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An Exploration of the Effectiveness of Problem-Based Learning in Nursing Education

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COLLEGE OF EDUCATION

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Yvette Marie Jackson

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Walden University
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MSN, University of South Alabama, 1995

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Doctoral Study Submitted in Partial Fulfillment

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Abstract

Critical-thinking is an essential skill that graduate nurses need to make sound clinical decisions. While traditional lecturing is the method most commonly used in nursing education, incorporating problem-based learning (PBL) into nursing curricula has been suggested as a better option for students' learning of theory and practice. The purpose of this study was to explore the difference in critical-thinking and problem-solving skills between nursing students taught using PBL versus those taught with traditional classroom lectures. A quasi-experimental approach, with cognitive learning theory as the foundation, was used to compare the results of an Assessment Technologies Institute (ATI) Comprehensive Predictor posttest in the control group, taught using the traditional learning method, and the experimental group, taught using PBL. Two-way ANOVA was used to analyze the effect of 2 independent variables: archived ATI Fundamentals Nurse exam proxy pretest scores, divided into low and high groups, and control or experimental group assignment, on the posttest scores of 192 nursing students at the study site. The results of the study showed that the main effect of the treatment, PBL vs. non-PBL, was significant, $F(1, 191) = 116.77$, $p < .001$, and the main effect for pretest groups was significant, $F(1, 191) = 121.79$, $p < .001$. The interaction effect was also significant, $F(1, 191) = 8.04$, $p = .005$, indicating that the effect of PBL was greater for nursing students in the low pretest group. The results of this study provide the premise for recommendations for nurse educators regarding the use of alternative teaching methods. The study may promote social change by providing preliminary research results to the local site that may contribute to improving the quality of nurse education.

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Acknowledgments

Accomplishing a feat of this magnitude required the involvement of many individuals whom I hold near and dear to my heart. I would first like to thank My Lord and Savior Jesus Christ, and my husband, Drew, my blanket of comfort and joy, who stepped in the "gap" without any complaints. For that, I am forever thankful, and no words can express what an awesome human being he has always been. Our children, Nyla (my biggest critic and cheerleader), Andrew, and Rico, have grown up with a mother who wears many "hats" but not one that fits better than that of mother. Through it all, my children have grown into beautiful and productive human beings. Without my faith and trust in almighty GOD, I would not have been able to accomplish the feat of obtaining my doctorate. Throughout this process, there have been many challenges, both good and bad. There were many days when I wanted to throw in the towel, but I had to remind myself that GOD did not bring me this far to leave me and for me to cast aside all of my blood, sweat, and many tears that were shed along the way. It is often said that the Lord does not put on us more than we can bear, and I can testify that this has been a true test of my faith and belief in this.

Being a huge Alabama fan (ROLL TIDE!), I find myself looking at the Southeastern Conference Channel (SEC) whenever I can. After a replay of the 2015 Cotton Bowl, the SEC Network aired a show called "SEC Storied." This particular episode was about a track and field athlete named Lorie "Lo Lo" Jones. The life of this phenomenal athlete was documented, and it told of her ups and downs, the good, the bad, and the ugly. Through all of her trials and tribulations, even wanting to give up and give in many times, she persevered. There are many others out there like her, but the telecast of her story seemed to come at just the right time for me. Her life mirrors all that I have gone through, and that episode gave me that little nudge of courage and perhaps a little message from GOD saying, be encouraged and keep pressing on because that light at the end of the tunnel will manifest itself soon and will shine bright in the fruit of your labor and hard work. For that, I was encouraged and thankful.

Lastly, a special acknowledgement and words of appreciation for all of the wisdom and guidance of the faculty of Walden University, specifically my committee chair, Dr. Billie Andersson. I wish to thank Dr. Kamna Mantode for her guidance and contribution to this study. Lastly, thank you to Teresa Riddell, who is truly a gem that is priceless, for her unending support, inspiration, and assistance in achieving this goal.

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Section 1: Introduction to the Study

The knowledge base and ability to use new and ever-changing technologies that health professionals are expected to have is more complex than ever (Fawcett, 2007; Fawcett & Desanto-Madeya, 2012). It is critically important that the training of allied health professionals be geared toward the demands of these expectations and advances. Consequently, nursing professionals must be able to think critically and use clear, expedient decision making when faced with healthcare demands.

Many students enter nursing programs with learning habits from their prior learning experiences (Thompson, Licklider, & Jungst, 2003). Lujuan and Di Carlo (2006) argued that such habits result from the curriculum being filled with so much material that educators simply tell students what they need to know so students can commit facts to memory. As a result, allied health nurses frequently have a difficult time producing highly skilled and personalized solutions to unpredictable circumstances. The need for development of critical-thinking and problem-solving in nurses is gaining importance.

In a local community in a southern state, the growth of the community and an increase in the length of hospitalizations of residents increased the need for healthcare professionals (Centers for Disease Control and Prevention [CDC], 2014; J. J., personal communication, August 7, 2013; MediaPosts, 2011). Educators at the local community college are considering alternative teaching techniques to aid students in the development of their critical-thinking and problem-solving skills, due to a high number of nursing students not completing their nursing programs, (J. J., personal communication, August 7, 2013). It is conjectured that students who use their critical-thinking and problem-solving skills will be more successful in progressing through nursing programs, and will be more skilled and better prepared nursing professionals (J. J., personal communication, August 7, 2013).

A nursing professional is a healthcare practitioner with clinical training and formal education who has been credentialed through certifications, licensure, and/or registration (Health Professional Network, 2008). Nurse educators increasingly use problem-based learning (PBL) to enhance health students' critical-thinking learning process. The majority of research on PBL began in in the field of medicine, but it is now used in an array of practices (Savery, 2006). PBL is student-centered learning, learning influenced by the educational needs of the student (Felder & Brent, 2009). PBL uses everyday problems to stimulate learning and to promote critical-thinking and problem-solving skills; this learning approach is gaining attention in the context of the increasing challenges faced by nurses (Chen, Chang, & Chiang, 2001).

Nursing education has entered a new era—one that involves innovative and technologically advanced methods in clinical education. Nurse educators are seeking new ways to meet present-day and projected educational requirements. Although the number of qualified nurses is low (Simpson, 2002), the demand for nurses has increased (National Advisory Council on Nurse Education and Practice, 2008), and registered nurses (RNs) continue to be in high demand (Bureau of Labor Statistics, 2012).

Between 2004 and 2008, the American Hospital Association (2014) reported a 17.7% increase in the number of RNs employed in hospital settings and a 68% increase in the number of RNs in home healthcare environments, while other areas of employment remained virtually unchanged. Older RNs, defined as those older than 50, comprise an increasing percentage of the nursing workforce. This age group accounted for 33.4% of the RN workforce in 2000, 41.1% in 2004, and 44.7% in 2008 (National Advisory Council on Nurse Education and Practice, 2008). In 2004, RNs older than 60 years of age comprised 13.6% of the total population of working RNs, and in 2008, that number jumped to 15.5% (National Advisory Council on Nurse Education and Practice, 2008). Clearly, the nursing shortage is not a short-term problem. As demand increases and more nurses retire, the shortage will likely increase. Nurse educators are now using new technology and teaching strategies to supplement the clinical experiences of nursing students (Starkweather & Kardong-Edgren, 2008). The use of PBL to foster critical-thinking and problem-solving in nurses is increasing.

Historically, critical-thinking and problem-solving in nursing programs were associated with the nursing process: assessment, planning, implementation, and evaluation. This process is a "systemic, orderly, step-by-step progression with a beginning and an end" (Nugent & Vitale, 2012, p. 9). Educators contend that in addition to using the nursing process, nursing professionals also need to develop critical-thinking to address the demands of the ever-changing world of healthcare (Youngblood & Beitz, 2001). Allied health nurses with critical-thinking skills can approach a myriad of scenarios with a scientific foundation (Nugent & Vitale, 2012). Allied health nurses may be likely to rely on rote memorization of a step-by-step template, and may not be able to provide solutions to situations that deviate from the norm unless they have competent critical-thinking skills (Nugent & Vitale, 2012). The tendency to adhere to traditional learning methods such as lecture is not easily bypassed.

The National League for Nursing (NLN) identified critical-thinking as a fundamental proficiency for nurses, as exemplified by the NLN Core Competencies for Nurse Educators, which outlined the competencies required for certification as a Certified Nurse Educator (NLN, 2005). These competencies include an ability of the nurse educator to pattern reflective- and critical-thinking and to create opportunities that promote student development of critical- and reflective-thinking skills in the classroom, laboratory, and clinical environments. Ulsenheimer, Bailey, McCullough, Thornton, and Warden (1997) proposed that critical-thinking is a reasoning method that any individual can become proficient in, suggesting that such a reasoning method will give nurses the ability to justify their work, if necessary, in the event that there is an unexpected or fatal outcome in the care of a patient. If nursing students are to cope successfully with the complex changes in healthcare, they must become proficient in higher level reasoning.

Classroom nursing curricula traditionally presented classroom content in the lecture format, whereas the PBL method presents classroom content through the use of practical problems to facilitate the use of student-centered learning and the use of critical-thinking skills (Beachey, 2007). Critical-thinking skills are not prioritized in the typical training modalities of allied health nursing, such as classroom lectures with note taking, standardized testing, and recall of template skills with a return demonstration. However, nursing programs are now mandated to teach critical-thinking as a required skill for the nursing professional (Jones, 2010). Nurse educators must carefully evaluate any major changes in nursing education to determine their effect on the critical-thinking skills of nursing graduates. While evaluating the major changes in nursing education, nursing instructors started using PBL to help their students adapt to the changes.

Oja (2001) stated that PBL encourages critical-thinking skills and should be inherent in allied health education programs. Traditional learning in allied health is didactic and focuses on lecture presentations (Beachey, 2007). Textbooks are the predominant source of course material, and pencil-and-paper exams are the classic method of assessment (Beachey, 2007). Though some proponents claim that there are significant benefits of using PBL (Ceconi, Op't Holt, Zip, Olson, & Beckett, 2008; Mishoe, 2007), others contend that it is no better than the traditional approach to teaching and learning (Beachy, 2007). PBL encompasses the cognitive domain and often uses the same steps of the nursing process for knowledge acquisition and comprehension: analysis, synthesis, implementation, and evaluation. The cognitive domain "includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills" (Clark, 2010, p. 1) and is centered on thinking and problem-solving in the classroom (Brunning, Schraw, Norby, & Ronning, 2004).

In the community of the current study, nursing students consistently failed to demonstrate the knowledge and critical-thinking ability needed to achieve the level of competence required to successfully progress to the next semester and beyond. According to an internal document from the community college in this study, this problem was evident from 2006 to 2013, with only 30% of nursing students passing to the second block of their core nursing curriculum, and only 10% of those students completing the program. For the past 5 years, at Southern State Community College (a pseudonym, subsequently referred to as SSCC), scores on the critical-thinking component of core nursing exams have consistently been below the 80% minimum that is required for nursing students to pass their courses. Having a substantial number of students not meeting the minimum standard has led to high attrition rates. Tipton et al. (2008) asserted that scores at or above the 80% minimum requirement are associated with success in core nursing courses, which in turn leads to success on the National Licensure Examination (NCLEX). Conversely, scores below the 80% minimum are associated with fewer nursing students progressing in their programs, leading to a shortage of qualified nurses (Tipton et al., 2008).

Role of Critical-Thinking

Yıldırım and Özkahraman (2010a, 2010b) stressed the development of critical-thinking as a chief element of nursing education. Colucciello (1997) asserted that the use of critical-thinking is essential to the evaluation of the delivery of basic and more involved activities in nursing care. Furthermore, such evaluation appears to be positively correlated with quality of care (Jones, 2010). Healthcare is now multisystem and multidimensional (Beck, Bennett, McLeod, & Molyneaux, 1992). Nurses should be compelled to develop critical-thinking skills to meet the challenges and complexities of the modern healthcare system. Beck et al. (1992) asserted that an interdisciplinary perspective is needed to solve problems in nursing practice. Critical-thinking benefits nurses in decision making, diagnostic reasoning, and therapeutic judgment. Colucciello emphasized that it is “imperative for nurses to reason critically about the judgments they face to ensure favorable outcomes” (p. 236). Additionally, nursing pundits identified critical-thinking and problem-solving as necessary for the effective management of healthcare needs in diverse settings (Maynard, 1996; Rubenfeld & Scheffer, 1999; Saucer, 1995; Yıldırım & Özkahraman, 2010a, 2010b).

Doenges and Moorhouse (2003) viewed critical-thinking in the nursing profession as a sum of assessment, nursing diagnosis, and planning as well as nursing intervention and evaluation. PBL developed as a result of the need for a more context-driven approach for making clinical decisions and judgments in life-and-death situations. Critical-thinking is a problem-solving technique for applying logical reasoning in the nursing process (Ennis, 1962; Siegel, 1988). Nursing education is currently facing numerous challenges. One of these challenges is the limited clinical time available. Simpson (2002) noted two factors contributing to decreased clinical time for nursing students: (a) the downsizing of acute healthcare agencies that led to a reduced number of clinical facilities; and (b) increasing amounts of theoretical content in nursing education curricula. New approaches for nurse educators to prepare nursing students for practice must be found to maximize the educational effectiveness of clinical time.

With a predicted shortage of nurses expected to continue until 2020 or later and a decreased number of clinical agencies available for use in clinical education, new methods to educate nurses are essential (NLN, 2003). The current and predicted shortage of nurses demonstrates that traditional methods of nursing instruction have not and will not be able to meet the increasing demand. It is not enough, however, to develop new strategies for educating nursing students. It is essential that research on new methods of nursing instruction be conducted to ensure that these methods are sound and will not jeopardize the quality of nursing education. In August 2003, the NLN Board of Governors released a position statement on nursing education that called for educators to "overhaul traditional pedagogies to reform the way the nursing workforce is educated" (p. 2) and ensure that these methods are research-based. Critical-thinking skills continue to be identified among the essential skills for nurses. The NLN position statement, titled *Innovation in Nursing Education: A Call to Reform*, further stated that nurses should be educated to "champion health promotion and disease prevention, function effectively in ambiguous, unpredictable, and complex environments, demonstrate critical-thinking and flexibility, and execute a variety of roles throughout a lifetime career" (NLN, 2003, p. 3). These skills are necessary in the complex environment of modern healthcare.

Problem Statement

At SSCC, 50% of nursing students currently taught with a traditional learning method did not learn to use critical-thinking or problem-solving skills and, therefore, were unable to successfully pass the academic nursing program (J. J., personal communication, August 7, 2013). From 2006 to 2013, the attrition rate at SSCC has consistently been between 30% and 70% (J. J., personal communication, August 7, 2013). Nursing programs must ready students to pass the National Council Licensure Examination (NCLEX). In an attempt to help nursing students achieve the level of knowledge and competence needed to pass the NCLEX, the use of critical-thinking has grown into a key focus of nursing curricula. Many nursing programs focus on developing effective learning methods to help students advance critical-thinking and problem-solving skills (Duffy, 2009).

