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FOR HEALTH SCIENCE

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SAVINGLIFE®: AN EDUCATIONAL TECHNOLOGY FOR BASIC AND ADVANCED CARDIOVASCULAR LIFE SUPPORT IN NURSING

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RESUMO

A taxa de sobrevivência da parada cardiopulmonar continua pobre, apesar dos avanços na Ressuscitação Cardiopulmonar e no Suporte Avançado de Vida em Cardiologia (ACLS). Muitas deficiências têm sido relatadas por pesquisadores durante a realização de cuidados de ressuscitação. Métodos de treinamento convencionais são muitas vezes insuficientes para treinar profissionais para oferecer alta qualidade nos cuidados de reanimação. Por outro lado, a abordagem da Aprendizagem Baseada em Problemas (PBL) mostrou-se como um melhor método de ensino para a ressuscitação cardiopulmonar e o treinamento em suporte avançado de vida em cardiologia. O desenvolvimento das tecnologias da informação e da comunicação e a acessibilidade dos dispositivos móveis aumentaram as possibilidades do processo de ensino-aprendizagem em qualquer lugar e a qualquer hora. Aplicações móveis e web permitem a produção de modelos de ensino e aprendizagem construtivos em vários contextos educacionais, mostrando o potencial de aprendizagem ativa em enfermagem. A tese teve como objetivo: Desenvolver e avaliar, o Savinglife®, uma tecnologia educacional para suporte cardiovascular básico e avançado de vida em Enfermagem.Os resultados foram divididos em três fases: a primeira fase consistiu na realização de uma revisão sistemática que avaliou o uso de métodos e tecnologias de aprendizagem baseada em problemas no ensino em ressuscitação cardiopulmonar e suporte avançado de vida em cardiologia. A metodologia de revisão sistemática Cochrane foi seguida para pesquisar em quatro bases de dados eletrônicas: PubMed, LILACS, COCHRANE e Science Direct dos estudos publicados. Entre os 164 artigos obtidos, 9 estudos foram incluídos. As evidências disponíveis sugerem que as abordagens e tecnologias de aprendizagem baseada em problemas é um melhor método de ensino para o ensino de RCP e ACLS e aumentam o conhecimento, as habilidades e as competência dos alunos. Na segunda fase, apresentamos o desenvolvimento de uma tecnologia educacional (Savinglife®, um aplicativo) para a aprendizagem em ressuscitação cardiopulmonar e o treinamento em suporte avançado de de vida cardiovascular. Savinglife® é uma produção tecnológica, baseada no conceito de aprendizagem virtual e com a abordagem de aprendizagem baseada em problemas. O estudo foi desenvolvido de janeiro de 2016 a novembro de 2016, utilizando cinco fases (análise, projeto, desenvolvimento, implementação, avaliação) do processo de desenvolvimento de sistemas de ensino. A tecnologia apresentou 10 cenários e 12 simulações, abrangendo diferentes aspectos do suporte básico e avançado da vida em cardiologia. O conteúdo do aplicativo pode ser acessado de forma não linear, deixando os alunos livres para construir seus conhecimentos com base em sua experiência anterior. Na terceira fase, analisamos a qualidade e a usabilidade do Savinglife®. Para validade da qualidade e conteúdo, o aplicativo foi avaliado com a ferramenta LORI. O instrumento de avaliação baseado na norma ISO 9241-11 foi utilizado para avaliação de usabilidade do Savinglife®. A avaliação envolveu 15 especialistas em enfermagem e 4 programadores de computadores. Os especialistas em enfermagem avaliaram e analisaram a qualidade e a validade do conteúdo por meio do instrumento LORI, e os programadores avaliaram a usabilidade de Savinglife® usando instrumento de usabilidade composto de 15 itens. Os resultados extrapolaram a média alvo (4 - Muito Bom) na avaliação pelos especialistas em enfermagem (4,71) e pelos programadores (4,43). A análise das médias atribuídas a todas as nove variáveis na ferramenta LORI e todas as quinze variáveis na ferramenta Usabilidade tiveram pontuações elevadas (média geral de 4,71 e 4,43, respectivamente). Dentre as variáveis que compõem o instrumento LORI 2.0, a "Interação e Usabilidade" (4,93 ± 0,25) teve a média mais alta. Entre as variáveis que compõem o instrumento de Usabilidade, o "O usuário é capaz de acessar o aplicativo facilmente" (5 ± 0,00) teve a média mais alta. A partir dos resultados, é possível confirmar que Savinglife® tem critérios de Qualidade e Usabilidade e é adequado para ser utilizado no ensino em Suporte Básico e Avançado de vida. O Savinglife® pode preencher as lacunas de aprendizagem e das habilidades na tomada de decisão dos alunos de forma segura e ética.

Palavras-chave: Tecnologia Educacional, Informática em Enfermagem, Suporte Básico e Avançado de Vida em Cardiologia, Aprendizagem Baseada em Problemas

ABSTRACT

The survival rate from cardiac arrest remains poor despite advances in Cardiopulmonary Resuscitation and Advanced Cardiovascular Life Support (ACLS). Many shortcomings have been reported by researchers during the performance of resuscitation care. Conventional training methods are often insufficient to train professionals to deliver high-quality resuscitation care. On the other hand, Problem Based Learning (PBL) approach has been shown a better instruction method for cardiopulmonary resuscitation and advanced cardiovascular life support training. The development of information and communication technologies and the accessibility of mobile devices has increased the possibilities of the teaching and learning process anywhere and anytime. Mobile and web application allows the production of constructive teaching and learning models in various educational settings, showing the potential for active learning in nursing. The objective of this thesis was to develop and evaluate, Savinglife®, an educational technology for basic and advanced cardiovascular life support in nursing. The results were divided in three phases: **first phase** consists of conducting a systematic review with the aim to evaluate the use of problem-based learning methods and technologies in the education of cardiopulmonary resuscitation and advanced cardiovascular life support. The Cochrane systematic review methodology was followed to search the four electronic databases of PubMed, LILACS, COCHRANE and Science Direct for published studies. Among 164 articles retrieved, 9 studies were finally included in the review. The available evidence suggests that problem based learning approaches and technologies is a better instruction method in the education of CPR and ACLS and enhance the knowledge, skill and competency of learners. In the **second phase**, we presented the development of an educational technology (Savinglife®, an app) for learning cardiopulmonary resuscitation and advanced cardiovascular life support training. Savinglife® is a technological production, based on the concept of virtual learning and problem-based learning approach. The study was developed from January 2016 to November 2016, using five phases (analyze, design, develop, implement, evaluate) of the instructional systems development process. The technology presented 10 scenarios and 12 simulations, covering different aspects of basic and advanced cardiac life support. The contents of the application can be accessed in a non-linear way leaving the students free to build their knowledge based on their previous experience. In the **third phase**, we analyze the quality and usability of Savinglife®. For quality and content validity the App was evaluated with LORI tool. The evaluation instrument based on the ISO 9241-11 standard was used for usability assessment of the Savinglife®. The evaluation involved 15 nursing experts and 4 computers programmers. The nursing experts assessed and analyzed the quality and validity of the content through LORI tool, and the programmers assessed the usability of Savinglife® using Usability instrument consist of 15 items. The results exceeded the target level (4 - Very Good) in the evaluation of nursing experts (4.71) and computer programmers (4.43). The analysis of the averages assigned to all nine variables in the LORI tool and all fifteen variable in the Usability tool have high mean scores (with general average of 4.71 and 4.43 respectively). Among the variables that make up the LORI 2.0 instrument, the ”Interaction and Usability” (4.93 ± 0.25) has the highest average. Among the variables that make up the Usability instrument, the ”The user is able to access the application easily” (5 ± 0.00) has the highest average. In the light of the obtained results, it is possible to confirm that Savinglife® has the Quality and Usability criteria and is adequate and suitable to be used in the education of BLS and ACLS. It is believed that Savinglife® can fill the gaps in learning and decision making abilities of students and can promote learning of BLS and ACLS skills in a safe and ethical manner.

Keywords: Educational Technology, Nursing Informatics, Basic Cardiac Life Support, Advanced Cardiac Life Support, Problem-based Learning

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LIST OF ABBREVIATIONS

PBL	Problem based Learning
CVD	Cardiovascular Disease
UFSC	Universidade Federal de Santa Catarina
GIATE	Grupo de Pesquisa Clíınica, Tecnologias e Informática em Saúde e Enfermagem
PEN	Programa de Pós-Graduação em Enfermagem
SDL	Self Directed Learning
BLS	Basic Life Support
ICU	Intensive Care Unit
ECG	Electrocardiogram
VLE	Virtual Learning Environment
ALSO	Advanced Life Support in Obstetrics
NI	Nursing Informatics
ANA	American Nurses Association
IS	Information System
AHA	American Heart Association
IT	Information Technology
ICT	Information and Communication Technology
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia
HCP	Health Care Providers
PEA	Pulseless Electrical Activity
CPR	Cardiopulmonary Resuscitation
JISC	Joint Information Systems Committee
LORI	Learning Object Review Instrument
TCLE	Termo de Consentimento Livre e Esclarecido

CONTENTS

1 INTRODUCTION

Cardiac arrest occurs when heart stop pumping sufficient blood to the brain and body. This may be due to abnormal or irregular heart rhythm, also known as Arrhythmia. A cardiac arrest is different from a heart attack and heart failure. A heart attack is caused by an obstruction that stops blood flow to the heart while in a heart failure blood circulation is inadequate and poor, but the heart is still working to sustain life. Cardiac arrest is reversible, if treated with immediate defibrillation if a *shockable* rhythm exists otherwise cardiopulmonary resuscitation (CPR) is used in order to induce a *shockable* rhythm (SURESH;FATHIMA, 2015).

Despite recent advances in prevention and treatment, cardiac arrest remains a significant public health problem and a leading cause of death in many parts of the world (ROGER et al., 2011). Cardiac arrest occurs both in and out of the hospital. 17.5 million people die each year from cardiovascular disease (CVDs) representing an estimated 31% of all deaths worldwide (WHO, 2015). More than 75% of CVD deaths occur in low-income and middle-income countries while 80% of all CVD deaths are due to heart attacks and strokes (WHO, 2015).

In the US and Canada, approximately 350000 people/year (approximately half of them in-hospital) suffer a cardiac arrest and receive attempted resuscitation (NICHOL et al., 2008; NADKARNI et al., 2006). This estimate does not include the number of victims who suffer an arrest without attempted CPR. While attempted CPR is not always appropriate, there are many lives lost because adequate CPR is not performed. The estimated incidence of out-of-hospital cardiac arrest in the US and Canada is about 50 to 55/100000 persons/year and approximately 25% of these have pulseless ventricular arrhythmias (NICHOL et al., 2008). The estimated incidence of in-hospital cardiac arrest is 3 to 6/1000 admissions and similarly, approximately 25% of these have pulseless ventricular arrhythmias (NADKARNI et al., 2006). The vast majority of cardiac arrest victims are adults, but thousands of infants and children suffer either an in-hospital or out-of-hospital cardiac arrest each year in the US and Canada (NADKARNI et al., 2006). Cardiac arrest continues to be a common cause of premature death, and small improvements in survival can translate into thousands of lives saved every year.

According to Ministry of Health Brazil, from January 2000 to December 2004, cardiovascular diseases were the leading cause of death in the country (31.78%), followed by cancer (15.32%) and other causes (14.58%). The state of Santa Catarina has values similar to the national average with 32.35% of deaths from cardiovascular diseases in the same period (Ministerio da Saude, 2015).

The survival rate from cardiac arrest remains poor despite advances in cardiopulmonary resuscitation (CPR) and post-resuscitation therapies. Recognition of a cardiac arrest and prompt action by the rescuer are vital for the survival of the cardiac arrest patient (ASSOCIATION et al., 2010; LINK et al., 2015). It is also a fact that the quality of CPR performance also influences the outcome of patients (ABELLA et al., 2005; WIK et al., 2005; WALLACE; ABELLA; BECKER, 2013).

Nursing professionals are usually the first to witness a cardiac arrest at the hospital (GOMBOTZ et al., 2006). They are those who frequently call the assistance team. Nurses are recognized by the community as the most capable individuals to perform effective CPR. The ability to respond quickly and effectively to a cardiac arrest situation depends on the competence and learning abilities of nurses in cardiopulmonary resuscitation (MADDEN, 2006). Nurses working in departments such as cardiology, cardiac and Intensive Care Units and accident and emergency departments should therefor become more active members of the multidisciplinary team during CPR and should be more willing to attend CPR seminars and trainings (TERZI, 2008). These professionals need to have updated technical knowledge and practical skills developed to contribute more efficiently to cardiac arrest activities.

The purpose of nursing education is to enable nurses to think independently and critically and utilize nursing process. They must be competent enough to correctly determine the health conditions of an individual, to provide direct, safe and effective nursing care, as well as be able to conform to the changing health care environment, particularly in emergency situations (HSU; TANG; HUANG, 2005).

Traditional education with face to face teaching methods can introduce new ideas, transmit knowledge and resolve doubts. However due to limited time, this type of education is not useful because students have to study intensively over a short time of period and with insufficient training and critical thinking. With traditional education, students may become incapable of professional judgment and autonomous thinking in case of variable clinical working environment (ALEXANDER et al., 2002). Recent studies have documented many shortcomings during the performance of resuscitation care. Conventional training methods are often insufficient to train professionals to deliver high-quality resuscitation care (SEETHALA; ESPOSITO; ABELLA, 2010).

Problem-based learning, on the other hand, has been shown a better instruction method for CPR training with improved quality of resuscitation (CREUTZFELDT et al., 2007; POLGLASE et al., 1989). Despite several changes in nursing school's curricula related to the BLS and ACLS, most of the graduate nurses are not effective in emergency situations which require a quick and correct response from health professionals to avoid any serious consequences. Therefore, universities and institutions are developing their curricula and disciplines with aims to break the traditional teaching models in order to make health education more effective and creative.

Problem-based learning (PBL) emerged as a teaching method in medical education in the late 1960s at McMaster University Medical School in Canada. PBL allows students to participate in active learning and improve their communication ability, creative thinking, and problem-solving skills in diverse learning environment (TSENG et al., 2006). PBL provides a bridge to the learner to connect with real life situations and enhance their learning power, decision-making skill and critically thinking ability. In a PBL classroom, the student becomes a partner in the learning process by utilizing real-life scenarios to recognize what they know and what they need to know, to understand the situation, thus creating their own knowledge. This approach gives the student the responsibility of analyzing information and communicating it to other students in class (BEERS, 2005).

PBL works in small groups and can be regarded as self-directed active learning. In PBL students identify what they already know, what they need to know and why and from where they can access new information that may lead to solve the problem. In PBL, ill-structured and real-life problems are used as the starting points. Students work as a team to solve the problems through collecting and analyzing relevant information and then applying the learned knowledge. PBL is self-directed learning (SDL) with learners in-charge of the process. Learners choose the topics they wish to study, the information to search, and the methods for solving problems. Therefore, the roles of the students are as thinkers and knowledge creators while the role of teachers are those of designers, facilitators, and supporters.

Problem-based learning methodology in training nurses for cardiopulmonary arrests has been indicated an effective approach resulting in a better integration of the theory and practice of the CPR process (SARDO; SASSO, 2008b). Similarly, PBL is considered as the most significant innovation in education for the health professionals (POLYZOIS; CLAFFEY; MATTHEOS, 2010). Its effective learning approach prepares students as critical thinkers and lifelong learners and also able them to respond to the changing health environment.

Computer technologies can play an important role in supporting PBL in various ways. For instance, mobile based PBL is beneficial for the students, especially in remote areas where the system is accessible, convenient, low cost, easy to operate and highly interactive (TANG; LIN; LAI, 2014). Many medical applications such as I-Surgery Notebook, Eponyms, Netter's Atlas of Human Anatomy, Netter's Anatomy Flash Cards, Blausen Ear Atlas, Oxford Handbook of Clinical Specialties, Cranial Nerves, and Instant ECG for smartphones have been developed and widely used by health professionals and patients. The use of information and communication technologies are getting more attention in healthcare day by day. Medical applications make computer useful tools in the practice of evidence-based medicine at the point of care, in addition to their use in clinical communication (MOSA; YOO; SHEETS, 2012). Higher education institutions in most of the countries are already focusing on integrating the internet, multimedia, web tools and other technologies in order to provide students with improved experiences of teaching and learning.

In the context of rapid technological change and the possibility of enhancing the teaching-learning processes in specific areas of nursing through the inclusion of information technologies such as mobile devices, we therefore proposed a theme of the study that meet both the demands of nursing self-learning and the use of innovative technologies in teaching and learning. So we choose to design and develop an mApp (Savinglife®) for teaching BLS and ACLS with the help of different clinical scenarios and simulations of cardiac arrest of adult patients.

1.1 JUSTIFICATION

The opportunity to attend bachelor and master level education in Pakistan and now doctorate at Federal University of Santa Catarina, Brazil, allowed me to acquire a more comprehensive view of the nurses training process. Work experience of six years at ICU in Pakistan and attending BLS and ACLS training courses have increased my desire to play an active role in training nursing students in this field.

The GIATE/LAPETEC (Grupo de Pesquisa Clınica, Tecnologias, e Informatica em Saude e Laboratorio de Producao Tecnologica em Saude) research Group is linked to the Graduate Program in Nursing at the Federal University of Santa Catarina. It conduct clinical research on methods, processes, techniques, tools, products and technological nursing care devices for patient safety in intensive care. It also develops and evaluates intelligent learning systems that allow active learning, collaboration, and simulated nursing while at the same time working on the improvement of information standards for Nursing Informatics and Tele Nursing in Brazil.

Keeping in mind, the importance of active learning in nursing, the growing availability of information and communication technologies for general public and discussion with GIATE research group and postgraduate nursing program at UFSC, it was, therefore, deemed important to design, develop and evaluate an educational technology (Savinglife®) for basic and advanced cardiovascular life support in nursing.

One of the main advantages of Savinglife® is to provide simulated environments of cardiac arrest patients without actual exposure of the patient and without any harm to the patient. It opens the possibility of mass public training anywhere and at anytime. With Savinglife® , students can learn, evaluate and improve their critical thinking ability using different simulated clinical scenarios of cardiac arrest patients.

1.2 RESEARCH QUESTION

The use of problem-based learning approach in a virtual learning environment is an attractive alternative to shift the focus of education from ”*teaching*” to ”*learning*”. In this context, the guiding research question of this study is: *What are the evaluation of the application of Savinglife® (an educational technology for basic and advanced cardiovascular life support) from nursing experts and computer programmers?*

1.3 RESEARCH HYPOTHESES

The following hypothesis was established for the study: The Savinglife® , an educational technology for basic and advanced cardiovascular life support in nursing, satisfy the criteria of quality and usability to be applied with nursing experts.

1.3.1 General Objectives

Considering the guiding question of the study the objectives of this study are:

– To develop and evaluate, Savinglife® , an educational technology for basic and advanced cardiovascular life support in nursing

1.3.2 Specific Objectives

- To identify and evaluate the usefulness of Problem Based Learning approaches and technologies in the education of cardiopulmonary resuscitation and advanced cardiovascular life support programs.
- To structure and organize the content of cardiopulmonary resuscitation (CPR) and advanced cardiovascular life support.
- To design and develop SavingLife® , an educational technology for basic and advanced cardiovascular life support in nursing.
- Apply SavingLife® with nurses and nursing professors and analyze the quality of the SavingLife® with the criteria for evaluation of educational software Learning Object Review Instrument (LORI) - version 2.0.
- Apply SavingLife® with computer programmers and engineers to evaluate its usability .

1.4 THESIS ORGANIZATION

After the chapter one (Introduction), the remaining parts of this thesis are organized as follows. In the chapter 2 the focus is on the literature review. It begins with presenting an overview to health and nursing informatics, followed by a discussion on the critical thinking, decision making, and virtual learning environment Besides, it include a brief introduction to 2015 American Heart Association guidelines for BLS and ACLS. Chapter 3 discuss theoretical framework including a discussion on problem based learning. Chapter 4 explains study methodology. Chapter 5 present 3 resultant manuscripts while chapter 6 presents the overall conclusion and future research directions.

2 LITERATURE REVIEW

In this chapter, we briefly describe how health and nursing informatics has emerged and what is its applicability in nursing education. We discuss virtual learning environment in education and explain how critical thinking is important in nursing. We also present an overview to American Heart Association guidelines for basic life support and advanced cardiovascular life support.

This chapter focus on the following outlines.

- Health Informatics
- Nursing Informatics
- Critical Thinking and Decision Making
- Virtual learning Environment
- Overview of BLS and ACLS
- American Heart Association 2015 Guidelines for BLS and ACLS

2.1 HEALTH INFORMATICS

Health informatics is referred to as the use of information and communication technologies (ICT) to improve the quality of health care system. Health informatics promote health care by analyzing, designing, implementing, and evaluating information and communication systems that enhance the health outcomes of individual and population and strengthen the clinician-patient relationship.

A mobile phone based system (NGABO et al., 2012) was used in Rwanda to monitor pregnancy and newborn information. The SMS-based project was developed to monitor the lifecycle of pregnancy. It enabled instant reporting of the pregnancy-related event and timely notification for emergencies, alerting health facilities, hospital, and ambulances. The system managed to minimize the delay in seeking appropriate care through a short SMS sent by a community health worker. The system also served as a remote data entry point for pregnant women into the national health information systems, and as a unique interface to provide real-time data to health care providers.

The association between a mobile phone intervention and perinatal mortality in a low resource setting was evaluated in (LUND et al., 2013). At their first antenatal care visit, 2550 pregnant women (1311 interventions and 1239 controls) who attended antenatal care at primary health care facilities were included in this study and followed until 42 days after delivery. Twenty-four primary health care facilities were randomized to either provide mobile phone intervention or standard care. The intervention was based on the text message of mobile phones. Mobile phone applications were found to be effective for newborn and were recommended in low-resource settings.

There are a number of health technologies which are relatively simple to develop and safe to apply and it has no adverse effects. These includes different type of high-fidelity simulations and training programs, educational and awareness programs for women and communities, decision support tools and Hospital Information Systems such as Brazil SUS, virtual learning through different Apps and computerized protocol (NAZ et al., 2016).

There are hundreds of android and windows apps specially made for nurses based on I/V administration of drugs, nurse pharmacology, nurse leadership, medical and drugs dictionary and Glasgow coma scale etc. The aim of these applications is to promote of self-learning process in nurses.

2.2 NURSING INFORMATICS

The American Nurses Association in 2008 (BICKFORD, 2008) defines nursing informatics as: *"a specialty that integrates nursing science, computer science, and information science to manage and communicate data, information, and knowledge in nursing practice. Nursing informatics facilitates the integration of data, information and knowledge to support patients, nurses and other providers in their decision making in all roles and settings."*

In recent years, the development and applicability of informatics have influenced all areas of knowledge, disseminating information, creating educational programs, generating controversy and enabling new forms of learning. These innovations in IT have greatly influenced our daily personal and professional (SASSO; BARBOSA, 2000).

Nursing Informatics (NI) can be defined as a discipline that uses information technology to perform different functions within nursing (BALL et al., 2011). Nursing informatics integrates nursing science, computer science, and information science to manage and communicate data, information, knowledge in order to improve nursing care practice (BICKFORD, 2008; BALL et al., 2011). NI supports patients, nurses, and other healthcare providers in their decision-making abilities through the use of information structures, information processes, and information technology. The aim of NI is to improve the health outcome of populations, communities, families, and individuals by optimizing information management and communication.

These activities include the design and use of informatics solutions and/or technology to support all areas of nursing, including, but not limited to, the direct provision of care, establishing effective administrative systems, designing useful decision support systems, managing and delivering educational experiences, enhancing lifelong learning, and supporting nursing research.

NI is a discipline-specific informatics within the broader category of health informatics. NI has become well established within nursing since its recognition as a specialty for registered nurses by the American Nurses Association (ANA) in 1992 (BALL et al., 2011). NI deal with the representation of nursing data, information, knowledge, and wisdom as well as the management and communication of nursing information. Nursing informatics provides:

1. a nursing perspective
2. illuminates nursing values and beliefs
3. denotes a practice base for nurses in NI
4. produces unique knowledge
5. distinguishes groups of practitioners
6. focuses on the phenomena of interest for nursing, and
7. provides needed nursing language and word context to health informatics

2.2.1 Nursing Informatics and Nursing Practice

Nursing science and education is continuously expanding in ways that have significant implications for nursing practice. An understanding of different challenges related to nurses and their use of nursing information helps in the development and introduction of IT in health care organizations. For instance, evaluating the current systems in hospitals from nurses' perspectives will help make the essential modifications to meet nurses' needs. The use of IT reshapes the professional environment of nurses and influences the way they work in accessing and analyzing patient information from any location at any time (PRISELAC, 2003).

It is important for hospital administrators and nurses' leaders to consider factors related to nurses' IS use, such as nurses' involvement in system development and implementation. It is essential to support nurses by adapting or restructuring the appropriate work environment to enhance their IT use. Additionally, nursing educators can design the essential educational and training programs for improving nurses' IS use. For example, in-service education and training on how to use the system will improve nurses' informatics skills and increase their self-efficacy to use IS efficiently. To design appropriate and effective IS for complex and dynamic socio-technical organizations, such as health care organizations, designers need to evaluate the existing system by understanding how the nurses, who are one of the largest group of users of IS, perceive the available IS (BALL et al., 2011).

2.2.2 Nursing Informatics in Brazil

In the last decade, there has been a major expansion in the use of computers and mobile devices, which enabled the development and use of multiple applications. The Internet, computer networks, and database management technology allow an easy access to a lot of information available in the health systems, libraries, schools, and other different networks. In order to keep up with advances in more developed countries, some nurses and professors from the Federal University of Rio Grande do Sul started the development of a computer system for learning activities. In the same period a number of different hospitals started to develop their own systems in order to support and finance the hospital administration.

So it was around 1985 that began to appear the first publications in the area that showed, among other things, the involvement of nurses in the development and deployment of so-called Hospital Information Systems and Simulation Systems in Nursing Education and fostered the development of Nursing Informatics in Brazil.

Since then, several people have interest and developed projects in area of nursing informatics and we have seen the consolidation of multiple cores, Research Groups, Companies, and others, such as:

- The Information Technology Nursing Center of the Federal University the State of Sao Paulo (UNIFESP)
- The Center for Study and Research in Nursing Informatics (NEPIEn)
  Ribeir˜ao Preto College of Nursing (EERP) at the University of S˜ao Paulo (USP)
- GIATE UFSC
- The Brazilian Society of Health Informatics (SBIS)

According to SASSO (2001), the nurses should promote and ensure the evolution of nursing knowledge using information technologies in research, education, assistance and administration. (SASSO; SOUZA, 2006) add that more and more nurses have sought to update their knowledge and that IE can contribute positively to the development of education and nursing care. The current goal of the nurse as an educator does not go simply by learning how the student should use information technologies to it, but above all, how to use these technologies in their knowledge construction process on specific issues in Nursing and Health. (LEITE et al., 2006) analyzing the Brazilian reality, emphasizes the development of several virtual learning environments from the realization of Master and Doctoral Theses.

