECHANICS OF RESPIRATION

I. Introduction

  A. Definitions

  B. A preview of the mechanical events of the respiratory cycle

  C. The muscles of respiration

    1. The diaphragm

    2. The intercostal muscles

    3. Accessory muscles of respiration

II. Dead space

  A. Anatomic dead space

  B. Physiologic dead space

III. Pressure difference during breathing

  A. Pressure in the intrapleural space

  B. Pressure difference across the lung wall

  C. Pressure difference across the chest wall

  D. Changes in alveolar and intrapleural pressures during the respiratory cycle

  E. Effects of pressure differences on airways in the lungs

    1. Definition of transmural pressure

    2. Regional variations in transmural pressure

3. Changes in transmural pressure during expiration

IV. Factors that affect the distensibility of the lungs

A. Compliance and elasticity

B. Surface tension

V. Resistance to air flow

A. The definition of resistance

B. Components of resistance

C. Laminar flow

D. Poiseuille's law

E. Turbulent flow

F. Smooth muscle tone and resistance to flow

VI. Summary

APPENDIX B

MATERIALS AND EQUIPMENT NEEDED TO PRODUCE THIS SELF-INSTRUCTIONAL TEACHING UNIT

MATERIALS AND EQUIPMENT NEEDED TO PRODUCE THIS SELF-INSTRUCTIONAL TEACHING UNIT

1. Plain white paper - 8 1/2 inch X 11 inch
2. Colored pens
3. Construction paper in a variety of colors
4. Acetate sheets - 14 inch X 17 inch
5. Press-on lettering in a variety of sizes
6. Large ruler
7. Scissors
8. Rubber cement
9. Flex tape in a variety of colors and widths
10. Cutting tool
11. Burnishing tool
12. Access to Xerox machine
13. 35 mm color film
14. Access to camera and slide mounting facilities

APPENDIX C

LETTER REQUESTING PERMISSION FOR STUDY

December 28, 1976

Miss Wynelle Huff, Dean
Walla Walla College School of Nursing
6014 S. E. Yamhill Street
Portland, Oregon 97215

Dear Miss Huff:

In partial fulfillment of the requirements for a Master's Degree in Nursing at the University of Oregon, I am asking for your help. I have developed a self-instructional teaching unit on the mechanics of respiration that consists of 35 mm slides and a written script. I plan to conduct a pilot test of the unit using students in the junior level of the nursing program at Walla Walla College School of Nursing.

The testing would involve approximately sixty students, and several instructors would be asked for their help and co-operation. Neither the students' nor the instructors' names will be included in the study. Copies of the completed study will be placed in the libraries of the University of Oregon Health Sciences Center and Walla Walla College School of Nursing.

Thank you for your help.

Sincerely yours,

Verlene Meyer
Instructor in Nursing

WALLA WALLA COLLEGE

SCHOOL OF NURSING
OFFICE OF DEAN

6014 SE YAMHILL
PORTLAND, OREGON 97215

503-235-8871, Ext. 371

January 19, 1977

Verlene Meyer
School of Nursing
Portland Campus

Dear Verlene:

Thank you for your letter of December 28 indicating your desire to conduct a pilot test of your self-instructional teaching unit on mechanics or respiration with some junior level students. We are always eager to promote research interests that will aid us also in evaluating teaching methods. It would be my desire to have us cooperate with you, if at all possible. Bonnie Meyer, as Level III Coordinator, can then work out the final decision and arrangements with you.

I wish you the best and hope all will go well for you in this project.

Sincerely yours,

Wynelle

Wynelle J. Huff
Dean

WJH:lc

cc: Edna Downing
Bonnie Meyer

APPENDIX D

INFORM CONSENT

I, ______________________________, herewith agree to serve as a subject in the pilot study named. "The Mechanics of Respiration: A Self-instructional Teaching Unit" by Verlene Meyer under the supervision of Barbara Gaines. The pilot study aims at validating the teaching unit. The procedures to which I will be subjected are three written tests. There are no risks involved in my taking part in the study. The information obtained will be kept confidential. My name will not appear in the completed study. Verlene Meyer has offered to answer any questions that I might have about my participation in this study. In understand I am free to refuse to participate or to withdraw from participation in the study at any time without effect on my relationship with or treatment at Walla Walla College School of Nursing.

I have read the foregoing.

______________________ (date)

______________________ (subject's signature)

______________________ (witness' signature)

I, ____________________________, herewith agree to serve as a subject in the pilot study named, "The Mechanics of Respiration: A Self-instructional Teaching Unit" by Verlene Meyer under the supervision of Barbara Gaines. The pilot study aims at validation of the teaching unit. The procedures to which I will be subjected are the teaching unit and three written tests. I may benefit from these procedures by gaining knowledge from the teaching unit. There are no risks involved in my taking part in the study. The information obtained will be kept confidential. My name will not appear in the completed study. Verlene Meyer has offered to answer any questions that I might have about my participation in this study. I understand I am free to refuse to participate or to withdraw from participation in the study at any time without effect on my relationship with or treatment at Walla Walla College School of Nursing. I understand that if I do withdraw from the study I must still complete the teaching unit and all tests as a requirement of section 343.