Despite the large number of students admitted to nursing programs each year, small numbers continue to graduate (Alfaro-LeFevre, 2004). Many students do not remain beyond the first semester, and only a small number of the remaining students graduate. This low number is in part due to a rise in the number of undergraduates failing the didactic and clinical portions of their nursing programs in the first semester (Alfaro-LeFevre, 2004). The majority of students who do not progress successfully in class either withdraw from the program or fail to meet the minimum requirements to pass core courses. Consequently, the number of qualified nursing professionals is diminishing, a factor that may exacerbate a shortage in a very important healthcare field (Hunt, 2009).

The attrition rate at SSCC has consistently been below the national average of 75%-80%, from 2006 to 2013, for the associate degree nursing programs (NLN, 2015; J. J., personal communication, August 7, 2013). Attrition is a concern for all nursing programs because of costs incurred due to student tuition, time spent, resources used, and staff retention (Bennett, 2003; Schneider & Yin, 2011). When students withdraw from the nursing program, their chairs remain vacant for the rest of the year. This results in fewer graduates available to fill vacant nursing positions (Gillis, 2007). “Hospitals in the local area continue to experience a rise in the quantity of in-patients, while the number of qualified nursing staff remains consistently low” (J. J., personal communication, January 23, 2014). There is increased worry that patients suffering from complex illnesses are injured by unprepared medical due to the complexity of care required in treating these patients (Welton, 2007). Kaddoura (2011) stated that critical-thinking and problem-solving are paramount to nursing students' success, which in turn produces professional nurses who use logical, scientific, rational, and sound clinical judgment in the delivery of patient care. Additionally, poor critical-thinking skills in nursing students has been linked with high attrition rates, which results in smaller numbers of graduates from year to year (Kaddoura, 2011). When nursing programs continually graduate small numbers of students, the shortage of nursing professionals continues (Hunt, 2009; NLN, 2012). It is of paramount importance to test PBL methods against the traditional method to determine whether nursing students being taught with PBL improve in critical- thinking and problem-solving ability over a group taught with the traditional learning method.

Nature of the Study

This quantitative study examined whether PBL enhances critical-thinking and problem-solving skills among nursing students. Specifically, the study was conducted to understand the difference in critical-thinking and problem-solving skills in nursing students as tested by the ATI Comprehensive Predictor Exam. The null hypothesis for this research was there will be no significant difference ($p > 0.05$) for the ATI Comprehensive Predictor test between students taught with PBL and students taught with traditional instructional methods when controlling for nursing fundamental knowledge. The alternative hypothesis was students taught using PBL *will have* significantly ($p < 0.05$) higher scores on the ATI Comprehensive Predictor test compared to students taught with traditional instructional methods when controlling for nursing fundamental knowledge. A quantitative quasi-experimental approach was used to compare the archived results of an Assessment Technologies Institute Comprehensive Predictor posttest. The control group was taught using the traditional learning method, and the experimental group used PBL. Analysis of covariance (ANCOVA) was used to compare the archived test scores between the two different teaching groups. However, upon ensuring that the data met the nine required assumptions for the use of ANCOVA, it was determined that one of the key assumptions, homogeneity of regression slopes, was violated. According to this assumption, the interaction variable between the covariate and independent variable should not be significant (Trochim, 2006). Because of the violation of homogeneity of regression slopes, a two-way ANOVA was performed. The independent variables were the instructional methods. The first group (Group A) of licensed practical nurses (LPNs) and registered nurses (RNs) was taught by PBL, and the second group (Group B) of LPN and RN students received traditional instruction. The dependent variable was the students' posttest scores, and the Fundamentals nurse exam scores were used as the proxy pretest scores.

The scores assessed in this study were compiled from students who completed an ATI Fundamentals pretest and an ATI Comprehensive Predictor posttest. After taking the ATI Fundamentals pretest, the students in Experiment Group A were taught using PBL, and the students in Control Group B were taught using traditional lecture presentations. Although the students were given an ATI pretest and posttest, the tests are not considered equivalent; therefore, the problem-based and traditional lecture groups were compared using the posttest scores as the dependent variable and the ATI Fundamentals nurse exam scores as the proxy pretest scores.

Critical-thinking and problem-solving skills can be measured reliably by questions such as those contained in the ATI Comprehensive Predictor 2010 (Assessment Technologies Institute, 2012b). A pretest and posttest was administered, followed by a straightforward analysis of the results. The proxy pretest scores were used as the covariate, and the posttest scores were used to compare critical-thinking and problem-solving ability between the two groups learning under the different teaching methods. More discussion of the instrumentation and data is included in Section 3.

Purpose of the Study

The purpose of the present study, using the archived scores of 200 nursing students, was to examine differences in critical-thinking and problem-solving skills in nursing students. This is a first step in assessing the effects of PBL on developing critical-thinking and problem-solving, and acquiring suitable comprehension of the cognitive domains in this instruction style (Abraham, Vinod, Kamath, Asha, & Ramnarayan, 2008). By measuring the success of the use of PBL in the development of critical-thinking and problem-solving skills, this study may assist educators in determining whether incorporating PBL into nursing curricula will be help nursing students formulate, develop, and exercise their critical-thinking abilities.

Theoretical Framework

Several frameworks were examined to assess how well they strengthened the research; however, cognitive learning theory, which is a learning theory focusing on thought process, the development of critical-thinking, and how individuals learn (Fritscher, 2011), was the most appropriate. At SSCC, students frequently rely on rote memorization to solve basic and complex scenarios in the class and laboratory setting; when faced with challenges that deviate from the norm, too often the response from these same students is “I do not know” or “I do not want to think, just give me the answer” (J. J., personal communication, August 7, 2013). It is believed by many educators at SSCC that it is not a matter of the students not wanting to think, but rather an issue of the students not knowing how to think and how to use problem-solving skills (J. J., personal communication, August 7, 2013).

Building on the work of Bloom and Dewey, Facione, Facione, & Giancarlo (2000) developed a theory of instructional practices to facilitate critical-thinking. Facione developed instructional practices in which students participate in case study analysis, role play, presentations, debates, open-ended discussions, modeling, self-evaluation, and reflective evaluation (Facione, 2000). When applied to PBL, constructing knowledge is the core of cognitive learning, and includes developing critical-thinking and problem-solving skills. Aligned with the goals of PBL, cognition integrates developing critical-thinking ability and problem-solving ability to appropriately apply knowledge to reasoning (Hmelo-Silver, 2009).

Definition of Terms

The key terms in this study must be elucidated with definitions. The following terms are essential to the present study:

Allied health professionals: These are healthcare practitioners with clinical training and formal education who are credentialed through certification, licensure, and/or registration (Health Professional Network, 2008). The *allied health profession* consists of many programs such as surgical technology and occupation therapy. In the surgical technology program, students learn to assist physicians in surgery by passing instruments to the surgeon, among other things. In the field of physical therapy, students learn to provide care for individuals who suffered some form of physical setback in order to help them restore or maintain function and movement throughout life (Miller-Keane, 2005).

Analysis of covariance of valence (ANCOVA): ANCOVA is a statistical analysis used to establish whether there are any notable variances or differences between the means of unrelated groups (Laerd Statistics, 2013a).

Analysis of variance (ANOVA): ANOVA is a statistical analysis used to determine if there is a correlation between the independent variables and the dependent variable (Laerd Statistics, 2013b).

Assessment Technology Institute comprehensive predictor (ATI): The ATI Comprehensive Predictor 2010 is an instrument used to determine a student's overall performance on specific critical-thinking skills that are considered necessary to succeed in a nursing program (Assessment Technologies Institute, 2012a).

Associate degree nursing (ADN) program: This is a 2-year program of study, usually at a community college. Graduates of an accredited ADN program are able to sit for the NCLEX-RN licensing exam to become registered nurses (Kozier & Erb, 2011).

Attrition: Attrition is a reduction or decrease in numbers. Attrition is typified as a withdrawal or postponement in the completion of a program (Gillis, 2007).

Cognitive learning theory: Cognitive learning theory focuses on the development of critical-thinking and the thought process that is fundamental and essential to how individuals learn (Fritscher, 2011).

Convenience sampling: Convenience sampling is a type of sampling in which the subjects are sampled because they are easily accessible (Creswell & Plano Clark, 2011).

Critical-thinking: Critical-thinking is the diligent undertaking of observation, analysis, application, synthesis, and evaluation of information as a guide to form beliefs and to define an individual's actions based on those beliefs (Scriven & Paul, 2008).

Critical-thinking skills: Such skills encompass examination, deduction, clarification, reasoning, and self-regulation of an individual's own thinking abilities and the elements that are used for problem solving (Tilus, 2012).

Licensed practical nurse (LPN): An LPN is a nurse who has undergone training at an accredited school of nursing and become licensed to provide basic-level nursing care under the supervision of a more advanced licensed practitioner such as a registered nurse or a physician (Gokenbach, 2012).

National Council Licensure Examination (NCLEX): The NCLEX is a standardized test taken after an individual graduates from an accredited institution. It is used by each state board to determine if an individual is prepared for basic entry-level nursing (Nugent & Vitale, 2012).

Nursing student: A nursing student is an individual enrolled in a program of study that trains individuals to become nurses (Gokenbach, 2012).

Problem-based learning (PBL): PBL is a teaching methodology that builds problem-solving skills. PBL starts with the demonstration of a difficult situation to be resolved or deciphered that potentially has many answers or results (Chen, Chang, & Chiang, 2001).

Problem-solving skills: Problem-solving skills are higher-order cognitive skills used to solve problems. There are four essential skills that are used: defining the problem, developing alternative solutions, evaluating and selecting alternative solutions, and implementing the solution (Kaiser, 2015).

Quantitative design: A quantitative design is a survey method that provides a numeric account of trends of a populace by analyzing a cross-section of the population in the study (Creswell, 2014).

Quasi-experiment: This type of experiment uses a control and experimental group in the research process. The population sampling is purposeful, and the participants are not randomly assigned to groups (Creswell, 2014).

Registered nurse (RN): An RN is a nurse who has undergone training at a college or school of nursing and has passed the national licensing exam (Gokenbach, 2012).

Traditional learners: These are students in a physical classroom who are taught with a predetermined curriculum (Skopek & Schumann, 2008).

Assumptions, Limitations, and Delimitations

In this study, the participants were first-year nursing students enrolled in the core curriculum and given an ATI Comprehensive Predictor exam. It was assumed that the participants had answered the questions on the ATI Comprehensive Predictor based on their experiences of being taught with and without a PBL method of teaching, and to the best of their capability. It was also assumed that students responded to the best of their individual abilities to the ATI questions as indicated by the college. Finally, it was assumed that critical-thinking and problem-solving develop in a linear fashion due to the implementation of PBL instruction.

This study was limited by being conducted on two groups of undergraduate nursing students of a certain institution with an unequal number of students in the groups. Findings may be different for a wider and more linear group of nursing students. Another limitation was the posttest-only experiment design. The major problems with this type of study design are threats to internal validity due to selection bias (Gorad, 2013). Convenience sampling was used, which did not provide generalizable results as compared to random sampling methods. Lastly, specific measures were used to assess critical-thinking and problem-solving, but a more varied approach might have been more valuable. A delimitation of this study was the use of posttest scores only to compare the critical-thinking and problem solving skills of the two groups. A well-established instrument was used for assessment purposes.

Significance of the Study

Education is the key to transforming society and resolving issues that contribute to the stagnant growth of society (Singer & Pezone, 2003). Hargreaves (2003) stated that one of the greatest tasks that educators face is to help build a dynamic social movement that precipitates positive change in education. “As instructors foster critical-thinking skills, it is important that they do so with the ultimate purpose of fostering traits of mind.

Intellectual traits or dispositions distinguish a skilled but sophisticated thinker from a skilled fair-minded thinker" (Elder & Paul, 2010, p. 38). Students develop and use their critical-thinking and problem-solving skills, enabling them to learn on every level, thereby making critical distinctions between good and bad, right and wrong, and so on (Elder & Paul, 2010).

PBL continues to be a chosen teaching approach in nursing education. Educators endeavor to implement teaching methods that will help their students to develop critical-thinking and problem-solving abilities, and continue to develop their own critical-thinking as well. PBL extends beyond medicine, and is increasing in nursing and other fields of education, but is relatively untested. Ultimately, it is expected that this work's focus on identifying the effects of PBL on nursing students' learning will help to change or otherwise reform nursing education curricula on the local level to focus more strongly on PBL. The present study may also promote social change by providing evidence of approaches, other than traditional lecture, that help students to appropriately apply knowledge and develop critical-thinking and problem-solving skills that will contribute to improving the quality of healthcare.

Summary

Critical-thinking improves the quality of thinking. Much thinking is biased, distorted, uninformed, and laden with prejudice (Scriven & Paul, 1998). Substandard levels of thinking can have a notable effect on both the finances and standard of living for the public that healthcare providers serve (Scriven & Paul, 2008). Critical-thinking is an ongoing process that begins with a question that requires deeper thinking. It is a higher form of cognition that society demands. Faculty seek to show that they are indeed educating students and exerting extra effort to engage their students in a higher order of thinking (Madden, 1998).

It is no longer acceptable for healthcare providers to limit themselves to knowing how to perform a skill. They must now know what the skill is, when and where they can perform the skill, how they can perform the skill, why they are using the skill, and what other alternatives exist (Khosravanic & Memarian, 2005). Critical-thinking is a technique, not an end result. Educators should encourage students to think critically and provide them with opportunities and resources that will aid them in augmenting their critical-thinking skills. Nursing faculties concur that students who know how to make deliberate and informed decisions make far better clinical decisions than students who have just committed facts to memory (Khosravanic & Memarian, 2005). Leaver-Dunn, Harrelson, Martin, & Wyatt (2002) asserted that although skillful ability does not indicate critical-thinking capacity, there is a direct correlation between good, skillful discernment and critical-thinking.

In summary, I have described in this section the need to assess the difference in critical-thinking and problem solving skills between nursing students taught using PBL and nursing students taught using traditional classroom lectures. The next section of this study contains a thorough analysis of the literature for the current study. Priority is given to defining critical-thinking, the role of critical-thinking and PBL, and traditional instruction styles in allied health training.

Section 2: Literature Review

This section is a literature review conducted primarily through searches using CINAHL, MEDLINE, ProQuest Nursing, OVID, Google, and a literature search conducted through the EBSCO databases on the Walden University website. Multiple combinations of terms were used in the literature search; however, the following terms produced the most insight: *critical-thinking, critical-thinking skills, critical-thinking in nursing education, critical-thinking and problem-solving, concept mapping, problem-solving in allied health education, student-centered learning, problem-based learning (PBL), simulation in nursing education, theoretical foundations in nursing education, nursing theories, cognitive learning theory,* and *social cognitive theory.* In addition, my personal library of nursing textbooks and bibliographies from nursing and medical journals were useful as resources. This section is organized into the following components: introduction, defining critical-thinking, PBL theoretical framework, and a conclusion. Each section is further divided into topics related to the underlying framework of this study, which is about critical-thinking in nursing education.