Therefore, the inclusion of information technology for nursing education requires a revision in the training process of students and training of nurses themselves, so that issues such as Information Systems in Health and Nursing, telehealth, Telenursing, Distance Education and Virtual Environments learning come to be a daily reality of nurses.

2.2.3 Informatics Applied in Education

The importance of including informatics knowledge and skills within nursing curricula is well supported in nursing literature and by major professional organizations (MCNEIL; ODOM, 2000). Full integration of nursing informatics education at all levels at academic institutions and in practice is critical to nursing as the profession faces the 21st century.

The American Nurses Association recently revised the Scope and Standards for Nursing Informatics Practice (American Nurses Association, 2007). Within these standards, computer literacy skills, information literacy skills and overall informatics competencies are described for the beginning nurse, experienced nurse and the Informatics Nurse Specialist. Computer literacy skills include use of word processor, database, and spreadsheet software, and using email and other informatics applications. Information literacy is a skill set that enables the nurse to locate, access and evaluate information. Access includes the ability to conduct bibliographic retrievals and to locate, retrieve, and evaluate information from the Internet. Overall informatics competencies are those that relate to the care of patients such as interpreting patient and nurse information, using informatics applications for nursing and addressing privacy, confidentiality and security of information in nursing practice.

Nursing Informatics can be applied in nursing education in many ways. It can be used in computerized record-keeping, computerized protocols, interactive video technology, distance Learning, web based applications, and use of mobile and computer based application.

LEITE et al (2006) analyzed the development of several virtual learning environments from the realization of Master and Doctoral Theses in Brazil. The first work in this context have a behaviorist perspective, they are mostly instructional and are distributed on CD-ROM. More recently, there has been the creation of multiple virtual learning environments using platforms developed by Brazilian universities themselves. On the other hand, MCNEIL et al. (2005) emphasis to include informatics concepts, informatics skills and the use of informatics tools in professional nursing practice within nursing curricula across the U.S.

Now a day many educational programs are offered by different institutions and universities with courses on nursing informatics. Informatics can be integrated in academic programs and curriculum with one or more courses. Technology requirements are also increasing, such as online learning, simulation, the use of hand-held mobile devices and mobile and computer applications.

2.3 CRITICAL THINKING AND DECISION MAKING

Critical thinking can be defined as a multidimensional way of thinking rather than an unidimensional one (MARTIN, 2002). As such, critical thinking requires a skillful application of knowledge for the judgment and evaluation of complex problem situation. (MARTIN, 2002) also emphasized that critical thinking should be interactive, process-oriented, and rational. Within this framework the knowledge is interpreted, assumptions are verified, hypotheses are generated, and justifications are made. Some educators urge that encouraging the students to ask questions, to consider different perspectives and alternatives, to analyze the problem and solutions in a new way, and to think beyond the first answer are important strategies for promoting critical thinking (POPIL, 2011). In fact, (OERMANN, 1990) predicted that future teaching will promote fewer lectures and more experiential practice such as PBL, simulations, and interactive videos to encourage students to think and consider alternate solutions to clinical problems (KHAN, 2012).

Popil (2011) identified different components in teaching critical thinking to students. First, start the class with a problem or a challenging issue to promote student interactions. Second, encourage reflection in the students by arranging classroom space to enhance interaction. Third, extend the lecture time whenever possible or required, and finally create a friendly environment for interaction and learning. Critical thinking ability is a dynamic attribute that can be improved by the nurse educators (POPIL, 2011).

The evaluation and assessment of the level of critical thinking skills of the nursing students has been a controversial issue (TURNER, 2005). Turner suggested that, by designing test questioning that requires students to assess, synthesize, search for evidence, recognize assumptions, hypothesize, and analyze the situation, the level of critical thinking of students can be evaluated.

2.4 VIRTUAL LEARNING ENVIRONMENT

A virtual learning environment (VLE) is an online system that allows teachers to share educational materials with their students via the web and mobile devices. This enable students to access a virtual classroom as either a duplicate or extension of their physical classroom and is a clear advantage for both learners and teachers. VLE opens an infinite number of communication channels between participants in the form of forums, discussion threads, polls, surveys and chat either as a group or individually. Moreover, students do not physically have to find their teacher or go to some particular location for learning. There are numerous online resources and embedded content available such as books, videos, graphics and webpages.

According to Franco; Cordeiro e Castillo (2003), the first versions of Virtual Learning Environments for education were modeled based on four key strategies. Incorporate existing elements on the web, such as electronic mail and groups thread, add elements to computer about specific activities, managing files and backups, create specific elements for educational activity, such as modules for content and evaluation, Add academic administration elements of courses, students, reviews and reports.

Virtual learning environments Computer systems available on the Internet that allow integrating multiple media, languages and resources, present information in an organized manner, developing interactions between people and objects of knowledge with the aim to achieve certain goals. The activities are carried in time and space in which each participant is located, according with an explicit intentionality and preplanning called educational design.

2.4.1 Component and Characteristics of Virtual Learning Environment

It is important to note that some characteristics need to be considered in the production and application of VLE in order to achieve positive results in learning (MULLER , 2012).

- **Accessibility:** It is the ability to access to resource from any remote location.
- **Customization:** Possibility to customize the learning environment according the requirements.
- **Flexibility:** Flexible to change or update the resources without recoding.
- **Interactivity:** Interactivity provide a way of communication between learning environment and user by providing graphical user interface.
- **Interoperability:** It is the ability of a system to work with other systems without special effort.
- **Modularity:** It is the degree to which a system’s components may be separated as independent and interchangeable modules and recombined.

- **Portability:** It is the usability of the same software in different environments and platforms.

- **Reusability:** Reusability is the extent to which existing code or assets can be used in different applications with minimal change.

Barbosa e Sasso (2007) reported that the VLE can be used in three ways. The first, to support the activities in the classroom (classroom activities), allowing to expand the class interactions in addition to the space and the physical meeting time. The second, to support the semi-face training activities, in which the VLE can be used both in classroom activities and in activities at a distance. The third, as an environment for distance learning subjects performed exclusively online. The third a specific method used that the virtual learning environments must ensure sense of telepresence. That is, even if the users are in distant spaces and access the same environment on different days and times, they feel like they are together physically, working in the same place and at the same time (BARBOSA; SASSO, 2007).

In these all perspectives the Virtual learning Environment is the best technology and tool for providing and transacting distance education, in safe environment, anywhere and self-study to students.

2.5 OVERVIEW OF BLS AND ACLS

2.5.1 Basic Life Support

Cardiopulmonary resuscitation is a set of procedure and interventions of life-saving actions that improve the chance of survival following a cardiac arrest. Effective Advanced Cardiovascular Life Support (ACLS) starts with good Basic Life Support (BLS) skills. The focus of the cardiac care guidelines for healthcare providers is to provide high-quality CPR for cardiac arrest patients.

Successful resuscitation following cardiac arrest requires an integrated set of coordinated actions represented by the links in the Chain of Survival as follows:

- Immediate recognition of cardiac arrest and activation of the emergency response system
- Early CPR with an emphasis on chest compressions
- Rapid defibrillation

- Effective advanced life support
- Integrated post-cardiac arrest care

Rescuers and health care providers should have a wide variety of knowledge, training experience, and skills to recognize the status and response of the cardiac arrest victims, as well as the settings and environment in which the cardiac arrests take place. The 2015 AHA Guidelines for CPR and ECC depend on the foundation of previous guidelines, but they are supported by new evidence whenever possible.

CPR must have integrated chest compressions along with rescue breathing with the aim to optimize circulation and oxygenation. The optimal application of the components of CPR depends on the characteristics of rescuer and victim. Cardiac arrest is associated with four electrocardiographic rhythms which are pulseless ventricular tachycardia (VT), ventricular fibrillation (VF), pulseless electrical activity (PEA), and asystole. VF as the initial rhythm is associated with a more favorable outcome than other three rhythms (CUMMINS et al., 1991). The survival of cardiac arrest in out-of-hospital patients depends on the step and quality of interventions in following the "chain of survival" (RINGH, 2014).

Patients who have an Out Hospital Cardiac Arrest (OHCA) depend on the community and their environment for support. Lay rescuers must recognize the cardiac arrest, call for help, and initiate CPR and use an AED as soon as it become available. Follow each shock immediately with CPR along with compressions. Continue this procedure until a team of professionally trained emergency medical service (EMS) providers arrived and transferred the patient to an emergency department and/or cardiac critical care unit for continued care.

2.5.2 Major Changes in BLS in 2015

Key points and major changes in the 2015 Guidelines Updates (AHA, 2015) for Health Care Providers which allow flexibility for activation of the emergency response system to better match the HCP's clinical setting, are as follows:

- Trained rescuers are encouraged to simultaneously perform multiple steps at the same time, in an effort to increase the chance of survival.

- A team of highly trained rescuers may use a choreographed technique to perform multiple steps and assessments simultaneously as compared to the sequential steps used by individual rescuers. For instance, one rescuer activates the emergency response system while another begins chest compressions, a third either provides ventilation, and fourth sets up a defibrillator).

- Increased emphasis has been placed on high-quality CPR using performance targets (compressions of adequate rate and depth, allowing complete chest recoil between compressions, minimizing interruptions in compressions, and avoiding excessive ventilation).

- The compression rate is modified to a range of 100 to 120/min.

- Compression depth for adults is modified to at least 2 inches (5cm) but should not exceed 2.4 inches (6 cm).

- To allow full chest wall recoil after each compression, rescuers must avoid leaning on the chest between compressions.

- Criteria for minimizing interruptions is clarified with a goal of chest compression fraction as high as possible, with a target of at least 60

- Where EMS systems have adopted bundles of care involving continuous chest compressions, the use of passive ventilation techniques may be considered as part of that bundle for victims of OHCA.

- For patients with ongoing CPR and an advanced airway in place, a simplified ventilation rate of 1 breath every 6 seconds (10 breaths per minute) is recommended.

These changes are designed to simplify training for HCPs and to continue to emphasize the need to provide early and high-quality CPR for victims of cardiac arrest.

2.5.2.1 Immediate Recognition and Activation of Emergency Response System

2015 (Updated): HCPs must call for nearby help upon finding the victim unresponsive, but it would be practical for an HCP to continue to assess the breathing and pulse simultaneously before fully activating the emergency response system (or calling for backup).

2010 (Old): The HCP should check for a response while looking at the patient to determine if breathing is absent or not normal.

Why: The intent of the recommendation change is to minimize delay and to encourage fast, efficient simultaneous assessment and response, rather than a slow, methodical, step-by-step approach.

2.5.2.2 Chest Compressions

2015 (Updated): It is reasonable for HCPs to provide chest compressions and ventilation for all adult patients in cardiac arrest, whether from a cardiac or non-cardiac cause. Moreover, it is realistic for HCPs to tailor the sequence of rescue actions to the most likely cause of arrest.

2010 (Old): It is reasonable for both EMS and in-hospital professional rescuers to provide chest compressions and rescue breaths for cardiac arrest victims.

Chest Compression Rate: 100 to 120/min

2.5.2.3 Airway and Ventilations

Opening the airway (with a head tilt-chin lift or jaw thrust) followed by rescue breaths can improve oxygenation and ventilation. However, these techniques can be technically difficult and require interruptions of chest compressions, particularly for a single untrained rescuer. Thus, the untrained rescuer will provide Hands Only (compression only) CPR (ie, compressions without ventilations), and the lone rescuer who is able should open the airway and give rescue breaths with chest compressions. Ventilation should be provided if the victim has a high likelihood of an asphyxial cause of the arrest (e.g. infant, child, or drowning victim). Once an advanced airway is in place, healthcare providers will deliver ventilations to deliver 1 breath every 6 seconds (10 breaths per minute) while continuous chest compressions are being performed (ie, during CPR with an advanced airway) (AHA, 2015).

2.5.2.4 Defibrillation

The victim's chance of survival increase with decreasing the interval between the cardiac arrest and defibrillation (VALENZUELA et al., 2000). Thus early defibrillation remains very important for ventricular fibrillation and pulseless ventricular tachycardia. Communities and hospitals should aggressively work to reduce the interval between arrest and defibrillation (HALLSTROM; ORNATO, 2004). Similarly, defibrillation outcome is improved if interruptions (for rhythm assessment, defibrillation, or advanced care) in chest compressions are kept to a minimum (REA et al., 2006).

In a prehospital setting, the order of the CPR steps performed may switch between a sequenced model to a choreographed model depending on the proficiency of the provider and the availability of resources.

2.5.2.5 Quality Improvement in Resuscitation

Cardiac arrest is an important public health issue which involve a broad spectrum of individuals and groups. Individuals include victims, family members, and rescuers. Key groups include the emergency medical dispatchers, public safety organizations, EMS systems, hospitals, civic groups, and policymakers at the national and international level.

Because the links in the Chain of Survival are interdependent, an effective resuscitation strategy requires these individuals and groups to work in an integrated fashion and function as a system of care (REA; PAGE, 2010). Fundamental to a successful resuscitation system of care is the collective appreciation of the challenges and opportunities presented by the Chain of Survival. Thus, individuals and groups must work together, sharing ideas and information, to evaluate and improve their resuscitation system. Leadership and accountability are important components of this team approach (ASSOCIATION et al., 2010).

2.5.3 Advanced Cardiovascular Life Support

Basic life support, advanced cardiovascular life support, and post-cardiac arrest care each describe a set of skills and knowledge that are applied sequentially during the treatment of patients who have a cardiac arrest (LINK et al., 2015). There is an overlap as each stage of care progress to the next, but generally, ACLS includes the level of care that lies between BLS and post cardiac arrest care. It is a set of interventions that starts after analyzing heart rhythm of a patient. The ACLS health care provider makes decisions based on rhythm and vital signs of the patient.

Only qualified health care providers can provide ACLS as it requires the skill and ability to manage the victim airway, initiate IV access, read and interpret electrocardiograms, and understand emergency pharmacology. When a sudden cardiac arrest occurs, immediate CPR is a vital link in the chain of survival. Another important link is early defibrillation, which has improved greatly with the widespread availability of Automated External Defibrillators (AEDs).

ACLS often starts with analyzing the patient's heart rhythms with a manual defibrillator. In contrast to an AED in BLS, where the machine decides when and how to shock a patient, the ACLS team leader makes those decisions based on rhythms on the monitor and patient's vital signs. The next steps in ACLS are the insertion of intravenous (IV) lines and placement of various airway devices. Commonly used ACLS drugs, such as epinephrine and amiodarone, are then administered. The ACLS experts quickly search for possible reversible causes of cardiac arrest (i.e. the H's and T's, heart attack) (AHA, 2015).

1. Hs; Hypovolemia, Hypoxia, Hydrogen ions (acidosis), Hyperkalemia or hypokalemia, and Hypothermia

2. Ts; Tablets or toxins, Cardiac tamponade, Tension pneumothorax, Thrombosis (myocardial infarction), Thromboembolism (pulmonary embolism) and Trauma. More specific treatments are given according to the Hs and Ts.

The American Heart Association performs a science review every five years and publishes an updated set of recommendations and educational materials on BLS and ACLS. The current ACLS guidelines of 2015 are set into several groups of "algorithms" - a set of instructions that are followed to standardize treatment, and increase its effectiveness. These algorithms usually come in the form of a flowchart, incorporating 'yes/no' type decisions, making the algorithm easier to memorize (AHA, 2015).

2.5.4 Major Changes in ACLS in 2015

Key issues and major changes in the 2015 Guidelines Update (AHA, 2015) recommendations for advanced cardiac life support include the following:

- The combined use of vasopressin and epinephrine offers no advantage when compared to the standard-dose of epinephrine in cardiac arrest. Also, vasopressin does not offer an advantage over the use of epinephrine alone. Therefore, vasopressin has been removed from the Adult Cardiac Arrest 2015 Algorithm.
- Low end-tidal carbon dioxide (ETCO2) in intubated patients after 20 minutes of CPR is associated with a very low likelihood of resuscitation. While this value should not be used alone for decision making, providers may consider low ETCO2 after 20 minutes of CPR in combination with other factors to help find when to stop resuscitation.
- Steroids may provide some benefit when bundled with vasopressin and epinephrine in treating IHCA. But its routine use is not recommended.
- When rapidly implemented, ECPR can prolong viability as it may provide time to treat potentially reversible conditions or arrange for cardiac transplantation for patients who are not resuscitated by conventional CPR.
- In cardiac arrest patients with non-shockable rhythm and who are otherwise receiving epinephrine, the early provision of epinephrine is suggested.
- Studies about the use of lidocaine after ROSC are conflicting, and routine use of lidocaine therefore is not recommended. However, the initiation or continuation of lidocaine may be considered immediately after ROSC from VF/pulseless ventricular tachycardia (pVT) cardiac arrest.

2.6 AHA 2015 GUIDELINES FOR BLS AND ACLS

In this section we discuss the American Heart Association (AHA) 2015 guidelines (AHA, 2015) for BLS and ACLS. One of the crucial components of effective BLS and ACLS training is to understand the major algorithms for different scenarios. These algorithms are a set of instructions that are followed to standardize treatment, and increase its effectiveness. These algorithms usually come in the form of a flowchart, incorporating 'yes/no' type decisions, making the algorithm easier to memorize.

2.6.1 BLS Primary survey

The Basic Life Support (BLS) primary survey is used in all cases of cardiac arrest and is the foundation for saving lives. Fundamental aspects of adult BLS include immediate recognition of sudden cardiac arrest and activation of the emergency response system, early CPR, and rapid defibrillation with an automated external defibrillator (AED). Initial recognition and response to heart attack and stroke are also considered part of BLS. Key changes and points of importance in the 2015 Guidelines Update include the following:

- Ensuring chest compressions of adequate rate: push hard and fast (100-120/min)
- Ensuring chest compressions of adequate depth: (5-6cm) 2-2.4inches
- Allowing full chest recoil between compressions
- Minimizing interruptions in chest compressions: less than 10 seconds
- Ventilation the patient: 1 every 6 seconds or 10 times/min

This Guidelines Update consist of an updated recommendation for a simultaneous, choreographed approach for chest compressions, airway management, rescue breathing, rhythm detection, and shocks by a team of highly trained rescuers. Successful resuscitation in case of a cardiac arrest requires an integrated set of coordinated actions represented by the links in the Chain of Survival (see Figure 1)

Figure 1 – IHCA and CHCA Chain of Survival; Source: (AHA, 2015)

Source: (AHA, 2015)

A team of highly trained rescuers may use a systematic approach that perform multiple steps and assessments simultaneously rather than in the sequential manner used by individual rescuers. For instance, in a team one rescuer activates the emergency response system while another begins chest compressions, a third either provides ventilation or retrieves the bag-mask device for rescue breaths, and a fourth may sets up a defibrillator (AHA, 2015).

The Universal Adult Basic Life Support (BLS) Algorithm is a conceptual framework for all levels of rescuers in all settings. It emphasizes the key components that any rescuer can and should perform. The systematic approach of the BLS Survey is assessment and then taking necessary action as shown in Figure 2.

2.6.2 Respiratory Arrest

In respiratory arrest the patient is unresponsive and unconscious. Respirations are absent or inadequate to maintain effective oxygenation. The patient has a pulse. Even though the patient is in respiratory arrest and not in cardiac arrest, the BLS Primary Survey and the ACLS Secondary Survey are used (NEUMAR et al., 2010).

For unconscious patients in arrest (cardiac or respiratory), healthcare providers should conduct the ACLS Survey after completing the BLS survey.

For conscious patients who may need more advanced assessment and management techniques, healthcare providers should conduct the ACLS Survey first.

The main focus of the BLS Primary Survey is on early CPR and early defibrillation, if needed. For a patient in respiratory arrest, however, the focus is on breathing and airway issues. First the patient is assessed, and then appropriate action is performed (NEUMAR et al., 2010).

- Is the patient breathing NORMALLY? (small gasping breaths are not considered normal.
- If no Pulse, BEGIN COMPRESSIONS at a rate of 100/min to 120/min
- If not sure if a pulse is present, BEGIN COMPRESSIONS at a rate of 100/min to 120/min
- If pulse is present and breathing absent, begin ventilation at a rate of 10 per minute or once every 6 seconds using mouth to mouth or bag valve mask.
- The last step, defibrillation, is part of the primary survey, but is not required for respiratory arrest, as the patient has a pulse for this case. Therefore, the AED will advise the user ”no shock advised, continue CPR if necessary.”

Table 1 – BLS for respiratory arrest (AHA, 2015)

Assessment	**Action**
Is the patient breathing?	Look for the rise and fall of the patient’s chest.
Does the patient have a pulse?	Take 5-10 seconds to check for a pulse.
AED	When the AED arrives, place electrode on patient’s chest and follow the instructions

2.6.3 Ventricular Fibrillation Treated with CPR and AED

Ventricular fibrillation is life-threatening condition of someone. VF is the most serious cardiac rhythm disturbance. The lower chambers quiver and the heart can’t pump little or no blood, causing cardiac arrest. Electrical activity of the heart becomes disordered. When this happens, the lower pumping chamber of the heart lower contract rapidly in an unsynchronized way. The ventricles ”fibrillate” rather than beat. The heart pumps little or no blood causing Collapse and sudden cardiac arrest this is a medical emergency that requires prompt Advanced Cardiac Life Support. Ventricular fibrillation can be treated with a defibrillator, which gives an electrical shock to the heart (NEUMAR et al., 2010).

In case of cardiac arrest, BLS survey must first be initiated. The BLS survey is used in all cases of cardiac arrest. When VF is present, CPR can provide a small amount of blood flow to the heart and brain but cannot directly restore an organized rhythm. The likelihood of restoring a normal rhythm is achieved with immediate CPR and defibrillation within a few minutes of the initial arrest. The earlier the defibrillation occurs, the higher the survival rate (NEUMAR et al., 2010).

2.6.4 Ventricular Fibrillation Pulseless VT

This case discusses the assessment and treatment of a patient with VF or pulseless VT. You receive a patient with no pulse, no respiration and no blood pressure. This algorithm assumes that you first have completed the BLS Survey, including activation of the emergency response system, call other HCP's to get in the room to help you if you are the first person immediately began CPR, when other persons arrived, someone put patient on oxygen by mask, other attached the cardiac monitor, when get the monitor the most important step is to analyze the rhythm. Rhythm shows VF/VT and patient has shockable rhythm you shock him (NEUMAR et al., 2010).

Continue 5 cycles of CPR approximately for 2 minutes immediately after the first shock. Each cycle contains 30 chest compressions followed by 2 breaths. After 2mints CPR again check the rhythm in less than 10 seconds, if shockable rhythm, deliver shock, otherwise began CPR for 2mints. During this time, you must follow other things. In the first time around Place an I/V or I/O line, in second time administer epinephrine 1mg repeat every 5mint. Also considered advanced airway (ETT, LMA). In the next 2 mint CPR start injection amiodarone 300mg first dose. And second dose is 150mg. for good CPR the team leader also rotate the CPR guy after every 2mint without any pause during CPR to avoid fatigue. HCPs also identifies the 5 H's and T's for definitive cause (NEUMAR et al., 2010).

2.6.5 Pulseless Electrical Activity

This case focuses on assessment and management of a cardiac arrest patient with PEA. During the BLS Survey, team members will demonstrate high-quality CPR with effective chest compressions and ventilation with a bag-mask. In the ACLS Survey the team leader will recognize PEA and implement the appropriate interventions outlined in the Cardiac Arrest Algorithm. Because correction of an underlying cause of PEA, if present and identified, is critical to patient outcome, the team leader will verbalize the differential diagnosis while leading the resuscitation team in the search for and treatment of reversible causes (NEUMAR et al., 2010).

Patients with PEA have usually poor outcomes. The best chance of survival is through early identification of an underlying reversible cause and correct treatment. The very important step is to consider all the H's and T's, particularly hypovolemia, which is the most common cause of PEA.

In case of PEA, immediately start CPR and attach monitor. Continue CPR at a rate of 100 to 120 per minute throughout the resuscitation without interruptions of more than 10 seconds (for evaluating pulse). Compressors should be switched every 2 minutes to ensure high quality compressions and to avoid fatigue (NEUMAR et al., 2010).

Administer Epinephrine 1 mg IV/IO every 3-5 minutes and find and treat the definitive causes. Establishing IV/IO access is a priority over advanced airway management. If an advanced airway is placed, change to continuous chest compressions without pauses for breaths. Give 10 breaths per minute and check rhythm every 2 minutes. Stop CPR when absolutely check rhythm and pulse (NEUMAR et al., 2010).

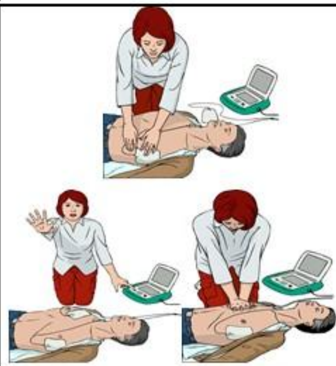
2.6.6 Asystole

Asystole also referred to as flat line is a cardiac arrest rhythm associated with no visible electrical activity on the ECG. The prognosis for cardiac arrest with asystole is very poor. A large percentage of asystole patients do not survive. Cardiac function has diminished until electrical and functional cardiac activity finally stop and the patient dies. Asystole is also the final rhythm of a patient initially in VF or VT (NEUMAR et al., 2010).

The presence of asystole must be verified in at least two leads. In case of Asystole CPR must be started at a compression rate from 100-120 per minute. Team members must be rotated every 2 minutes to help maintain high quality CPR. As soon as IV or IO access is available, epinephrine 1mg IV/IO repeat every 3-5 min must be administered. CPR must not be stopped during drugs administration. During CPR differential causes (H's and T's) must be searched and treated. If electrical activity is revealed, see if the patient has a pulse. If the patient does not have a pulse or have a pulse, CPR must be resumed. If a good pulse is present and the rhythm is organized, post-resuscitative care must be started (NEUMAR et al., 2010).

Without a pulse or electrical activity on the ECG, the emergency care team needs to decide when resuscitation efforts should be stopped. The patient's wishes and the family's concerns need to be considered in this regard.

