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Multimedia-aided instruction in teaching basic life support to undergraduate nursing students

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INTRODUCTION

Basic life support (BLS) is a primary medical life-saving aid in situations of cardiac arrest. It includes recognition of signs, e.g., sudden cardiac arrest, heart attack, stroke, and foreign-body airway obstruction; cardiopulmonary resuscitation (CPR); and defibrillation with an automated external defibrillator. As an early CPR step, the American Heart Association (AHA) guidelines recommend adult and pediatric BLS sequence of chest compressions-airway-breathing because effective chest compressions are crucial for the victim’s survival (1, 4, 5, 11). Nurses during their professional practice may have to deal with cardiac arrest situations and may have to perform BLS procedures for the survival of the affected individual. Thus BLS training is a necessary and important topic in any nursing curriculum.

At our school, undergraduate nursing students are given BLS courses in their second and fourth year of the nursing program. Second-year undergraduate nursing students learn only theoretical BLS knowledge. A practical BLS training course is provided in the fourth year, consisting of a 1-day program, with a lecture and practice on a manikin. The core content of the program follows the BLS guidelines recommended by AHA (5). The lecture session on BLS knowledge during the program is given without a problem-based approach and emphasizes integration of basic science principles with BLS knowledge. Despite skillful BLS practice, students lacked sound knowledge of basic nursing science. Many fourth-year undergraduate nursing students indicated (informally) they do not remember much from their basic science courses and are unable to link basic science knowledge with BLS practice. A study of Thai university nursing students in 2012 revealed poor BLS knowledge among healthcare providers and students have learned from basic science classes.

The decision to perform BLS requires immediate recognition of signs and symptoms of cardiac arrest, which needs an understanding of the underlying physiology and biochemistry. When a cardiac arrest occurs, immediate recognition and application of early CPR with effective chest compressions can help the victim through pumping blood to vital organs and preventing damage to brain cells (5, 12). This is based on the knowledge of heart function, oxygen transportation, and the role of mitochondrial oxidative phosphorylation, all of which students have learned from basic science classes.

The main problem of basic science education among nursing and other health science students in many nations is the difficulty of students to assimilate the information of basic science, which often leads to possible misconceptions regarding cardiovascular physiology, blood circulation pathway, and lung function. A previous study of undergraduate students in science courses at a university in the U.S. found misconceptions regarding dual blood circulation pathway (70% of students), types of blood vessels (33%), mechanism of gas ex-
change (55%), and lung function (20%) (18). For example, students believe that blood flows in a circular route from the heart around the body before returning to the heart, that arteries connect to veins without requiring capillaries, that all carbon dioxide molecules are exchanged for new oxygen molecules, and that lungs function to clean blood. Another study conducted in the Islamic Republic of Iran found 80–98% of nursing and other health science students have the misconception that heart ventricles pump more volume from the left than from the right because of the thicker wall of the former (16). A recent study involving healthcare providers in the U.S. reported students are unable to answer questions on basic human physiology and on reasons for performing chest compression (7). A clear comprehension on oxidative phosphorylation and adenosine triphosphate (ATP) generation by mitochondria proved difficult according to a study of undergraduate students at a university in India (10).

It would be helpful to create an instruction tool that can help students correct their misunderstanding of relevant basic science knowledge and enhance their ability to integrate the understanding of BLS principles before putting them into practice under simulated and actual situations. Educational multimedia, including text material, graphics, illustrations, photographs, and animations, is one such tool that can provide presentations of specific contents so as to make them easier to understand (13). Results of a Brazilian university nursing student study conducted in 2017 (22) shown effectiveness of an online course for teaching and learning key BLS skills, and a study conducted in the northeastern United States in 2015 also indicated positive learning outcomes of nursing staff participating in online methods for BLS renewal (20), but neither study focused on instruction of BLS that integrated basic science knowledge. In the era of transformative nursing education, a student-centered approach should be considered, where instructors act as facilitators, providing active learning skills to achieve the desired learning objectives (21, 23). A multimedia learning approach on intrapartum nursing care supplemented with group discussions resulted in higher scores in knowledge and performance assessments among nursing students compared with traditional teaching practices (8). In addition, a previous study suggested any new designs of teaching and learning strategies to improve bioscience (anatomy and physiology) performance among nursing students are unable to answer questions on basic human physiology and on reasons for performing chest compression (7).