I have read the foregoing.

____________________ (date)	____________________ (subject's signature)
	____________________ (witness' signature

APPENDIX E

TEST COVERING UNIT

THE MECHANICS OF RESPIRATION

Multiple Choice: Choose the best answer

1. Which of the following factors determine resistance to flow?

    1. Length, radius, and viscosity
    2. Length, radius, and driving pressure
    3. Length and viscosity
    4. Driving pressure and radius

2. Internal friction (viscosity) is caused by:

    1. opposing pressures
    2. molecules colliding with each other
    3. the resistance to flow
    4. the radius of the airway

3. Length of the tube, viscosity of the material flowing through the tube, and radius are all factors of:

    1. compliance
    2. surface tension
    3. resistance
    4. velocity

4. Surface tension is caused by:

    1. pressure differences
    2. attracting forces of molecules
    3. muscle contraction
    4. elastic recoil of the alveoli

5. With a decrease in surface tension the alveoli become:

    1. less compliant
    2. more compliant
    3. no change in compliance

6. Turbulent flow:

    1. develops at low velocities of flow
    2. is observed in alveoli
    3. develops at high velocities of flow
    4. is not influenced by the velocity of flow

7. The law of Laplace states that:

   1. the pressure within an alveolus is directly proportional to the surface tension and inversely proportional to the radius of the alveolus.
   2. the pressure within an alveolus is inversely proportional to the surface tension and directly proportional to the radius of the alveolus.
   3. the pressure within an alveolus is inversely proportional to the surface tension and inversely proportional to the radius of the alveolus.
   4. the pressure within an alveolus is directly proportional to the surface tension and directly proportional to the radius of the alveolus.

8. The parasympathetic nervous system causes:

   1. the airways to decrease in diameter
   2. the airways to increase in diameter and decreases the resistance to flow
   3. the airways to decrease in diameter, and increases the resistance to flow
   4. has no direct effect on the airways

9. As turbulent flow develops:

   1. it requires a decrease in driving pressure to obtain a specific flow and the work of breathing is decreased.
   2. it requires an increase in driving pressure to obtain a specific flow and the work of breathing is increased.
   3. it requires an increase in driving pressure to obtain a specific flow and the work of breathing is decreased.
   4. it requires a decrease in driving pressure to obtain a specific flow and the work of breathing is increased.

10. At the end of inspiration the respiratory muscles relax, the lungs begin to recoil, and the pressure within the alveoli:

    1. increases
    2. decreases
    3. remains the same

11. The patient with emphysema purses his lips during expiration. This act:

1. decreases the pressure within the airways
2. increases the pressure within the airways
3. decreases compliance of the lungs
4. increases compliance of the lungs

12. In the normal, healthy individual at rest air flow is:

    1. laminar only
    2. a combination of laminar and turbulent flow
    3. turbulent only
    4. is neither laminar nor turbulent

13. During forced expiration intrapleural pressure is:

    1. increased
    2. decreased
    3. not changed

14. The pressure within the intrapleural space is:

    1. atmospheric
    2. subatmospheric
    3. greater than atmospheric
    4. the same during inspiration and expiration

15. Inspiration:

    1. is an active process at rest
    2. requires no work at rest
    3. is a passive process
    4. is due to the recoil of the chest wall

16. When the transmural pressure across the subsegmental bronchi becomes negative in the healthy lung, the airways remain open due to:

    1. a pressure gradient
    2. connective tissue support
    3. surface tension
    4. compliance factors

17. At a negative transmural pressure the airway:

    1. tends to collapse
    2. tends to expand

3. does not change
4. contracts due to expansion

18. Expiration:

    1. is an active process at rest
    2. requires work at rest
    3. is a passive process at rest
    4. is due to the expansion of the chest

19. The external intercostal muscles:

    1. elevate the anterior end of each rib
    2. depress the lower ribs
    3. flex the trunk
    4. limit outward bulging between ribs during forced expiration

20. Transmural pressure is:

    1. the intrapleural pressure minus the luminal pressure
    2. the intrapleural pressure minus atmospheric pressure
    3. luminal pressure minus intrapleural pressure
    4. atmospheric pressure minus luminal pressure

21. Functions of the thin fluid lining within the intrapleural space include:

    1. acts as a cushion and acts as a barrier
    2. acts as a linkage and lubricant between the pleural surfaces
    3. serves as an important reservoir
    4. protects the lungs from collapse during forced expiration