Figure 2 – Summary of Assessment Techniques and Actions in BLS; Adopted from (AHA, 2015)

Check Responsiveness Tap and shout "are you all right?" Patient is unresponsive and unconscious	
Call for Emergency and AED Activate the emergency response system and get an AED if one is available or send someone to activate the emergency response system and get an AED or defibrillator	
Cardiopulmonary Resuscitation Start CPR; Compress the center of the chest (lower half of the sternum). Push hard and fast Compress the chest of adequate depth: (5-6cm) 2-2.4inches Continuous compressions at a rate of 100-120/min Give 1 breath every 6 seconds (10 breaths/min) • Allow complete chest recoil after each compression. • Minimize interruption in compression 10second or less • Switch providers about every 2 minutes to avoid fatigue • Avoid excessive ventilation • Check pulse about every 2 minutes	
Defibrillation • If no pulse, check for shockable rhythm with an AED/defibrillator as soon as it arrives • Attach pads on casualty's bare chest • Stand clear deliver shock • Follow each shock immediately with CPR, beginning with compressions	

3 THEORETICAL FRAMEWORK

Keeping in mind the general objective of this work, this chapter present a theoretical framework to understand the learning process and key knowledge of the theory involved. We present a theoretical framework that understands learning as a process of knowledge construction, that allows the student as an active participant (student centered) and the teacher as a facilitator of learning.

3.1 CONSTRUCTIVISM

Constructivism is a theory based on the scientific study of how people learn. According to constructivism, people create their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. When we encounter something new, we check it with our previous ideas, knowledge and experience, and generate our own knowledge. To do this, we must ask questions, explore, and evaluate what we already know.

According to constructivist theories, learning is a social advancement that involves language, real world situations, interaction and collaboration among learners (MOLL, 1992).

According to Matui (1995), constructivism applied to education is essential in creating environments and situations that generate knowledge. Not only the student needs to follow the teacher’s reasoning, but the teacher also identifies and follow the thinking and reasoning of students. The teacher encourages the students to use active learning techniques with the help of experiments, and solving real-world problem to create new knowledge and then to reflect on what is done and how the understanding is changing (MATUI, 1995).

The conceptual links between constructivism and PBL are rarely explained in the literature. However, examining constructivism more closely shows some insights into the origins of the PBL practice. One of the implications of constructivism in the context of PBL is that, as a teacher, making a decision to adopt a teaching method of PBL require explicit and implicit commitments (KEMP, 2011). Explicit commitments could be described in terms of specific stages used, roles of students and teachers, formation of groups, adoption of specific assessment methods, and so on. Implicit commitments include what is known as knowledge, and what are the objectives of teaching and learning.

These commitments highlight the importance of teacher understanding of what the goals of teaching are in that particular context. In a PBL context, the goal of teaching relates directly to the student understanding more than transmitting information (KEMP, 2011). If the goal of teaching is to promote student understanding, rather than transfer information as usually emphasized in PBL, this has particular implications for teaching practice.

Savery e Duffy (1995) identify and elaborate eight instructional principles for constructivist learning environment and considered that Problem Based Learning is one of the best example of a constructivist learning environment.

3.2 PROBLEM BASED LEARNING

In the view of constructivist theory, PBL is a detailed instructional model and is consistent with the principles of instruction arising from constructivism with the aim to provide a clear link between theory and practice. Some of the features of the PBL environment are that the students actively participate in activities which are authentic to the environment in which they would be used. The focus is on students as constructors of their own knowledge. Students are encouraged and expected to think critically and creatively and to control their own understanding. Social negotiation is an important part of the structure of problem-solving team and the facts of the case are considered facts only when the group decides they are (SAVERY; DUFFY, 1995).

Problem-Based Learning (PBL), as a general model, was developed in medical education in 1970's and since then has been improved and applied in many medical schools. The most widespread application of the PBL approach has been in the first two years of medical education where it replaces the traditional lecture based approach in anatomy, pharmacology, physiology and many other medial subjects. Like other instructional models, there are different techniques for implementing PBL. Instead of trying to provide a general characterization of PBL, Barrows' model (Barrows, 1992) can be focused which provide a concrete way of the implementation of this process in medical schools (SAVERY; DUFFY, 1995).

The ability of the teacher to use his/her teaching skills during the learning process is the major determinant of the quality and the success of any educational method. Its aim is to develop reasoning and critical thinking of students as they learn and helping them to become independent and self-directed learners (WILSON, 1996).

Therefore, the PBL approach is not only giving a problem to the student and standing back to see what they do with it. It is essential to provide them clear and well-written objectives to ensure the student to achieve the content knowledge they required. And the tutor has the vital role to observe the students either they are on track and productive in their work.

Based on the guidelines of (WALSH, 2005), PBL has the following steps that are followed for each problem at hand.

3.2.1 Steps in Problem Based Learning

PBL has seven steps as shown in Figure 3 and explained as below.

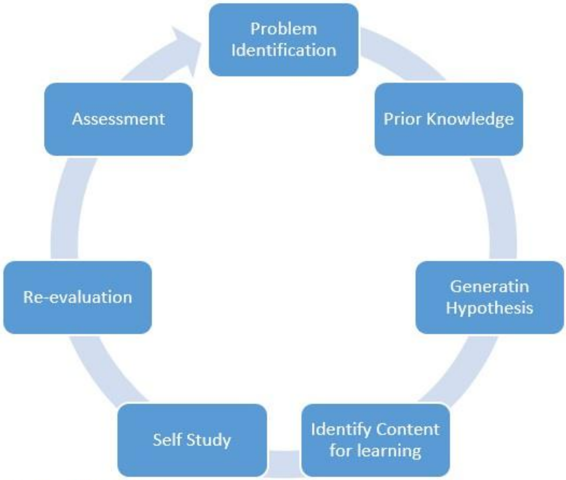
Problem Identification: In this step the students presented with a problem, students read the problem and discuss it with other group members, the tutor encouraged the students they fully understand about all possible questions and clear about why's, how's and when's (WALSH, 2005).

Explore pre-existing knowledge: In this step before going on to indepth exploration, students may use an existing knowledge and their personal life experiences. So this second step allows the student to access their own prior knowledge and skill in order to decide what information need to manage the problem. All students should participate in this step, to help the members in gathering information. The tutor needs to ensure that all participants contributes to the group and understanding the problem (WALSH, 2005).

Generating Hypothesis: After analyzing and identification the problem, the hypothesis is generated which is related to the learning objective of the problem.

The tutor guides the students to assess all the clinical aspects and to diagnose the problem. It is important for the students to have a focus on understanding the main concepts which are illustrated by each problem. All students should engage in this step (WALSH, 2005).

Figure 3 – Steps in Problem based Learning



Source: Naz (2016)

Identify learning issues: This is an important part of the PBL in this step student identifying knowledge deficiencies related to the problem. Students individually find out that what the learning issues are. They note all the questions and search resources and information to answer these question, they list ideas, and hypothesis about the problem.

Self-Study: Students apply their own knowledge, skill and experience and their new knowledge to evaluate hypothesis regarding the problem. They use text, computer also tutor guidance to enhance knowledge about the problem (WALSH, 2005).

Re-evaluation and application of new knowledge to the problem: All participants evaluate their prior and new knowledge in order to apply it to the original problem. The teacher makes sure that students work and engaged actively in the learning process while at the same time encourage them to ask questions from each other (WALSH, 2005).

Assessment and reflection on learning: Before the health care problem and the tutorial can be considered complete, it is important that each group of students have an opportunity to reflect on the learning process that was carried out. This includes an analysis of the learning process, feedback about contributions to learning and group, and an evaluation of how the group is working together. Some students and teachers may not appreciate the importance of this evaluation component. However, the importance of facilitating the group to frame its functioning and make adjustments before problems grows big cannot be underestimated. Those who have worked in a dysfunctional group appreciate the benefits of regularly attending to the smooth operations of the tutorial group. Moreover, summarizing new learning goals helps consolidate its future application (WALSH, 2005).

3.2.2 Tutor Role in Problem Based Learning

Tutors who are unfamiliar with the problem or content are more likely to let the students develop doubts and hesitation in their mind. Therefore, it is important that the tutor master content and understand key topics and knowledge (WALSH, 2005). However, there are no fixed rules for particular lecturing, but the following must be considered:

- Environment - Create a safe and supportive environment for self-directed learning
- Planning - Organize and structure the tutorials
- Clarify the learning needs - Define the objectives of learning and set goals;
- Draw a learning plan - Helping students plan learning, developing strategies;
- Engage in learning activities - Supervise the activities to ensure that students are on track
- Evaluate the learning outcomes
- Focused on students - Student centered
- Create a motivating environment
- Ensure constructive feedback

An experienced tutor helps students understand and recognize important concepts that are emerged during the problem (WALSH, 2005). Moreover, he encourages students to demonstrate their understanding through use of charts, graphs and verbal explanations.

3.2.3 Problem Based Learning in Nursing Education

Barrows e Tamblyn (1976) introduced and defined PBL as the learning that resulted from the work process to understand or solve a problem. The problem is encountered first in the learning process and serves as a stimulus for the application of problem solving and reasoning as well as for the search for the knowledge needed to understand the mechanisms responsible for the problem and how it might be resolved. PBL has emerged as an innovative solution to the challenges that contemporary medical education faced with respect to the quality of student learning outcomes.

The shift from a subject-based curriculum to a PBL based curriculum in nursing education resulted mainly due to the adoption of the medical education paradigm. School of Medicine in McMaster University set a precedent as a leader in adopting PBL in the curriculum because of the school's excessive course content and restriction of teaching to lecturing (BARROWS, 1985). PBL, one of the most popular developments in health professional education in the later part of the 20th century, was developed by Howard Barrows at McMaster University in Canada (BARROWS; TAMBLYN, 1976) which was then later adopted by most medical educators as the educational and philosophical basis of their curricula.

A PBL curriculum consists of subject integration within the sphere of professional practice situations. Learners acquire a broad base of knowledge through the process of progressive inquiry related to real nursing practice situations (LAMBIE; MACLEAN; MCGUIRE, 1981).

An educational method for promoting problem-solving skills in student nurses is problem-based learning. Therefore, ways of developing learner proficiency in problem solving are crucial and should occupy a substantial part of an educator's activity. It is the challenge of nursing education to explore ways to enhance student learning and clinical decision making. So, nurse educators have to investigate new teaching methods that promote active learning and increase critical thinking skills in nurse students. In the reality of a complex healthcare structure with changing society needs, it is important for students to learn how to access knowledge, synthesize the information, apply these data into practice and commit to life-long learning (HAMDAN et al., 2014).

PBL allows students to engage in active learning, to improve their communication skills, critical, analytical and creative thinking and problem-solving skills in diverse learning environment (TSENG et al., 2006). Problem-based learning provides a bridge to the learner to connect with real life situations and increase their learning power. Mobile technologies can play an important role in supporting PBL in different ways. mPBL is beneficial for self-directed learning if the system is practical, economical, inexpensive, easy to operate, near to real-life and interactive. Appropriate modifications to the system will be based on the suggestions of the participants and users (TANG; LIN; LAI, 2014).

3.2.4 Problem based Learning in BLS and ACLS

The theoretical knowledge and practical skills of the BLS and ACLS are the most important determinants of the success rates of cardiopulmonary resuscitation (FILHO et al., 2006). Both BLS and ALS maneuvers require well-trained staff, since cardiac arrest requires fast, efficient and integrated actions and is therefore better performed by a team than by a single team member.

Sardo e Sasso (2008a) carried out a study in the educational practice of PBL in CPR and BLS with 24 students in the third stage of the Nursing Undergraduate Course at the UFSC Brazil. The study used the PBL methodology and focused on different situations with CPR problems. The study showed that the PBL allows the educator to evaluate several aspects of the academic learning process and serves as a motivation factor for both teachers and students.

Cardiopulmonary resuscitation training is essential for all health care providers. Recently many studies have focused on the efficacy of the different methods of CPR training and have pointed out the drawbacks of the conventional training methods (BHANJI et al., 2010). In traditional teaching method, a great volume of theoretical content should be presented during a limited lecture time, which may tire trainees and lessen the workshop efficacy (SEMERARO; SIGNORE; CERCHIARI, 2006). Therefore, recently some new CPR training methods have been developed, which are believed to improve the resuscitation knowledge and skills of health care provider and nursing professionals.

Hosseini et al., (2013) assessed PBL method for routine CPR training which improved the quality of resuscitation training in the study population. They suggest that PBL training method must be employed as an alternative method to the traditional lecture-based method for the ACLS training of the junior clinical student.

Similarly, Szogedi et al., (2010) conducted a study to used problem based learning approach to train nurses for CPR to determine whether PBL is more effective over conventional teaching methods. For this PBL model, the authors used the European Resuscitation Council Guidelines of

2005 for Resuscitation. The authors reported that the PBL was a superior instruction method for CPR training. Those students who attended PBL classes achieved greater theoretical Knowledge. And during demonstration they had better resuscitation skills when tested.

3.2.5 Problem based learning and Information Technology

Information technology has been used in teaching, learning, and assessment for many years, from programmed learning and on-line tutorials, which are teaching-centered, at one end of the spectrum, to computer-supported collaborative environments, which are learning centered. The term e-learning has developed over recent years to absorb these and related terms.

A number of specifications and standards about e-learning are beginning to develop. For instance, in relation to the communication interface (how resources communicate with other systems or metadata, how to describe consistent learning resources and how to collect resource into useful forms (UDEN, 2006). In this regard, one of the challenge is to integrate e-learning technologies into PBL learning system.

Within the PBL learning system, (RONTELTAP; EURELINGS, 1997) classified student-related PBL activities into two sets. The first is information-related learning activities. These are largely related to individual research and comprise resource-based search, selection, collection, analysis, synthesis, and presentation activities. The second set is comprised of communication and collaboration activities. These include peer, tutor, and expert communications that question, challenge, and co-construct knowledge. A third set of PBL activities is associated with assessment and reflection. These three activities are, of course, closely interrelated.

Information Related Activities: PBL requires students to perform research. This allow access to appropriate resources and the ability to search, select, collect, analyses, evaluate, and present the results of their research. Information technology can provide good support for all of these tasks (UDEN, 2006). A critical factor in the success of PBL is the provision of appropriate resources for students, so that they can perform active research and locate information to solve the problem posed. Many students head straight for the Web as the first port of call. (WATSON, 2002) claims that the Web is an excellent proving ground for engaging and developing critical thinking skills. Since selection and evaluation of information for relevance and accuracy is important in PBL, the Web provides students with opportunity to develop these skills.

Communication and Collaboration Activities: The second major set of activities in PBL involves team working and associated communication. Problem-based learning is dependent on student collaboration for its success. This is traditionally achieved in face-to-face meetings, which raises a question. Mobile phones are now ubiquitous and students use them as a prime means to organize and schedule meetings. Instant messaging, with tools such as Skype, Facebook and Twitter, are regularly used by students in their social lives. There are numerous other social networking websites and tools for synchronous and asynchronous communications (UDEN, 2006).

Assessment-Related Activities: The third step concerns assessment-related activities. Reflection is the commonly used term for it, since it is a form of self-assessment. Reflection is one of the skills that help students construct meaning and traditionally the use of paper-based feedback forms has been used. Recently, online tools such as blogs, websites, and Wikis, may possibly provide a role facilitating reflection, though their very public nature is likely to influence the nature of the contributions. Perhaps they constitute more of a team reflection (UDEN, 2006).

4 METHODOLOGY

Scientific research is the set of ongoing process that start with observation, followed by developing hypothesis and doing experiments and then analyzing data and drawing conclusion. This chapter describes in detail, the aspects related to the study design, ethical issues, and the steps of development of production technology.

4.1 NATURE OF STUDY

This is a quantitative study with statistical analysis of data.

4.2 TYPE OF STUDY

This is technological production of an app named Savinglife® and methodological quantitative study (POLIT; BECK, 2004). Savinglife® , an educational technology based on the approach of PBL for basic and advanced cardiovascular life support in nursing, was designed, developed and evaluated.

4.3 LOCATION OF STUDY

The study was developed with direct support of the Research Group of GIATE/LAPETEC (Grupo de Pesquisa Clínica, Tecnologias, e Informática em Saúde e Laboratório de Produção Tecnológica em Saúde) and post graduate program in nursing, Federal University of Santa Catarina (UFSC).

4.4 POPULATION AND SAMPLES

A total of 20 postgraduate nursing experts and nursing professors and 5 computer programmers from PEN/UFSC were invited to participate in the study. 15 nursing experts and professors and 4 computer programmers accepted to participate in the study. Access to participants was authorized by the coordinator of postgraduate nursing program at PEN/UFSC, after detailed explanation of the objectives and methodology of the study.

4.5 INCLUSION AND EXCLUSION CRITERIA OF PARTICIPANTS

Inclusion criteria for Nurses/Professors are:

- Being a nurse or professor with minimum experience of 1 year in service or teaching in the critical care area, cardiovascular disease / CPR / ACLS
- Have mobile device (smart phone, PDA, tablet) with internet access
- Do not be in vacation or leave/license during the study period

Inclusion criteria for Computer programmer are:

- Being a computer programmer.
- Have availability to participate in study.
- Have mobile device (smartphone, PDA, tablet) with internet access

Exclusion criteria for participants are:

Participant's withdrawal in any of the stages of the study.

4.6 ETHICAL CONSIDERATIONS

This study considered the conditions set out in resolution n.466/12 (SAUDE, 2012) that determines the guidelines and standards regulating research involving human subjects, and thus respecting the bioethical principles of autonomy, anonymity and beneficence.

The research project was submitted to the ethics committee of UFSC by Brazil Platform[1] and was approved with certificate n. CAAE: 25453013.6.0000.0121 (Appendix A). Participants received all relevant information and had complete freedom to participate or not and were able to withdraw at any time. Participation was based on informed written consent (see Appendix B).

Autonomy: All participants had complete freedom to participate or not in the study and were able to give up the study whenever they deemed appropriate.

Anonymity: The identity of the participants was strictly preserved, assuring, therefore, full anonymity regarding their identity. For purposes of publication and dissemination of results, computer programmer were

[1] Available at http://aplicacao.saude.gov.br/plataformabrasil/login.jsf.

identified as ”CP1”, ”CP2”, ”CP3”, ”CP4”” and Nurses as ”N1”, ... , ”N15”. In addition, the data was stored in a specific file and will be saved for at least 5 years, under the sole responsibility of the study investigator.

Furthermore, participation in this study did not pose any risk to physical, emotional, ethical and intellectual abilities of participants.

4.7 DEVELOPMENT OF TECHNOLOGICAL PRODUCTION

4.7.1 Development Team

The design and development of the application was started in January 2016 and completed in November 2016. A team of three members was used for the development of Savinglife®. A programmer and graphic editor, a lead designer and content generator (Najma Naz, the author herself) and a supervisor (Prof. Grace TM Dal Sasso).

4.7.2 Instructional Design

The development of mSavinglife® will consider the development stages of instructional systems development (ISD) (DICK et al., 2001; FILATRO; PICONEZ, 2004).

The methodology involves a process consisted of five steps, which are Analyze, Design, Develop, Implement, and Evaluation (DICK et al., 2001; FILATRO; PICONEZ, 2004).

- **Analyze:** The first phase of content development is analysis. This phase consists of gathering information about the target population, the tasks to be completed, how the learners will view the content, theme definition and analysis of available technologies feasible for implementation.

- **Design:** The second phase is the design phase. The design phase consists of writing a learning objective, planning and production of educational content, preparing the storyboard (screenplay with texts and following screens) and layout design technology (color, font, arrangement of images and buttons).

- **Develop:** The third phase, development, involves the creation of the activities that will be implemented. It consist of designing the navigation structure, settings and programming, generating images, content (Portuguese and English) and animations.

- **Implement:** After the content is developed, it is then implemented. This stage consists of installation of Savinglife® files on the server of the Research Group of GIATE / PEN / UFSC.
- **Evaluate:** The final phase, evaluate, ensures the materials achieved the desired goals. This consist of review and testing scenarios of Savinglife® with different mobile and making necessary adjustments.

4.7.3 Technology used in the Development of Savinglife®

For Savinglife® our goal was to develop an application which can be accessed through any computing device (mobile, tablets and desktops) with or without internet connectivity. The application was intended to be responsive (adjusted automatically according to the device size) so that it look good on all devices including small mobile devices, tablets and desktops.

Two different modules of the application with the same content and design were developed. One was a web-based application accessible from any computing device with an active internet connection. The other was a standalone application (initially for windows platform only) accessible from any windows device. The standalone application can be installed on any windows device in the presence of internet and can then later be used offline. Production of standalone application is necessary for offline access (when there is no internet connectivity) while web-based version is important since it is very difficult to develop the standalone application for all available platforms and operating systems. So developing both these modules were hoped to fill the gap and cover all kind of users.

Hypertext Pre-processor platforms (PHP) and Eclipse were used for the web-based version[2]. PHP is a server-side scripting language designed for web development but can also be used as a general-purpose programming language. In computer programming, Eclipse is an integrated development environment (IDE). It contains workspace and an extensible plug-in system for customizing the environment. Eclipse can be used to develop web and desktop applications.

[2] available at http://savinglife.info

Visual Studio Community 2015 Edition, a free and rich integrated development environment for creating desktop, web and mobile applications, was used for the development of standalone application[3]. Visual Studio Community 2015 Edition comes with Xamarin, which is a tool used to share code across multiple platforms and write native Android, iOS, and Windows apps with native user interfaces. Xamarin tool, together with C# programming language, was used for the development of the standalone application, whose shared code can then later be used to develop native application for Android and iOS as well.

For the production of two-dimensional graphics, manipulating and retouching photos, MS Paint®, GIMP® and Adobe PhotoShop® CS4 were used. Adobe Flash CS4®, a vector graphics program to create interactive animations, was used.

For managing the database in Savinglife® we used MySQL Query Browser and MySQL Administrator tool, to make it possible to insert text for each languages, providing greater autonomy for editing content when necessary. The MySQL database is selected because it is free and open source, and is the most popular database used worldwide. MySQL Query Browser is a graphical tool made for creating, executing, and optimizing queries in a graphical environment. MySQL Administrator was created to administer a MySQL server.

In order to optimize the data flow in Savinglife® , improve interaction with the user, and also facilitate adaptation to different types of mobile devices the following resources will be used:

- **PHP + MySQL server side:** due to easy installation and availability in various hosting environments available.

- **Web 2 + Asynchronous JavaScript and XML (AJAX):** in order to reduce the amount of data sent from the server to the client.

- **Javascript (client side with jQuery 1.5):** a cross-browser, open source JavaScript library developed to simplify client side scripts that interact with HTML, making simpler navigation of the HTML document, creating animations, event handling and development of AJAX applications. It also offers the possibility to create plugins on it.

- **WordPress** is a free web software that can be used to create website, blog, or apps.

[3] app submitted to Microsoft. Can be downloaded from windows Store once accepted for inclusion in the windows store

4.7.4 Contents and Navigation Structure of SavingLife

The seven steps in PBL described by (WALSH, 2005) are implemented in Savinglife® as shown in Table 2.

Table 2 – Structure of Savinglife® with respect to PBL

PBL	**Savinglife®**
Problem Identification	Presentation of learning clinical scenarios
Prior Knowledge Exploration	Quizzes pre content and post content
Hypothesis & Action Mechanism	ACLS and BLS scenarios
Identify Content for Learning	Get more information about scenarios and Feedback
Individual Study (self-study)	Scenarios, Simulation, Videos and Knowledge Base
Re-Evaluation	Quizzes after content reading (post content)
Discussion & learning evaluation	Quizzes, feedback and quality evaluation of technology

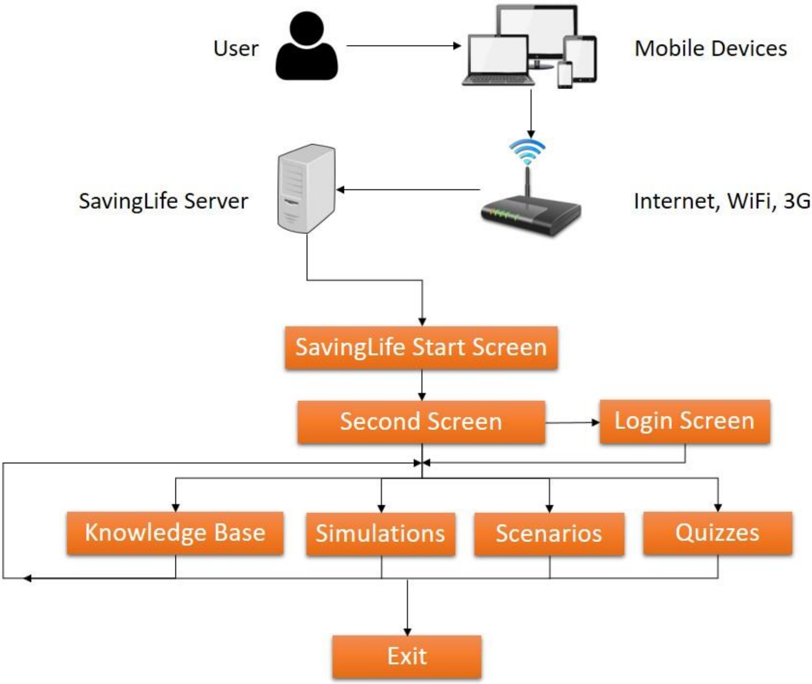
Source: Najma Naz (2016)

Navigation structure of the mSavinglife® is shown in Figure 4. It must be noted that users can access the clinical scenario, simulations and quizzes in a non-linear way, without any specific order to navigate the Savinglife® leaving students free to establish the construction of knowledge from their past experiences.

The contents in Savinglife® have been organized in Scenarios, Simulations, Algorithms, Knowledge base, Quizzes and Videos as shown in Figure 5.

An educational instructional technology (Savinglife®) based on the approach of problem-based learning, was developed for enhancing

Figure 4 – Navigation structure of Savinglife®

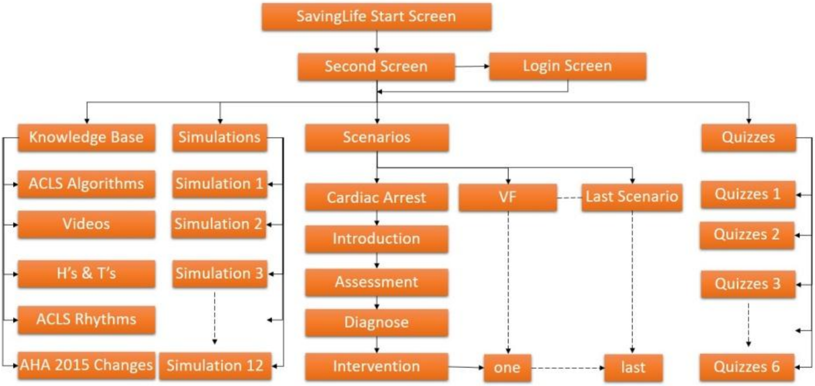


Source: Najma Naz (2016)

the learning of basic and advanced cardiovascular life support. Two different modules of Savinglife® were produced. One is a web-based application accessible through any computing device which has a web browser and an active internet connection. The web-based version is available at http://savinglife.info. The other is a standalone application (initially developed for windows platform only) accessible through any windows device. The standalone application can be installed on any windows device in the presence of internet and can then later be used offline.