Methods

Participants. A single group pretest-posttest design was employed in the study to determine the efficacy of multimedia-aided instructions on BLS learning among undergraduate nursing students in Thailand. The participants were third-year undergraduate nursing students of Ramathibodi School of Nursing, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, who were enrolled in a “Nursing of Child and Adolescent Practicum” course in the second semester of 2013 and who previously studied basic sciences and attended lectures on the principles of BLS. Convenience sampling was used in the study. Sixty-five students volunteered to participate and were. Each student, as the objectives and procedures of the study, and each participant submitted a signed consent form. The research project was approved by the Research Ethical Committee of Mahidol University Institutional Review Board (Certificate of Eligibility no. MU-IRB 2011/022.2712). In giving consent, the names of the participants were not revealed, and the participants had the right to withdraw from the study at any time. Their results were reported as aggregate, and their responses did not affect any scores in their regular course of study.

Multimedia and its components. As misconceptions and difficulties among college students abound regarding cardiorespiratory physiology, and oxidative phosphorylation and ATP generation by mitochondria (10, 16, 18), together with an inability to integrate relevant science knowledge (7, 14), a multimedia instruction package for undergraduate nursing students was developed. The multimedia package was created with a focus on correcting the misconceptions and reducing the barrier to attain basic science knowledge required for proper understanding of BLS. Another focus was on integrating basic science knowledge, such as anatomy, physiology, and biochemistry, into the learning of BLS principles. The software was developed using Adobe Creative Cloud (Mahidol University). This multimedia package displayed animation, audio, pictures, and text to reduce cognitive load and make learners understand clearly the basic knowledge of BLS. The contents of the multimedia tool consisted of four concepts relevant to the main components of BLS, namely, purposes of BLS and early CPR, chest compression, airway, and breathing. The first concept reviews the purpose of BLS and early CPR by displaying the functional features of the medulla oblongata, circulation, and energy metabolism of the brain. The second concept reviews chest compression and chest recoil by displaying the mechanisms of heart function, dual-circulation pathways, thoracic pump function, and cardiac pump function. The third concept reviews airway management by displaying the skull, airway anatomy, and airway management in children and adults. The fourth concept reviews the causes of cardiac arrest in children and adults.

The story-board content for creating the multimedia tool was validated by four experts experienced in preclinical or clinical teaching at our school, one in biochemistry, one in anatomy, one in pediatric critical care (registered nurse), and one in adult critical care (registered nurse). The process of validation comprised three distinct phases. The first phase aimed to develop instruments in the form of a checklist for the validation process. In the second phase, the first version of the multimedia was validated for the educational content, namely, structure, scope, and accuracy. Then it was revised according to the experts’ comments, such as on simplifying and chunking the content, clarification of symbols, and modification of images. In the third phase, a prototype was produced and validated by the same four experts and another expert in educational multimedia design. The aim of this phase was to assess the ergonomics as well as the educational content. The final revised multimedia package comprising the revised content, design, and organization was used in the study.

Multimedia instruction and knowledge testing process. Students’ achievements were evaluated by a 10-question open-ended questionnaire. Each student was provided with a printed copy of the questionnaire to complete individually in 30 min. The questions were developed to examine knowledge related to BLS. Ten questions (Tables 1 and 2) consisted of 1) three questions on the purpose of BLS and early CPR, 2) two questions on chest compression and chest recoil, 3) three questions on managing airway, and 4) two questions on causes of cardiac arrest. The questionnaire was validated by three experts: an instructor in critical care nursing, an instructor in anatomy and medical science, and an instructor in biochemistry. The total score is 10, with one point for each question. The scores were based on the level of accuracy of their descriptive response, with a score of 1 for correct and complete answer and 0 for incorrect or incomplete answer.
Table 1. Correct answers to the test questions