22. Surfactant:

    1. lubricates the alveoli
    2. reduces the attracting forces between water molecules
    3. increases the surface tension
    4. decreases the viscosity of the fluid lining of the alveoli

23. The volume of the conduting airways is approximately:

    1. 450 milliliters
    2. 350 milliliters
    3. 250 milliliters
    4. 150 milliliters
    5. 50 milliliters

24. If the surface tension remains constant in an alveolus, as the radius increases the pressure required for inflation:

    1. decreases
    2. increases
    3. remains the same

25. When a person is in an upright position (sitting or standing) the transmural pressure at resting mid-position in the apices of the lungs is:

    1. less than the transmural pressure at the bases of the lungs
    2. equal to the transmural pressure at the bases of the lungs
    3. greater than at the bases of the lungs
    4. the same when the person stands on their head

26. The term anatomical dead space refers to:

    1. the exchange of gases that occurs with the blood in the conducting airways
    2. lack of gas exchange in alveoli due to insufficient flow of blood
    3. lack of gas exchange in the conducting airways due to insufficient flow of blood
    4. the conducting airways where there is no significant exchange of O_2 and CO_2 with the blood

27. At the end of expiration:

    1. the pressure in the conducting airways is equal to atmospheric pressure
    2. the pressure surrounding the alveoli is equal to atmospheric pressure
    3. there is no pressure difference across the alveolar wall
    4. the lungs are completely collapsed

28. In order for inspiration to occur the pressure within the alveoli must be:

    1. equal to atmospheric pressure
    2. greater than atmospheric pressure
    3. less than atmospheric pressure
    4. independent of atmospheric pressure

29. At sea level atmospheric pressure is:

    1. 0 torr
    2. 713 torr
    3. 760 torr
    4. 807 torr
    5. 706 torr

30. In order for expiration to occur the pressure within the alveoli must be:

    1. equal to atmospheric pressure
    2. greater than atmospheric pressure
    3. less than atmospheric pressure
    4. independent of atmospheric pressure

31. The following condition increases compliance:

    1. emphysema
    2. tuberculosis
    3. pleural fibrosis
    4. silicosis

32. If compliance of the lung is increased the elasticity of the lung is:

    1. increased
    2. decreased
    3. not changed

33. The flow of gases:

    1. is independent of pressure difference
    2. occurs from an area of lower pressure to an area of higher pressure
    3. occurs from an area of higher pressure to an area of lower pressure
    4. is dependent upon the concentrations of the gases

34. As compliance is decreased the pressure needed to inflate the lungs:

    1. decreases
    2. increases
    3. does not change

35. Physiologic dead space may be defined as:

    1. the volume of gas in the conducting airways that does not participate in gas exchange with the blood
    2. the areas of the lung that do not receive adequate ventilation
    3. the portion of the tidal volume reaching alveoli that does not participate in gas exchange with the blood
    4. the cranial cavity

36. As a tube is lengthened to maintain a specific flow, driving pressure:

    1. is increased
    2. is decreased
    3. is not changed

37. At a constant driving pressure as the radius of a tube decreases:

    1. flow increases
    2. flow decreases
    3. flow does not change

38. Compliance for the lungs and thoracic cage is defined as:

    1. the volume change produced by a unit of pressure change, measured under static conditions
    2. the volume change produced by a unit of pressure change, measured under dynamic conditions
    3. the length produced by a unit change of force
    4. the pressure change produced by a unit of volume change

39. At a constant driving pressure as the viscosity increases:

    1. flow decreases
    2. flow increases
    3. no change in flow

40. In emphysema the "barrel chest" appearance is due to:

1. an increase in the elastic recoil of the lungs
2. the increased volume of the lungs forcing the thoracic cage outward
3. a decrease in the compressive forces exerted upon the thoracic cage by the lungs
4. an increase in the pressure difference across the chest wall

41. The chest wall is normally under compression due to:

1. a pressure difference across the chest wall
2. a pressure difference across the lung wall
3. a pressure difference between the atmospheric pressure and luminal pressure of airways
4. atmospheric pressure alone

42. At the end of expiration the alveoli remain inflated due to:

1. the elastic recoil of the alveoli
2. the pressure difference across the alveolar wall
3. the pressure difference across the chest wall
4. the compliance of the alveoli
5. the surface tension of the alveoli

43. Hooke's law states that:

1. when a perfectly elastic body is acted on by one unit of force it will stretch in length by two units
2. when a perfectly elastic body is acted on by two units of force it will stretch in length by two units
3. when a perfectly elastic body is acted on by two units of force it will stretch in length by one unit

44. Laminar flow:

1. is characterized by gas molecules flowing in layers
2. is characterized by eddy currents
3. can be heard with a stethescope placed over the chest
4. is the only kind of flow in airways