Standalone applications are useful for offline access (when there is no internet connectivity) while web-based applications are effective for online access since it is very difficult to develop a standalone application for all available platforms and operating systems. The design,

Figure 5 – Content structure of Savinglife®



Source: Najma Naz (2016) architecture, look and feel of both versions is essentially the same on all devices including smartphones, tablets, laptops, and desktops.

The application interface is responsive and adjust automatically according to the screen size of the device. All the content of Savinglife® is based on the updated 2015 American Heart Association (AHA) guidelines for BLS and ACLS. The content of Savinglife® is presented in two languages (English and Portuguese). Content language of Savinglife® is automatically selected according to the default language of operating system of the device from which the application is accessed. However, preferred language can be manually switched anytime by user from within the application menu.

The contents in Savinglife® have been organized in a way to offer students the options to improve their learning and perform self evaluation. Six learning nodes namely Scenarios, Simulator, Algorithms, Knowledge base, Quizzes and Videos, are created. It must be noted noted that the student can select any node from the main menu without a mandatory order (Non-linear model) leaving learners free to improve their knowledge from their experiences.

4.8 DATA COLLECTION INSTRUMENTS FOR EVALUATION

Data collection took place entirely online, with the instruments and procedures described below.

Data collection instruments were developed in Portuguese language using Google Drive R tools. Google Drive R is a free tool which allows the creation of various electronic forms.

4.8.1 Instrument developed for Nurse / Professionals

1. **Socio-demographic data** 9 questions about the socio characteristics and access to computer technologies in daily life of participants (see Appendix C).

2. **Quality Assessment using LORI 2.0:** 9 quality measurement variables (see Appendix C)

4.8.2 Instrument developed for Computer Programmers

1. **Usability Assessment** 15 quality measurement variables (see Appendix D)

4.8.3 Quality of Technological Production (LORI tool)

In order to standardize the quality assessment of educational software, LORI instrument was developed in Canada (VARGO et al., 2003). LORI version 2.0 (NESBIT; BELFER; LEACOCK, 2009) has been used for evaluating the quality of Savinglife® .

In evaluating a learning object with LORI, reviewers can rate and comment with respect to nine variables (NESBIT; BELFER; LEACOCK, 2009):

1. **Content Quality:** Accuracy, balanced presentation of ideas, and appropriate level of detail

2. **Learning Goal Alignment:** Alignment among learning goals, activities, assessments, and learner characteristics

3. **Feedback and Adaptation:** Adaptive content or feedback driven by differential learner input or learner modeling
4. **Motivation:** Ability to motivate and interest an identified population of learners

5. **Presentation Design:** Design of visual and auditory information for enhanced learning and efficient mental processing

6. **Interaction Usability:** Ease of navigation, predictability of the user interface, and quality of the interface and help features

7. **Accessibility:** Design of controls and presentation formats to accommodate disabled and mobile learners

8. **Re-usability:** Ability to use in varying learning contexts and with learners from differing backgrounds

9. **Standards Compliance:** Adherence to international standards and specifications

Each variable of the instrument was assessed using a scale from 1 to 5 where 1 is Bad, 2 is Regular, 3 is good, 4 means Very Good, and 5-mean Excellent. If one of the items were considered irrelevant to Savinglife® , or when the appraiser did not feel qualified to judge one of these variables, he could leave the item by selecting "Not applicable (NA)" in the scale.

The LORI 2.0 can be applied both to individual assessments as for panel reviews. The results of each of the variables are usually expressed as average values, accompanied by comments of the evaluators (NESBIT; BELFER; LEACOCK, 2009). An electronic version of the instrument was developed for the study.

4.8.4 Usability

The usability evaluation instrument based on the ISO 9241-11 standard (BEVAN, 2001; UsabilityNet, 2006) was used for assessing the usability of Savinglife® . Standards related to usability can be categorized as (BEVAN, 2001):

- The use of the product (effectiveness, efficiency and satisfaction in a particular context of use).
- The user interface and interaction.
- The process used to develop the product.
- The capability of an organization to apply user centered design

The usability instrument (see Appendix D) consist a total of 15 items by evaluated by computer programmers. The items were distributed on a scale of values with the following categories of Answers: (5) for Excellent, (4) for Very Good, (3) for Good, (2) Average, (1) Bad.

4.9 DESCRIPTION AND CHARACTERIZATION OF THE VARIABLES

4.9.1 Independent Variable

Savinglife® App: The PBL based educational technology for Basic and Advanced Cardiovascular Life Support for adult patients, is the independent variable.

4.9.2 Dependent Variable

Usability and Quality of Savinglife® : The quality of the contents of of Savinglife® and usability of Savinglife® , are the dependent variables.

4.9.3 Sociodemographic Variables of Participants

– **Age:** described in years, according to the distribution: up to 19, 20 to 29 years of 30 to 39, 40 to 49 years and 50 to 59 years;

– **Gender:** Male (M) or female (F);

– **Education Level:** Bachelor, Master, PhD and Other;

– **Occupation:** Student, Nurse, Professor and Other;

– **Experience in BLS and ACLS:** Nil, Minimum, Average, Good, and Excellent;

– **Frequent User of Internet:** Yes or No;

– **Use Internet at:** call, Skype, WhatsApp; Social Networking; Studying e-books and literature; Use applications / educational website / material.

4.9.4 Quantitative Variable

Quality Evaluation Score: It is described as the evaluation result of Savinglife® by nursing experts on the quality and characteristics of a educational tool described in LORI Tool version 2.0, described in section 4.8.3. The nine variables described in LORI Tool (NESBIT; BELFER; LEACOCK, 2009) are:

1. Content Quality

2. Learning Goal Alignment
3. Feedback and Adaptation
4. Motivation
5. Presentation Design
6. Interaction Usability
7. Accessibility
8. Re-usability
9. Standards Compliance

Usability Evaluation Score: The usability evaluation instrument based on the ISO 9241-11 standard (BEVAN, 2001; UsabilityNet, 2006) was used for assessing the usability of Savinglife® . Usability tool consists the following 15 variables.

1. Savinglife® runs easily on all computing devices with internet connection without interference.
2. Savinglife® screens are clear and easy to read and interpret
3. The user is able to access the application easily
4. The navigation and structure of the information is easy to use
5. The contents meet the functions set for Savinglife® goals
6. The application favors efficient interventions in emergency situations.
7. Exchange of information between user and system is efficient
8. The system allows the efficient handling of the data that it uses
9. Memory requirements do not prevent the program to stop
10. The system does not accept data that does not exist
11. Communication between the system and user is adequate
12. Hardware requirements are compatible with reality
13. SavingLife is integrated into a database

14. It is easy to adapt to other environments

15. It is easy to install/use in other environments

4.10 ANALYSIS OF EVALUATION DATA

We used descriptive statistics (absolute frequency, mean, median, standard deviation) and inferential (t-test) for the quantitative analysis.

The variance (ANOVA) is used to analyze the differences among group means and their associated procedures (such as ”variation” among the participants).

At the end of data collection, the results obtained in electronic instruments were exported to spreadsheets compatible with Microsoft Excel^{R} 2016 and Stata^{R} IC 12.0. Microsoft Excel^{R} 2016 and Stata^{R}

IC 12.0 are integrated statistical tools that provides everything for data analysis and organization. For all analyzes, we considered, a significance level of $p < 0.05$ for a 95% confidence interval (COHEN; MANION; MORRISON, 2013). Help from a mathematical professional engaged in the teaching area in statistics was used for the analysis of the study results.

4.11 FINANCIAL RESOURCES

The research is a part of a macro-project of GIATE’s research Group entitled **mAPP: PLATAFORMA MOVEL ABERTA PARA´ DESENVOLVIMENTO DE SISTEMAS mSAUDE NA INOVAC¸´ AO DO CUIDADO HUMANO˜** and will be financed from the resources of CNPQ.

5 RESULTS

Considering the goals previously set for the study, the result and discussion obtained in this study are presented in three manuscripts according to the PEN UFSC Normative Instruction 01/PEN/2016. Titles of the manuscripts are:

- A Systematic Review of Problem Based Learning approaches and technologies in the Education of Basic and Advanced Cardiovascular Life Support
- Savinglife® : An Educational Technology for Basic and Advanced Cardiovascular Life Support
- Establishing Content Quality and Usability of Savinglife® : An Educational Technology for Basic and Advanced Cardiovascular Life Support

MANUSCRIPT 1 - A SYSTEMATIC REVIEW OF PROBLEM BASED LEARNING APPROACHES AND TECHNOLOGIES IN THE EDUCATION OF BASIC AND ADVANCED CARDIOVASCULAR LIFE SUPPORT

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Abstract

Background The survival rate from cardiac arrest remains poor despite advances in cardiopulmonary resuscitation (CPR) and advanced cardiovascular life support (ACLS). Many shortcomings have been reported by researchers during the performance of resuscitation care. Conventional training methods are often insufficient to train professionals to deliver high-quality resuscitation care. On the other hand, Problem Based Learning approach has been shown a better instruction method for cardiopulmonary resuscitation and advanced cardiovascular life support training. **Objectives**. The aim of this study was to evaluate the use of problem-based learning methods and technologies in the education of cardiopulmonary resuscitation and advanced cardiovascular life support. **Methods**. A systematic review without meta-analysis was performed. The Cochrane systematic review methodology was followed to search the four electronic databases of PubMed, LILACS, COCHRANE and Science Direct for published studies. The descriptors available in Health Sciences Descriptors (DeCS) were used during the search process. **Results**. Among 164 articles retrieved, 9 studies were included in the review. These studies used different PBL supported approaches and technologies to train and educate learners. e.g. computer based course with voice advisory

manikin, PBL based courses for CPR and ACLS, web based instructional method on quality and retention of CPR skill, web based micro simulation scenarios training by making correct decision, and BLS and ACLS problem based method courses. The approaches were compared with traditional instructor-led or conventional methods. The studies show enough evidence to support PBL approaches for CPR and ACLS to improves the knowledge and Skill of health care providers. Eight out of nine studies reported effectiveness of PBL method when compared to traditional instructor-led or conventional method. Only one study reported that without realistic scenarios, PBL have not promising results. **Conclusion**. The available evidence suggests that problem based learning approaches and technologies is a better instruction method in the education of CPR and ACLS. PBL enhanced the knowledge, skill and competency of health care providers during BLS and ACLS.
keywords: Problem-Based Learning, Cardiopulmonary Resuscitation, Nursing Education, Cardiopulmonary Ressuscitation, Advanced Cardiac Life Support

1 INTRODUCTION

Cardiovascular diseases are one of the most common cause of deaths worldwide. About 17.5 million people die each year from cardiovascular disease (CVDs), which represents about 31% of all deaths globally (WHO, 2016).

More than 75% of all CVD deaths occur in low and middle-income countries while 80% of all CVDs deaths are due to heart attacks and strokes (WHO, 2016). These deaths are often prevented by timely and effective lifesaving interventions, such as cardiopulmonary resuscitation (CPR) and Automated External Defibrillators (AED) if a shockable rhythm is present.

Nurses are often the first responder to cardiac arrests in hospitals, clinics, and other health facilities (GOMBOTZ et al., 2006; NYMAN; SIHVONEN, 2000). They are the ones who frequently call the support staff. They must have updated technical knowledge, decision-making abilities and practical skills in order to contribute more efficiently to cardiac arrest cases. In this regards, several nursing school’s curricula offer contents related to Basic Life Support (BLS) and Advanced Life Support (ALS). However, it is reported that most of the nurses do not feel confident while performing CPR and ACLS in emergency situations, especially in Cardiopulmonary Arrest (CPA) cases (SARDO; SASSO, 2008).

It is argued that educators can no longer rely on traditional teaching methods and more effective learner-centered education techniques are required. In an observational study in (ABELLA et al., 2005), 67 patients who experienced in-hospital cardiac arrest, found that the quality of CPR was inconsistent and frequently did not meet established guidelines. Similar findings for out-of-hospital CPR have also been reported.

Studies indicated that the old ACLS training program has proven inconsistent and inadequate, with numerous studies reporting that trainees have poor retention and practice and ineffective ACLS skills (DEVITA, 2005; LATORRE et al., 2001). Similarly, many international studies indicate that doctors and nurses are not uniformly trained in basic CPR to let alone ACLS (BROWN et al., 1995).

Well-planned and well organized ACLS training, using experiential learning theory, has the potential to improve patient outcomes from cardiac arrests within hospitals (BROWN et al., 1995). In experiential learning, students apply their knowledge and conceptual understanding to real-world problems or situations where the instructor directs and facilitates learning. Classroom and laboratories can serve as a setting for experiential learning through integrated learning activities such as case based studies, problem-based studies, guided inquiry, simulations and experiments (WURDINGER; CARLSON, 2009). ACLS effective training requires the learner to develop critical thinking skills and confidence, along with the technical expertise in implementation, communication and evaluation (SCHERER et al., 2003).

Problem-Based Learning methodology in training nurses for cardiopulmonary arrests has been indicated an effective approach resulting in a better integration of the theory and practice of the CPR process (SARDO; SASSO, 2008). Its effective learning approach prepares students as critical thinkers and lifelong learners and also able them to respond to the changing health environment. PBL is considered a method of instruction that the structure of knowledge in a clinical setting, strengthens the motivation to learn, develop clinical reasoning skills and improve self-directed and long-lasting learning. In the light of these considerations, the aim of this review is to analyze and evaluate the existing data on the use of PBL in the education and training of CPR and ACLS skills.

2 MATERIALS AND METHODS

2.1 Aim: To identify and evaluate the usefulness of Problem Based Learning approaches and technologies in the education of Cardiopulmonary resuscitation and advanced cardiovascular life support programs.

2.2 Design: A systematic review without meta-analysis was performed. The Cochrane methodology of systematic review (HIGGINS; GREEN et al., 2008) was adapted as a basis for the overall study approach. The research question was adjusted according to the PICO protocol P (population/participants) representing nursing and health care students; I (intervention/procedure) represent the use of Problem Based Learning Methods (simulation, manikin, the internet and others); C shows comparator(s), comparison between two groups to evaluate the outcomes. O is for the outcome of interest, the effectiveness of the PBL in the education of CPR and ACLS skills.

2.3 Search Strategy and Sources

A systematic search was conducted from November 2015 to march 2016 to investigate the question of ”*What are the outcome of PBL supported technologies in the education of basic and advanced cardiovascular life support programs?*” The electronic databases of PubMed, Latin American and Caribbean Health Sciences Literature (LILACS), COCHRANE and SCIENCEDIRECT were searched for published studies.

Search limits: No restriction was imposed on the publication date in order to select as many relevant studies as possible. Other filters activated were: full text available in English language, Systematic Reviews; Comparative Study; Clinical Trial; Clinical Trial, Phase I; Clinical Trial, Phase II; Meta-Analysis; Randomized Controlled Trial;

Clinical Trial, Phase III; Multicenter Study; well-designed case-control and cohort studies, descriptive quantitative studies.
Inclusion criteria: Articles related only to only adult's CPR and ACLS training were selected. There was no restriction on the publication date. Original published articles using problem based learning approaches for health care providers in the education and training of BLS and ACLS protocols in cardiac arrest cases were included.

Exclusion criteria: Studies that were not written in English language and that did not assess problem-based learning approaches in the education of CPR and ACLS for Health care providers were not selected. Similarly, articles on pediatric advanced life support (PALS) or neonatal resuscitation program (NRP) training were also not included.

Search Terms: The search strategy was based on the keywords (shown in Table 1) aiming to include as many relevant articles as possible.

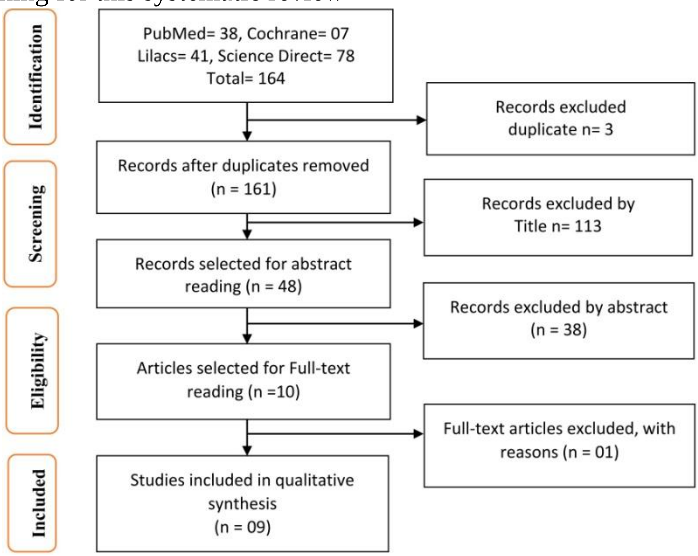
Search Outcomes: A total of 164 articles were initially identified using the search criteria from all the four databases, of which three duplicate items were found. Titles screening of the total 161 articles resulted in 48 relevant articles being selected for abstract screening. The abstracts of these 48 papers were then examined resulting in 10 papers being examined in full. Out of these, 1 were excluded after reading the full texts. The remaining 09 studies were included in the review, as shown in PRISMA flowchart (see Figure 1). Screening and eligibility of each article was done by two independent reviewers and disagreements was resolved by discussion.

Table 1 – Databases and Search Terms

Database	**Keywords**
Cochrane	Problem-Based Learning AND Cardiopulmonary Resuscitation
LILACS	(tw:(Problem Based Learning)) AND (tw:(Cardiopulmonary Resuscitation)) AND (tw:(Advanced Cardiovascular life support)

PubMed	("Problem-Based Learning"[Mesh] AND "Education, Nursing, Baccalaureate"[Mesh]) AND ("Cardiopulmonary Resuscitation"[Mesh] OR "Advanced Cardiac Life Support"[Mesh])
Science Direct	(Problem-Based Learning) and (Cardiopulmonary Resuscitation)[All Sources(Nursing and Health Proessional)

Figure 1 – Flow diagram showing the process of identification and screening for this systematic review



2.3.1 Quality Assessment

Two independent reviewers assessed the methodological quality of the included studies and rated all studies using the process applied by International Liaison Committee On Resuscitation (ILCOR) worksheet review process of the published literature related to resuscitation and emergency cardiovascular care (MORLEY, 2009; MORLEY et al., 2010). The levels of evidence (LOEs) used by review process are a tool to create order and simplicity from the heterogeneity of published studies. The principles of allocating levels of evidence for studies of therapeutic interventions according to ILCOR are as follow:

LOE 1: Randomized Controlled Trials (or meta-analyses of RCTs)
LOE 2: Studies using concurrent controls without true randomization (e.g. pseudo-randomized)
LOE 3: Studies using retrospective controls
LOE 4: Studies without a control group (e.g. case series)
LOE 5: Studies not directly related to the specific population (e.g. different population, etc.)

Three quality terms (”good”, ”fair”, and ”poor”) were defined on the basis of quality items in these lists. Studies were labeled as ”good” if they had all or most of the relevant quality items and ”fair” if they had some of the relevant quality items. Studies were tagged ”poor” if they had only few of the relevant quality items but had enough quality to be include in the review.

2.4 Data Extraction and Synthesis

Two independent reviewers read all articles meeting the inclusion criteria, reached agreement on the type and quality of study design for each study, and extracted data, using standardized data collection forms. The following information was extracted from the included studies. (a) General information about authors, publication date, country (b) research design, location, participants, aim (c) sampling method, sample size, (d) study results and outcomes (e) evidence of use of PBL method in CPR and ACLS. Synthesis of the studies involved categorizing PBL approaches and technologies by their characteristics, narrating and summarizing its effectiveness and presenting data visually.

3 RESULTS

Of the 09 articles met the proposed inclusion criteria for the systematic review, 2 were randomized controlled trails, 1 was experimental quantitative, 1 was prospective, retrospective randomized trial, 1 was descriptive exploratory, 2 were retrospective comparative, 1 was prospective randomized trial and 1 was prospective comparative study. Geographically, 2 studies were based in Netherlands and 1 each in United State, Austria, Brazil, Turkey, Hungary, Georgia and Iran. Characteristics of the included studies are shown in Table 2.

All studies have assessed the use of different PBL supported approaches and technologies in the learning of CPR and ACLS skills. Most studies have compared PBL method with traditional instructor let courses. Different flavors of PBL techniques have been tested and implemented for training CPR and ACLS skills such as classroombased PBL approach with demonstration on simulator and manikins, computer and web-based applications for self-learning with and without manikin (scenario based and non-scenario based), and video based training. One study used an innovative PBL approach of ”learning by teaching”. A detail discussion on these medications is presented in section 4 while their summarized results are provided Table 2.

4 DISCUSSION

4.1 Traditional Instructor Led Course

Traditional instructor led classes consist of theoretical and skills development (theory and demonstration). All contents are provided in a face-to-face manner in which the teachers talk, and the students listen during 70% of class time. First the tutor explain the theory and then individual students are allowed to ask questions for clarity. Demonstrations involved the tutor showing and explaining the implementation and practical work on a manikin or simulator for the entire class. Students then took turns individually or in pairs to practice the skills demonstrated beforehand.

4.2 Classroom based PBL with Simulators and Manikin

One of the examples of instructional methods for skill development is problem-based instruction, which includes scenario-based activities and role-playing, providing students with real life experiences (HAMILTON, 2005).

In this model usually small groups of students are formed, supervised by a tutor. A set of learning objectives for each chapter/section is developed. These objectives can be written so that students studying independently could review the objectives and understand what material is important. When the ACLS text described a clinical skill such as defibrillation, those skills were also included as skills objectives for later practice. Citations to the ACLS text and appropriate supporting materials are included. Different clinical cases are then written by the instructors. These cases are often a phenomenon or an event such as a clinical situation or problem (cardiac arrest, choking, accident, drowning, electric shock and poisoning by gas etc), to be analyzed by the groups. These cases became the basis for a weekly tutorial session. Each case, centered around a patient, emphasized a certain portion of the ACLS curriculum that had already been incorporated in the form of learning objectives in the course. The course involve presentation, discussions, questioning and practical demonstrations.

Table 2: Characteristics of the included studies

Ref.	Year/ Country	Design	Participants	Instruction Method	Results	Quality
(VRIES; HANDLEY, 2007)	2007/ Netherland	Experimental Quantitative	16 Volunteers	Web-based Application	Web-based interactive application can be used to train people in BLS and AED skills	LOE 4 Fair
(KARDONG-EDGREN et al., 2010)	2010/ US	RCT	604 Nursing Students	Traditional Course vs PBL with High Fidelity Simulators	Students in PBL group performed more compressions with adequate depth and ventilations with adequate volume than students who had instructor-led courses.	LOE 1 Good
(ROBAK et al., 2006)	2006/ Austria	Prospective, retrospective randomized Study	116 Medical Students	PBL using an innovative idea of "learning-by-teaching"	"learning-by-teaching" strategy was highly accepted by all participants and had a longer lasting benefit than regular lecture courses in CPR.	LOE 3 Fair
(SARDO; SASSO, 2008)	2008/ Brazil	Descriptive Exploratory	24 Undergraduate Nursing Students	Classroom based PBL with dummies	PBL result in a better integration of the theory and practice of the CPR knowledge and allow students to take a more active role in their learning process.	LOE 4 Fair
(SARAÇ; OK, 2010)	2009/ Turkey	RCT	90 University Students	Traditional vs Case-based vs Web-based	Traditional and case-based groups were better than web-based group that used video self-instruction as a learning tool	LOE 1 Good
(HOSSEINI et al., 2013)	2013/ Iran	Retrospective Comparative pre and post test	450 Medical Students	Traditional Course vs PBL with High Fidelity Simulators	PBL improved the quality of resuscitation training in the target population and should be used for the ACLS training.	LOE 3 Fair
(SZÖGEDI et al., 2010)	2009/ Hungary	Retrospective Comparative	1775 Nursing Students	Traditional Course vs PBL with Simulators	PBL was a superior instruction method for CPR training, results in greater theoretical knowledge and better resuscitation skills	LOE 3 Fair
(VRIES et al., 2010)	2010/ Netherland	Prospective, Randomized Study	396 Volunteers	Traditional vs three DVD-based Trainings	Video-based training alone is insufficient to teach the use of AED, when compared to instructor-led course.	LOE 3 Fair
(POLGLASE et al., 1989)	1989/ Georgia	Prospective Comparative	14 Undergraduate Medical Students	Classroom base PBL	PBL results in better resuscitation skills	LOE 3 Fair

Students met with their tutor once or twice a week, often two hours per session. Each session focus on the questions raised in the discussions of the relevant case. At the end of each lesson, the students comment on the next week case and set topics for discussions.

Between sessions, each student used the text to identify and study relevant material. Their goal is to study sufficient material to develop an understanding of the issues presented by the forthcoming case. The tutors did not lecture, but served as facilitators, guiding group discussion toward appropriate topics. Eventually, the contents discussed and practical training were synthesized through simulations and on specific dummies, with the goal of inter-relating theory with practice.

A classroom based PBL approach with advanced equipment and arrhythmia simulator was assessed in (HOSSEINI et al., 2013) at Tehran University of Medical Sciences in 2009-2010. 290 first-year residents were trained via a problem-based method and 160 first-year residents were trained via a lecture-based method. The participants self-evaluated their own CPR knowledge and skills pre and post workshop. The difference in the mean scores between the problem-based and lecture-based groups was 32.36 ± 19.23 vs. 22.33 ± 20.35 for CPR knowledge (p value = 0.003) and 10.13 ± 7.17 vs. 8.19 ± 8.45 for CPR skills (p value = 0.043). The problem-based approach improved the quality of education and training in the target group.

Similarly, in (SZOGEDI et al.¨ , 2010) a study was conducted in Hungary to assess whether problem-based learning is more effective over conventional teaching methods in training nurses for CPR. Data were collected from three institutions in Hungary who have started problem-based courses in CPR training for nursing students. In this study, the majority of nurses learned about CPR for the first time. For this PBL model, the authors used the European Resuscitation Council Guidelines of 2005 for Resuscitation. A significant difference (($t = 3.569$; $p < 0.001$) between PBL and conventional methods favoring PBL instructed students was found. PBL instructed students had better final CPR exam grades and achieved greater theoretical knowledge than traditionally trained students.

The ACLS course has been described as a course of reviewing skills, not as a course of learning them (ATKINS, 1986). Many medical students have little experience with the clinical skill taught in the ACLS courses. An extended nontraditional ACLS course was developed in (POLGLASE et al., 1989) for undergraduate emergency medical education in Georgia. The authors designed a self-directed ACLS program using the problem based learning approach where the tutors served as a facilitator, guiding group discussion toward appropriate topics and relevant case. When compared the results with the senior medical students, the self-directed ACLS students scored higher and performed better in ACLS knowledge.