| Question                                                                 | Answer                                                                                                                                                                                                 |
|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. What is the main purpose of BLS?                                      | BLS helps restores normal breathing and blood circulation after cardiac arrest by providing ventilation through airway management and breathing resuscitation, and circulation function through chest compression and recoil. It enables oxygen and glucose transportation to organs for cellular metabolism by using oxygen and glucose to generate ATP via oxidative phosphorylation. |
| 2. Why is it important to start CPR immediately after cardiac arrest?    | A person succumbs to death if not receiving CPR immediately owing to a lack of blood glucose and oxygen supply, resulting in dysfunction of the medulla oblongata, the respiratory center, and the circular center. |
| 3. How do you tell whether you should continue or cease CPR?             | In a living person, look for chest or abdomen movement and listen for sounds of breathing, as they represent an adequate circulation function for oxygen and glucose blood flow to maintain medulla oblongata activity in the brain stem. |
| 4. Describe the mechanism of cardiac function.                           | Myocardial function depends on synchronized coupling of electrical excitation of the heart and the mechanical contraction and relaxation. The sinoatrial (SA) node, located in the posterior wall of the right atrium, gives an action potential depolarization for innervation of the heart through the atrioventricular (AV) node located in the floor of the right atrium above the insertion of the tricuspid valve, depolarizing the ventricles, which give electrical excitation from the AV node spreading throughout bundle of His, down the bundle branch, and through the Purkinje fibers. Blood travels to dual-circuit pathways from contractions of the right and left atriums through the right and left ventricles, then relaxation of the right and left atriums next to the right and left ventricles. |
| 5. Why is it important to allow complete chest recoil after each compression? | The complete chest recoil after compression is important because it leads to chest decompression and the heart to function as a passive conduit for blood flow in the heart chambers. Chest decompression results in decompression of the sternum and the vertebral column, generating relaxation of cardiac muscle of the left and right ventricles, and decreases plural cavity pressure, generating relaxation of cardiac muscle and dilatation of vessels. This allows the heart to function as a passive conduit, thereby allowing blood to flow into the heart chambers. |
| 6. Explain why children are not simply small-sized adults? (Explain in aspect of growth and development.) | Children have incompletely growth and development, which include the structure of their airways, such as the occiput, the thyroid cartilage, the cricoid cartilage, the ribs, and size of the lungs. |
| 7. Describe the difference between the airway structure of children and adults, and explain the airway management that is appropriate for each. | The differences in techniques for airway clearance in children and adults: In the former, airway is opened by supporting the shoulder in a supine position using a head tilt-chin lift maneuver or jaw thrust, avoiding overextending the head or neck as an infant tongue is more rostral and larger relative to the size of the oropharynx; whereas, in the latter, the head tilt-chin lift maneuver or jaw thrust is employed to open the airway or by adopting a lateral position to decrease airway obstruction. The respiratory assessment in children includes that of airway and breathing, the former by looking for chest or abdomen movement and listening for airflow and sounds of breathing, and the latter by observing respiratory rate, respiratory effort, chest expansion, and lung sounds. |
| 8. How do you assess airway and breathing?                               | The respiratory assessment in children includes that of airway and breathing, the former by looking for chest or abdomen movement and listening for airflow and sounds of breathing, and the latter by observing respiratory rate, respiratory effort, chest expansion, and lung sounds. |
| 9. What is the common cause of cardiac arrest in children?               | In children, the respiratory center in the brain stem and respiratory muscle ineffectively function, causing respiratory failure due to the lack of oxygenated blood and glucose delivery to the brain. The cardiovascular system compensates by increasing heart rate until cardiac muscle weakness results in cardiac arrest. |
| 10. What is the common cause of cardiac arrest in adults?                | Adults have complete growth and development, and the cause of cardiac arrest arises from deterioration of cardiac muscle, cardiac impulse, and/or the vascular system, leading to myocardial infarction or dysrhythmia. |

BLS, basic life support; CPR, cardiopulmonary resuscitation.

The pretest determined their prior knowledge of BLS. After completing the pretest, the participants were asked to improve their own understanding of the topics using the multimedia-aided instruction package via individual computers for 45 min. Then the students were divided into small cooperating learning groups of five persons for a 45-min facilitator-led discussion.

The posttest contained the same set of questions given in the pretest. In a cooperative learning group, students were asked to discuss important science knowledge in BLS practice and their viewpoints. The facilitator visited one group at a time, helping them clarify their thinking and learning by asking guiding questions.