Critical-thinking and problem-solving skills are essential in achieving success as a learner (Nugent & Vitale, 2004). Researchers believe that critical-thinking is more than just a task-oriented, behavioral approach to problem solving. The belief is that critical-thinking should be based on an emancipatory model that “stresses critical-thinking as a process rather than just a method of producing a product or solution” (Nugent & Vitale, 2004, p. 9). Critical-thinking has been welcomed in education, but there is little consensus on how it should be defined and how it should be measured (Williams, Schmidt, Tillis, Wilkins & Glasnapp, 2006). Many authorities in higher education, while embracing the concept of critical-thinking, do not embrace the idea that students should be taught how to think (Halpern, 1999).

A seminal comparison study on the performance of medical students was conducted by Boshuizen, Schmidt, and Wassmer (1990) on a problem-solving task between medical schools using problem-based and traditional method curricula. A similar performance test involved internists and biochemists. The students described how a biochemical deficiency was related to any specific disease. The result had the internists and traditional curriculum students using a memory-based approach as opposed to the analytical approach used by the biochemists and PBL students. The former were less accurate in their responses.

Students taught with a PBL curriculum are more capable of using their knowledge with everyday quandaries, and use more tacit, self-directed learning tactics than novices taught with traditional curricula (Hmelo, 1998; Hmelo & Lin, 2000; Schmidt et al., 2009). Recent research emphasized the success of PBL in targeted education disciplines such as critical-thinking ability (Iwaoka, Li, & Rhee, 2010; Sendaq & Odabas, 2009). The relation between PBL and critical-thinking is largely favorable in higher education. Semerci (2006) showed that a PBL-led group illustrated higher critical-thinking ability. Semerci used self-developed questions that resulted in increased critical-thinking ability. The measuring criteria for critical-thinking ability were based on students' ability to clarify solutions, analyze, understand, focus, make assumptions, and infer with judgment. In support of this finding, Sendaq and Odabas (2009) measured the change in critical-thinking ability after applying a PBL approach using the Watson Glaser Critical-Thinking Appraisal Test (WGCTA). The WGCTA was used as a means of measuring critical-thinking ability. The test measured the ability to evaluate ideas, infer, recognize, assume, and interpret information. The result showed an escalation in the critical-thinking capacity of students given the PBL approach in comparison to students given the traditional approach to learning.

Defining Critical-Thinking

Various researchers define critical-thinking as thinking about how to think, and not what to think, while others define it as a person's step-by-step analytical process (O'Dell et al., 2009; Scriven & Paul, 2008). Moore, Dolansky, Palmieri, Singh, & Alemi (2010) asserted that critical-thinking is an act whereby an individual reflects on and improves the way he or she reasons and uses reasoning to come to a correct solution. According to Angelo and Cross (1993) and in accordance with the definition provided by the National Council for Excellence, "a critical-thinking approach should be applied to virtually all methods of inquiry practiced in the academic disciplines and is a key goal of liberal arts and general education courses" (p. 65-66). Egege and Kutieleh (2004) felt that this definition preludes the assumption that one cannot participate in valuable academic activities without using reason, logic, or a critical-thinking approach. They further asserted that if this holds true, then cultures such as a nursing culture that do not take this approach may reflect a strong cultural bias on the part of the thinker in their reasoning.

Nugent and Vitale (2012) maintained that critical-thinking should be defined in levels, and that there is a basic-level critical thinker, a complex-level critical thinker, and an expert-level critical thinker. A lack of agreement on the meaning of critical-thinking poses challenges to clinical educators.

Divergent definitions of critical-thinking exist in both academia and everyday settings (Al-Mahrooqui, Thakur, & Roscoe, 2014). The National Council for Excellence in Critical-Thinking claimed that “critical-thinking is based on universal intellectual values which transcend subject-matter divisions; clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth and fairness” (Egege & Kutieleh, 2004, p. 79). Another study asserted that critical-thinking is encompassed by clinical reasoning where clinicians must scrutinize data, generate hypotheses about health discoveries, establish plans for patient care, prioritize care, and research inferences based on available information to raise the likelihood of a desired outcome (Williams et al., 2006). Additionally, critical-thinking is described as a system of assembling and scrutinizing information collected from examination, contemplation, transmission, disclosure, or logical thinking (Scriven & Paul, 2008).

One of the main hurdles to agreement on a definition is nested in an array of conceptualizations of higher order reasoning. Psychologists directed their attention to the method of cognition in the mental process in gaining knowledge and comprehension (Scriven & Paul, 2008). Philosophers, on the other hand, concentrated on the quality and nature of the effect of critical-thinking such as logical reasoning (Kuhn, 1992; Kurfiss, 1988; Marzano, 1993; Quellmalz, 1987; Weinstein, 1995). Regardless of the definition given for critical-thinking, one can safely contend that critical-thinking is an intricate construct that necessitates multiple abilities (Williams et al., 2006).

Dunn, Halonen, and Smith (2009) asserted that although the ability to think critically is not entirely essential for the least amount of proficiency in professional practice, it is essential for a high-caliber standard of practice and highest level of skillful growth. As a consequence, educators must aim to help their pupils grow to desire and be inclined to develop their critical-thinking skills (Dunn et al., 2009).

Facione et al. (2000) described the inclination for critical-thinking as the ongoing central drive to use one's unique critical-thinking capacity in deciding what action to take in any circumstance to increase professional competence. However, Leaver-Dunn et al. (2002) countered that research has not shown any evidence of a link between critical-thinking and professional competence based on the idea that any clinician can follow a template and arrive at a viable result without exercising critical-thinking skills. While it may be true that any clinician can follow a template and arrive at a solution, what keeps that clinician from achieving success and reaching expert status is reflection, which comes about through the ability to think critically (Facione et al., 2000).

Role of Critical-Thinking in Nursing Education

Given the importance of critical-thinking skills in nursing, the exploration of PBL to foster the development of this skill in nursing education may yield benefits. Nursing is a complex profession. The American Nurses Association (ANA) defined *nursing* as "the protection, promotion, and optimization of health and abilities, prevention of illness and injury, alleviation of suffering through the diagnosis and treatment of human response, and advocacy in the care of individuals, families, communities, and populations" (ANA, 2010a, p. 66). ANA stressed the importance of mobilizing healthy living patterns and supporting self-defined goals of families and society as a whole.

Nursing involves the delivery of essential healthcare services in the context of a kind-hearted association that makes health and healing possible (Alfaro-LeFevre, 2011). Nurses must be attentive to the entire scope of humane encounters and reactions to the well-being and diseases of individuals within community and physical domains (Alfaro-LeFevre, 2011). Critical-thinking is needed to integrate assessment data with existing knowledge to form sound clinical judgments. Apart from accomplished nursing comprehension via literary analysis and strategies for promoting social justice, the development of critical-thinking skills is essential (Amer, 2012).

The North American Nursing Diagnosis Association (2011) nursing interventions, the Nursing Interventions Classification (University of Iowa College of Nursing, 2011), and the Nursing Outcomes Classification (Moorhead, Johnson, Maas, & Swanson, 2013) are aimed at defining the essential work components of nursing. Nursing experts are aware that critical-thinking is imperative for the effective application of knowledge. Dr. Patricia Benner, from the Carnegie Foundation Study on nursing education (Benner, Sutphen, Leonard, & Day, 2010), emphasized the significance of critical-thinking while asserting that there is wide disagreement and little unity on what it involves.

Various theoretical models, such as the T.H.I.N.K. model (Rubenfeld & Scheffer, 1999), novice vs. expert/struggling vs. exemplary nurses' model (Beeken, 1997), nursing judgment model (Kataoka-Yahiro & Saylor, 1994), and critical-thinking interaction model (Miller & Babcock, 1996; Tarricone, 2011), stress the importance of critical-thinking for nursing students. Many authors emphasize critical-thinking as being the key to effective nursing (Romeo, 2010). This type of thinking involves searching, evaluating, obtaining, analyzing, synthesizing, and conceptualizing data for ethical decision-making in the nursing profession. The nursing process involves critical-thinking in the form of assessment, observation, diagnosis, planning, implementation, and evaluation.

Nursing requires innovative, individualized solutions to circumstances that are unforeseeable (Miller & Malcolm, 1990). It also involves the ability to reconsider clinical judgments (Facione & Facione, 1996). Kataoka-Yahiro and Saylor (1994) identified five elements of critical-thinking: nursing-based comprehension, applied skills, critical-thinking competences, approach, and intellectual as well as professional standards. They also emphasized the significance of critical-thinking in the nursing profession.

Yıldırım and Özsoy (2011) identified critical-thinking as “the process of searching, obtaining, evaluating, analyzing, synthesizing and conceptualizing information” to serve as a “guide for developing one’s thinking with self-awareness,” enhancing the capacity for “adding creativity and taking risks” (p. 158). This skill is critical in the context of nursing. Furthermore, knowledge work, which necessitates critical-thinking, plays a vital role in healthcare delivery, as nurses are now seen as knowledge workers (Sorrells-Jones, 1999). The administration of knowledge encompasses routine work and nonroutine work. Routine work includes checking vital signs, administering medical doses, and walking the patient. Nonroutine work involves exception and use of knowledge and judgment for effective delivery of healthcare services. In the comprehension-based environment, an individual’s role and reverence are not as essential as his or her expertise. The most crucial components that a knowledge worker must possess include coordination, analysis, teamwork, collaboration, evaluation, flexibility, and critical-thinking.

Knowledge workers recognize the inevitability of change and the principal way to tackle it, and see it as a chance for learning and growth (Mooney, 2011). Nurses use this knowledge on a daily basis in routine as well as nonroutine work. They work in an environment that is constantly changing, and critical-thinking is a necessary addition to their skill set. According to Mooney (2011),

> Transitioning to an evidence-based practice requires a different perspective from the traditional role of nurse as "doer" of treatments and procedures based on institutional policy or personal preference. Rather, the nurse practices as a "knowledge worker" from an updated and ever-changing knowledge base. (p. 17)

Knowledge workers focus on acquisition, analysis, synthesis, and application of evidence to guide practice decisions (Dickenson-Hazard, 2002). Nursing now involves multiple intelligences, capacity for teamwork, outcome-based practice, and a mobile skill set, in contrast to previous requirements of functional analysis, established aptitude, system value and execution, manual dexterity, and single-handed performance (Porter-O'Grady & Malloch, 2007).

From this viewpoint, the nurse is an aloof intellectual who is valued by proprietors and clients for what he or she knows, and the purpose for which this wealth of knowledge is used is tending to the results of patient care, rather than just specialized mechanical proficiency (Kerfoot, 2002). The Carnegie Foundation Report on nursing education suggested that rather than predominantly concentrating on what is included in nursing curricula, nurse educators must concentrate on teaching skills such as how to approach, enter, manipulate, and use data (Benner et al., 2010). This underscores the significance of critical-thinking in nursing education.

Psychology-Based Theories and Definitions

A wealth of psychological research about critical-thinking exists within developmental psychology (Bransford, Brown, & Cocking, 2000). Halpern's (2003) model for critical-thinking presents thinking as purposeful and involving reasoning and problem-solving. It is the kind of thinking that involves decision-making and outcome analysis to determine how fully a problem has been solved. Additionally, Halpern (2000) asserted, "there are identifiable critical-thinking skills that can be taught and learned, and when students learn these skills and apply them appropriately, they become better thinkers" (p. 71). Many cognitive researchers in addition to Halpern have focused attention on examining the problem-solving process and presenting representations for critical-thinking with individual and dissimilar cognitive research as the foundation. However, Bloom's (1984) taxonomy continues to serve as the foundation for many psychological thinking skills programs (Johnson, 1994).

Intellectual engagement in didactics has traditionally measured students' interaction with instructors, attendance, homework completion, or level of motivation while engaging in conversations and debates in the classroom (Appleton, Christenson, Kim, & Reschly, 2006). Rotgans and Schmidt (2011) argued that cognitive engagement depends on the assignment at hand, because the assignment the student is engaged in determines the degree of autonomy and critical-thinking skills used when completing the task. Consequently, depending on the parameters of a task change, as is the case with PBL, students will perceive different levels of autonomy. When students approach a task with a certain level of independence or freedom, the thought is that this autonomy will enhance their critical-thinking ability (Rotgans & Schmidt, 2011).

Philosophy-Based Theories and Definitions

Critical-thinking has been placed at the forefront of allied health programs in response to a world of accelerating change and informal logic. Informal logic is concerned with interpretation and evaluation, much like the nursing process (Johnson, 1996). Johnson (1996) asserted that informal logic is narrowly focused on argumentation and reasoning, but has contributed to the foundation of critical-thinking. Paul (2002) stated, “critical-thinking is the disciplined art of ensuring that you use the best thinking you are capable of in any set of circumstances” (p. 7).

Paul and Elder (2002) posed questions such as “where does our thinking come from? How much of it is of good or poor quality?” (p. 7). In response to these questions, Paul insisted little is known about thinking or how it works. Paul maintained that thinking necessitates a combination of cognitive and affective domains, and that it is crucial to be aware that thinking is not difficult. Paul and Elder’s concept of critical-thinking indicated that participation in a type of labor that people find repugnant and agonizing, cerebral work, is needed to improve standards of thinking (2002). Despite widespread citation of Paul and Elder’s work, no studies have tested the success of Paul and Elder’s model of critical-thinking.

Problem-Based Learning (PBL)

Many institutions have implemented PBL into their curricula to provide new approaches to students' learning and problem-solving (Walker & Leary, 2009). PBL originated at McMaster University Medical School in Canada in reaction to student dissatisfaction with their overall learning (Barrows, 1998), and educators seeking to improve medical students' education (Jubien, 2008). Interest in the PBL method grew and in 1979, as an alternative to the conventional curriculum, the University of New Mexico Medical School was the first academic establishment in the United States to provide PBL (Jubien, 2008). The curricula of several medical schools incorporated PBL by using real scenarios to treat patients so that the learners learn to think like clinicians. Although no medically accepted definition of PBL exists (Butler, Inman, & Lobb, 2005; Taylor & Miflin, 2008) social scientist and academics from other disciplines have defined PBL as follows:

- A student-centered method of learning where students have more command over their learning (Walker & Leary, 2009).
- An atmosphere of learning where students are given genuine, unstructured scenarios and issues in which the authenticity of the issue provides a real world experience, allowing students the opportunity to provide multiple thoughts on how to solve the issues (Abraham et al., 2008; Kong, Li, Wang, Sun, & Zhang, 2009).

- A classroom setting where the instructor takes on the role of facilitator, allowing the students to construct knowledge for themselves (Becker & Maunsaiyat, 2004).
- A student-centered method in which novices decide what they are obligated to know, determine the main points of the problem presented, pursue and investigate missing knowledge about the problem, and explore multiple solutions (Barrows, 2002: Hmelo-Silver & Barrows, 2006).

Barrows (1986) proposed a taxonomy of six levels of PBL methods centered on case scenarios and the method in which the scenarios are presented by the PBL creator. The first level is lecture-based case presentations, followed by the second level of clinical reason, the third level of student motivation, then followed by case-based methods and PBL. The fifth and final method in Barrow's taxonomy is "closed loop, or reiterative problem-based methods, which involve the learners on problem-solving skills" (p. 484). Harden and Davis (1998) proposed an eleven-step continuum, beyond Barrow's taxonomy. These eleven steps are as follows:

1. hypothetical learning
2. task-orientated-learning
3. task-assisted learning
4. problem-solving learning
5. problem-focused learning
6. task-based mixed approach
7. problem-initiated learning

8. task-centered learning

9. problem-centered discovery learning

10. problem-based learning

11. task-based learning

Each of these levels present more focus on self-directed learning in the teaching method (Harden & Davis, 1998, p. 218).