A problem-based cardiopulmonary resuscitation educational practice course for undergraduate nursing students at a university in the South of Brazil was developed in (SARDO; SASSO, 2008). The study used the problem-based learning methodology on 24 nursing students. The study showed that PBL allows the educator to analyze the academic learning process in several aspects, serving as a motivating element for both the educator and the learner, and result in a better integration of the theory and practice of the teaching process. PBL encourage students to take a more active role in their learning process and allow them to start building a solid knowledge base.

4.3 Classroom based PBL with an innovative idea of ”Learning by Teaching”

The ”*learning by teaching*” model presents an innovative idea of using motivated medical students to teach CPR and the use an AED to lay people. Laymen are happy to be trained in BLS and the use of an AED by medical students. The advantages for both parties, the person who is trained and the student who learns by teaching, are evident. In order to get the best possible outcome for both the student and the trainee, lectures had to be held for the students where they should obtain all relevant information and training about CPR and the AED. Unconsciousness, cardiac arrest, and basic physiological principles, necessary for the understanding of an AED and CPR in general, should be well explained to laymen.

The AED and its major functions should be explained and demonstrated. Also the need of correct placement of the pads and the importance of external chest compressions need to be stressed. All questions should be answered and all participants should be encouraged to practice as long and as often until they feel confident about BLS and defibrillation using an AED.

PBL with an innovative ideas of ”teaching by learning” has been introduced in (ROBAK et al., 2006) where medical students train cardiac death survivors who were fully reintegrated into their normal lives at their homes in BLS and the use of an AED. This idea improves the confidence as well as knowledge of students in performing CPR and the use of an AED. Also laymen welcome the training in BLS by medical students. This strategy of ”learning by teaching” is viable and might provide a more thorough knowledge and a deeper insight of BLS skills for students when they are performing as trainers.

4.4 Web-based/Computer-based Courses using PBL

Advances in technology increased the availability and the functionality of the Internet. Web-based and computer supported instructional methods were suggested as an alternative way to teach first aid (MONSIEURS et al., 2004). This model include theory, scenario training and self-testing in a web-based application but without practice on a manikin, or any instructor input. In a web-based application, students are provided with an account to use the web-site that contains the first aid related information. Teacher-to-student and student-to-student interaction occur through asynchronous communication. The application consists of sections covering the theory with manuals, text videos, a section for self-assessment, and sections where the trainee can simulate each scenario.

A web-based simulation program for self-learning BLS and AED skills was introduced in (VRIES; HANDLEY, 2007). The application consisted of a section for BLS and AED theory, a section for self-assessment, a micro-simulation section where the trainee had to use to each scenario by making the correct decisions, and a section for checking if these decisions were correct. The application was based without practice on a manikin, and without any instructor guidance. After the assessment of 16 volunteers, most of the BLS skills were performed well (84-100% of the participants performed correctly). Chest compression depth and rate were performed less well (59% and 67%, respectively, of the participants, performed correctly). Opening the airway and lung inflation were performed poorly (38% and 13%, respectively, of the participants, performed correctly), as was checking for safety (19% participants performed correctly). Overall, the results recommend that it might be possible to achieve reasonable proficiency in BLS and AED skills using a web-based interactive program, even before practice on a manikin can be provided.

The authors in (SARAC¸; OK, 2010), evaluated the effects of three instructional methods (traditional, classroom-based, and web-based) on the acquisition and retention of CPR skills in 90 students, where 30 students were randomly assigned to each group. The web-based instruction group performed poorer than the traditional and classroom-based instruction groups in "*average compression rate, percentage of correct chest compressions, the number of too low hand positions, the number of wrong hand positions, the average number of ventilations, the average volume of ventilations, the number of too fast ventilations, the total number of ventilations, and the percentage of correct ventilations*" ($p < 0.05$). The authors reported that the traditional and classroom-based instructions result in better CPR training than web-based instructions.

CPR skills in 604 nursing students from 10 Nursing Schools in the United States were assessed and compared in (KARDONG-EDGREN et al., 2010) on two types of CPR courses: a computer-based course (HeartCode*TM* BLS) with voice assisted manikin (VAM) and instructor-led training with traditional manikins. The VAM provided verbal feedback and prompts as students practiced their CPR psychomotor skills. Students who were trained using HeartCode BLS and VAMs performed more compressions with adequate depth, used correct hand placement and provided more ventilations with adequate volume than students who had Instructor-Led courses particularly when learning on hard molded manikins.

Web based application opens the possibility of mass public training via the internet. However, it would be important to ensure that participants receive sufficient incentive to use the on-line program. a web-based training program might be effective, efficient and practical as part of a distance-learning education for BLS and use of an AED.

Although self-learning methods through web-based applications are considered to be useful to teach CPR, researchers should be aware of the importance of the instructor's feedback and expertise for answering student questions related with the emergency conditions. Furthermore, this method could be more useful if each student in web-based instruction group is provided with mini CPR kit to provide them with a self-learning CPR tool. It should not be seen as replacing other methods of training, and practice on a manikin should be encouraged when circumstances permit. It must also be remembered that not everyone is as computer literate as the volunteers in this study.

4.5 DVD-based Trainings Using PBL Approaches

Video-based self-instruction have also been suggested as a popular and innovative method for teaching CPR (TODD et al., 1998).

An instructor-led AED-training was compared with three video-based AED-training in (VRIES et al., 2010). Vide-based training consisted of videos without practice and scenarios, videos with manikin practice but without scenarios and video with manikin practice and scenarios training. 396 participants were assigned to each AED-training methods. Participants were assessed immediately after the training (posttest) and then 2 months later (retention-test). The performance of participants in all video-based training was significantly higher on the retention-test than on the post-test. Those receiving scenario based training scored higher on the post-test compared to the other videobased training ($p < 0.001$).

However, the performance of video-based training was lower when compared to instructor-led AED course. The addition of scenario training improves the effectiveness of video training, but this remains inferior to instructor-led training. The authors concluded that the video-based AED-training without scenario is not recommended. Scenario training is a useful addition, but instructor-facilitated training remains the best method. The study suggest that video-training is insufficient to teach the use of CPR and AED. It is due to the fact that videos or not interactive and cannot fully utilize the power of PBL. Adding scenarios, interactivity of content with learners, and practice on a manikin or simulator can enhance the knowledge and skill of learners.

5 CONCLUSIONS

The purpose of this systematic review was to evaluate the effectiveness of PBL supported technologies in the education of CPR and ACLS skills. Problem based learning approaches were shown quite effective to enhance skill, knowledge retention, critical thinking and decision making. PBL is significantly better than traditional instructor led courses for teaching CPR and ACLS skills to nursing and medical students. Its effective learning approach prepares students as critical thinkers and also able them to respond to the changing health environment. PBL is considered an instruction method that structures knowledge in clinical contexts, strengthens motivation to learn, develops clinical reasoning skills, and enhances self-directed learning. The authors suggest that the problem-based training method should be used as an alternative method to the traditional lecture-based method for the BLS and ACLS training of health professionals. However, in order to take full advantages of PBL approach we need observer: PBL course should consist of clinical scenarios near to real life situations; Simulators, preferably high fidelity simulation should be used for training. This is practically important in BLS and ACLS; Web-based PBL applications opens the possibility of mass public training via the internet but for better results content should focus on scenario based training and practical demonstration sessions should be separately organized and; instructor's feedback for answering student questions related with the emergency conditions is important.

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MANUSCRIPT 2 - SAVINGLIFE®: AN EDUCATIONAL TECHNOLOGY FOR BASIC AND ADVANCED CARDIOVASCULAR LIFE SUPPORT

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Abstract
The development of information and communication technologies and the accessibility of mobile devices has increased the possibilities of the teaching and learning process anywhere and anytime. Mobile and web application allows the production of constructive teaching and learning models in various educational settings, showing the potential for active learning in nursing. The objective of this study was to present the development of an educational technology (Savinglife®, an app) for learning cardiopulmonary resuscitation and advanced cardiovascular life support training. Savinglife® is a technological production, based on the concept of virtual learning and problem-based learning approach. The study was developed from January 2016 to November 2016, using five phases (analyze, design, develop, implement, evaluate) of the instructional systems development process. The technology presented 10 scenarios and 12 simulations, covering different aspects of basic and advanced cardiac life support. The contents can be accessed in a non-linear way leaving the students free to build their knowledge based on their previous experience. Each scenario is presented through interactive tools such as scenario description, assessment, diagnose, intervention and reevaluation. Animated ECG rhythms, text documents, images and videos are provided to support procedural and active learning considering real life situation. Accessible equally on small to large devices with or without an internet connection, Savinglife® offers a dynamic, interactive and flexible tool, placing students at the center of

the learning process. Savinglife® can contribute to the student's learning in the assessment and management of basic and advanced cardiac life support in a safe and ethical way.

keywords: Problem-Based Learning, Cardiopulmonary Resuscitation, Nursing Education, Cardiopulmonary Ressuscitation, Advanced Cardiac Life Support, Educational Technology

1 INTRODUCTION

Cardiac arrest occurs when heart stop pumping adequate blood to the brain and body. This may be due to abnormal or irregular heart rhythm, also known as Arrhythmia. Cardiac arrest is reversible, if treated with immediate defibrillation if a *shockable* rhythm exists otherwise cardiopulmonary resuscitation (CPR) is used in order to induce a *shockable* rhythm (SURESH; FATHIMA, 2015).

The cardiovascular disease strikes every nation around the world. Despite recent advances in the prevention and treatment, cardiac arrest remains a significant public health problem and a leading cause of death in many parts of the world (ROGER et al., 2011). About 17.5 million people die each year from cardiovascular disease (CVDs), which represents about 31% of all deaths globally (WHO, 2016).

More than 75% of all CVD deaths occur in low and middle-income countries while 80% of all CVDs deaths are due to heart attacks and strokes (WHO, 2016). The estimated incidence of out-of-hospital cardiac arrest in the US and Canada is about 50 to 55/100,000 persons/year and approximately 25% of these have pulseless ventricular arrhythmias (NICHOL et al., 2008). The estimated incidence of in-hospital cardiac arrest is 3 to 6/1000 admissions and similarly, approximately 25% of these have pulseless ventricular arrhythmias (NADKARNI et al., 2006). The vast majority of cardiac arrest victims are adults, but thousands of infants and children suffer either an in-hospital or out-of-hospital cardiac arrest each year in the US and Canada (NADKARNI et al., 2006). Cardiac arrest continues to be a common cause of premature death, and small improvements in survival can translate into thousands of lives saved every year. In Brazil about 347/100,000 person/year die due to cardiovascular diseases (CVD) and 134/100,000 by chronic heart diseases (CHD) (MOZAFFARIAN et al., 2016)

These deaths can be often prevented by timely and effective lifesaving interventions, such as cardiopulmonary resuscitation (CPR) and Automated External Defibrillators (AED) if a shockable rhythm is present. Recognition of a cardiac arrest and prompt action by the rescuer are vital for the survival of victim (AHA et al., 2010; LINK et al., 2015).

Nurses are usually the first responder to witness cardiac arrests in hospitals, clinics, and other health facilities (GOMBOTZ et al., 2006). They are the ones who frequently call the emergency staff. Nurses and other health professionals must have updated technical knowledge, decision-making abilities and practical skills in order to contribute more efficiently to cardiac arrest cases. However, it is reported that most of the nurses do not feel confident while performing CPR and ACLS in emergency situations, especially in Cardiopulmonary Arrest (CPA) cases (SARDO; SASSO, 2008). Resuscitation attempts are not always appropriate and as a result many lives are lost (AHA et al., 2010).

Conventional training methods are often insufficient to train professionals to deliver high-quality CPR and ACLS. In an instructor led Learning, all contents are provided in a face-to-face manner in which the teachers talk, and the students listen during 70% of class time. This method can introduce new ideas and transmit knowledge but it is not effective because students have to study intensively over a short time of period. With traditional education, students may become incapable of professional judgment and critical thinking in case of the variable clinical environment (OZTURK; MUSLU; DICLE, 2008).

More effective learner-centered education techniques are required since educators can no longer rely on traditional teaching methods. Studies indicated that the old ACLS training program has proven inconsistent and inadequate, with numerous studies reporting that trainees have poor retention and ineffective ACLS skills (DEVITA, 2005).

Problem-Based Learning (PBL), on the other hand, has been indicated an effective approach for training nurses and other health professionals, resulting in a better integration of the theory and practice (SARDO; SASSO, 2008; HOSSEINI et al., 2013). Its effective learning approach prepares students as critical thinkers and able them to respond well in different health settings. PBL encourage students to take a more active role in their learning process and allow them to start building a solid knowledge base.

Information and communication technologies (ICT) are rapidly improving and easily available. The number of mobile phones in the world was 97 per 100 people at the end of 2014 (The World Bank, 2016) and has exceeded the world population in 2016 and among those more than 50% are smartphones (Statista Inc., 2016). Similarly, the number of internet user worldwide was 3 billion in 2015 (Central Intelligence Agency, 2016; The World Bank, 2016). Mobile and wireless technologies offer exciting opportunities for a low cost, high reach educational and health care services for masses (WEST, 2012).

Mobile phones are in the hands of increasingly more people including those in some of the poorest and most difficult to reach areas of the world (SPECIALE; FREYTSIS, 2013). Mobile phone and internet connectivity are creating unprecedented opportunities by facilitating interactions and information sharing between people (BOULOS; MARAMBA; WHEELER, 2006). In recent years, the development and applicability of informatics have influenced all areas of knowledge, disseminating information, creating educational programs, and enabling new forms of learning.

Web and computer based interactive and self-learning programs to train people using a micro-simulation is effective in BLS and ACLS skills (VRIES; HANDLEY, 2007). Web and computer based programs include theory, training (with or without scenarios) and self-testing (VRIES; HANDLEY, 2007). In a web-based application, students are provided with an account to use the online content. Teacher-to-student and student-to-student interaction occur through asynchronous communication. The application consists of sections covering the theory, text, videos, a section for self-assessment, and sections where the trainee can simulate each scenario if any.

With web-based interactive programs it might be possible to achieve proficiency in BLS and ACLS skills, however, in order to take its full advantages, integration of PBL approach, and structuring the contents in the form of clinical scenarios near to real life situations, is very important (VRIES; HANDLEY, 2007; SARAC¸; OK, 2010; KARDONG-EDGREN et al., 2010).

Web-based applications opens the possibility of mass public training via the internet but for better results the content should focus on scenario based training and instructor's feedback for answering student questions related with the emergency conditions should be available to learners (KARDONG-EDGREN et al., 2010).

Being a member of GIATE/LAPETEC (Grupo de Pesquisa Cl´ınica, Tecnologias e Inform´atica em Sau´de e Laborat´orio de Produ¸c˜ao Tecnol´ogica em Sau´de) research group, I was motivated to design and structure the content of basic and advanced life support using the updated 2015 American Heart Association guidelines that meet both the demands of self-learning and the use of innovative technologies in teaching and learning in nursing. The aim of this study was to integrate the PBL approach with simulated scenarios, feedback and self-assessment in an application that is both accessible online and offline from all computing devices including smartphones, tablets and PCs. Therefore, the application of Savinglife® was designed and developed which structures the knowledge of BLS and ACLS in clinical contexts, strengthens motivation to learn, develops clinical reasoning skills, and enhances self-directed learning, anywhere any time.

2 METHODOLOGY

This was a methodological research (POLIT; BECK, 2004) and technological production of an app named Savinglife® , developed at the Federal University of Santa Catarina Florianopolis, Brazil having been previously approved by the research and ethics committee of the university (Certificate number CAAE: 25453013.6.0000.0121)(see Appendix A).

The design and development of the application was started in January 2016 and completed in November 2016. A team of three members was used for the development of Savinglife® . A programmer and graphic editor, a lead designer and content generator and a supervisor. The resources required for the development of technology Savinglife® were funded by CAPES and CNPQ.

The development of Savinglife® consider the development stages of instructional systems development (ISD) (DICK et al., 2001; FILATRO; PICONEZ, 2004). The model consists of an action plan, development and implementation of specific teaching scenarios incorporating mechanisms that favor the contextualization of new learning (FILATRO; PI-
CONEZ, 2004).

The methodology involved a process consisted of five steps, which are Analyze, Design, Develop, Implement, and Evaluation (DICK et al., 2001; FILATRO; PICONEZ, 2004).

- **Analyze:** This phase consist of gathering information about the target population, the tasks to be completed, theme definition and analysis of available technologies feasible for implementation.

- **Design:** The design phase consist of writing a learning objective, planning and production of educational content, preparing the storyboard (screenplay with texts and following screens) and layout design technology (color, font, arrangement of images and buttons).

- **Develop:** The development phase involves the creation of the activities that were later implemented. It consist of designing the navigation structure, settings and programming, generating images, content (Portuguese and English) and animations.

- **Implement:** This stage consist of installation of SavigLife files on an online server and submitting to different application stores.

- **Evaluate:** The final phase, evaluate, ensures the materials achieved the desired goals. This consist of review and testing scenarios of Savinglife® with different devices and making necessary adjustments.

2.1 Technologies Used

For Savinglife® the goal was to develop an application which can be accessed through any computing device (mobile, tablets and desktops) with or without internet connectivity. The application was intended to be responsive (adjusted automatically according to the device size) so that it look good on all devices including small mobile devices, tablets and desktops.

Two different modules of the application with the same content and design were developed. One was a web-based application accessible from any computing device with an active internet connection. The other was a standalone application (initially for windows platform only) accessible from any windows device. The standalone application can be installed on any windows device in the presence of internet and can then later be used offline. Production of standalone application is necessary for offline access (when there is no internet connectivity) while web-based version is important since it is very difficult to develop the standalone application for all available platforms and operating systems. So developing both these modules were hoped to fill the gap and cover all kind of users.

Hypertext PreProcessor platforms (PHP) and Eclipse were used for the web-based version[4]. PHP is a server-side scripting language designed for web development but can also be used as a general-purpose programming language. In computer programming, Eclipse is an integrated development environment (IDE). It contains workspace and an extensible plug-in system for customizing the environment. Eclipse can be used to develop web and desktop applications.

Visual Studio Community 2015 Edition, a free and rich integrated development environment for creating desktop, web and mobile applications, was used for the development of standalone application[5]. Visual Studio Community 2015 Edition comes with Xamarin, which is a tool used to share code across multiple platforms and write native Android, iOS, and Windows apps with native user interfaces. Xamarin tool, together with C# programming language, was used for the development of the standalone application, whose shared code can then later be used to develop native application for Android and iOS as well.

For the production of two-dimensional graphics, manipulating and retouching photos, MS Paint R , GIMP R and Adobe PhotoShop R CS4 were used. For animation, Adobe Flash CS4 R (vector graphics program used to creat interactive animations) was used.

For managing the database in Savinglife® we used MySQL Query Browser and MySQL Administrator tool, to make it possible to insert text for each languages, providing greater autonomy for editing content when necessary. The MySQL database is selected because it is free and open source, and is the most popular database used worldwide. MySQL Query Browser is a graphical tool made for creating, executing, and optimizing queries in a graphical environment. MySQL Administrator was created to administer a MySQL server.

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[4] available at http://savinglife.info

[5] app submitted to Microsoft. Can be downloaded from windows Store once accepted for inclusion in the windows store

In order to optimize the data flow in Savinglife® , improve interaction with the user, and also facilitate adaptation to different types of mobile devices the following resources will be used:

- **PHP + MySQL server side:** due to easy installation and availability in various hosting environments available.
- **Web 2 + Asynchronous JavaScript and XML (AJAX):** in order to reduce the amount of data sent from the server to the client.
- **Javascript (client side with jQuery 1.5):** a cross-browser, open source JavaScript library developed to simplify client side scripts that interact with HTML, making simpler navigation of the HTML document, creating animations, event handling and development of AJAX applications. It also offers the possibility to create plugins on it.

- **WordPress** **R** is a free web software that can be used to create website, blog, or apps.

2.2 Structure

The seven steps in PBL described by (WALSH, 2005) are implemented in Savinglife® as shown in Table 1.

Table 1 – Structure of Savinglife® with respect to PBL

PBL	**Savinglife®**
Problem Identification	Presentation of learning clinical scenarios
Prior Knowledge Exploration	Quizzes pre content and post content
Hypothesis & Action Mechanism	ACLS and BLS scenarios
Identify Content for Learning	Get more information about scenarios and Feedback

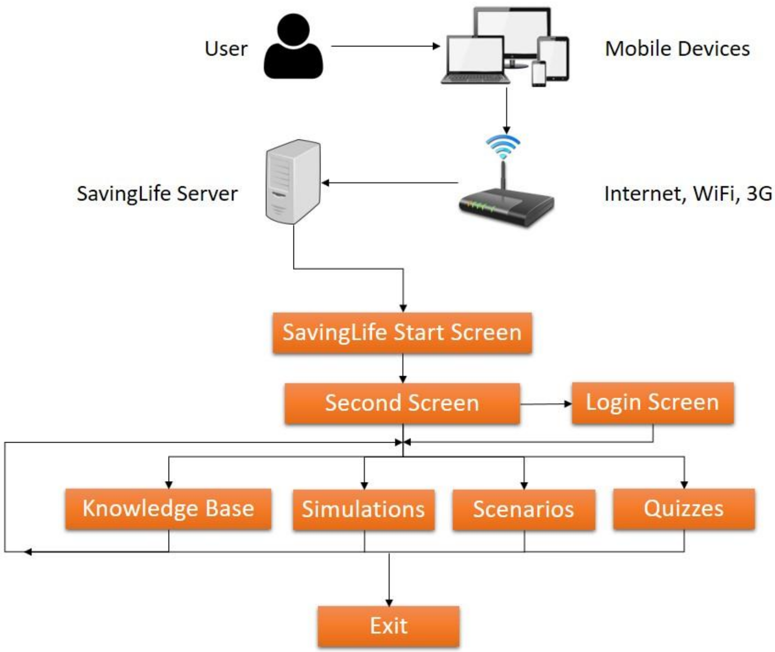
Individual Study (self study)	Scenarios, Simulation, Videos and Knowledge Base
Re-Evaluation	Quizzes after content reading (post content)
Discussion & learning evaluation	Quizzes and Feedback

Source: Najma Naz (2016)

Navigation structure of the Savinglife® is shown in Figure 1. It must be noted that users can access the clinical scenario, simulations and quizzes in a non-linear way, without any specific order to navigate the Savinglife® leaving students free to establish the construction of knowledge from their past experiences.

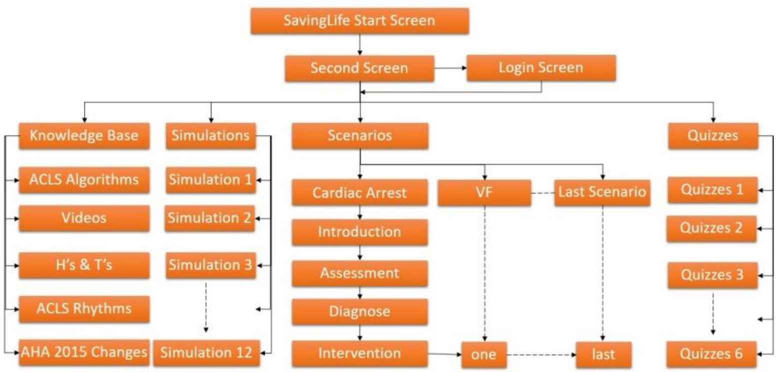
The contents in Savinglife® have been organized in Scenarios, Simulations, Algorithms, Knowledge base, Quizzes and Videos as shown in Figure 2.

Figure 1 – Navigation structure of Savinglife®



Source: Najma Naz (2016)

Figure 2 – Content structure of Savinglife®



Source: Najma Naz (2016)

3 RESULTS

An educational instructional technology (Savinglife®) based on the approach of problem-based learning, was developed for enhancing the learning of basic and advanced cardiovascular life support. Two different modules of Savinglife® were produced. One is a web-based application accessible through any computing device which has a web browser and an active internet connection. The web-based version is available at http://savinglife.info. The other is a standalone application (initially developed for windows platform only) accessible through any windows device. The standalone application can be installed on any windows device in the presence of internet and can then later be used offline.

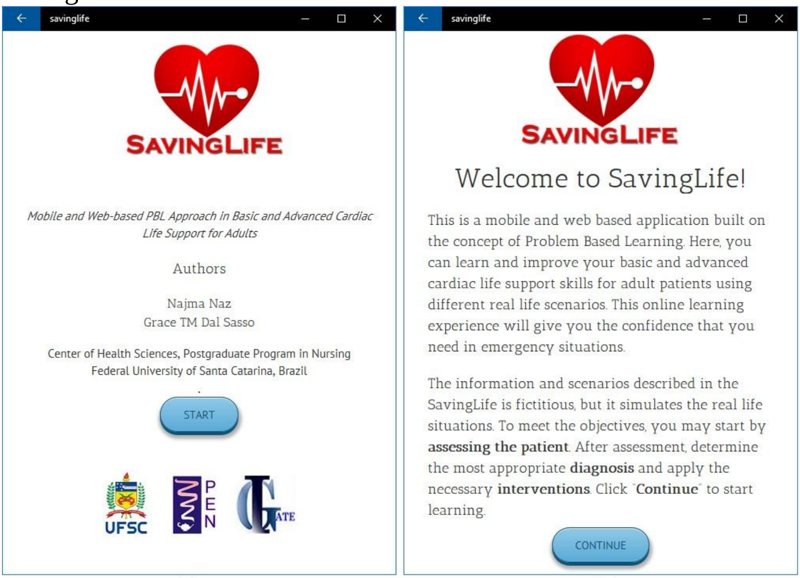
Standalone applications are useful for offline access (when there is no internet connectivity) while web-based applications are effective for online access since it is very difficult to develop a standalone application for all available platforms and operating systems. The design, architecture, look and feel of both versions is essentially the same on all devices including smartphones, tablets, laptops, and desktops.

The application interface is responsive and adjust automatically according to the screen size of the device (see Figure 5 and 10 for comparisons). All the content of Savinglife® is based on the updated 2015 American Heart Association (AHA) guidelines for BLS and ACLS. The content of Savinglife® is presented in two languages (English and Portuguese). Content language of Savinglife® is automatically selected according to the default language of operating system of the device from which the application is accessed. However, preferred language can be manually switched anytime by user from within the application menu.

The first screen (Figure 3-a) presents the name, logo and authorship of Savinglife® along with the institution of origin and year of production. The second screen (Figure 3-b) shows a brief introduction to the Savinglife® application. The third screen reveals a login form (Figure 4) if the user is not already logged in or the scenario screen (Figure 5) if the user is already logged in.

The contents in Savinglife® have been organized in a way to offer students the options to improve their learning and perform self-evaluation. Six learning nodes namely Scenarios, Simulator, Algorithms, Knowledge base, Quizzes and Videos, are created. It must be noted that the student can select any node from the main menu without a mandatory order (Non-linear model) leaving learners free to improve their knowledge from their experiences.