Students’ perception. Students’ perception of the multimedia-aided instruction package and the cooperating group learning was explored by focus group discussions. After the posttest, one of the authors (C. J.) was a moderator using the same interview questions to collect data for each cooperative learning group, spending 30 min with each group and audio-recording each session for subsequent comparisons. The interview guide consisted of two open-ended questions: “What do you think about the multimedia tool in aiding your learning?” and “What are the differences between the multimedia-aided instruction package supplemented with cooperating group learning and traditional learning practice?” At the end of the interview, the participants were asked to express their attitudes regarding other aspects of learning not covered in the interview.

Data analysis. Statistical Package for the Social Sciences (SPSS 18.0, Mahidol University) was used for analysis of students’ achievement scores. For each question in the pre- and posttest, descriptive statistics were employed to determine the percentage of students providing correct answers. Scores of knowledge of the four BLS concepts (3 points each for the first and the third concepts, and 2 points each for the second and the fourth concepts) are reported as range and means ± SD. As the data did not have a normal distribution, the Wilcoxon signed-rank test was used to compare difference in knowledge of BLS between pre- and posttest (significance at P value <0.05). For data from the focus group discussions, recordings of each group interview were transcribed verbatim. Codes were generated and grouped into two preliminary categories, namely, positive and negative responses, and subsequently into subcategories. Preliminary information then was verified.

RESULTS AND DISCUSSION

The multimedia-aided instruction package on learning BLS was developed based on an integration of basic science knowl-
Table 2. Correct responses on knowledge of BLS for pretest and posttest

| Question                                                                 | Pretest |          | Posttest |          |
|--------------------------------------------------------------------------|---------|----------|----------|----------|
|                                                                           | n       | %        | n        | %        |
| **Concept 1: The purpose of BLS and early CPR**                           |         |          |          |          |
| 1. What is the main purpose of BLS?                                      | 5       | 8        | 64       | 98       |
| 2. Why is it important to start CPR immediately after cardiac arrest?    | 1       | 1        | 45       | 69       |
| 3. How do you tell whether you should continue or cease CPR?             | 0       | 0        | 53       | 81       |
| **Concept 2: Chest compression and chest recoil**                         |         |          |          |          |
| 4. Describe the mechanism of cardiac function.                           | 1       | 1        | 56       | 86       |
| 5. Why is it important to allow complete chest recoil after each         | 3       | 5        | 43       | 65       |
| compression?                                                             |         |          |          |          |
| **Concept 3: Managing airway**                                           |         |          |          |          |
| 6. Explain why children are not simply small-sized adults (explain in    | 14      | 21       | 57       | 88       |
| aspect of growth and development).                                       |         |          |          |          |
| 7. Describe the difference between the airway structure of children      | 8       | 12       | 61       | 94       |
| and adults, and explain the airway management that is appropriate for   | 4       | 12       | 43       | 66       |
| each.                                                                   |         |          |          |          |
| 8. How do you assess airway and breathing?                               |         |          |          |          |
| **Concept 4: Causes of cardiac arrest**                                   |         |          |          |          |
| 9. What is the common cause of cardiac arrest in children?               | 3       | 5        | 57       | 88       |
| 10. What is the common cause of cardiac arrest in adults?                | 2       | 3        | 58       | 89       |

Values shown are n (no.) and percentage of correct responses (out of n = 65 responses total). BLS, basic life support; CPR, cardiopulmonary resuscitation. *P value <0.05 (Wilcoxon signed-rank test) between pre- and posttest for every concept of BLS.

edge underlying BLS concepts to assist nursing students in gaining a better understanding of BLS. In concordance with the existing studies (3, 19), it is crucial to integrate the science content throughout the nursing curricula, which results in improved nursing practices and health care outcomes. The multimedia-aided instruction package contained learning tools of four BLS concepts: 1) the purpose of BLS and early CPR, 2) chest compression and chest recoil, 3) managing airway, and 4) causes of cardiac arrest.

Each student’s achievement was evaluated from knowledge of BLS using a 10-question pre- and posttest. More students provided correct answers in the posttest than the pretest (Table 2). The Wilcoxon signed-rank test revealed significantly higher posttest than pretest scores for every concept of BLS (P value <0.05). The mean posttest score was higher than that of the pretest score for every concept of BLS (Table 3).