With PBL moving into other disciplines, such as nursing education, Barrows (1986) and Hmelo-Silver (2009) described the objectives of PBL as building a knowledge base for use in real world settings, developing effective clinical reasoning and problem-solving skills, building lasting academic skills, and increasing one's motivation to learn. In 2006, Hwang and Kim conducted a study that showed a significant relationship between PBL and clinical knowledge scores of nursing students compared to traditional learners. Szogedi, Zrinyi, Betlhem, Ujvarine, and Toth (2010) conducted a comparison study on the effectiveness of PBL in contrast to traditional learning in the training of nurses. The researchers conducted *t*-tests on differences in exam grades between experiment and comparison groups. Results yielded significant differences ($p < 0.001$) between the nursing students taught using PBL and nursing students taught using the traditional method. The students taught using PBL had higher final exam scores, indicating that PBL may be a better method of learning than the traditional method (Szogedi et al., 2010).

In a study in Saudi Arabia, Mohammad and El Sebai (2010) examined the effect of PBL on 30 female nursing students using a quasi-experimental design based on before-and-after effects. The results indicated that the posttest mean score was higher than the pretest score ($p < .0001$), therefore the researchers concluded that PBL improves professional performance in nursing education (Mohammad & El Sebai, 2010).

Not all studies found a relationship between PBL and the development of critical-thinking skills and improved clinical skills performance. Leung (2002) suggested that students taught using the traditional method of classroom lecture may have problems transitioning to the PBL method. Using nursing students' pre and posttest scores, Beers (2005) found that the PBL method is no different than the traditional teaching method. Beers used an independent *t*-test comparing the pre and post-test scores of nursing students instructed using PBL and those instructed using traditional lectures. Beers (2005) concluded that there were no statistical differences between the two study groups and that PBL is just as effective as traditional teaching. PBL should be evaluated based on critical-thinking and higher-level synthesis of knowledge rather than standard test knowledge.

Problem-Based Learning in Nursing Students

PBL focuses on engaging students in real life scenarios that prompt the students, to develop and use critical-thinking, to provide solutions for the scenarios (Iwaoka et al., 2010). Several studies sought to identify the role of PBL in developing critical-thinking skills (Ahlam & Gaber, 2014; Mohammad & El Sebai, 2010; Twari et al., 2006; Williams et al., 2006). Twari, Lai, So, and Yuen (2006) studied the effects of both PBL and the traditional learning approach on nursing students' critical-thinking ability. The research used students registered in an undergraduate nursing program at the University of Hong

Kong. A longitudinal study was conducted that contrasted 40 students in the lesson group with those using the PBL approach. The control group was comprised of 39 students who were exposed to lectures using the traditional method of learning. The students were tested for critical-thinking disposition through use of the California Critical-Thinking Disposition Inventory (CCTDI). For the pretest, the overall CCTDI and subscale scores for the PBL group were not significantly different from those of the lecture group. However, after the posttest, the study showed that a strong correlation existed between PBL instruction and the development of critical-thinking skills in nursing students. Twari et al. (2006) found that,

> Compared with the lecture students, the PBL students showed a significantly greater improvement in overall CCTDI ($p = 0.0048$), Truth-seeking ($p = 0.0008$), Analyticity ($p = 0.0368$) and Critical-thinking Self-confidence ($p = 0.0342$) subscale scores from the first to the second time points; in overall CCTDI ($p = 0.0083$), Truth-seeking ($p = 0.0090$) and Analyticity ($p = 0.0354$) subscale scores from the first to the third time points; and in Truth-seeking ($p = 0.0173$) and Systematicity ($p = 0.0440$) subscale scores from the first to the fourth. (p. 547)

The participants exposed to PBL instruction were given everyday scenarios appropriate to their group. Analysis of the outcomes of the testing showed that the participants taught with PBL instruction had a mean score above the 50th percentile, and students taught with the traditional lecture method consistently had mean scores well below the 50th percentile (Twari et al., 2006).

Research Studies on Critical-Thinking in Nursing Students

Research has sought to identify critical-thinking skills in nursing students. Hunter, Pitt, Croce, and Roche (2014) conducted a cross-sectional descriptive study examining 269 students across 3 years of an undergraduate nursing course. The critical-thinking skills of the participants were assessed through the Health Science Reasoning Test (HSRT). Linear regression analysis of results revealed that students in the third year developed advanced critical-thinking skills when compared to the HSRT norms. There was a corresponding increase in critical-thinking skills as the knowledge base of the students grew over the period of the course. The inculcation of such skills has definite benefits for ensuring effective diagnoses and accurate clinical judgments (Hunter et al., 2014).

Bittencourt and Crosetti (2013) and Chan (2013) conducted exploratory descriptive studies to identify the importance of critical-thinking skills for improving the nursing diagnostic process. Content analysis of descriptive data revealed that scientific and technical knowledge as well as logical reasoning skills were critical for making effective diagnoses. Such thinking skills can improve nursing education and instruction.

PBL can be used to foster critical-thinking skills in a wide variety of settings. Many researchers sought to identify the role of PBL in the development of critical-thinking skills (Bae, Lee, Kim, & Sun, 2005; Oh et al., 2011). Others assessed the effects of various PBL teaching approaches on critical-thinking (Eom, Kim, Kim, & Seong, 2010; Maneval, Filburn, Deringer, & Lum, 2011). Dong-Hee (2012) studied the changes in PBL-induced critical-thinking abilities of nursing students at the commencement and completion of the academic year, and found that development of such critical-thinking skills is not linear, which meant the score of total critical-thinking disposition and subcategories other than intellectual fairness did not change significantly.

The use of specific teaching strategies, such as traditional teaching and the Socratic method of teaching, had an effect on the degree to which such skills developed among nursing students (Alfaro-LeFevre, 2006). Researchers also evaluated the success of different teaching plans in promoting critical-thinking skills in nursing students (Ellermann, Kataoka-Yahiro, & Wong, 2006; Giddens & Gloeckner, 2005). Critical-thinking skills are essential for nurses to be competent professionals. Alfaro-LeFevre (2009) noted that critical-thinking is a process that leads to sound clinical judgment. He indicated four components of clinical judgment: theoretical and experiential knowledge, interpersonal skills, technical skills or competencies, and critical-thinking attitudes and behaviors. These skills can be learned and improved through a combination of theoretical instruction and practical experience (Alfaro-LeFevre, 2009).

Critical-thinking is essential for processing information and engaging in skilled analysis in different patient care settings (Alfaro-LeFevre, 2006). Effective healthcare interventions such as acid-base management, airway management in emergency situations, and seizure management by nurses involve some amount of critical-thinking (Lee, Mann, & Frank, 2010). A nursing intervention is “any treatment, based upon clinical judgment and knowledge, which a nurse performs to enhance client outcomes” (Joanna Briggs Institute, 2011, p. 2). According to some research studies, nursing students with higher problem-solving ability and critical-thinking skills are more competent (Chaung, 2011; Park & Kim, 2009). Researchers also suggested that nursing education should prepare professionals to meet potential and actual client needs by inculcation of critical-thinking skills using PBL (Castledine, 2010).

Several governing bodies, such as State Nursing Boards, the Association of Colleges of Nursing, and the National Advisory Committee on Institutional Quality and Integrity, incorporate PBL for developing critical-thinking, as a core component of training and educating nurses (ANA, 2010a, 2010b; Korean Accreditation Board of Nursing, 2012). Many investigators from a wide range of cultures explored this topic (Brookfield, 1997; He & Van de Vijver, 2012; Oermann, 1990, 2012; Saeed et al., 2012; Schmidt et al., 2009). Yang (2010) suggested going beyond teacher-centered models and using the PBL approach to foster critical-thinking skills. Educators should enhance their ability to teach such skills to nursing students for best results (Saeed et al., 2012).

Conclusion

The concept of critical-thinking continues to grow in importance in nursing education; it is viewed as essential to providing optimal healthcare. The ANA guidelines proclaim that the nursing process involves the use of critical-thinking (ANA, 2010a). This skill involves mindful thinking with no abrupt or sudden decision-making. Theoretical and experiential knowledge in the form of intellectual skills and competencies are an important part of critical-thinking (ANA, 2010a).

Knowledge, caring (interpersonal relationships and attitudes), and technical expertise are all the components of critical-thinking. Important critical-thinking skills include influential learning, moral reasoning and values, understanding, analysis, synthesis, interpretation, mastery of knowledge, discernment and evaluation, and self-awareness (Finkelman, 2012). Intellectual humility is the most important component of critical-thinking (Paul, 1995). The willingness to admit limits of knowledge is critical for students, because it helps them have an upward learning curve. Intellectual integrity is another essential feature of critical-thinking. Continuous evaluation of thinking and understanding the limitations of cognition or intellectual integrity is vital for making correct clinical judgments. Intellectual courage, or the capacity to undertake and challenge concepts, viewpoints, and beliefs that may invoke critical emotions, is also needed for nurses to excel in their profession (Paul, 1995).

Critical-thinking plays a valuable role in the reduction of dichotomous thinking. Dichotomous thinking can lead to very selective black-and-white perspectives that limit decision-making capabilities in clinical situations (Paul, 1995; Scriven & Paul, 2008). Nurses cannot afford to use dichotomous thinking, because their decisions and judgments make a massive difference in patients' lifespans.

Effective problem solvers use critical-thinking. Therefore, nursing educators are exploring the use of PBL to help nursing students develop critical-thinking skills. PBL was originally designed for use in medical education, but the use of PBL has expanded and may well be suited for use in nursing education. PBL is associated with the evolution of critical-thinking skills, improved learning, and clinical performance, but findings displaying a difference between PBL and traditional teaching methods are mixed. Further research is warranted to assess the use of PBL in nursing education as a novel method in promoting critical-thinking, as there are limited studies that have been conducted on the use of PBL in nursing education.

Section 3: Research Method

This section provides a discussion of the research design and methodology used for this study. It includes a discussion of the field work, model design, background and trials, instrumentation and materials, data collection, and analysis. It also includes information about protecting participants' rights.

Researchers used a variety of methodologies and designs when conducting research on PBL (Kong et al., 2009; Mohammad & El Sabai, 2010; Twari, 2006; Walker & Leary, 2009). To assess critical-thinking through PBL in nursing education, I used a posttest methodology for this study. As part of the quasi-experimental research design, the first group was the experimental group, Group A, and the comparison group was Group B. Both groups were given the ATI Comprehensive Predictor exam at the end of the core nursing curriculum. Over the course of the first three semesters in the Fall 2012 program and Fall 2013 program, Group A was taught using PBL, and Group B was taught using traditional classroom lecture. By assessing critical-thinking and problem-solving skills after conducting a PBL exercise, I sought to determine whether PBL is a method that could be used to help nursing students develop critical-thinking and problem-solving skills (Beers, 2005; Ceconi et al., 2008).

Research Design and Approach

The purpose of this study, using archived quantitative data, was to examine the difference in critical-thinking and problem-solving skills between nursing students taught using PBL and those taught with traditional teaching methods. I used a quasi-experimental study design using methods that were humanistic and interactive (Creswell, 2008, 2014). This design allowed me to conduct the research in a natural setting under typical classroom learning conditions. The majority of nursing research is comprised of quantitative studies that focus on cause and effect, and mixed method studies sparked controversy over whether or not there is a binary distinction between quantitative and qualitative that will not hold up in practice (Cramer & Howitt, 2004; Creswell, 2008; Drew, Hardman, & Hosp, 2008; Salkind, 2010; Vogt, 2005).

In this study, I used data gathered from students enrolled in LPN and RN nursing programs. The data consisted of archived test scores for the ATI Comprehensive Predictor exam for students in the 2012 LPN and RN programs who were taught with either traditional classroom lecturing or PBL in all courses and students in the 2013 LPN and RN programs who had also been taught with traditional classroom lecturing or PBL in all courses. Two nursing instructors taught a group of LPN students in the 2012 nursing program and a group of RN students in the 2013 program using PBL. Two other instructors taught a group of RN students in the 2012 program and a group of LPN students in the 2013 program using traditional classroom lecturing.

Research Question

Through this study, I addressed one main research question: what is the difference in critical-thinking and problem-solving skills between nursing students taught using PBL and those taught using traditional methods? This research question was answered by testing the following hypothesis:

Null Hypothesis 1: There will be no significant difference ($p > 0.05$) for the ATI Comprehensive Predictor test between students taught with PBL and students taught with traditional instructional methods when controlling for nursing fundamental knowledge.

Alternative Hypothesis 1: Students taught using PBL *will have* significantly ($p < 0.05$) higher scores on the ATI Comprehensive Predictor test compared to students taught with traditional instructional methods when controlling for nursing fundamental knowledge.

Setting and Sample

This study was conducted with a group of nursing students enrolled in a nursing program at a community college in a southern state (SSCC). This nursing program was started in 2000, and has graduated more than 300 students into the local workforce. Entrance into the SSCC nursing program is competitive, with applications being accepted only twice a year (fall and spring) at two of the college's campus locations. The associate degree registered nurse, associate degree mobility registered nurse (ADN), and licensed practical nurse (LPN) programs consist of a year of prerequisites and five semesters in the core curriculum. In the fall and spring semesters, 135-160 students (RN and LPN students combined) are admitted into the programs; depending on the attrition rate in subsequent semesters, the number of students in each program can range from 10 to 60.

The total sample population for this study was approximately 200 students enrolled in the LPN and RN nursing programs for 2012 and 2013. Convenience sampling was used because the students were in naturally formed classroom groups and their archived information was readily accessible. The sample from the 2012 nursing programs consisted of 45 LPN and 52 RN students. The sample from the 2013 nursing programs consisted of 47 LPN and 56 RN students. This sample size was due to the restricted number of students admitted into the program and the trend of there being approximately 20 or 60 students remaining in the LPN and RN programs, respectively. Using G Power software to calculate sample size (with settings of .5 for effect size, .05 for err probability, .95 for power, and .85 for n2/n1 allocation ratio), the total required sample size would be 176, with Group 1 including 95 students and Group 2 containing 81. Based on the analysis, a total sample of 200 students, with 108 in Group 1 and 92 in Group 2, was appropriate. Participant consents were not obtained because this study used deidentified, archived information.

Treatment

The two groups assessed consisted of full-time LPN and RN students enrolled in the nursing program. After IRB approval was granted, the archived data for both groups were retrieved and analyzed using ANCOVA on the ATI Fundamentals nurse exam proxy pretest scores and the ATI Comprehensive Predictor posttest exam scores. One group of students received instruction through the PBL method, which incorporated case scenarios. The other group of students received instruction by traditional methods of content delivery, such as classroom lectures. Both groups of students took the ATI Fundamentals pretest at the beginning of the first semester in the core curriculum and the ATI Comprehensive Predictor posttest at the end of the program year. The pretest consisted of 60 questions that tested the students' knowledge of basic fundamental nursing concepts. The posttest consisted of 150 questions that tested comprehensive knowledge of nursing concepts, skills, and applications. The pretest and posttest are not considered equal; therefore, the pretest scores were used as proxy pretest scores I occasionally teach a course in the nursing program, but I am not one of the primary instructors, and I did not teach either of the groups involved in the study. There were no conflicts of interest, in terms of association with the participants, especially given that the data were deidentified.