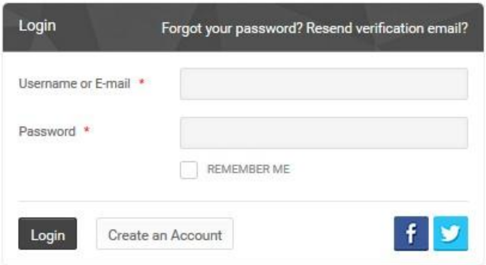
Figure 3 – (a). First screen of SavingLife. (b). Second screen of Savinglife® .



(a) (b)

Source: Najma Naz (2016)

Figure 4 – Login screen of Savinglife®

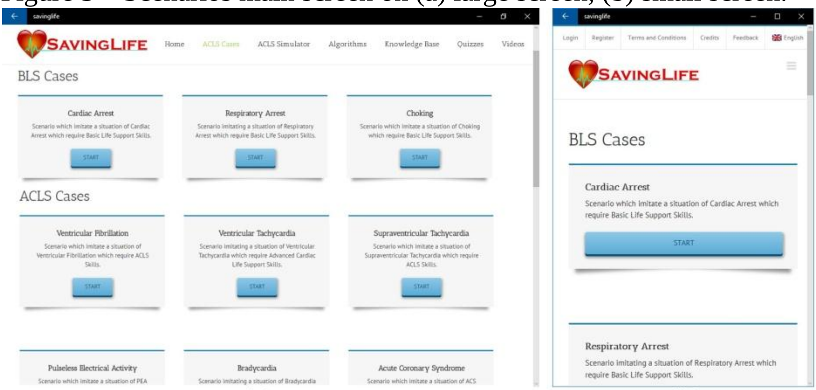


Source: Najma Naz (2016)

3.1 Cases / Scenarios

After successfully logging in, the user is directed to the selection screen of clinical scenarios Contents are organized in 10 different cases which representing the scenarios of real life situations covering BLS and ACLS guidelines according to the AHA 2015. These cases include respiratory arrest, cardiac arrest, choking, ventricular fibrillation, pulseless electrical activity, pulseless ventricular tachycardia, supraventricular tachycardia, bradycardia, acute coronary syndrome, and suspected stroke.

Figure 5 – Scenarios main screen on (a) large screen, (b) small screen.



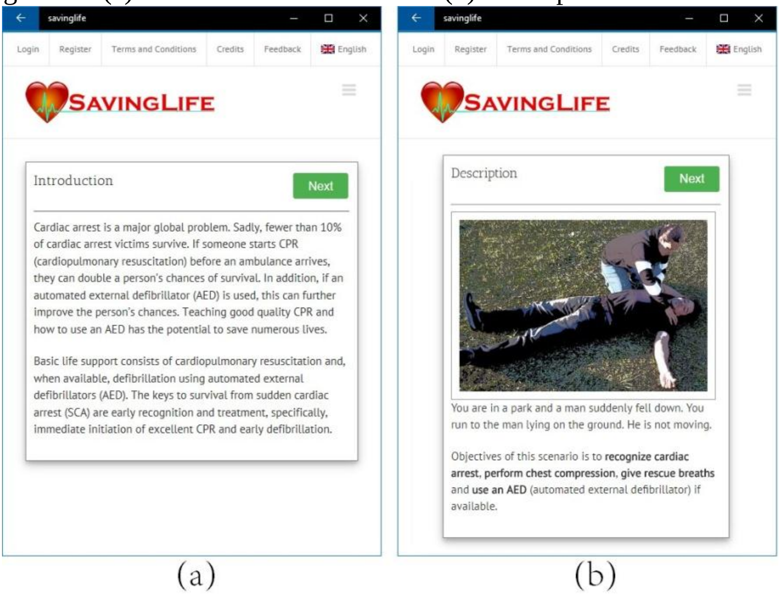
(a) (b)

Source: Najma Naz (2016)

Each case consist of one factitious problem situation of cardiac arrest, arrhythmias or other special circumstances. Students can try to solve the problem through step by step guideline of AHA.

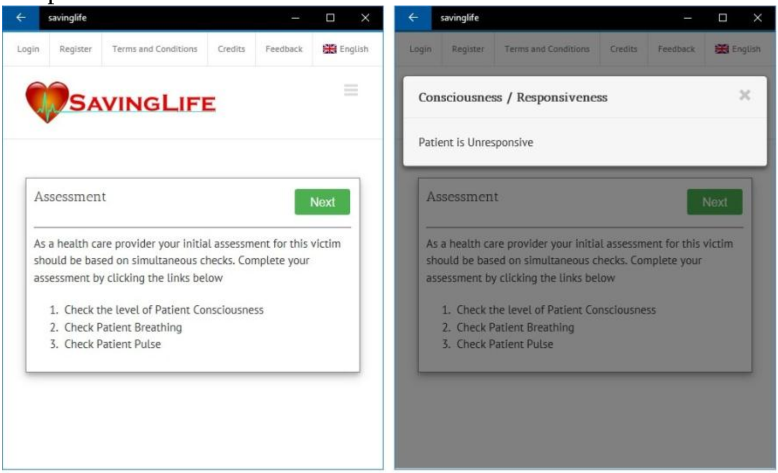
Each clinical scenario presents a patient with necessary details. When a user click to start learning a case, first they are presented with a brief introduction and case description as shown in Figure 6. Then the user moves on to the next screen for necessary assessment, as shown in Figure 7.

Figure 6 – (a) Introduction of a scenario. (b) Description of a scenario.



Source: Najma Naz (2016)

Figure 7 – (a) Assessment screen (b) Simulated victim response when first option is clicked.



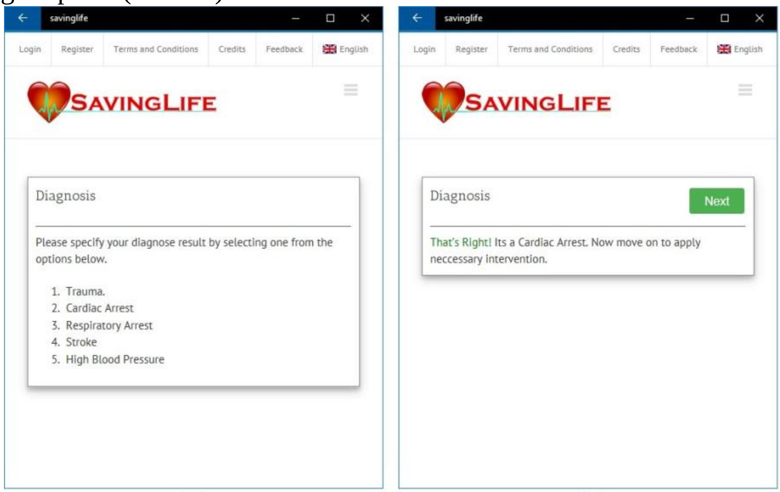
(a) (b)

Source: Najma Naz (2016)

Assessment of the patient can be performed by virtual communication with the victim through different options available on the assessment screen. After assessment, student make a hypothesis and diagnose the patient using the option available on the diagnose screen (Figure 8). After successful diagnose, user immediately begins intervention and re-evaluation as shown in Figure 9. The cycle of intervention and re-evaluation continues until the victim is stabilized. In this way the students continue to use the essential steps of assessment, diagnose, intervention and evaluation while improve their knowledge and skill. The students have different options to decide on the actions to be taken during different scenarios considering real situations of nursing practice.

After each (re)evaluation, the select the right option from the available choices. On selecting the right option, the scenario moves forward. Depending on the condition the victim is then reevaluated and next intervention is decided. On selecting a wrong option, the application let the student try again for the right option, until the right option is selected.

Figure 8 – (a) Diagnosis screen (b) Response of the system when the right option (the 2nd) is clicked.

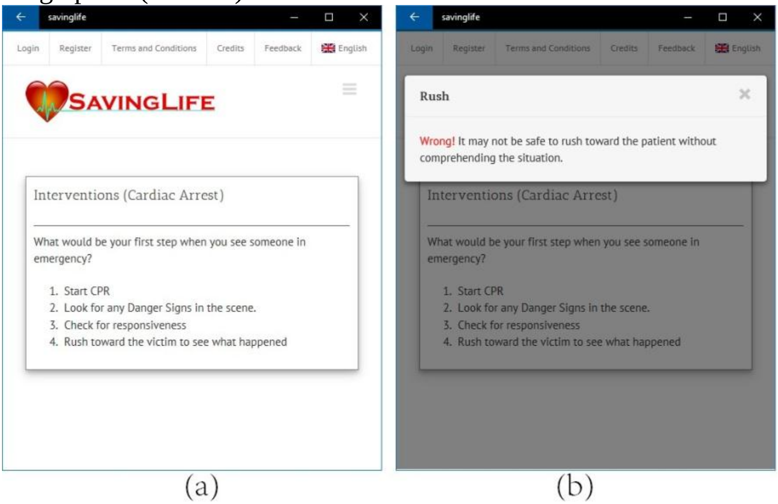


(a) (b)

Source: Najma Naz (2016)

Backward button, when a scenario is in progress, in not given intentionally since the scenarios are based on the approach of PBL. The aim was to present the scenario as close to a real life situation as possible. Such a situation only moves forward and the student have to focus on the current evaluation and decide on the next interventions. However, the student can always restart a scenario whenever required.

Figure 9 – (a) Interventions screen (b) Response of the system when a wrong option (the 4rth) is clicked.



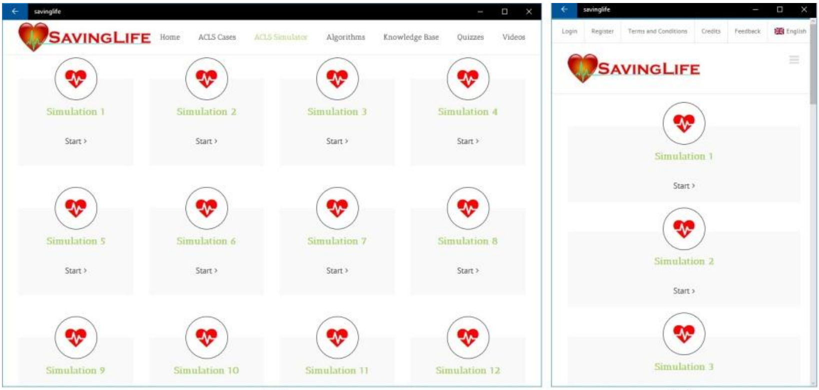
Source: Najma Naz (2016)

3.2 Simulations

Simulations section (see Figure 10) present total twelve real life situations. The scenarios in this section are almost similar to the ones in the Scenarios section but are more real and at advance level.

The purpose of simulations is to enable students to learn and handle all the possible emergencies occurred in Cardiac Arrest or in ACLS in the intensive coronary care unit. Unlike the situations in Scenario section, in simulation students are presented only the signs, symptoms and rhythm (see Figure 11) from which they identify the case and continue on with the necessary interventions. In simulations, the patient condition changes from one algorithm to another algorithm, thus mimicking a closer real life patient.

Figure 10 – Simulations main screen on (a) large screen, (b) small screen.



(a) (b)

Source: Najma Naz (2016)

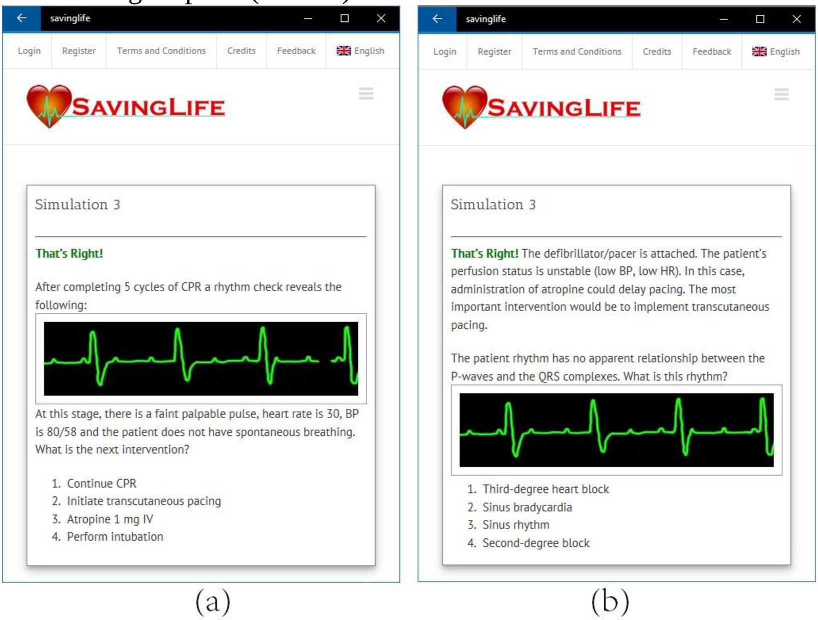
3.3 Algorithms

Algorithms are one of the most important components in effective learning of BLS and ACLS. Every emergency health care provider and nurse can save a life if they are familiar with ACLS algorithms. Algorithms are step by step procedures to solve a particular problem. Six different algorithms, adopted from the updated 2015 AHA guidelines (American Heart Association, 2016), available in Savinglife® are:

- BLS Primary Survey (Figure 12-a)
- Adult Cardiac Arrest (for VF, pVT, PEA and Asystole)
- Adult Ventricular Tachycardia (Figure 12-b)
- Adult Bradycardia
- Acute Coronary Syndrome

– Suspected Stroke

Figure 11 – (a) A screen from simulation 3. (b) Response of the system when the right option (the 2nd) is clicked.



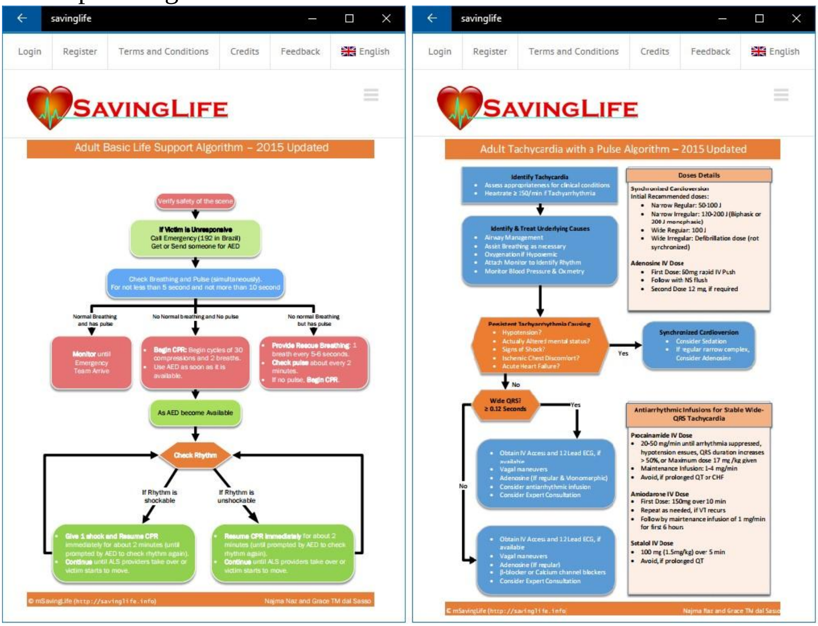
Source: Najma Naz (2016)

3.4 Knowledge Base

Knowledge base is designed to help students become familiar the prerequisite knowledge and improve their learning. The knowledge base includes the H's and T's of ACLS, 2015-2020 ACLS Changes Updates by AHA, and ACLS Rhythms Identification and Interpretation as shown in Figure 13-a.

H's and T's: While all algorithms in Savinglife® contain step-by-step, definitive treatment interventions. It often requires professionals to identify and address the causal factor associated with cardiopulmonary arrests. H and T are most commonly associated with PEA but it also helps in finding the underlying causes for any of the arrhythmias associated with ACLS (LINK et al., 2015). H's and T's in Savinglife®

Figure 12 – (a) Adult basic life support algorithm. (b) Adult tachycardia with a pulse algorithm.



(a) (b)

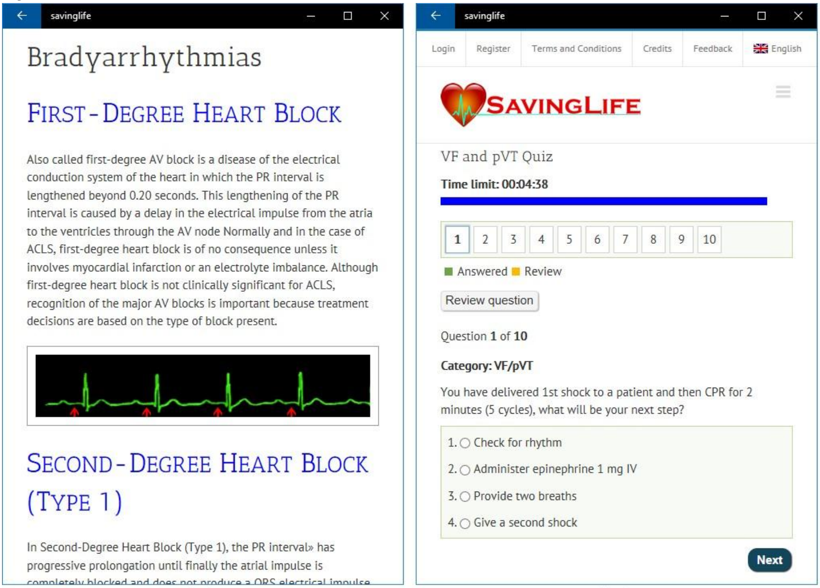
Source: Najma Naz (2016)

help prepare you for any ACLS scenario.

Rhythm identification and recognition: Adults BLS and ACLS require that health care providers should be able to recognize and interpret a number of basic cardiac rhythms from normal sinus rhythm to Asystole. This section describes 12 of the most commonly encountered ECG animated rhythms.

2015–2020 AHA Changes: American Heart Association released their new updated guidelines for BLS and ACLS in October 2015. These guidelines will be useful through 2020. They made some minor changes to both the BLS and ACLS Guidelines. The article content was developed from information released by the American Heart Association (LINK et al., 2015).

Figure 13 – (a) Learning rhythms interpretations and identifications. (b) Quiz for self-evaluation.



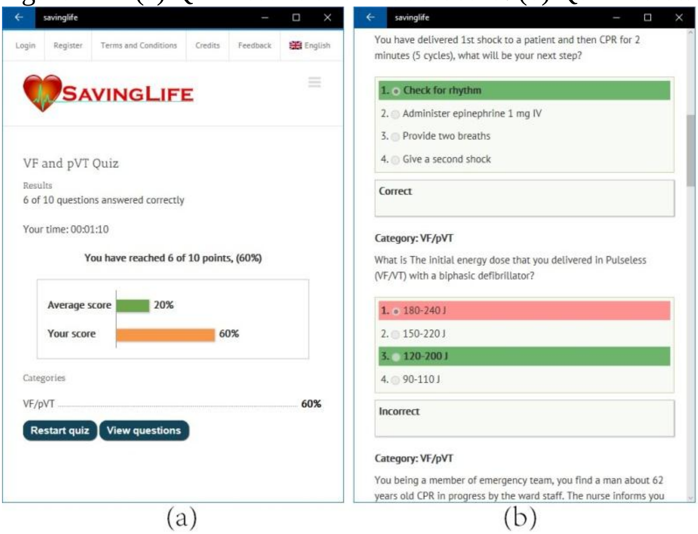
(a) (b)

Source: Najma Naz (2016)

3.5 Quizzes

Self-assessment had an important role in active learning (BOUD et al., 2013). The main purpose of quizzes, a tool for self-evaluation and self-assessment in Savinglife® is to enable students to evaluate their pre and post learning. The quizzes section consists of BLS and ACLS practice test (four cardiac arrest cases), bradycardia, and tachycardia. A variety of questions covering all aspect of different cases are presented. This section tests the knowledge of the systematic approach of students to treat acutely ill cardiac arrest patients, with return of spontaneous circulation (ROSC) being the ultimate goal. A sample test is shown in Figure 13-b. A timer (30s for each question) is used for each quiz in order to improve the power of quick decisions in a situation where time is of extreme value. Students can see their progress and scores (see Figure 14-a) along with the leaderboard and can identify their mistakes and improve the weak point by reviewing their answers (see Figure 14-b). Each time the student starts a quiz, all the questions and answer shuffles and their order and position changes so that the student learning ability is effectively evaluated.

Figure 14 – (a) Quiz results and Leaderboard. (b) Quiz review.



Source: Najma Naz (2016)

3.6 Videos

Three videos regarding BLS, VF/pVT, and Asystole in order to improve the confidence of students while practicing BLS and ACLS skills. More videos covering different details of all BLS and ACLS aspects are intended to be provided as an additional media for learning.

3.7 Feedback

Although self-learning methods through computer applications are considered to be useful to learn BLS and ACLS, it should be noted that the instructor's feedback for answering student questions related with the emergency conditions is important. In PBL, it is also important that each student have an opportunity to reflect on the process of learning that has taken place. This includes reviewing the learning achievements and listing ideas, improvements and deficiencies in the learning process so that it can be consolidated for future application (WALSH, 2005). For this a feedback option is available where student can establish asynchronous communication with the administrator and teacher for additional help and guidance.

4 LIMITATIONS

The current educational technology opens the possibility of mass public training via the internet. However, it would be important to ensure that participants receive sufficient incentive or motivation to use the online program or download it to their mobile devices.

5 CONCLUSIONS

Nursing professionals are usually the first to witness in hospitals cardiac arrest. They are working in the departments such as cardiology and ICU. It is a basic requirement in all health institute for nurses to be trained well in BLS and ACLS. Various methods, including self-instruction, web based programs, DVD based training, have been used to try to improve the acquisition of basic and Advanced Life Support skills. However, the survival rate from cardiac arrest remains poor despite advances in CPR training and therapies while it is a fact that the quality of CPR performance influences the outcome of patients.

Educational technologies can play a vital role in effective teaching and learning. Information and communication technologies are rapidly improving and easily available. Mobile devices, WiFi, 3G and

4G internet are everywhere providing an innovative, motivating and flexible method, in particular by not restricting space and time for learning.

Savinglife® technology meet both the demands of self-learning and the use of innovative technologies in teaching and learning in nursing. Savinglife® is an educational technology incorporating problembased learning approach for training nurses and other health students in BLS and ACLS skills. It is believe that Savinglife® helps to fill the gaps in learning about BLS and ACLS in a safe and ethical manner.

It is expected that the Savinglife® can promote conditions for the establishment of a differentiated process of construction of knowledge and decision making about BLS and ACLS.

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MANUSCRIPT 3 - ESTABLISHING CONTENT QUALITY AND USABILITY OF SAVINGLIFE®: AN EDUCATIONAL TECHNOLOGY FOR BASIC AND ADVANCED CARDIOVASCULAR LIFE SUPPORT

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Abstract

This was methodological quantitative study with the objective to analyze the content quality and usability of an educational technology (App Savinglife®). For quality and content validity the App was evaluated with LORI tool. LORI is an online form consisting of rating nine items (Content Quality, Alignment of the Learning Objectives, Feedback and Adaptation, Motivation, Project Presentation, Interaction and Usability, Accessibility, Re-usability and Conformity with Standards). The evaluation instrument based on the ISO 9241-11 standard was used for usability assessment of the Savinglife® . The evaluation involved 15 nursing experts and 4 computers programmers. The nursing experts assessed and analyzed the quality and validity of the content through LORI tool, and the programmers assessed the usability of Savinglife® using Usability instrument consist of 15 items. The results exceeded the target level (4 - Very Good) in the evaluation of nursing experts (4.71) and computer programmers (4.43). The analysis of the averages assigned to all nine variables in the LORI tool and all fifteen variables in the Usability tool have high mean scores (with general average of 4.71 and 4.43 respectively). Among the variables that make up the LORI 2.0 instrument, the ”Interaction and Usability” (4.93 ± 0.25) has the highest average. Among the variables that make up the Usability instrument, the ”The user is able to access the application easily” (5 ±

0.00) has the highest average. In the light of the obtained results, it is possible to confirm that Savinglife® has the Quality and Usability criteria and is adequate and suitable to be used in the education of BLS and ACLS. It is believed that Savinglife® can fill the gaps in learning and decision making abilities of students and can promote learning of BLS and ACLS skills in a safe and ethical manner.

keywords: Educational Technology, Nursing Informatics, Nursing Education, Basic Cardiac Life Support, Advanced Cardiac Life Support, Educational Technology

1 INTRODUCTION

Cardiovascular diseases remain a significant public health problem and a leading cause of deaths in many parts of the world (ROGER et al., 2011). About 17.5 million people die each year from cardiovascular disease (CVDs), which represents about 31% of all deaths globally (WHO, 2016).

These deaths can be often prevented by timely and effective lifesaving interventions, such as cardiopulmonary resuscitation (CPR) and Automated External Defibrillators (AED). The survival rate from cardiac arrest remains poor despite the advancements in technologies for training CPR and advanced cardiovascular life support (ACLS). Recognition of a cardiac arrest and prompt action by the rescuer are vital for the survival of the cardiac arrest patient (AHA et al., 2010; LINK et al., 2015). It is also a fact that the quality of CPR performance also influences the outcome of patients (ABELLA et al., 2005; WIK et al., 2005;
WALLACE; ABELLA; BECKER, 2013).

Recently data published by the National Registry of Cardiopulmonary Resuscitation revealed that 30% of in-hospital cardiac arrest patients who had reported initial rhythm of pulseless ventricular tachycardia or ventricular fibrillation were not defibrillated within 2 minutes per AHA recommendations (CHAN et al., 2008). Poor compliance with American Heart Association (AHA) guidelines is reported both in- and out-of-hospital cardiopulmonary arrests (CHAN et al., 2008). Most of the nurses do not feel confident while performing CPR and ACLS in emergency situations, especially in cardiopulmonary arrest cases (SARDO; SASSO, 2008). Resuscitation attempts are not always appropriate and as a result many lives are lost (AHA et al., 2010).

Conventional training methods are usually insufficient to train professionals to deliver high-quality CPR and ACLS (HAZINSKI; FIELD, 2010). In an instructor led Learning, all contents are provided in a face-to-face manner in which the teachers talk, and the students listen during 70% of class time. This method can transmit knowledge but students may become incapable of professional judgment and critical thinking in case of the variable clinical environment (OZTURK; MUSLU;DICLE, 2008).

More effective learner-centered education techniques are required since educators can no longer rely on traditional teaching methods. Studies indicated that the old ACLS training program has proven inconsistent and inadequate, with numerous studies reporting that trainees have poor retention and ineffective ACLS skills (DEVITA, 2005).

Information and communication technologies (ICT) are rapidly improving and have been applied in the area of nursing and education (BARBOSA; SASSO, 2007). Mobile and wireless technologies have been increasingly accelerating the teaching-learning process and offer exciting opportunities for a low cost, high reach educational services for masses (WEST, 2012).