45. If the thoracic cage is opened to the atmosphere via trauma which of the following will occur?

a. atmospheric pressure will force air into the intrapleural space

b. intrapleural pressure will become more subatmospheric
c. intrapleural pressure will become equal to atmospheric pressure
d. the thoracic cage will be drawn inward
e. the thoracic cage will expand outward
f. the lungs will collapse
g. the lungs will expand
h. intrapleural pressure will force air out into the atmosphere

1. b, e, f, h
2. a, e, g
3. a, c, e, f
4. b, d, g, h

46. Which of the following describe the resting mid-position of the lungs and the thoracic cage for a person at rest?

a. there is no air flow
b. the respiratory muscles are relaxed
c. pressure within the alveoli is atmospheric
d. there is air flow into the lungs
e. opposing forces of the lung and thoracic cage are equal, but opposite in direction
f. pressure within the alveoli is subatmospheric
g. the thoracic cage exerts a greater opposing force than the lungs
h. the respiratory muscles are contracted

1. a, b, c, e
2. d, e, f, h
3. a, c, e, h
4. b, d, f, g

47. Number the following steps of inspiration in the correct order.

_1_ Resting mid-position of the lungs and thoracic cage
____ Thoracic volume is enlarged
____ Pressure within the lungs (alveoli) falls below atmospheric pressure
____ Respiratory muscles contract
____ Intrapleural pressure becomes more subatmospheric
____ Air flows through conducting airways
____ Inflation of the lungs occurs due to increased pressure difference across the wall of the lungs

48. Number the following steps of expiration in the correct order.

____ Elastic recoil of the lungs is greater than opposing forces and the lungs begin to recoil
_1_ Respiratory muscles relax
____ Alveolar pressure becomes greater than atmospheric pressure
____ Lung volume decreases
____ Air flows out through conducting airways
____ Alveolar pressure equals atmospheric pressure
____ Resting mid-position of lungs and thoracic cage

APPENDIX F

RAW DATA FOR PRETEST, POSTTEST, AND RETENTION TEST FOR BOTH GROUPS

Raw Data for Pretest, Posttest, and Retention Test for Group I

Group I

Student Number	Pretest Score	Posttest Score	Retention Test Score
1	22	31	27
2	22	32	34
3	23	42	45
4	17	40	42
5	27	33	29
6	20	41	30
7	29	36	35
8	20	32	19
9	24	45	40
10	22	31	27
11	25	37	34
12	25	37	44
13	23	46	46
14	31	42	43
15	22	41	35
16	23	44	45
17	16	29	33
18	28	36	41
19	19	37	40
20	19	31	28
21	17	35	32
Means	22.571	37.048	35.667

Raw Data for Pretest, Posttest, and Retention Test for Group II

Group II			
1	21	20	20
2	21	26	20
3	20	18	24
4	25	22	18
5	27	22	28
6	19	22	23
7	21	25	27
8	17	17	19
9	24	29	24
10	18	16	18
11	28	19	24
12	17	20	18
13	29	21	31
14	23	28	28
15	27	26	31
16	21	22	28
17	23	24	33
18	25	31	28
Means	22.556	22.667	24.555

AN ABSTRACT OF THE CLINICAL INVESTIGATION OF

VERLENE CAROL MEYER

for the Master of Nursing

Date of receiving this degree: June 11, 1977

Title: A SELF-INSTRUCTIONAL TEACHING UNIT:

[redacted]TION

Approved: [redacted]

The purpose of this study was to demonstrate how a self-instructional teaching unit in the area of respiratory physiology could be developed and be used by nursing students in a baccalaureate nursing program.

The unit on the mechanics of respiration was developed and consisted of a narrative script and 35 mm slides. A pilot test was conducted to determine the usefulness of the teaching unit. Data were collected on thirty-nine junior nursing students in a baccalaureate nursing program. The students were divided into two groups, the study group (Group I) and the control group (Group II). Each of the students was given a pretest, posttest, and retention test with a six-week time period between the posttest and the retention test.

Both groups had the same mean score on the pretest. There was a significant difference between the posttest and retention test. In the study group (Group I) posttest scores were significantly higher than pretest scores ($p < .01$), but there was no significant difference

between the mean scores obtained from the posttest and retention test. In Group II there was no significant difference in mean scores between pretest and posttest. Statistically there was a significant difference between mean scores on pretest and retention test for Group II. This difference was probably due to statistical artifact or concomitant clinical experiences caring for patients with respiratory disease.

Conclusions

From the results of this study it may be concluded:

1. students were able to significantly improve their test scores by completing the content in the self-instructional teaching unit, and
2. students were able to retain a majority of the information learned for a period of six weeks.

Recommendations for further study:

1. Groups of students at different levels should be tested.
2. Students' attitude toward self-instructional teaching units should be evaluated.
3. A retention test that deals with application should be developed to test the students' understanding of the content.