Instrumentation and Materials

The data collection instruments used in the study were the ATI Fundamentals nurse exam and the ATI Comprehensive Predictor exam. The ATI test is specifically designed to allow educators to supplement coursework, restructure courses and staff development, refine students' problem-solving ability and test outcomes, and lower attrition rates (Assessment Technologies Institute, 2012b). The design of the ATI test is given as both a fundamentals nurse exam pretest and a comprehensive predictor posttest. The ATI Fundamentals nurse exam pretest scores are used to measure nursing students' fundamental knowledge of basic nursing skills and concepts after beginning core nursing courses and to provide educators with baseline data on students' critical-thinking and problem-solving ability (Assessment Technologies Institute, 2012b). The ATI Fundamentals pretest scores are also used to "guide remediation efforts based on the exam content missed" (Assessment Technologies Institute, 2012b, p. 30). The ATI Comprehensive Predictor test is an instrument used to measure students' overall knowledge of all nursing concepts and skills after completing the core nursing courses, and to assist faculty in improving student and program outcomes (Assessment

Technologies Institute, 2012a). The ATI Comprehensive Predictor posttest scores are used as an indicator of the predicted probability that a student will or will not pass the NCLEX-RN/PN exam required to obtain licensure (Assessment Technologies Institute, 2012a, 2013).

The overall ATI Comprehensive Predictor score, composed of scores from different content areas, was used as the dependent variable to determine statistical differences ($p < 0.05$) between Group A and Group B. The results of the archived Fundamentals nurse exam scores indicated the individual and group proficiency levels and areas where continued, focused review was needed to maintain and/or improve the students' knowledge, critical-thinking ability, and understanding of the content areas (ATI Fundamentals Score Explanation, 2012a, 2013). An example of a detailed explanation of the ATI Comprehensive Predictor posttest scores is provided in Appendix C: Example of ATI Comprehensive Score Interpretations. The results of the posttest scores showed the individual students' probability of passing the NCLEX-RN and NCLEX-PN exams, and a list of content areas and topics that needed further review (Assessment Technologies Institute, 2012a, 2013).

The ATI testing was administered prior to the study; these test scores were used as archival data. The ATI tests were given to each group simultaneously using computers at SSCC as proctored group tests to ensure that none of the questions on the test were disclosed. Prior to the participants logging into the exam, all testing computers were checked for readiness and proper functioning. Instructions for checking the computers for readiness were provided by ATI. Once logged into the testing site, each test taker was assigned a unique ID number, which allowed for tracking the scores of the participants. The ATI test is completely self-directed, and proctors supervised all test takers.

An analytical report of each ATI test taken by the participants was provided and measured the following constructs of critical-thinking: examination, reasoning, deduction, judgment, clarification, and self-regulation (Assessment Technologies Institute, 2001). An example of the results provided after the participants took the ATI Comprehensive Predictor (Appendix B) shows each individual's overall, national, and program percentile ranking; the predicted probability of the individual passing the NCLEX; whether the institutional benchmark was met; and the adjusted individual score.

Although the descriptive nature of the test captures many different types of data, the overall ATI Comprehensive Predictor 2012 and 2013 scores were used in the analysis as these scores represent overall critical-thinking and problem-solving ability. Greater ATI scores indicate a greater critical-thinking capacity, while lower scores suggest a decreased critical-thinking capacity (Assessment Technologies Institute, 2012b). A two-group postest-only *t*-test analysis was used to determine whether there were any significant differences ($p < 0.05$) between the two different groups' posttest scores. I hypothesized that the mean score for the group taught using PBL would be significantly higher than the mean score for the group taught using traditional class lectures.

Ensuring content and construct validity was of the utmost importance. *Content validity* refers to the ability of a test to identify and capture a pertinent domain and indicates that the testing instrument correlates the questions with the subject matter, skills, and behavior the field identifies as critical and necessary (Assessment

Technologies Institute, 2001). The ATI Comprehensive Predictor shows evidence of construct validity in the improvement of students' test scores after they have taken a critical-thinking course or received an instructional method that is geared toward assisting learners in developing critical-thinking. "The construct validity for the ATI Comprehensive Predictor was established by an extensive review of the literature regarding critical-thinking theory" (Assessment Technologies Institute, 2001, p. 22). *Construct validity* is primarily used in theory testing and refers to the level to which a tool measures a hypothetical construct (Assessment Technologies Institute, 2001). Much research regarding construct validity on the ATI Comprehensive Predictor shows that this ATI test demonstrates validity to measure critical-thinking ability and the overall performance of specific critical-thinking and problem-solving skills that are determined necessary for students to be successful in an academic program for nursing (Assessment Technologies Institute, 2001). ATI testing instruments consistently met the threshold for strong internal consistency reliability (Assessment Technologies Institute, 2012b). The ATI Technical Manual (2012b) also explains how the ATI Comprehensive Predictor provides information on the number of test items, standard deviations, alpha internal reliability coefficients, and standard errors of measurement for total test scores.

> The reliability coefficients on the Comprehensive Predictor are lower, and the corresponding standard error of measurement higher, for the subscores than the total scores. This is to be expected given that the content area scores are based on fewer items than the total test scores. (Assessment Technologies Institute, 2012b, p. 17)

The overall ATI scores represent general critical-thinking and problem-solving ability, with higher scores indicating an increased critical-thinking capacity and lower scores suggesting a decreased critical-thinking capacity. The raw data for this research are available upon request.

Data Collection and Analysis

The data were retrieved from SSCC's archived ATI Fundamentals pretest and the ATI Comprehensive Predictor 2012 and 2013 posttest scores. Hellerstein (2008) noted that a prominent source of data quality issues is data entry errors. Students take ATI tests online, and they are scored automatically. The testing system feeds the scores to a database at the college. This system, which Hellerstein (2008) termed the *data entry interface design*, should prevent data entry errors. To prevent data entry errors, each data point was carefully checked as the information was entered and then checked again after all data had been entered into an SAS file. Upon receiving the data, I performed a descriptive statistical analysis and visually inspected the data to identify any outliers that could adversely affect the analysis, a process Hellerstein called *outlier detection*. Additionally, any scores on the Fundamentals pretest exam that did not have a corresponding score on the Comprehensive Predictor exam were eliminated from the data set.

The ATI Fundamentals nurse exam scores were used as proxy pretest scores because the pretest and posttest scores are not considered equivalent and because the ATI Fundamentals nurse exam scores were obtained after students began their first semester of nursing core courses. The data were analyzed with SAS Version 9.2 software (SAS

Institute, Inc., Cary, NC, USA). Internal reliability was ensured with Cronbach's alpha, and prior to running the posttest-only ANCOVA, all data were tested for normality and the assumptions of homogeneity. The ANCOVA yielded an analysis of the difference between the mean ATI Comprehensive Predictor scores (dependent variable) of the experimental and control groups (Laerd Statistics, 2013a). The ANCOVA was used to examine the relationship between the two different teaching groups and the ATI posttest scores for individual reasoning skills, reflective decision making, and problem-solving in healthcare. For each posttest-only analysis, the individual ATI overall score and the individual percentile ranking for students from the two groups were compared. The percentile rankings of students were arch sine square root transformed prior to analysis. Further exploratory tests compared the relationship of the two research groups with the scores in the areas of interpretation, analysis, evaluation, inference, explanation, and self-regulation.

Protection of Participants' Rights

To safeguard the participants and assure the protection of their rights throughout this research, the highest level of ethical research standards was upheld. I successfully completed the National Institutes of Health (NIH) web-based training course Protecting Human Research Participants as evidenced by the certificate in Appendix A. Prior to starting the research, authorization was granted to collect data from SSCC's Director of Nursing and the IRB at Walden University. The data collected from the SSCC Director of Nursing was coded for each student in both groups to ensure that no one could be identified.

To protect the privacy of the participants, the data obtained was deidentified, precluding any opportunity to inadvertently disclose distinctive or recognizable student information in any lecture or dialogue about the outcome of the study. Because of the proprietary nature of the ATI Comprehensive Predictor, specific test questions will not be divulged. At all times, electronic information was cached on a safe, desktop computer in my office and/or home, and at the research site. Additionally, all hardcopy information was kept in a sealed credenza in my office. All information will be kept for a minimum of 5 years, and then destroyed per SSCC’S policy regarding the destruction of institutional information.

Summary

This section described the methods that informed the research study on the impact of PBL on nursing education as compared to traditional forms of nursing education, particularly that which is delivered in a lecture format. These different forms of instruction were analyzed to ascertain the affect they had on 200 nursing students' performance in the core curriculum of the nursing program and their results on the ATI pretest and posttest. Through this consideration of the means by which these students’ education methodologies inform their performance in class and on the tests in question, an assessment of the use of PBL and traditional classroom lecturing was made.

This section also established the means by which the validity of the ATI tests, as well as the assessment procedure itself, was determined. Validity is a crucial element because it ensured that the experimental methodology was informed by a testing tool that is consistent across both study criteria. Critical-thinking and problem-solving are not skills that are tested by traditional means of assessment, but the ATI can evaluate students' skills reflective of the experimental groups' problem-based nursing education. The participants of the control group were assessed on their skills and learning reflective of a traditional lecture format, and their retention of information was tested by the same instrument. The ATI was shown to be a valid means by which both experimental PBL-based education and the control lecture-based education can be assessed. Section 4 will present the results of this study, and Section 5 will provide discussions, conclusions, and recommendations.

Section 4: Results

Introduction

The purpose of this study was to examine the difference in critical-thinking and problem-solving skills in nursing students after being exposed to a treatment. Specifically, this study addressed one main research question: What is the difference in critical-thinking and problem-solving skills between nursing students taught using PBL and those taught using traditional methods? The data for this study were extracted from the archived Assessment Technology Institute (ATI) Fundamentals pretest and Comprehensive Predictor 2012 and 2013 posttest scores. As the pretest and posttest scores measure different concepts, the pretest scores were not a factor in comparing posttest scores.

Sample Data

Using SPSS software, I analyzed the results of archived test scores for the ATI Comprehensive Predictor for two groups of nursing students. The sample consisted of 45 LPN and 52 RN students from the 2012 nursing programs, and 47 LPN and 56 RN students from the 2013 nursing programs. All participants met the requirements to be accepted into the nursing programs and were given an ATI Fundamentals pretest during the first semester of core nursing curricula. The ATI Fundamentals pretest tested the participants' knowledge of basic nursing concepts and skills prior to being exposed to the treatments. The research groups were an experimental group and a control group. Experiment Group A consisted of 45 LPN students from the 2012 nursing program and 56 RN students from the 2013 nursing program, who were taught using PBL.

Comparison Group B consisted of 52 RN students from the 2012 nursing program and 47 LPN students from the 2013 nursing program, who were taught using traditional classroom lectures.

Data Cleaning

Prior to data analysis for this research, the data were cleaned and the ATI Comprehensive Predictor scores were subjected to descriptive analysis, which provided mean scores for overall comprehension in individual categories such as interpretation, analysis, evaluation, inference, explanation, and self-regulation. An example of a detailed explanation of the ATI Posttest score is provided in Appendix E (ATI Comprehensive Predictor 2012a, 2013). The results of the posttest scores showed the individual students' probability of passing the NCLEX-RN and NCLEX-PN exams and a list of content areas and topics that needed further review (ATI Comprehensive Predictor 2012a, 2013).

Descriptive Analysis

The data for this study were first placed into an Excel spreadsheet (Appendix D) and then transferred into SPSS for analysis. Any scores on the Fundamentals exam that did not have a corresponding score on the Comprehensive Predictor exam were eliminated from the data set prior to being analyzed. Archived data were collected from participants representative of both the LPN and RN programs who had been taught by the same instructor. The scores of LPN students from the 2012 group and RN students from the 2013 group were used because these two groups were taught by instructor 1AK (identification used to represent the instructor who taught using PBL). Conversely, the scores of RN students from the 2012 group and LPN students from the 2013 group were used because these two groups were taught by instructor 2MD (identification used to represent the instructor who taught using traditional classroom lectures). The archived pretest scores were based on 60 questions testing the students' fundamental knowledge of basic nursing concepts.

Assumptions for ANCOVA

Before estimating an ANCOVA, the data must meet nine assumptions without any of the assumptions being violated. The nine assumptions that must be met are as follows (Laerd Statistics, 2013):

- Assumption 1: Dependent and covariation should be measured on a constant scale. Both the dependent variable and covariate are percentage scores.
- Assumption 2: Independent variable should consist of more than two unequivocal, independent groupings. In this study, the two groups were those who were taught with PBL and those who were not.
- Assumption 3: Independence of observations. Participants should be different in each independent group. In this study, the participants were assigned using convenience sampling to control and treatment groups.
- Assumption 4: No outliers. The data series should not have outliers when estimating ANCOVA.
- Assumption 5: Dependent variable should be roughly spread naturally for every group of independent variables.
- Assumption 6: Homogeneity of variances.

- Assumption 7: Covariate should be linearly associated with the dependent variable at each extent of the independent variable.
- Assumption 8: Homoscedasticity of residual after fitting the ANCOVA model.
- Assumption 9: Homogeneity of regression slopes. The interaction variable between covariate and independent variable should not be significant.

Assumptions Testing for ANCOVA

The data series for the Fundamentals nurse exam proxy pretest scores and the Comprehensive Predictor posttest scores were transformed using arcsine transformation prior to the ANCOVA analysis. The assumptions of dependent and covariation, independent variable consisting of at least two groups, and independence of observation were met by virtue of the data being continuous, the participants being assigned through convenience, and the presence of two independent groups (PBL taught and non-PBL taught). Outliers were identified and removed from the analysis as shown in Figures 1 and 2.