Mobile phones are in the hands of increasingly more people including those in some of the poorest and most difficult to reach areas of the world (SPECIALE; FREYTSIS, 2013). Mobile phone and internet connectivity are creating unprecedented opportunities by facilitating interactions and information sharing between people (BOULOS; MARAMBA; WHEELER, 2006). In recent years, the development and applicability of informatics have influenced all areas of knowledge, disseminating information, creating educational programs, and enabling new forms of learning. The rapid advances in speed and processing power mobile devices provide a platform for development of instructional application in the educational environment (WALKER, 2013).

Web and computer based interactive and self-learning programs to train people using a micro-simulation is effective in BLS and ACLS skills (VRIES; HANDLEY, 2007). With web-based interactive programs it might be possible to achieve proficiency in BLS and ACLS skills, however, in order to take its full advantages, integration of

Problembased learning approach, and structuring the contents in the form of clinical scenarios near to real life situations, is very important (SARAC¸;OK, 2010; KARDONG-EDGREN et al., 2010).

Nurses are usually the first to witness in-hospitals cardiac arrest (GOMBOTZ et al., 2006). It is a basic requirement in all health institute for nurses to be trained well in BLS and ACLS. The design and development of innovative educational strategies for BLS and ACLS education, based on the web, and mobile have been emphasized and supported by important reference organizations such as the American Heart Association (LINK et al., 2015).

It is considered fundamental to develop educational, motivating and innovative strategies for the evaluation of CPR and ACLS skills. Which facilitate the construction of knowledge about the cardiopulmonary resuscitation, Automated external defibrillators, manual defibrillators, Evaluation of heart rhythms and the use of emergency medication.

Savinglife®, an educational technology for basic and advanced cardiovascular life support, was developed to meet both the demands of self-learning and the use of ICT in teaching and learning in nursing. Savinglife® provide learners with clinical scenarios and simulation to practice their skills of assessment, diagnosis, intervention and evaluation. The app integrates PBL approach with web-based technologies with the possibility to simulate cardiac arrest scenarios without exposure to real patient, contributing to the training of students regarding BLS and ACLS education in different context. Savinglife® constitute an active and constructive teaching-learning strategy and provide new paradigm of instructional projects for problem-based learning in nursing.

Currently, decisions regarding which Apps to use in school settings are being made without a consistent framework to evaluate their quality and hence, potential impact are made on teaching and learning (WALKER, 2013).

The challenge for educators is to identify Apps that have the greatest potential to positively impact outcomes for students. An evaluation tool for measuring an App quality must be broad enough to address multiple levels, quality and validity of content and usability, and must be specific enough to specify the inclusion of best apps in teaching and learning (WALKER, 2013).

In this context, the objective of this study was to analyze the quality of Savinglife® with the Learning Object Review (LORI) version 2.0 (NESBIT; BELFER; LEACOCK, 2009). Similarly, the usability of Savinglife® was evaluated with an instrument based on the ISO 9241-11 standard (BEVAN, 2001; UsabilityNet, 2006).

2 METHODOLOGY

It is a methodological research (POLIT; BECK, 2013) with quantitative approach that involved 15 nursing experts and 4 computers programmers. In order to standardize the quality assessment of educational software, LORI instrument was developed in Canada (VARGO et al., 2003) where version 2.0 (NESBIT; BELFER; LEACOCK, 2009) has been used to evaluate the quality of SavingLife. The usability evaluation instrument based on the ISO 9241-11 standard (BEVAN, 2001; UsabilityNet, 2006) was used for assessing the usability of SavingLife.

The nursing experts assessed the quality and validity of the content through LORI tool, and computer programmers assessed the usability of Savinglife® using the evaluation instrument, based on the ISO 9241-11 standard.

2.1 Population and Samples

A non-probabilistic sample of 20 postgraduate nursing experts and nursing professors and 5 computer programmers from PEN/UFSC were invited to participate in the study. 15 nursing experts and professors and 4 computer programmers accepted to participate in the study. Access to participants was authorized by the coordinator of postgraduate nursing program at PEN/UFSC, after detailed explanation of the objectives and methodology of the study. The research was approved by the research and ethics committee of the university (Certificate number CAAE: 25453013.6.0000.0121) (see Appendix A).

Inclusion criteria for Nurses/Professionals were:

- Being a nurse or professor with minimum experience of 1 year in service or teaching in the critical care area, cardiovascular disease / CPR / ACLS

- Have mobile device (smart phone, PDA, tablet) with internet access

- Do not be in vacation or leave/license during the study period

Inclusion criteria for Computer Programmer were:

- Being a computer programmer or a professional in information technology
- Have mobile device (smartphone, PDA, tablet) with internet access

2.2 Ethical Considerations

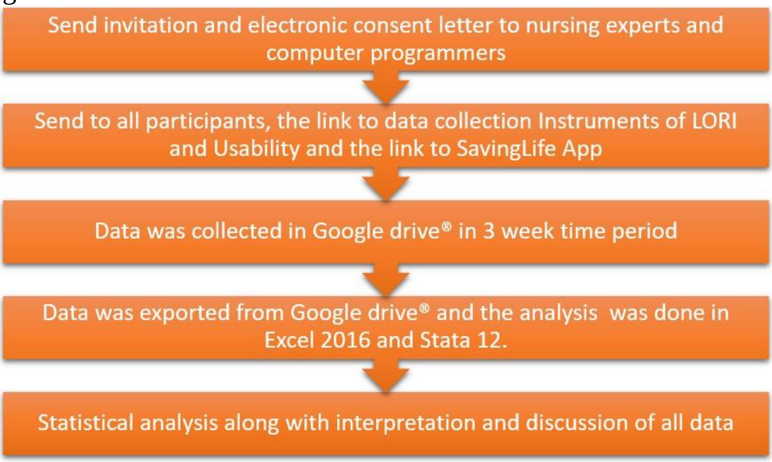
This study considered the conditions set out in resolution n.466/12 (SAUDE, 2012) that determines the guidelines and standards regulating research involving human subjects, and thus respecting the bioethical principles of autonomy, anonymity and beneficence. Participants received all relevant information and had complete freedom to participate or not and were able to withdraw at any time. Participation was based on informed written consent (see Appendix B).

The identity of the participants was strictly preserved, assuring, therefore, full anonymity regarding their identity. For purposes of publication and dissemination of results, computer programmer were identified as ”CP1”, ”CP2”, ”CP3”, ”CP4”” and Nurses as ”N1”, ... , ”N15”. In addition, the data was stored in a specific file and will be saved for at least 5 years, under the sole responsibility of the study investigator.

2.3 Data Collection

Data collection took place from 15 Oct 2016 to 15 Nov 2016. Invitation and electronic consent letter to nursing experts and computer programmers were sent by email. Separate electronic instruments for LORI (See Appendix C) and usability (See Appendix D) were created using Google Form ^{R} . These instruments were used for online data collection. Links to those data collection instruments of LORI and Usability and link to SavingLife App was sent to all participants. Data were collected in Google drive [R] in 3 week time period. Data was then exported from Google Form [R] and the analysis was done in Excel [R] 2016 and Stata [R] version 12 programs. A protocol created and followed during the collection and analysis of study is shown in Figure 1.

Figure 1 – Data Collection Protocol



Source: Najma Naz (2016)

2.4 Data Analysis

The results were exported to compatible spreadsheets with Excel [R] 2016. The analysis of the results was based on descriptive statistics (mean, maximum and minimum value, standard deviation) as well as on inferential statistics through single-sample t test and analysis of variance (ANOVA). In this study, single-sample t-test was performed by comparing the general average (of 9 LORI variables and 15 usability variables) with a predetermined value of ”4” (Very Good) for the quality of content and ”3” (Good) for usability evaluation

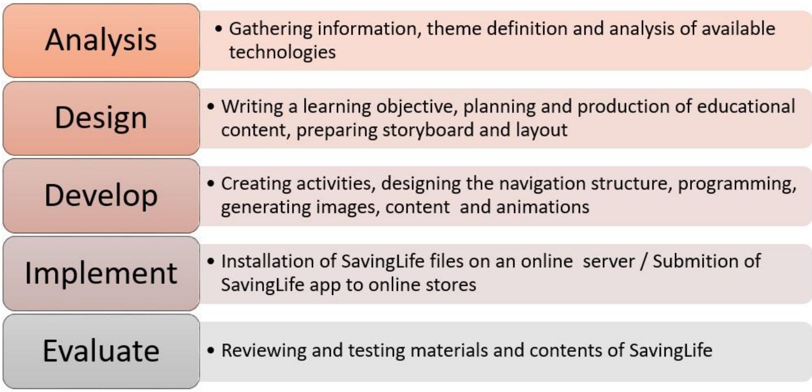
From the statistical data obtained through the single-sample ttest, the probability of significance (pValue), which is defined as the probability of obtaining a result equal to or ”more extreme” than what was actually observed, when the null hypothesis is true. For the analysis a level of 95% confidence was considered, adopting a level of significance ($p < 0.05$). That is, if the ”pValue” (significance level) is greater than 0.05, the hypothesis is rejected and, if it is less than 0.05, the hypothesis is accepted. All calculation can be found in Appendix E and F.

2.5 Educational Technology of Savinglife®

The design and development of the application was started in January 2016 and completed in November 2016. A team of three members was used for the development of Savinglife® . A programmer and graphic editor, a lead designer and content generator (Najma Naz, the author herself) and a supervisor (Prof. Grace TM Dal Sasso).

The development of Savinglife® consider the development stages of instructional systems development (ISD) (DICK et al., 2001; FILATRO; PICONEZ, 2004). The model consists of an action plan, development and implementation of specific teaching scenarios incorporating mechanisms that favor the contextualization of new learning (FILATRO; PICONEZ, 2004). The methodology involved a process consisted of five steps, which are Analyze, Design, Develop, Implement, and Evaluation as shown in Figure 2.

Figure 2 – ISD steps for development of Savinglife®



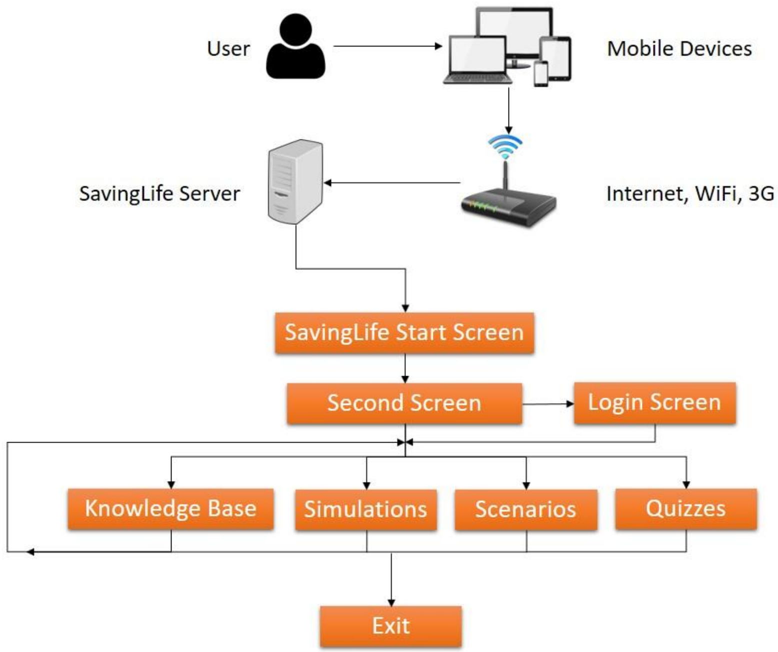
Source: (DICK et al., 2001; FILATRO; PICONEZ, 2004)

For Savinglife® , the seven steps in problem based learning described by (WALSH, 2005) was considered. The seven steps of PBL was implemented to provide an environment to the students, in which they investigate and respond to an authentic, engaging and complex problem, that improve the learning processes of students.

The Savinglife® is based on advanced cardiac life support cases, ACLS simulations, algorithms, quizzes and knowledge base according to the updated 2015 AHA guidelines for CPR and ECC (LINK et al., 2015). Savinglife® can be accessed through any computing device (mobile, tablets and desktops) with or without internet connectivity. The application was intended to be responsive (adjusted automatically according to the device size) so that it look good on all devices including small mobile devices, tablets and desktops.

Navigation structure of the Savinglife® is shown in Figure 3. It must be noted that users can access the clinical scenario, simulations and quizzes in a non-linear way, without any specific order to navigate the Savinglife® leaving students free to establish the construction of knowledge from their past experiences.

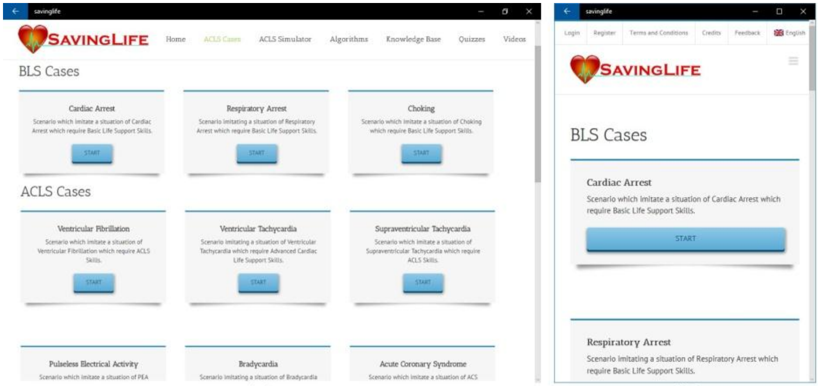
Figure 3 – Navigation structure of Savinglife®



Source: Najma Naz (2016)

The contents in Savinglife® have been organized in Scenarios, Simulations, Algorithms, Knowledge base, Quizzes and Videos as shown in Figure 4.

Figure 4 – Content structure of Savinglife®



(a) (b)

Source: Najma Naz (2016)

2.6 LORI Tool

In order to standardize the quality assessment of educational software, LORI instrument was developed in Canada (VARGO et al., 2003). LORI is used to evaluate the quality of e-learning resources. LORI is an online form consisting of rating scales and comment fields. LORI is a logical choice for these purposes as it allows for a judgment of quality, specifically where each domain supports or enhances the instructional process. LORI version 2.0 (NESBIT; BELFER; LEACOCK, 2009) has been used for evaluating the quality of SavingLife. In evaluating a learning object with LORI, reviewers can rate and comment with respect to nine variables. The nine variable in LORI describe in Figure 5.

Each variable of the instrument was assessed using a scale from 1 to 5 where 1 is Bad, 2 is Regular, 3 is good, 4 means Very Good, and 5- mean Excellent. If one of the items were considered irrelevant to Savinglife®, or when the appraiser did not feel qualified to judge one of these variables, he could leave the item by selecting ”Not applicable (NA)” in the scale.

The LORI 2.0 can be applied both to individual assessments as for panel reviews. The results of each of the variables are usually expressed as average values, accompanied by comments of the evaluators (NESBIT; BELFER; LEACOCK, 2009). An electronic version of the instrument was developed for the study.

2.7 Usability Tool

The usability evaluation instrument, based on the ISO 9241-11 standard was used for assessing the usability of Savinglife® . The usability tool (see Appendix D) consist a total of 15 items by evaluated by computer programmers. The items were distributed on a scale of values with the following categories of Answers: (5) for Excellent, (4) for Very Good, (3) for Good, (2) Average, (1) Bad. Usability tool consists the following 15 variables.

1. Savinglife® runs easily on all computing devices with internet connection without interference.
2. Savinglife® screens are clear and easy to read and interpret
3. The user is able to access the application easily
4. The navigation and structure of the information is easy to use
5. The contents meet the functions set for Savinglife® goals
6. The application favors efficient interventions in emergency situations.
7. Exchange of information between user and system is efficient
8. The system allows the efficient handling of the data that it uses
9. Memory requirements do not prevent the program to stop
10. The system does not accept data that does not exist
11. Communication between the system and user is adequate
12. Hardware requirements are compatible with reality
13. SavingLife is integrated into a database
14. It is easy to adapt to other environments

15. It is easy to install/use in other environments

Figure 5 – Nine variable in LORI

Variables	Description
Content Quality	Veracity, accuracy, balanced of presentation, ideas and appropriate level of detail.
Learning Goal Alignment	Alignment between learning objectives, Activities, assessments and student characteristics.
Feedback and Adaptation	Adaptive content or feedback driven by differential student input into the system.
Motivation	Ability to motivate and simulate the interest or curiosity of a student population.
Presentation Design	Design of visual and auditory information for problem-based learning and efficient mental processing.
Interaction and Usability	Ease of navigation, user interface predictability, and quality of interface help features.
Accessibility	Design of controls and formats to accommodate students in mobile and web app learning experience.
Reusability	Ability to use in varying contexts of learning and in different contexts (mobile, face-to-face, semi-face, individual and group).
Standards Compliance	Reliability and Safety (ability to maintain a specified level of performance and security in private access to information).

Source: (NESBIT; BELFER; LEACOCK, 2009)

3 RESULTS

The Learning Object Review Instrument (LORI v 2.0) which consist of total 9 variables, was used to evaluate the quality of Savinglife® with nursing experts. The socio-demographic characteristics of nursing experts (n = 15) participated revealed a middle age sample, with a mean age of 37.12 years, of which 80% were female. Qualification of the participants include doctorate (53.3%), master degree (20%), bachelor (13.3%) and post-doctorate (13.3%).

Data regarding the occupation of the experts revealed that most of them were nurses 8 (53.3%), professors 2 (13.3%), PhD students 4 (26.7%) and physiotherapist 1. Data about experience in BLS and ACLS suggested that expert have experience in BLS and ACLS as observed was good. 40% of experts has good experience and knowledge in BLS and ACLS, 27.6% have excellent, 13.3% have medium experience while and 20% have minimum.

All(100%) of the participants reported the use of internet in their daily lives. Most of experts were using internet at home (93.3%), in the university (73.3%), and at work (40%). 86.7% were using internet for assessing social networks, 60% of experts using internet for studying electronic books, and 60% for learning App and literature study.

Statistical analysis including mean, standard deviation, ANOVA, single-sample t-test and pValue, were performed on the collected data regarding the 9 variables of the LORI tool. Analysis was completed with the help of Excel ^{R} 2016 and Stata ^{R} version 12 programs. The analysis allowed to compare the average of 9 LORI variables with a predetermined average of (4 - Very Good). A level of 95% confidence was considered, adopting the level of significance ($p < 0.05$). The results are presented in Table 1 while all calculation can be found in Appendix E.

The analysis of the averages assigned to all nine variables have high mean scores (with general average of 4.71). They all have accepted pValues for the established target average (4 - Very Good). Among the variables that make up the LORI 2.0 instrument, the ”Interaction and Usability” (4.93 ± 0.25, pValue=0.00) has the highest average. Similarly, ”Motivation” (4.73 ± 0.59, pValue=0.0001), ”Presentation Design” (4.73 ± 0.45, pValue=0.00), ”Accessibility” (4.73 ± 0.45, pValue=0.00) and ”Re-usability” (4.73 ± 0.45, pValue=0.00) were more prominent in the expert evaluations.

For usability evaluation, statistical analysis including mean, standard deviation, single-sample t-test and pValue, were performed on the collected data regarding the 15 variables of the Usability tool. Analysis was completed with the help of Excel ^{R} 2016 and Stata ^{R} version 12. The analysis allowed to compare the average of 15 LORI variables with a predetermined average of (3 - Good). A level of 95% confidence was considered, adopting the level of significance ($p < 0.05$). The results are presented in Table 2 while all calculation can be found in Appendix F.

Table 1 – Quality Evaluation of SavingLife® with LORI

Variables	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	Min	Max	Mean	St.Dev	t-test	p-value
Content Quality	4	4	5	5	5	4	4	4	5	5	5	5	5	5	5	4	5	4.66	0.48	5.291	0.0001
Learning Goal Alignment	4	5	4	5	5	5	5	4	5	4	5	4	5	5	5	4	5	4.66	0.48	5.291	0.0001
Feedback and Adaptation	5	5	5	5	5	4	5	4	4	5	5	4	4	4	4	4	5	4.53	0.51	4.000	0.0007
Motivation	4	5	5	5	4	5	5	3	5	5	5	5	5	5	5	3	5	4.73	0.59	4.784	0.0001
Presentation Design	4	5	5	5	4	4	5	4	5	5	5	5	5	5	5	4	5	4.73	0.45	6.204	0.0000
Interaction and Usability	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4.93	0.25	14.00	0.0000
Accessibility	4	5	5	5	4	5	5	5	4	5	5	5	5	4	5	4	5	4.73	0.45	6.204	0.0000
Reusability	4	5	5	5	5	4	5	4	5	4	5	5	5	5	5	4	5	4.73	0.45	6.204	0.0000
Standards Compliance	5	5	5	5	5	5	5	4	4	4	5	5	5	4	4	4	5	4.66	0.48	5.291	0.0001
General Mean																		4.71			

Table 2 – Usability Evaluation of SavingLife®

Description	CP1	CP2	CP3	CP4	Min	Max	Mean	St.Dev	Variance	t-test	p-value
SavingLife® runs easily on all computing devices with internet connection without interference.	5	5	5	4	4	5	4.75	0.50	0.25	7.00	0.003
SavingLife® screens are clear and easy to read and interpret	5	5	5	4	4	5	4.75	0.50	0.25	7.00	0.003
The user is able to access the application easily	5	5	5	5	5	5	5.00	0.00	0.00	7.00	0.000
The navigation and structure of the information is easy to use	4	4	5	4	4	5	4.25	0.50	0.25	5.00	0.007
The contents meet the functions set for SavingLife® goals	4	4	5	4	4	5	4.25	0.50	0.25	5.00	0.007
The application favors efficient interventions in emergency situations.	4	5	4	4	4	5	4.25	0.50	0.25	5.00	0.007
Exchange of information between user and system is efficient	3	5	4	5	3	5	4.25	0.96	0.91	2.61	0.039
The system allows the efficient handling of the data that it uses	4	5	4	4	4	5	4.25	0.50	0.25	5.00	0.007
Memory requirements do not prevent the program to stop	5	5	4	4	4	5	4.50	0.56	0.33	5.19	0.0069
The system does not accept data that does not exist	5	5	4	4	4	5	4.50	0.56	0.33	5.19	0.0069
Communication between the system and user is adequate	4	5	4	5	4	5	4.50	0.56	0.33	5.19	0.0069
Hardware requirements are compatible with reality	5	5	4	4	4	5	4.50	0.56	0.33	5.19	0.0069
SavingLife is integrated into a database	4	5	4	4	4	5	4.25	0.50	0.25	5.00	0.0070
It is easy to adapt to other environments	4	4	4	5	4	5	4.25	0.50	0.25	5.00	0.0070
It is easy to install/use in other environments	4	4	4	5	4	5	4.25	0.50	0.25	5.00	0.0070
General Mean							4.43				

The analysis of the averages assigned to all fifteen variables have high mean scores (with general average of 4.43). They all have accepted pValues for the established target average (3 - Good). Among the variables that make up the Usability instrument, the ”The user is able to access the application easily” (5 ±runs easily on all computing0.00, pValue=0.00) has the highest average. Similarly, ”Savinglife® devices with internet connection without interference” (4.75 ± 0.50, pValue=0.003), and ”Savinglife® screens are clear and easy to read and interpret” (4.75 ± 0.50, pValue=0.003) were more prominent in the evaluations of computer programmers.

4 DISCUSSION

The analysis of the averages assigned to all nine variables of the LORI instrument have high average scores (with general average of 4.71). They all have accepted pValues for the established target average (4 - Very Good). Among the variables that make up the LORI

2.0 instrument, the ”Interaction and Usability” (4.93 ±, ”Presentation0.25) has the highest average. Similarly, ”Motivation” (4.73Design” (4.73 0.45), ”Accessibility” (4.73 0.45)± 0.59)and ”Re-usability”

(4.73 ±These results confirms the quality of SavingLife0.45) were more prominent in the expert evaluations.± ± R and highlight the suitability of its implementation in the education of BLS and ACLS to nursing and medical students. Fernandes et al (FERNANDES; RAABE; BENITTI, 2004) described that for a technology to be used as a good teaching tool, its interface should be well-designed, user-friendly, interactive and provide the user with data that can enrich their knowledge. It can be noticed that the experts’ perception of ”Interaction and Usability” make presentation of the layout and content of Savinglife® , interactive and user-friendly. Similarly the other prominent variables were ”Presentation Design”, ”Re-usability” and ”Accessibility”. These facts may be related to user-interface, navigation structure, responsiveness, the presence of animations, clinical scenarios and simulations, thus providing a good experience of Learning.

The results also recognized the potential of Savinglife® Reusability to be used in different learning contexts. It is believed that the possibility of accessing the App from all type of computing devices at any place or time, may have contributed to highest score of re-usability feature.

The analysis of the averages assigned to all fifteen variables in the Usability instrument have also high mean scores (with general average of 4.43). They all have accepted pValues for the established target average (3 - Good). Among the variables that make up the Usability instrument, the ”The user is able to access the application easily” (5 ± 0.00) has the highest average. Similarly, ”Savinglife® runs easily on all computing devices with internet connection without interference” (4.75 ± 0.50), and ”Savinglife® screens are clear and easy to read and interpret” (4.75 ± 0.50) were more prominent in the evaluations of computer programmers. Again, this confirms the highly accessible nature of Savinglife® from any computer or mobile device with ease. Again the presentation design, the content layout and easy to follow structure of Savinglife® is highlighted. It can also be noted that all the items of the Usability instrument have received an average of VERY GOOD score by evaluators.

About the positive and negative aspects Savinglife® in the Usability instrument, the evaluators pointed out:

CP1: *”Interface of the Savinglife® is clean, clear and easy to follow. The App also support Portuguese and English languages.”*

CP2: *”The navigation is simple, the content is easy to access, and the app has good compatibility with mobile devices.”* CP2 also suggested to allow downloading scenarios and tutorials in PDF format.

CP3: *”System represent text in Portuguese and in English and the interface is very beautiful and has compatibility with mobile phones.”*

CP4: *”Interface is clear and easy to use. Look good on Mobile phones.”*

The findings reveal that experts recognize the choices of learning nodes on the skills of BLS and ACLS proposed in Savinglife® are suitable for implementation in the teaching-learning process. Similarly, the results from Usability instrument indicate that educational technology is usable and adequate, and can thus be available in the online teaching-learning process to nursing and medical students.

In this way, given the results obtained, the analyzes and the reflections carried out, it is possible to affirm that Savinglife® has the Quality and Usability criteria, since they were considered by the evaluators to be VERY GOOD. In this sense, it is considered that the first part of the cycle of this technological production is finished, that is, it can be concluded that Savinglife® developed, implemented and evaluated by nursing experts and computer programmers is adequate to be used in the teaching of BLS and ACLS. It is important to note that this system will always require constant revisions, updates and feedback.