These findings indicate that the multimedia-aided instruction package on BLS concepts supplemented with cooperating learning group improved undergraduate nursing students’ understanding of BLS. This could be explained by the contents of the multimedia tool developed to focus on the misconceptions and difficulty of integrating basic science knowledge (anatomy, physiology, and biochemistry) into a comprehensive and cohesive picture, and by linking this pertinent knowledge to the concepts of BLS. According to the cognitive theory of multimedia learning, humans learn more deeply from words and pictures than from words alone (13). The multimedia tool displayed a combination of animation, audio, picture, and text that was designed to keep nursing students’ attention focused on the content and to engage them in an active learning process. Consistent with previous studies (6, 9, 23, 25), the multimedia-aided instruction package was able to enhance students’ understanding of the information and to create an enabling learning environment.

The multimedia contents enabled >80% of the nursing students to answer questions correctly on the posttest for questions 1, 3, 4, 6, 7, 9, and 10. They performed less well for questions 2, 5, and 8. The correct answers to the questions posed are presented in Table 1.

An additional result from the focus group discussions showed two categories of the students’ responses: positive and negative perceptions. The majority of participants (92%) had positive perception toward the multimedia-aided instruction of BLS supplemented with the cooperating learning groups. The majority of students stated that they prefer this learning method over the traditional learning practice for a number of reasons. First, the multimedia-aided instruction package helped them to link basic science knowledge to BLS concepts, allowing them to gain a better understanding of BLS. In the past, students employed a fragmented memorization strategy and practice using a step-by-step BLS guideline without much clear understanding. Second, the multimedia-aided instruction combining animation, audio, pictures, and text kept their attention focused on the contents, satisfied their learning needs, and made the contents easier to understand. Third, learning activities in the cooperating learning groups provided interpersonal interactions with their peers and the instructor, which allowed them an
opportunity to share their thought and understanding and to make a more reasoned discussion.

These findings support the notion that multimedia-aided instruction supplemented with a cooperating learning group could enhance nursing students’ achievements in their understanding of BLS concepts. Similar to previous studies (2, 8, 21), the use of multimedia-aided instruction and group activities improved knowledge and understanding. This may be due to students being satisfied and pleased with using the multimedia tool, and to their perception that it helps them learn more easily. In addition, students stated the cooperating learning activities allow them to discuss learning issues with their peers. Students learn from peers in the group to help fill gaps in their understanding, and, conversely, students giving advice obtain a deeper understanding of the subject at hand. One student stated, “I enjoyed discussing in the group and learned more than sitting alone with a computer.”

There were some examples of negative perception. 1) The multimedia package contained too much information on the four concepts of BLS to be learned within 45 min and needed more time to assimilate the information. For future applications, the multimedia content should be made available online for access anywhere and anytime. 2) The multimedia package made a number of students feel less interest in the content presented. This could be due to their inability to recall their prior basic science knowledge and thus made the content presented difficult to understand.

In conclusion, using the multimedia-aided instruction package on BLS key concepts supplemented with cooperating learning groups for undergraduate nursing students has the potential to improve their understanding of basic sciences and improve their ability to integrate such knowledge to BLS. In addition, students were satisfied with this new learning method, which provided them not only knowledge but communication skill as a cooperative group member. The results of the study can also be used to provide basic information for developing new teaching and learning methods to enhance the competency of nursing and other health science students. However, there are a number of limitations in the study. First, the study design (a single group, pre- and posttest) made it difficult to claim that the multimedia-aided instruction with cooperating learning groups was superior to the traditional learning approaches. Second, the volunteer students in the study were drawn from a group motivated to improve their learning skills. Third, additional data were not collected on a later date after the posttest, and thus retention of knowledge was not evaluated over time. Fourth, the study was conducted at only one nursing school, and thus generalization of the findings was not possible. Nevertheless, this study contributes to a learning approach that integrates knowledge with true understanding.

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DISCLOSURES

No conflict of interests, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

C.J., K.J., S.L., and R.P. conceived and designed research; C.J. performed experiments; C.J. and K.J. analyzed data and interpreted results of experiments; C.J. drafted manuscript; C.J. and K.J edited and revised manuscript; C.J., K.J., S.L., and R.P. approved final version of manuscript.

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