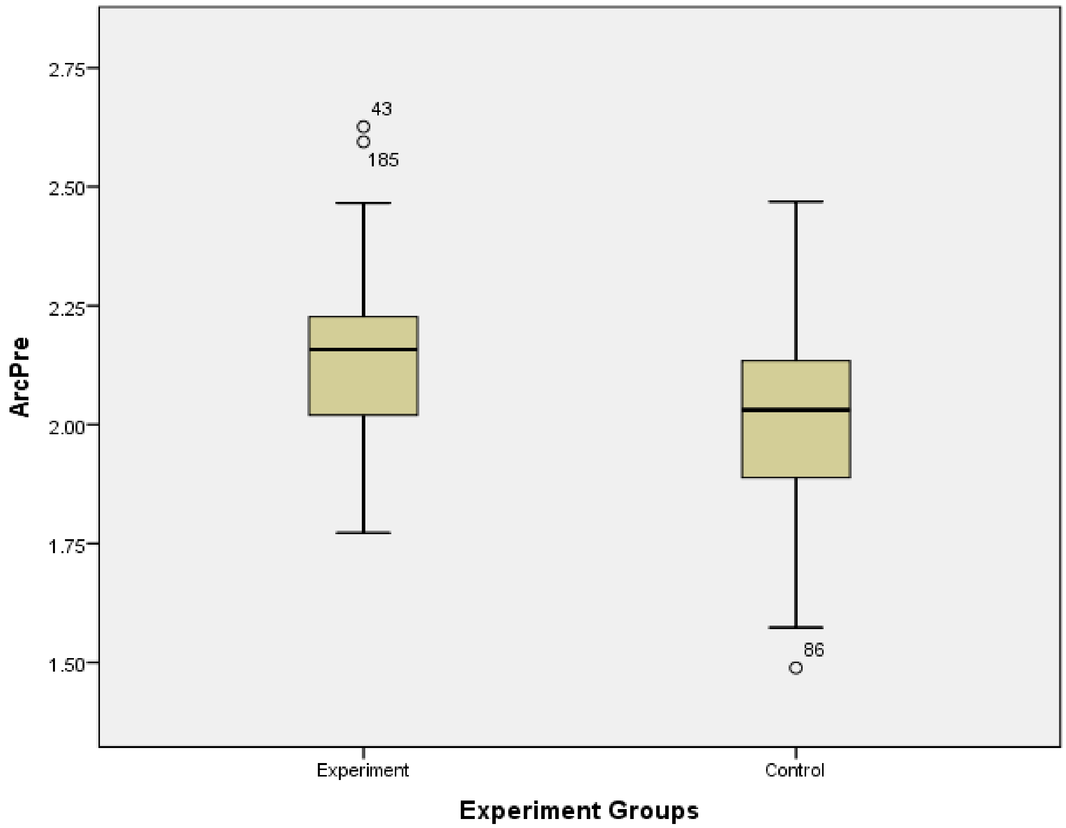

Figure 1. Identified outliers removed from analysis of proxy pretest scores for experiment (PBL) and control (non-PBL) groups.

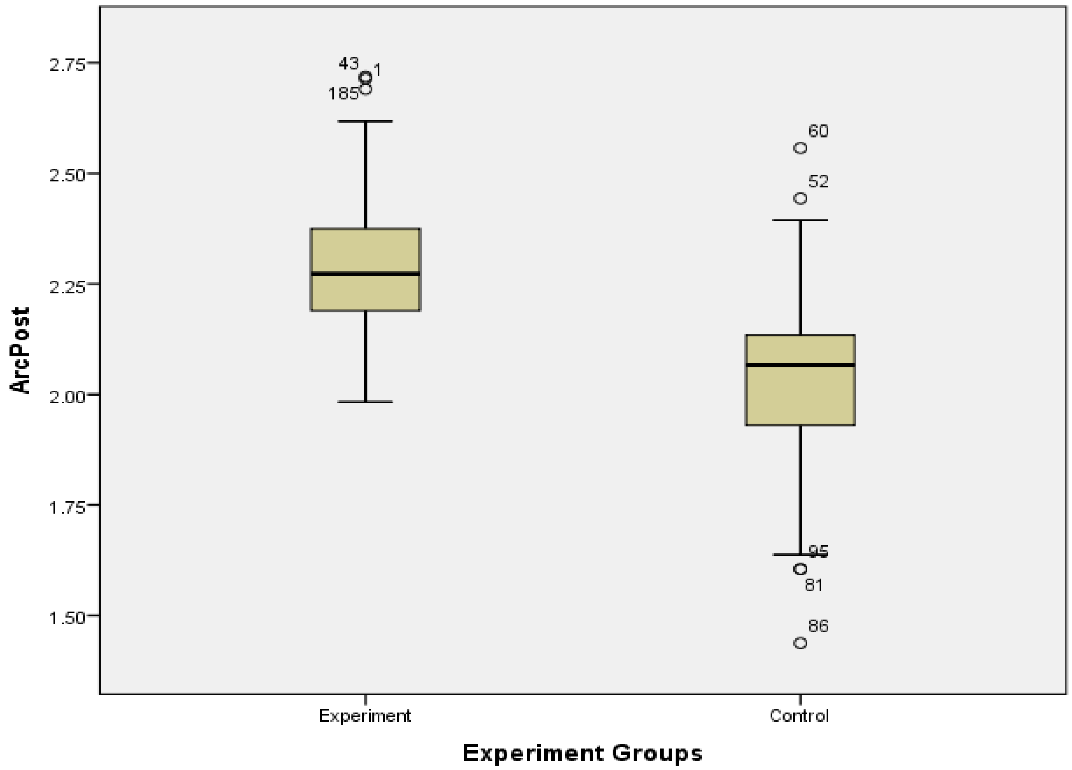

Figure 2. Identified outliers removed from analysis of posttest scores for experiment (PBL) and control (non-PBL) groups.

The Shapiro-Wilk test was used to establish the test of normality. The sig value or *p* value was > alpha value of 0.05. The results of the Shapiro-Wilk test showed the data to be normally distributed and nonsignificant; therefore, the null hypothesis could not be rejected as shown in Table 1 and Figures 3 and 4. Fundamentals nurse exam proxy pretest is normally distributed and thus meets the assumptions of a posttest-only design, and the control posttest is not normally distributed; however, this did not pose a significant problem because the experimental group is normally distributed.

Table 1

Test of Normality Experiment (PBL) and Control (Non-PBL) Group's Proxy Pretest Data and Posttest Data

Tests of Normality

	Experiment groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	*df*	Sig.	Statistic	*df*	Sig.
ArcPre	Experiment	.102	98	.013	.983	98	.225
	Control	.070	94	.200*	.984	94	.313
ArcPost	Experiment	.084	98	.082	.981	98	.181
	Control	.086	94	.085	.981	94	.174

Note. This is a lower bound of the true significance.

[a]Lilliefors significance correction

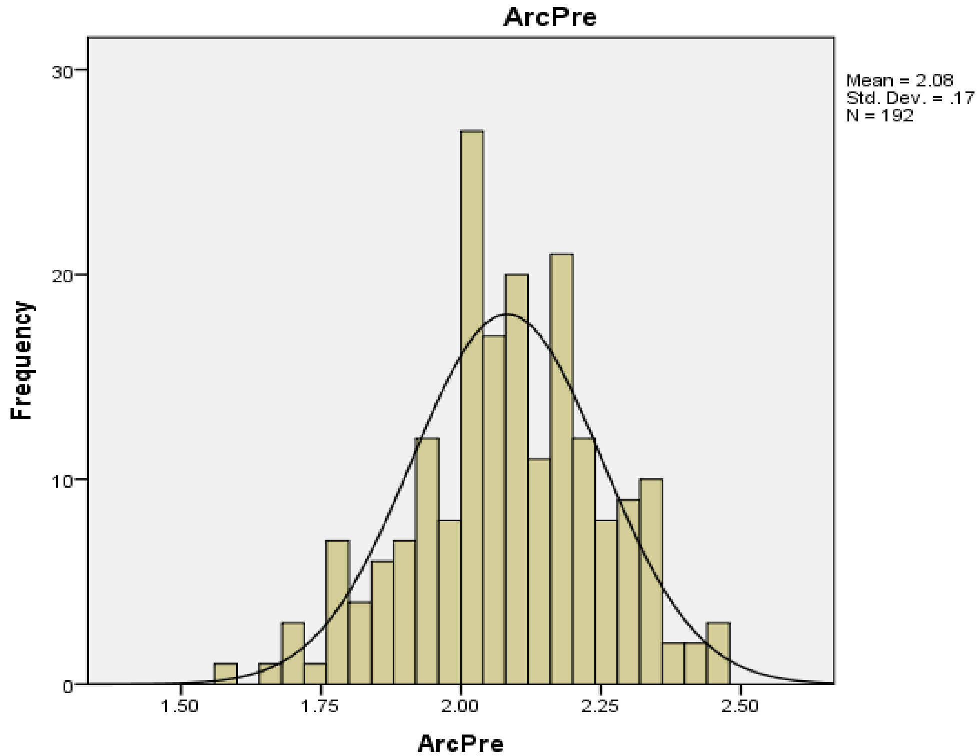

Figure 3. Histogram of fundamentals exam proxy pretest scores for experiment (PBL) and control (non-PBL) groups.

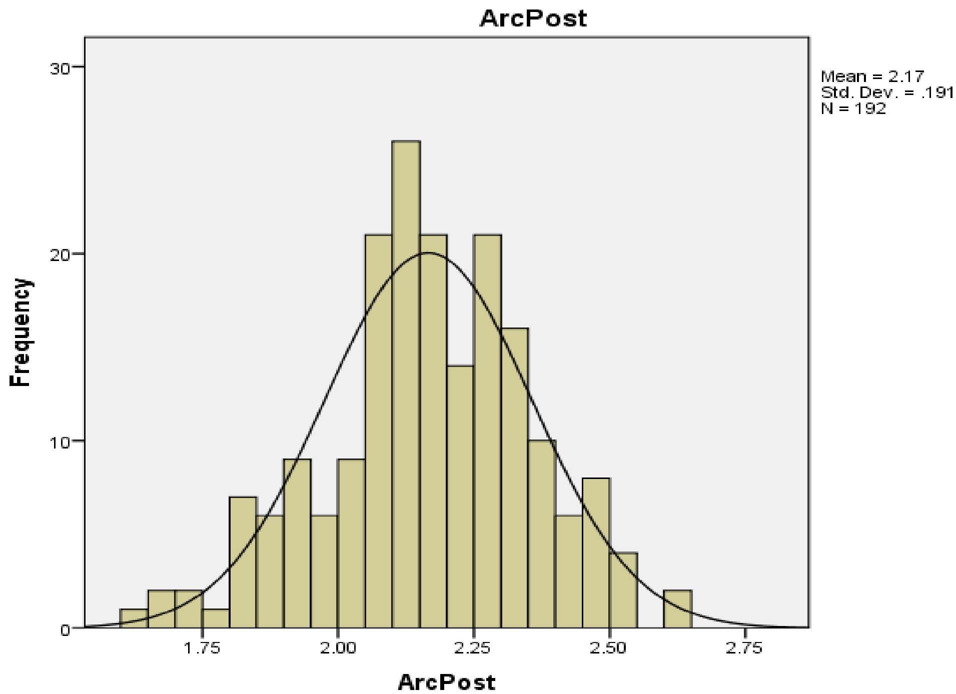

Figure 4. Histogram of comprehensive predictor exam posttest scores for experiment (PBL) and control (non-PBL) groups.

The Levene's test of homogeneity of variance was performed. The sig value was greater than the alpha level (0.05), which indicated that the data met the homogeneity of variance assumption as shown in Table 2.

Table 2

Levene's Test of Homogeneity of Variances for Proxy Pretest Scores and Comprehensive Predictor Posttest Scores

	Levene's statistic	*df1*	*df2*	Sig.
ArcPre	2.502	1	190	.115
ArcPost	2.869	1	190	.092

Figures 5 and 6 show evidence that the covariate (Fundamentals nurse exam proxy pretest) was linearly associated with the dependent variable at each level of the independent variable. The scatterplot of the experimental data showed a linear relationship between the dependent variable and independent variable.

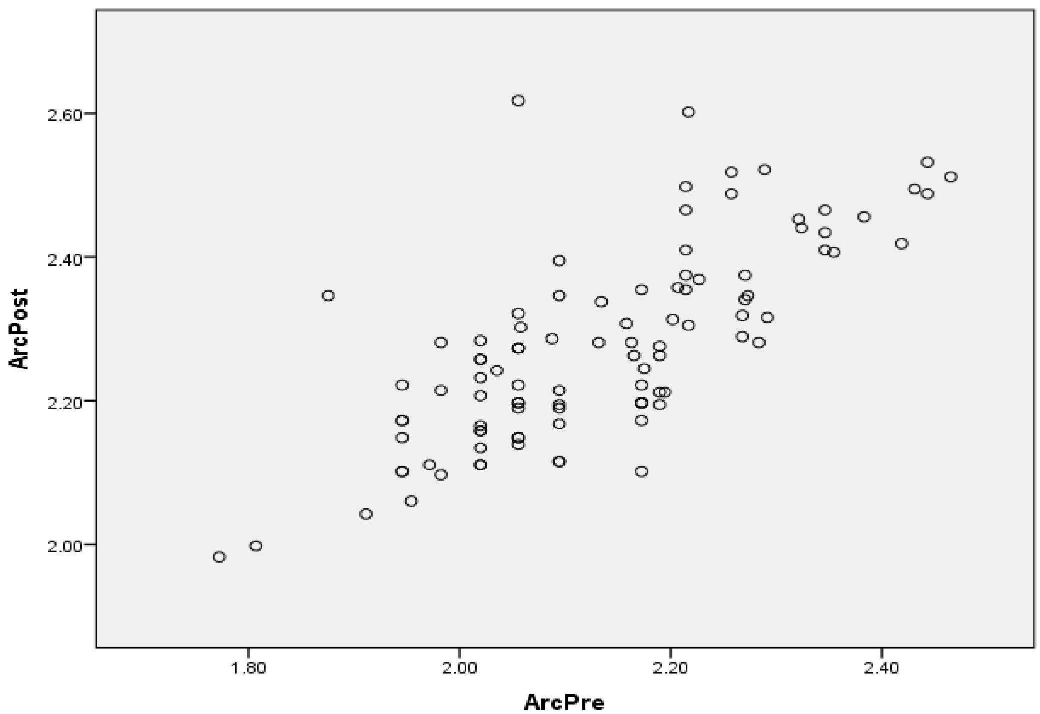

Figure 5. Scatterplot for experiment (PBL) groups data for proxy pretest and comprehensive predictor posttest.

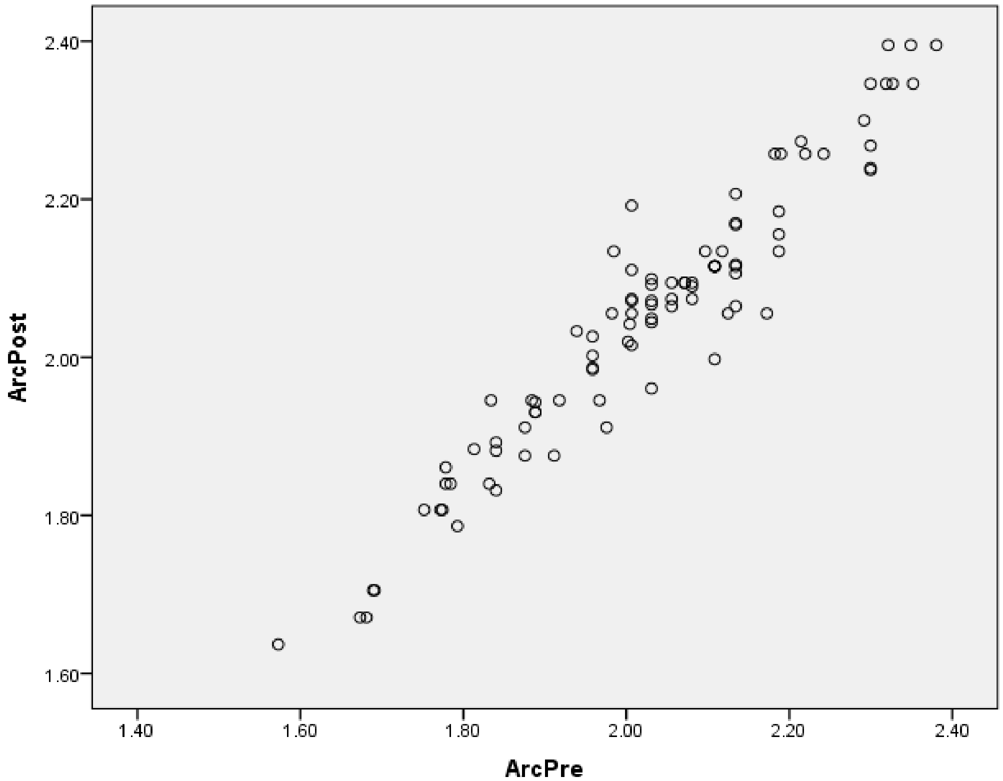

Figure 6. Scatterplot for control groups (non-PBL) data for proxy pretest and comprehensive predictor posttest.