5 LIMITATIONS

The usability and quality of Savinglife® is evaluated and established with limited number of computer programmers and nursing experts. It is recommended that other studies be developed to better understand the impact of online educational technologies on the learning outcomes of future nurses.

6 CONCLUSIONS

The aim of this study was to analyze the quality and usability of Savinglife® with the Learning Object Review (LORI) version 2.0 and the usability instrument based on the ISO 9241-11 standard. In the light of the obtained results, it is possible to confirm that Savinglife® has the Quality and Usability criteria, since they were considered by the evaluators to be VERY GOOD. In this sense, it can be concluded that Savinglife® evaluated by nursing experts and computer programmers is adequate and suitable to be used in the teaching of BLS and ACLS. It is believed that Savinglife® can fill the gaps in learning and decision making abilities of students and can promote learning of BLS and ACLS skills in a safe and ethical manner.

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6 FINAL CONSIDERATION

The cardiovascular disease strikes every nation around the world. Despite recent advances in the prevention and treatment, cardiac arrest remains a significant public health problem and a leading cause of death in many parts of the world (ROGER et al., 2011). About 17.5 million people die each year from cardiovascular disease (CVDs), which represents about 31% of all deaths globally (WHO, 2016).

Problem-based learning methodology in training nurses for cardiopulmonary arrests has been indicated an effective approach resulting in a better integration of the theory and practice of the CPR process (SARDO; SASSO, 2008b). Similarly, PBL is considered as the most significant innovation in education for the health professionals (POLYZOIS; CLAFFEY; MATTHEOS, 2010). Its effective learning approach prepares students as critical thinkers and lifelong learners and also able them to respond to the changing health environment.

Computer technologies can play an important role in supporting PBL in various ways. For instance, mobile based PBL is beneficial for the students, especially in remote areas where the system is accessible, convenient, low cost, easy to operate and highly interactive (TANG; LIN; LAI, 2014). The use of information and communication technologies are getting more attention in healthcare day by day. Higher education institutions in most of the countries are already focusing on integrating the internet, multimedia, web tools and other technologies in order to provide students with improved experiences of teaching and learning.

In the context of rapid technological change and the possibility of enhancing the teaching-learning processes in specific areas of nursing through the inclusion of informational technologies such as mobile devices, it was therefore proposed to design and develop an mApp (Savinglife®) for teaching BLS and ACLS with the help of different clinical scenarios and simulations of cardiac arrest of adult patients. The aim was to improve learning and decision-making abilities in nursing students in regard to BLS and ACLS skills.

First, we conducted a systematic review to identify and evaluate the usefulness of Problem Based Learning approaches and technologies in the education of Cardiopulmonary resuscitation and advanced cardiovascular life support programs. The available evidence suggests that problem based learning approaches and technologies are better instruction methods in the education of CPR and ACLS. PBL enhanced the knowledge, skill and competency of health care providers during BLS and ACLS.

Second, we designed and developed an educational technology for teaching BLS and ACLS to nursing and other health students. The application was developed using the instructional systems development process and presented 10 scenarios and 12 simulations, covering different aspects of basic and advanced cardiac life support. The contents can be accessed in a non-linear way leaving the students free to build their knowledge based on their previous experience. Each scenario is presented through interactive tools such as scenario description, assessment, diagnose, intervention and reevaluation. Animated ECG rhythms, text documents, images and videos are provided to support procedural and active learning considering real life situation.

Third, quality and usability evaluation of Savinglife® was performed using an educational instrument described in LORI Tool version 2.0 and in ISO 9241-11 standard. In the light of the obtained results, it is possible to confirm that Savinglife® has the Quality and Usability criteria and is adequate and suitable to be used in the education of BLS and ACLS. It is believed that Savinglife® can fill the gaps in learning and decision making abilities of students and can promote learning of BLS and ACLS skills in a safe and ethical manner.

Accessible equally on small to large devices with or without an internet connection, Savinglife® offers a dynamic, interactive and flexible tool, placing students at the center of the learning process. Savinglife® is usable and can contribute to the student's learning in the assessment and management of basic and advanced cardiac life support in a safe and ethical way, anywhere and anytime.

Future work

- To check the quality of SavingLife on nursing students (pre and post test)
- To evaluate the quality of SavingLife with nursing students
- To increase the visibility of SavingLife, by bringing it to all platforms (Android, iOS, Linux etc.) and by adding content in other major languages.

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APPENDIX A – Committee Aproval

Aprovação da Coordenação do Curso de Pos-Graduação em Enfermagem da UFSC para coleta de dados.

UNIVERSIDADE FEDERAL
DE SANTA CATARINA

Universidade Federal de Santa Catarina
Centro de Ciências da Saúde
Programa de Pós-Graduação em Enfermagem

DECLARAÇÃO

Declaro para os devidos fins e efeitos legais que, na condição de representante legal do PEN-UFSC, tomei ciencia do projeto de pesquisa: **SavingLife®: educational technology for Basic and Advanced Cardiovascular Life Support in nursing,** objeto da Tese de Doutoramento de Najma Naz, sob a orientação de Dra. Grace TM dal Sasso, docente permanente do PEN-UFSC e com coorientação de Dra. Maria de Lourdes de Souza. Declaro que estou ciente e aprovo o desenvolvimento do referido Projeto, considerando que o mesmo está vinculado ao Projeto de Pesquisa aprovado no CAAE sob o número 25453013.6.0000.0121.

Mediante o exposto, declaro dar cumprimento a todos os requerimentos da Resolução do Conselho Nacional de Saúde 466 e de suas complementares, face a que esta instituição tem condições para o desenvolvimento deste projeto. Desta forma, autorizo a sua execução nos temos propostos.

Florianopolis 26 May 2016

Dra Vânia Marli Schubert Backes

Coordenadora do PEN-UFSC

of. Dra. Vânia Marli Schubert Backes
Coordenadora do Programa de
Pós-Graduação em Enfermagem/UFSC
Portaria nº 1782/2015/GR

APPENDIX B – Written Consent for Participants

Termo de Consentimento Livre e Esclarecido (Especialistas)

Universidade Federal de Santa Catarina
Centro de Ciências da Saúde
Programa de Pós-Graduação em Enfermagem

Eu, Najma Naz, Doutoranda do Programa de Pós-Graduação em Enfermagem da Universidade Federal de Santa Catarina, venho por meio deste convidá-lo(a) participar de estudo denominado: **SavingLife®: Educational technology for Basic and Advanced Cardiovascular Life Support in nursing**.

O estudo tem por objetivos: Analisar a qualidade de um aplicação (mSavingLife®) móvel a partir dos critérios para avaliação de softwares educacionais do Learning Object Review Instrument - versão 2.0 (qualidade do conteúdo, alinhamento as objetivos de aprendizagem, feedback e adaptação, motivação, apresentação do design, interação e usabilidade, acessibilidade e conformidade com normas); para avaliar a consistência e qualidade da mApp pela opinião de especialistas.

Ao optar em participar do estudo você terá a oportunidade de avaliar os principais aspectos referentes a avaliação da ***Suporte básico da vida (SBV)*** e ***Suporte Avançado à Vida (SAV)*** habilidades, por meio de Aprendizagem baseada em problemas aplicação denominado mSavingLife®. O sistema foi desenvolvido para utilização em tecnologias móveis e conta com casos clínicos simulados nas áreas SBV e SAV. Sua participação colaborará para o desenvolvimento da produção científica e tecnológica na área de educação online em enfermagem mediada por tecnologia móvel proposta neste estudo, através da avaliação de qualidade.

A coleta dos dados ocorrerá de **14/11/2106 a 18/11/2016** e os resultados serão publicados em revistas científicas. Sua identificação será preservada, garantindo-se total anonimato e sigilo absoluto das informações pessoais. Não é necessário nenhum tipo de procedimento adicional para participação no estudo. Não é necessário nenhum tipo de procedimento adicional, sendo que não existe nenhum risco, físico, emocional, ético ou espiritual inerente à sua participação no estudo. Em caso de qualquer dúvida ou problema, entrar em contato com:

Najma Naz (doutoranda) (48) 98143896 / email: najma.sayyed@live.com
Endereço: Rua protenor vidal 59 Pantanal, 88040-320, Florianopolis Brazil.
Dra. Grace T.M.Dal Sasso (orientadora) grace.sasso@ufsc.br

Declaro que fui informado(a) sobre o objetivo do estudo e procedimentos para participação no estudo, de forma clara e objetiva, entendendo que todos os dados a meu respeito serão mantidos sob sigilo.

____________________	__/_____/_____
Assinatura do Participante	Data

APPENDIX C – Socio-demographic and LORI tool

REQUEST EDIT ACCESS

Avaliação de Qualidade de Tecnologia Educacional (LORI)

Prezado participante,

Este questionário é baseado no Instrumento de Revisão de Objetos de Aprendizagem (LORI) é utilizado para avaliar a qualidade dos recursos de e-learning. O LORI é um formulário on-line composto por rubricas, escalas de classificação e campos de comentários, traduzido e adaptado (NESBIT, BELFER, LEACOCK, 2009).

Em caso de dúvidas, entre em contato com najma.sayyed@live.com
Obrigada pela participação !

Questionário de coleta de dados sócio-demográficos

Perfil demográfico dos Especialistas:Estudo: mSavingLife: Uma tecnologia educacional pra suporte básico e avançado de vida cardíaca para estudantes de enfermagem.Caros Participantes, O objetivo deste questionário é coletar informações sobre os participantes do estudo. As informações baseadas em dados sócio-demográficos eo uso de internet, qualificação, experiência em SBV e SAV.

Idade (anos completos)

Your answer

Sexo

- ○ Fêmea
- ○ Masculino

Qual é o seu nível mais alto de educação?

- ○ Diploma de bacharel
- ○ Mestrado
- ○ Doutorado

- ○ Other : ____________

Qual é a sua ocupação?

- ○ Estudante
- ○ Enfermeira (o)
- ○ Professora (o)
- ○ Other : ____________

Experiência em suporte básico de vida e suporte avançado de vida

- ○ Mínimo
- ○ Média
- ○ Bom
- ○ Excelente
- ○ Nada

Você acessa regularmente a Internet?

- ○ Sim
- ○ Não

Onde você costuma usar mais Internet com freqüência?

- ☐ Em casa
- ☐ Na Universidade

- [ ] No trabalho
- [ ] Other: ____________

Quando você usa dispositivos móveis com conexão à Internet que são a funcionalidade mais utilizada?

- [ ] Call, Skype, whatsApp
- [ ] Redes sociais
- [ ] Estudar livros eletrônicos e literatura
- [ ] Utilizar aplicações / website educativo / material
- [ ] Other: ____________

Avaliação de Qualidade de Tecnologia Educacional (LORI). Clique na opção que melhor representa, na sua opinião, o nível de adequação do mSavingLife, considerando uma escala de 1 à 5 (1= pior avaliação, 5= melhor avaliação e NA= não se aplica). Após responder todas as perguntas, clique em "ENVIAR", no final do questionário para enviar suas respostas.

	1	2	3	4	5	NA
	○					
	○					
	○					
	○					
	○					
	○					

interface do usuário e qualidade dos recursos de ajuda da interface						
7. Acessibilidade: Design de controles e formatos para acomodar alunos em experiência de aprendizagem com mobilidade.	○	○	○	○	○	○
8. Reutilização: Capacidade de utilização em contextos variados de aprendizagem e em diferentes contextos (movel, presencial, semi presencial, individual e em grupo).	○	○	○	○	○	○
9. Cumprimento das Normas: CONFIABILIDADE e SEGURANÇA (Capacidade do produto de software de manter um nivel de desempenho especificado e segurança no acesso privativo a informação)	○	○	○	○	○	○

Page 1 of 1

SUBMIT

Never submit passwords through Google Forms.

APPENDIX D – Usability tool

INSTRUMENT FOR EVALUATION OF THE SAVINGLIFE®: AN EDUCATIONAL TECHNOLOGY FOR BASIC AND ADVANCED CARDIOVASCULAR SUPPORT IN NURSING

UNIVERSIDADE FEDERAL DE SANTA CATARINA

Universidade Federal de Santa Catarina
Centro de Ciências da Saúde
Programa de Pós-Graduação em Enfermagem

Formulário de avaliação ergonômica e de usabilidade para mSavingLife: aplicativo educacional móvel e baseado na web em enfermagem1) Dados Básicos:

Título do projeto: SavingLife®: An educational technology for Basic and Advanced Cardiovascular Life Support in nursing. http://savinglife.info/

User name: test. Password: test **Autor: Najma Naz**

Período avaliação: ____/___/_____ a _____/_____/____________

Instruções ao Avaliador

Você está recebendo um instrumento de avaliação quanto aos critérios ergonômicos e de usabilidade pra SavingLife® aplicative. Seu preenchimento é fundamental para que o sistema possa ser implementado e posteriormente utilizado em souporte basica da viada e suporte avencada da vida. A preservação e o respeito ao seu anonimato será assegurada. Agradeço sua valiosa participação e coloco-me a disposição para quaisquer esclarecimentos sobre este processo.

Quando terminar de observar o programa, por gentileza, dê sua opinião sobre os indicadores de cada uma das variáveis a seguir, assinalando com um X o nivel da escala que melhor reflete sua opinião de acordo com a legenda abaixo.

3) Avaliação Usabilidade

Legenda: 5 pra Ex (Excelente), 4 pra MB (Muito Bom), 3 pra B (Bom), 2 pra RG (Regular), e 1 pra
R
(Ruim)

Nº	DESCRIÇÃO	5 Ex	4 MB	3 B	2 RG	1 R
1	SavingLife é executado facilmente no dispositivo móvel(PDA), laptop, tablet smart phone com conexão à Internet sem interferência.					
2	As telas do SavingLife são claras, fáceis de ler e interpretar					
3	O usuário é capaz de acessar o SavingLife aplicativo facilmente					
4	O menu é viável e fácil de usar (a estrutura da informação disponibilizada é viável e fácil de usar)					
5	O menu atende as funções definidas para os objetivos do savinglife					
6	O programa favorece um intervenções eficiente aos situações emergencia.					
7	E eficiente para o intercâmbio de informação entre o usuário e o systema					
8	O sistema permite o manejo eficiente dos dadosque utiliza					
9	Memory requirements do not prevent the program from to roll					
10	O sistema não aceita dados inexistentes.					
11	A conexão e a comunicação entre o módulo fixo e móvel é adequada					
12	As exigências de hardware são compatíveis com a realidade					
13	O savinglife está integrado a um Banco de Dados					
14	E fácil adaptar a outros ambientes.					
15	E fácil instalar em outros ambientes.					

4) Emphasize the positive and negative aspects of the System you have observed:

____

5) Aponte possíveis soluções aos problemas levantados e faça sugestões para atividades futuras:

____

____

____

____

____

____

____

Obrigada pela sua importante tempo e participação!

Fundamentado em:

A ISO 9241-11 estabelece os Guidelines de Usabilidade disponível no site: http://www.usabilitynet.org/tools/r_international.htm#9241-1x

Instrumento previamente testado para avaliação do Sistema Computadorizado de regulação e avaliação da qualidade do SAMU: SIS_SAMU em 2006.

DAL SASSO, Grace T. M. A Concepção do Enfermeiro na produção tecnológica informatizada para ensino/aprendizagem em reanimação cárdio-respiratória. Florianópolis, 2001. 203f. Tese de Doutorado. Universidade Federal de Santa Catarina.

APPENDIX E – LORI Data Analysis

```
LORI Data Analysis   Thursday December 1 10:43:16 2016   Page 1

  ___  ____  ____  ____  ____ (R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/   12.0   Copyright 1985-2011 StataCorp LP
  Statistics/Data Analysis            StataCorp
                                      4905 Lakeway Drive
                                      College Station, Texas 77845 USA
                                      800-STATA-PC        http://www.stata.com
                                      979-696-4600        stata@stata.com
                                      979-696-4601 (fax)

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       Serial number:  08762859510
         Licensed to:  Najma Naz
                       USSC Brazil

Notes:

. use "C:\Users\Najma\Desktop\Lori Data Analysis.dta"

. summarize

    Variable         Obs        Mean    Std. Dev.       Min        Max

          cq          15    4.666667      .48795          4          5
         lga          15    4.666667      .48795          4          5
          fa          15    4.533333    .5163978          4          5
           m          15    4.733333    .5936168          3          5
          pd          15    4.733333    .4577377          4          5

          iu          15    4.933333    .2581989          4          5
           a          15    4.733333    .4577377          4          5
           r          15    4.733333    .4577377          4          5
          sc          15    4.666667      .48795          4          5

. ttest cq==4

One-sample t test

Variable      Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

      cq |     15    4.666667    .1259882      .48795    4.396449    4.936884

    mean = mean(cq)                                               t =   5.2915
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4               Ha: mean != 4                Ha: mean > 4
 Pr(T < t) = 0.9999       Pr(|T| > |t|) = 0.0001         Pr(T > t) = 0.0001

. ttest lga==4

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

     lga |      15    4.666667    .1259882      .48795    4.396449    4.936884

    mean = mean(lga)                                              t =   5.2915
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4               Ha: mean != 4                Ha: mean > 4
 Pr(T < t) = 0.9999       Pr(|T| > |t|) = 0.0001         Pr(T > t) = 0.0001
```

```
LORI Data Analysis   Thursday December 1,10:43:16 2016   Page 2

. ttest fa==4

One-sample t test

Variable      Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

      fa       15    4.533333    .1333333    .5163978    4.247362    4.819305

    mean = mean(fa)                                               t =   4.0000
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4                 Ha: mean != 4                 Ha: mean > 4
 Pr(T < t) = 0.9993         Pr(|T| > |t|) = 0.0013          Pr(T > t) = 0.0007

. ttest m==4

One-sample t test

Variable      Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

       m       15    4.733333    .1532712    .5936168    4.404599    5.062067

    mean = mean(m)                                                t =   4.7845
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4                 Ha: mean != 4                 Ha: mean > 4
 Pr(T < t) = 0.9999         Pr(|T| > |t|) = 0.0003          Pr(T > t) = 0.0001

. ttest pd==4

One-sample t test

Variable      Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

      pd       15    4.733333    .1181874    .4577377    4.479847     4.98682

    mean = mean(pd)                                               t =   6.2048
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4                 Ha: mean != 4                 Ha: mean > 4
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

. ttest iu==4

One-sample t test

Variable      Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

      iu       15    4.933333    .0666667    .2581989    4.790348    5.076319

    mean = mean(iu)                                               t =  14.0000
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4                 Ha: mean != 4                 Ha: mean > 4
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

```
LORI Data Analysis   Thursday December 1 10:43:16 2016   Page 3

. ttest a==4

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
       a |      15    4.733333    .1181874    .4577377    4.479847     4.98682

    mean = mean(a)                                                t =   6.2048
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4                 Ha: mean != 4                 Ha: mean > 4
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

. ttest r==4

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
       r |      15    4.733333    .1181874    .4577377    4.479847     4.98682

    mean = mean(r)                                                t =   6.2048
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4                 Ha: mean != 4                 Ha: mean > 4
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

. ttest sc==4

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
      sc |      15    4.666667    .1259882      .48795    4.396449    4.936884

    mean = mean(sc)                                               t =   5.2915
Ho: mean = 4                                     degrees of freedom =       14

    Ha: mean < 4                 Ha: mean != 4                 Ha: mean > 4
 Pr(T < t) = 0.9999         Pr(|T| > |t|) = 0.0001          Pr(T > t) = 0.0001

.
```

```
Usability Data Analysis   Thursday December 1 11:25:17 2016   Page 1

  ___  ____  ____  ____  ____(R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/   12.0   Copyright 1985-2011 StataCorp LP
  Statistics/Data Analysis            StataCorp
                                      4905 Lakeway Drive
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         Licensed to:  Najma Naz
                       UFSC Brazil

Notes:

. use "C:\Users\Najma\Desktop\Usability Data.dta"

. summarize

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
        var1 |         4        4.75          .5          4          5
        var2 |         4        4.75          .5          4          5
        var3 |         4        4.75          .5          4          5
        var4 |         4        4.25          .5          4          5
        var5 |         4        4.25          .5          4          5
-------------+--------------------------------------------------------
        var6 |         4        4.25          .5          4          5
        var7 |         4        4.25    .9574271          3          5
        var8 |         4        4.25          .5          4          5
        var9 |         4         4.5    .5773503          4          5
       var10 |         4         4.5    .5773503          4          5
-------------+--------------------------------------------------------
       var11 |         4         4.5    .5773503          4          5
       var12 |         4         4.5    .5773503          4          5
       var13 |         4        4.25          .5          4          5
       var14 |         4        4.25          .5          4          5
       var15 |         4        4.25          .5          4          5

. ttest var1==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var1 |       4        4.75         .25          .5    3.954388    5.545612
------------------------------------------------------------------------------
    mean = mean(var1)                                             t =   7.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9970         Pr(|T| > |t|) = 0.0060          Pr(T > t) = 0.0030
```

```
Usability Data Analysis   Thursday  December  1 11:25:17 2016    Page  2

. ttest var2==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var2 |       4        4.75         .25          .5    3.954388    5.545612
------------------------------------------------------------------------------
    mean = mean(var2)                                             t =   7.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9970         Pr(|T| > |t|) = 0.0060          Pr(T > t) = 0.0030

. ttest var3==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
    var3 |       4        4.75         .25          .5    3.954388    5.545612
------------------------------------------------------------------------------
    mean = mean(var3)                                             t =   7.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9970         Pr(|T| > |t|) = 0.0060          Pr(T > t) = 0.0030

. ttest var4==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
    var4 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var4)                                             t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

. ttest var5==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
    var5 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var5)                                             t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077
```

```
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. ttest var6==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var6 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var6)                                             t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

. ttest var7==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

    var7 |       4        4.25    .4787136    .9574271     2.72652     5.77348

    mean = mean(var7)                                             t =   2.6112
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9602         Pr(|T| > |t|) = 0.0796          Pr(T > t) = 0.0398

. ttest var8==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

    var8 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var8)                                             t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

. ttest var9==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

    var9 |       4         4.5    .2886751    .5773503    3.581307    5.418693

    mean = mean(var9)                                             t =   5.1962
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9931         Pr(|T| > |t|) = 0.0138          Pr(T > t) = 0.0069
```

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```
. ttest var10==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   var10 |       4         4.5    .2886751    .5773503    3.581307    5.418693
------------------------------------------------------------------------------
    mean = mean(var10)                                            t =   5.1962
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9931         Pr(|T| > |t|) = 0.0138          Pr(T > t) = 0.0069

. ttest var11==3

One-sample t test
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
   var11 |       4         4.5    .2886751    .5773503    3.581307    5.418693
    mean = mean(var11)                                            t =   5.1962
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9931         Pr(|T| > |t|) = 0.0138          Pr(T > t) = 0.0069

. ttest var12==3

One-sample t test
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
   var12 |       4         4.5    .2886751    .5773503    3.581307    5.418693
    mean = mean(var12)                                            t =   5.1962
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9931         Pr(|T| > |t|) = 0.0138          Pr(T > t) = 0.0069

. ttest var13==3

One-sample t test
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
   var13 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var13)                                            t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077
```

```
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. ttest var14==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   var14 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var14)                                            t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

. ttest var15==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   var15 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var15)                                            t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

.
```

```
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Notes:

. use "C:\Users\Najma\Desktop\Usability Data.dta"

. summarize

    Variable         Obs        Mean    Std. Dev.       Min        Max

        var1           4        4.75          .5          4          5
        var2           4        4.75          .5          4          5
        var3           4        4.75          .5          4          5
        var4           4        4.25          .5          4          5
        var5           4        4.25          .5          4          5

        var6           4        4.25          .5          4          5
        var7           4        4.25    .9574271          3          5
        var8           4        4.25          .5          4          5
        var9           4         4.5    .5773503          4          5
       var10           4         4.5    .5773503          4          5

       var11           4         4.5    .5773503          4          5
       var12           4         4.5    .5773503          4          5
       var13           4        4.25          .5          4          5
       var14           4        4.25          .5          4          5
       var15           4        4.25          .5          4          5

. ttest var1==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var1 |       4        4.75         .25          .5    3.954388    5.545612
------------------------------------------------------------------------------
    mean = mean(var1)                                             t =   7.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9970         Pr(|T| > |t|) = 0.0060          Pr(T > t) = 0.0030
```

```
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. ttest var2==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var2 |       4        4.75         .25          .5    3.954388    5.545612
------------------------------------------------------------------------------
    mean = mean(var2)                                             t =   7.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9970         Pr(|T| > |t|) = 0.0060          Pr(T > t) = 0.0030

. ttest var3==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var3 |       4        4.75         .25          .5    3.954388    5.545612
------------------------------------------------------------------------------
    mean = mean(var3)                                             t =   7.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9970         Pr(|T| > |t|) = 0.0060          Pr(T > t) = 0.0030

. ttest var4==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var4 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var4)                                             t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

. ttest var5==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var5 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var5)                                             t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077
```

```
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. ttest var6==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var6 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var6)                                             t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

. ttest var7==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

    var7 |       4        4.25    .4787136    .9574271     2.72652     5.77348

    mean = mean(var7)                                             t =   2.6112
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9602         Pr(|T| > |t|) = 0.0796          Pr(T > t) = 0.0398

. ttest var8==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

    var8 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var8)                                             t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

. ttest var9==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

    var9 |       4         4.5    .2886751    .5773503    3.581307    5.418693

    mean = mean(var9)                                             t =   5.1962
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9931         Pr(|T| > |t|) = 0.0138          Pr(T > t) = 0.0069
```

```
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. ttest var10==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   var10 |       4         4.5    .2886751    .5773503    3.581307    5.418693
------------------------------------------------------------------------------
    mean = mean(var10)                                            t =   5.1962
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9931         Pr(|T| > |t|) = 0.0138          Pr(T > t) = 0.0069

. ttest var11==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

   var11 |       4         4.5    .2886751    .5773503    3.581307    5.418693

    mean = mean(var11)                                            t =   5.1962
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9931         Pr(|T| > |t|) = 0.0138          Pr(T > t) = 0.0069

. ttest var12==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

   var12 |       4         4.5    .2886751    .5773503    3.581307    5.418693

    mean = mean(var12)                                            t =   5.1962
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9931         Pr(|T| > |t|) = 0.0138          Pr(T > t) = 0.0069

. ttest var13==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]

   var13 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var13)                                            t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077
```

```
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. ttest var14==3

One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   var14 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var14)                                            t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

. ttest var15==3

One-sample t test

Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
   var15 |       4        4.25         .25          .5    3.454388    5.045612
------------------------------------------------------------------------------
    mean = mean(var15)                                            t =   5.0000
Ho: mean = 3                                     degrees of freedom =        3

    Ha: mean < 3                 Ha: mean != 3                 Ha: mean > 3
 Pr(T < t) = 0.9923         Pr(|T| > |t|) = 0.0154          Pr(T > t) = 0.0077

.
```