Overall correlations, though not required by the assumption, were included in the output, as they were a measure of linear association. There was a highly significant positive correlation between the pre- and posttest scores as shown in Tables 3, 4, and 5.

Table 3

Pearson Correlation of Proxy Pretest and Comprehensive Predictor Posttest Scores

		ArcPre	ArcPost
ArcPre	Pearson correlation	1	.855**
	Sig. (2-tailed)		.000
	N	192	192
ArcPost	Pearson correlation	.855**	1
	Sig. (2-tailed)	.000	
	N	192	192

** Correlation is significant at the 0.01 level (2-tailed).

Table 4

Pearson's Correlation for Experiment (PBL) Group's Proxy Pretest and Comprehensive Predictor Posttest Correlation

		ArcPre	ArcPost
ArcPre	Pearson correlation	1	.740**
	Sig. (2-tailed)		.000
	N	98	98
ArcPost	Pearson correlation	.740**	1
	Sig. (2-tailed)	.000	
	N	98	98

** Correlation is significant at the 0.01 level (2-tailed).

Table 5

Pearson's Correlation for Control (Non-PBL) Group's Proxy Pretest and Comprehensive Predictor Posttest

		ArcPre	ArcPost
ArcPre	Pearson correlation	1	.961**
	Sig. (2-tailed)		.000
	N	94	94
ArcPost	Pearson correlation	.961**	1
	Sig. (2-tailed)	.000	
	N	94	94

** Correlation is significant at the 0.01 level (2-tailed).

Testing for homoscedasticity of residual showed that the residuals were equally distributed with regard to the 0 value on the y-axis. This result proved the assumption of homoscedasticity (Figure 7).

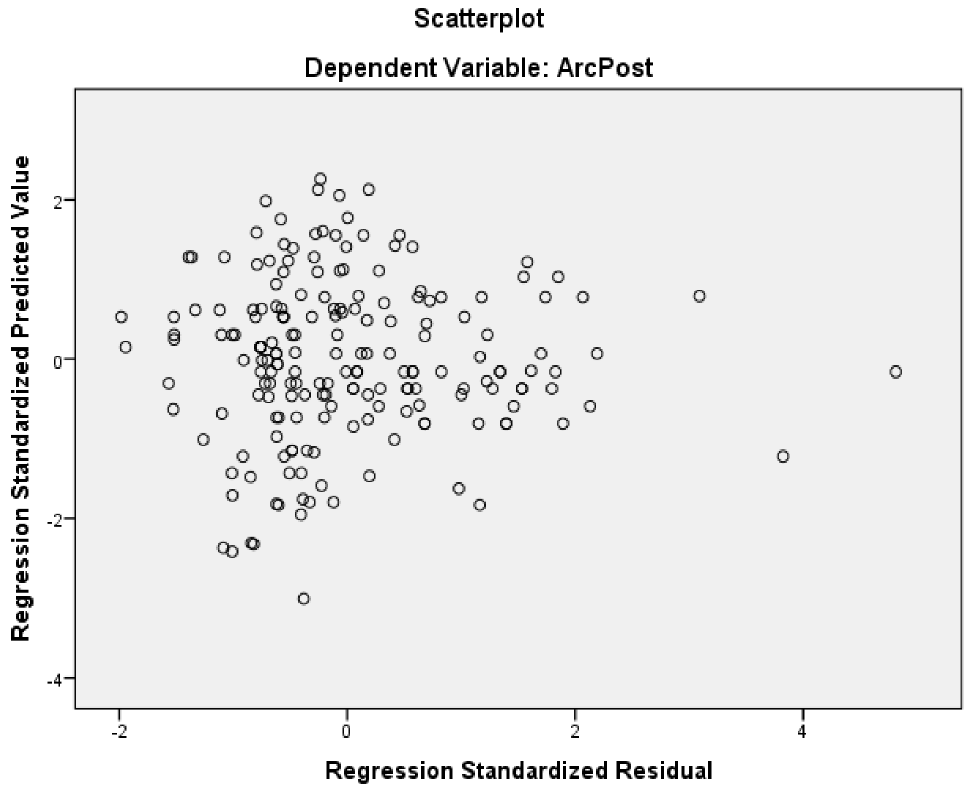

Figure 7. Scatterplot for dependent variable assumption of homoscedasticity

According to the assumption of homogeneity of regression slopes, the interaction variable between covariate and independent variable should not be significant. Table 6 shows the significance of the interaction term and shows that the regression lines of the covariate and dependent variable are not parallel for each group of independent variable (PBL and non PBL). Therefore, the interaction term of the independent variable and covariate is significant *(p* value = .001), which indicated that the critical assumption of homogeneity of regression slopes had been violated in the data. As a result, the ANCOVA model cannot be estimated. The interaction term is defined as PBL/Non-PBL*ArcPre.

Table 6

Test of Homogeneity of Regression Slopes

Source	Type III sum of squares	*df*	Mean square	*F*	Sig.	Partial eta squared
Corrected model	5.956[a]	3	1.985	366.462	.000	.854
Intercept	.243	1	.243	44.891	.000	.193
PBL/Non-PBL groups	.104	1	.104	19.259	.000	.093
ArcPre	3.167	1	3.167	584.621	.000	.757
PBL/Non-PBL groups * ArcPre	.064	1	.064	11.839	.001	.059
Error	1.018	188	.005			
Total	907.741	192				
Corrected total	6.974	191				

Note. Dependent variable: ArcPost.
[a]*R* squared = .854 (adjusted *R* squared = .852).

To address the violation of the assumption of homogeneity of regression slopes, I then conducted a two-way analysis of variance (ANOVA). The key reason for performing a 2x2 ANOVA is to see if there is a relationship between the independent variables, and the dependent variable (Laerd Statistics, 2013). The independent variables for this study were the experiment and control groups and the high/low groups, and the dependent variable was the ATI Comprehensive Predictor exam posttest scores. The two-way ANOVA juxtaposes the mean differences among groups that have been split into two factors or independent variables (Laerd Statistics, 2013).

Assumptions for ANOVA

Before performing an ANOVA, the data must meet six assumptions without any of the assumptions being violated. The six assumptions that must be met are as follows (Laerd Statistics, 2013):

- Assumption 1: Dependent variable (Comprehensive Predictor posttest scores) is measured continuously.
- Assumption 2: Two independent variables (the experiment and control groups and the high/low groups) consists of two categorical, independent groups.
- Assumption 3: Independence of observations or no relationship between observations within each group.
- Assumption 4: Normally distributed dependent variable data for each blend of groups (Shapiro-Wilk test was used to test normality $p > 05$). Q-Q plots, box plots were done to support the normality conclusion).
- Assumption 5: No sign of outliers.
- Assumption 6: Homogeneity of variances for each combination of the groups (Levene's test of equality of error variance has not been violated after the transformation $p = .064$).

Assumptions Testing for ANOVA

The data series for the Fundamentals nurse exam proxy pretest scores and the Comprehensive Predictor posttest scores were transformed using arcsine transformation prior to the ANOVA analysis. I first ran the ANOVA for the 2012 and 2013 experiment and control groups separately. Analysis of the scores for the 2012 experiment groups showed the assumption of normally distributed data for the group taught with PBL was violated and showed there were outliers in the posttest scores (Table 7).

Table 7

Test of Normality Experiment and Control Groups Before Outliers Removed

Tests of Normality[a]							
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	PBL/Non-PBL groups	Statistic	*df*	Sig.	Statistic	*df*	Sig.
ArcPost	PBL	.190	45	.000	.895	45	.001
	Non-PBL	.099	52	.200*	.982	52	.605

Note. This is a lower bound of the true significance.
[a]Year = 2012. [b]Lilliefors significance correlation.

I then removed the outliers, which resulted in a decrease of the number of LPN's to 43 from 45. I ran the ANOVA again and the results still showed a violation of the assumption of normally distributed data with the *p* value = .011. Normal Q-Q plots and a histogram were done to support the normality conclusion (Figures 8 and 9). Due to the failure of this assumption, the results were not deemed to be reliable (Laerd Statistics, 2013).

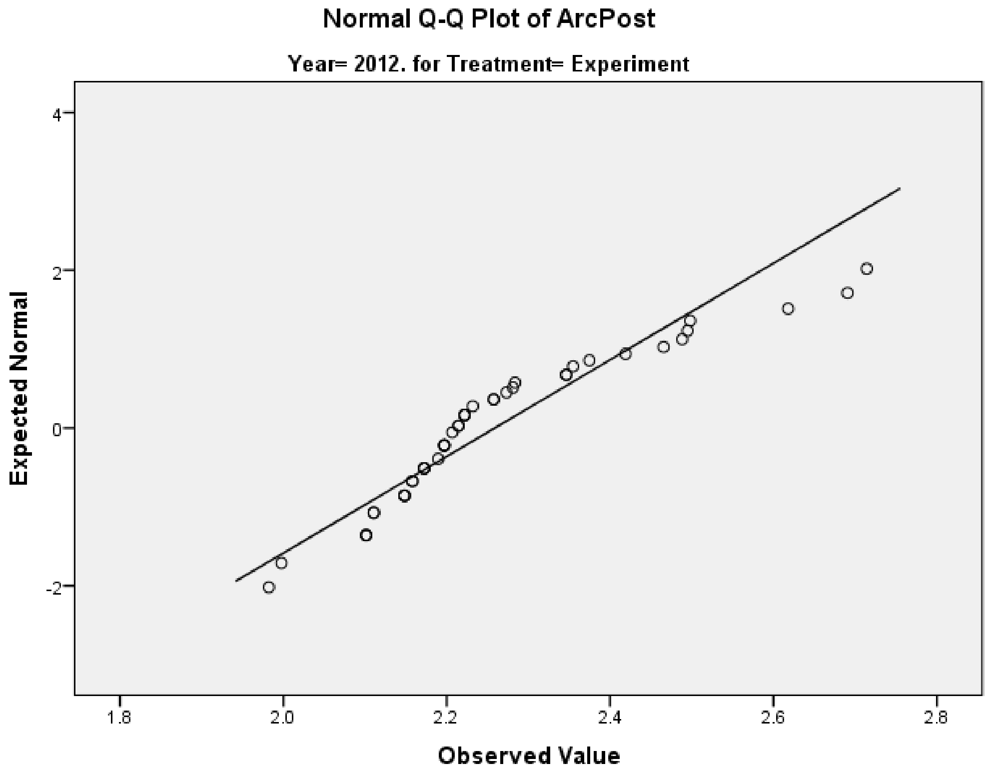

Figure 8. 2012 experiment (PBL) group dataset normal q-q plots after outliers removed.

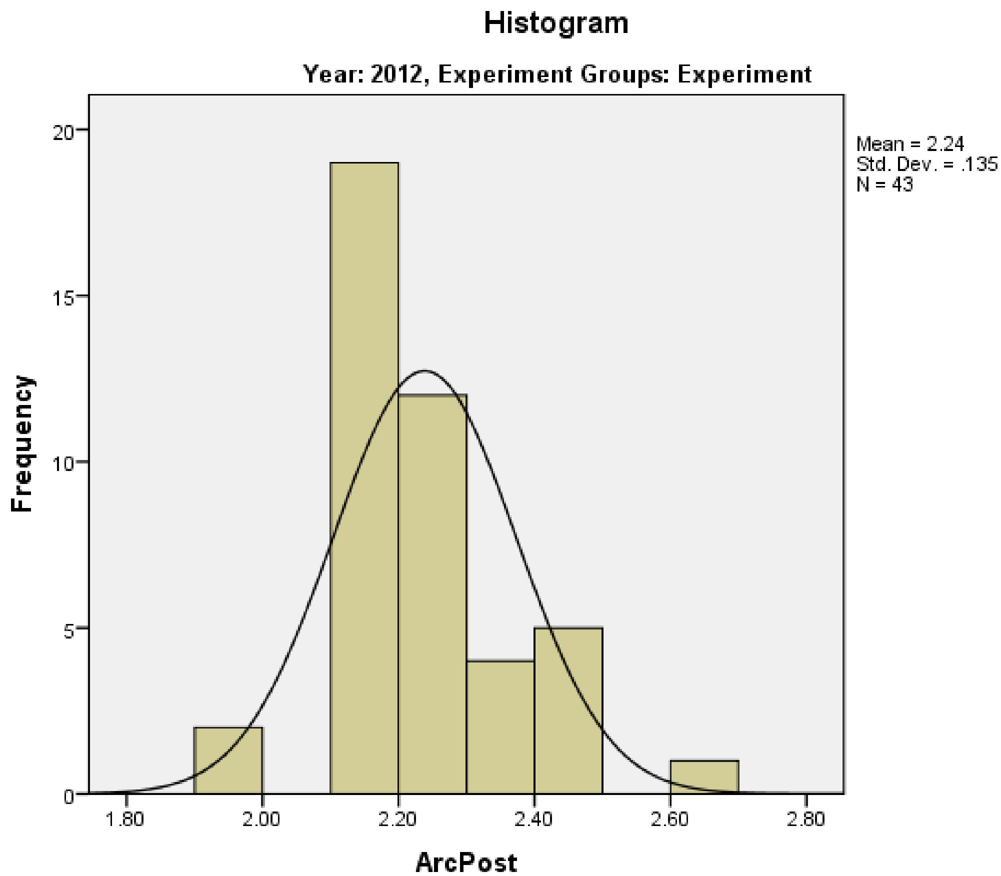

Figure 9. 2012 experiment (PBL) and control (non-PBL) group's histogram after outliers removed.

The assumptions of normality, for the 2013 PBL and non-PBL groups, and the pretest high and low groups, were not violated. However, the Levene homogeneity test of variance was violated (Table 8, 9, and 10), therefore the results may not be reliable (Laerd Statistics, 2013). Outliers were also identified and removed from this dataset. This action resulted in a decrease of the number of LPN's from 47 to 44 and RN's from 56 to 55, resulting in a total sample size of 192. The interaction between the PBL and non-PBL, and pretest high and low scores is not significant with a *p* value of .171.

Table 8

2013 Test of Normality Experiment (PBL) and Control (Non-PBL) Groups After Outliers Removed

Tests of Normality[a]							
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	*df*	Sig.	Statistic	*df*	Sig.
ArcPost	PBL Groups	.061	55	.200*	.987	55	.817
	Non-PBL	.136	44	.040	.971	44	.327

[a]Year = 2013. [b]Lilliefors significance correction.
*This is a lower bound of the true significance.

Table 9

Test of Normality High and Low Groups After Outliers Removed

Tests of Normality[a]							
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Pretest category	Statistic	*df*	Sig.	Statistic	*df*	Sig.
ArcPost	Low	.129	36	.135	.963	36	.261
	High	.100	63	.187	.967	63	.089

[a]Year = 2013. [b]Lilliefors significance correction.

Table 10

2013 Levene's Test of Equal Variances

Levene's Test of Equality of Error Variances[a,b]			
F	*df1*	*df2*	Sig.
4.461	3	95	.006

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.[a,b]
Dependent variable: ArcPost.
[a]Year = 2013. [b]Design: Intercept + Treatment + Pre_Category + Treatment * Pre_Category.

Due to the violations of normal distribution and homogeneity of variance, I then ran the ANOVA on the 2012 and 2013 years combined. The assumption of normally distributed data for each combination of the groups was violated, and outliers were present in the posttest scores. Arcsine transformation was conducted on the dependent variable (Comprehensive Predictor posttest exam). The Shapiro-Wilk test was used to test normality ($p > .05$), and normal distribution was no longer violated (Table 1). Levene's test of equality of error variance was performed, and homogeneity of variances (Table 11) for each combination of the groups was not violated after the transformation $p = .225$.

Table 11

Levene's Test of Homogeneity of Variances for Comprehensive Posttest Scores

Levene's Test of Equality of Error Variances[a]			
Dependent variable: ArcPost			
F	*df1*	*df2*	Sig.
1.467	3	188	.225

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
[a]Design: Intercept + Treatment + Pre_Category + Treatment * Pre_Category.

The 2012 and 2013 PBL and non-PBL groups, and the 2012 and 2013 high and low group's pre-test scores were significant main effects. The interaction between the PBL/non-PBL* and high/low pre-test scores is significant (*p* value = .005) as shown in Table 12. The interaction term is defined as PBL/non-PBL* and high and low pretest scores. High scores are ArcPre scores that range from 2.08 to 2.63. Low scores are ArcPre scores that range from 1.49 to 2.07.

Table 12

Testing of Main Effects and Interaction Between PBL and Non-PBL and High and Low Pretest Categories

Tests of Between-Subjects Effects						
Dependent variable: ArcPost						
Source	Type III sum of squares	*df*	Mean square	*F*	Sig.	Partial eta squared
Corrected model	4.284[a]	3	1.428	99.803	.000	.614
Intercept	869.205	1	869.205	60748.491	.000	.997
Treatment	1.671	1	1.671	116.773	.000	.383
Pre_Category	1.743	1	1.743	121.789	.000	.393
Treatment * Pre_Category	.115	1	.115	8.043	.005	.041
Error	2.690	188	.014			
Total	907.741	192				
Corrected total	6.974	191				

[a]*R* squared = .614 (adjusted *R* squared = .608).

The 38.3% variability in the Comprehensive Predictor exam posttest scores for the groups can be explained by the PBL versus non-PBL scores. The 39.3% variability in the Comprehensive Predictor posttest scores can be explained by the high versus low group Fundamentals nurse exam proxy pretest scores (Table 12). The mean difference in the Comprehensive Predictor exam posttest scores between the PBL and non-PBL groups, was significantly different, F (1, 191) = 116.77, $p < .001$. The posttest scores for the PBL group were an average of 9.35 points higher than the scores for the non-PBL group (Table 13).

Table 13

Mean Scores for PBL and Non-PBL Groups

Posttest

PBL and non-PBL groups	Mean	*N*	Std. deviation
PBL	82.12	98	5.049
Non-PBL	72.77	94	7.582
Total	77.54	192	7.933

To further explain the interaction between the PBL/non-PBL* and high and low pretest scores, a profile plot was created. The purpose of the profile plot was to determine if the means of the posttest scores for the high and low pretest group are the same across the PBL and non-PBL groups. The plot showed more variability between the high and low pre-test scores for the non-PBL group, as opposed to the PBL group. The mean difference for the non-PBL scores was nearly doubled the scores for the PBL group, which indicated that the low pretest score group appeared to benefit more from the PBL teaching strategy (Figure 10).

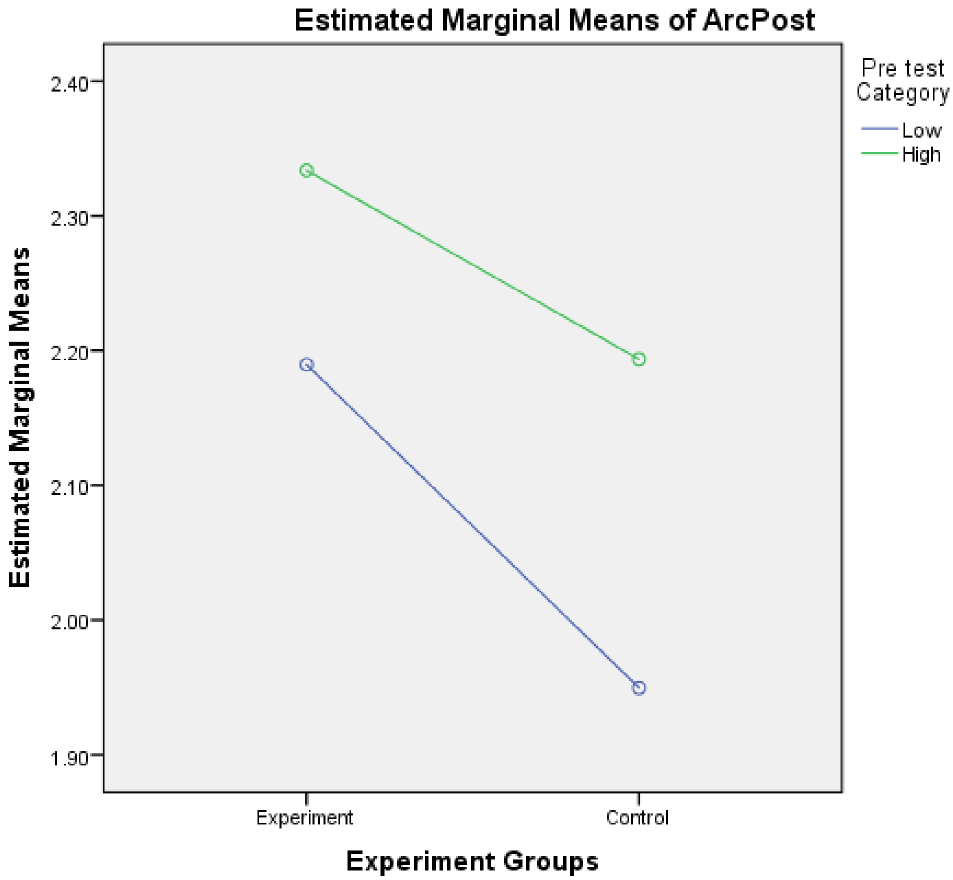

Figure 10. Profile plot for PBL and non-PBL and high and low pretest scores.

Conclusion

This quantitative study was conducted to understand the difference in critical-thinking and problem-solving skills in nursing students as tested by the ATI Comprehensive Predictor Exam. The null hypothesis for this research was there will be no significant difference ($p > 0.05$) for the ATI Comprehensive Predictor test between students taught with PBL and students taught with traditional instructional methods, when controlling for nursing fundamental knowledge. The alternative hypothesis was students taught using PBL will have significantly ($p < 0.05$) higher scores on the ATI Comprehensive Predictor test compared to students taught with traditional instructional methods, when controlling for nursing fundamental knowledge. The analyses showed a *p* value < 0.05, therefore the null hypothesis was rejected. Because there was a violation of one of the critical assumptions for the ANCOVA and due to the pretest and the posttest assessing different skill sets, having an unequal number of scored questions, and an unequal number of subjects in the two groups, the tests were not considered equal in nature. Subsequently, the two-way ANOVA was used to analyze the data. With the two-way ANOVA, there are three sets of hypotheses:

Null Hypothesis:

- H0: The treatment groups (PBL vs non-PBL) are equal.
- H0: The pre-test categories (high versus low) are equal.
- H0: There is no interaction between treatment groups and pre-test categories.

Alternative Hypothesis:

- HA: The treatment groups (PBL vs non-PBL) are not equal.
- HA: The pre-test categories (high versus low) are not equal.
- HA: There is an interaction between treatment groups and pre-test categories.

The results of this study suggested that PBL has a positive effect on the learning and comprehension ability of nursing students, especially those with lower pretest scores. The difference in the posttest scores of the experiment and control groups was statistically significant ($p < 0.001$) and likewise indicated that when students are taught using PBL, their critical-thinking and problem-solving ability increases, thereby producing higher posttest scores. Descriptive analysis of the scores in the areas of interpretation, analysis, evaluation, inference, explanation and self-regulation showed the following posttest group means for these individual categories shown in Table 14. An example of a detailed explanation of the implications of these scores can be found in Appendix E.

Table 14

Experiment Group and Control Group Posttest Mean Scores for Individual Categories

	Interpretation	Analysis	Evaluation	Inference	Explanation	Self-regulation
Experiment group	92%	88%	92%	89%	92%	89.5%
Control group	73%	73.3%,	72.8%	71%	72%	75%

Note. From ATI Comprehensive Predictor Exams 2012 and 2013, obtained from SSCC'S archived records. Reprinted with permission.

The overall mean increase in the scores of Experiment Group A by an average of 9.35 points, showed that there is a statistically significant difference in the posttest scores of students who were taught with PBL, compared to students taught using traditional lectures.

The current study is limited because it lacks a true pretest-posttest design and due to the numerous threats to internal validity. Nevertheless, PBL has increased in popularity undeterred by the fact that most studies, thus far, have been inconclusive regarding the efficacy of PBL on critical-thinking and problem-solving ability of nursing students (Beers, 2005; Hunter et al., 2014). Further research is needed to provide a solid foundation and support for the use of PBL, as an alternative teaching method to traditional lecturing in nursing curricula. The outcome of this research provides the premise for recommendations for nurse educators, as well as educators across other academic domains, regarding the use of alternative teaching methods.

Section 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this study was to examine the effect of PBL on nursing students' development of critical-thinking and problem-solving. I examined the difference in critical-thinking and problem-solving skills by comparing the archived test scores of 200 LPN and RN nursing students after being exposed to a treatment modality. ANCOVA was initially used to analyze the archived data. However, upon checking the nine assumptions that must be met for ANCOVA, it was determined that there was a violation of the assumption of homogeneity of regression slope. To address the violation, I conducted a two-way analysis of variance (ANOVA). The key reason for performing a two-way ANOVA was to determine whether there was a relationship between the independent variables and the dependent variable (Laerd Statistics, 2013). After removing the outliers from the data, the participant pool decreased to 192 from 200. For this study, Experiment Group A was taught using PBL and Control Group B was taught using the traditional instructional method of classroom lectures.

A quasi-experimental design was used to compare the results of the ATI Fundamentals nurse exam proxy pretest scores and Comprehensive Predictor posttest scores. The framework for this study was cognitive learning theory, which focuses on how individuals learn, the thought process, and the development of critical-thinking and problem-solving abilities (Fritscher, 2011). Aligned with the goals of PBL, cognition integrates developing critical-thinking ability and problem-solving ability to appropriately apply this knowledge to reasoning (Hmelo-Silver, 2009).

ANOVA was used to analyze the archived posttest scores of 192 nursing students at SSCC. The sample was a convenience sample because the participants were already in naturally formed classroom groups, and because of the convenience of accessibility. The study showed that nursing students taught using PBL had statistically significant higher posttest scores than students taught by the traditional method. Due to the sample size and the fact that the participants were from one institution, generalization of this study may be limited. The findings might prove to be different for a wider and more linear group of participants. However, the descriptive information obtained from this study will provide the premise for recommendations for educators across all academic domains regarding the use of alternative teaching methods.

Interpretation of Findings

ANOVA was used to examine the archived posttest scores of 192 LPN and RN students (after outliers were removed) from the 2012 and 2013 nursing programs at SSCC. Consent was not required because the data obtained were deidentified. The ATI tests are not considered public domain. Because of the proprietary nature of the ATI tests, I will not disclose any specific test questions. The research groups were an experiment group and a control group. Experiment Group A consisted of 43 LPN students from the 2012 nursing program and 55 RN students from the 2013 nursing program, who were taught using PBL. Comparison Group B consisted of 47 RN students from the 2012 nursing program and 47 LPN students from the 2013 nursing program, who were taught using traditional classroom lectures. Experiment Group A was taught by one instructor, and Control Group B was taught by a different instructor. Because both groups consisted of LPN and RN students, this was considered to be a fair distribution and representation of both nursing programs.

At the beginning of the core nursing curriculum, each participant was given the ATI Fundamentals pretest to assess the students' knowledge of basic nursing concepts. The pretest consisted of five unscored questions used for research purposes and 90 scored questions (ATI Fundamentals Score Explanation, 2012a, 2013). Prior to the start of the last semester in the nursing program and after receiving one of the treatment modalities, the same students were given the ATI Comprehensive Predictor posttest, which was a test of their knowledge of nursing concepts taught in all of the core nursing courses. This test is a predictor of the probability of each student of passing the NCLEX-RN or NCLEX-PN exam. The posttest consisted of 30 unscored questions used for research purposes and 150 scored questions for review (Assessment Technologies Institute, 2012a, 2013). Due to the pretest and the posttest assessing different skill sets and having unequal numbers of scored questions, as well as unequal numbers of subjects in the two groups, the tests were not considered equal in nature. Therefore, only the posttest scores were used for this research.

Barrows (1998) and Hmelo-Silver (2009) described the objectives of PBL as building a knowledge base for use in real-world settings, developing effective clinical reasoning and problem-solving skills, and building lasting academic skills. In Mohammad and El Sebai's (2010) study, a strong correlation was indicated in the results between PBL and the development of critical-thinking and problem-solving skills. The results of that study indicated that the participants' posttest mean scores were higher than the pretest scores ($p < .0001$); therefore, the researchers concluded that PBL improves professional performance in nursing education (Mohammad & El Sebai, 2010). Alfaro-LeFevre (2009) noted that critical-thinking is a process that leads to sound clinical judgment and that critical-thinking and problem-solving can be learned through a combination of practical experience and sound theoretical instruction presented in any format. Despite the fact that most studies of the efficacy of PBL in the development of critical-thinking and problem-solving skills have been inconclusive, educators must continue to search for factors that influence the improvement in these skills.

Overall analysis of the ATI test scores for both research groups showed that the group taught using PBL as the instructional treatment scored higher on the ATI Comprehensive Predictor posttest than the group taught by traditional learning. This difference (10.12) is statistically significant ($p < 0.00$), which shows that there is a statistically significant difference in the scores of students taught with PBL compared to students taught using traditional class lectures. However, the current study is limited because it lacks a true pretest and posttest research design and is susceptible to various threats to validity. One of the weaknesses of using a posttest-only design is the selection-mortality threat (Trochim, 2006). This is especially important if the two research groups have different dropout rates. Of the 192 participants in the current study, 84 out of 98 students in Experiment Group A graduated from the nursing program with a 100% pass rate on the NCLEX exam; 30 of the 94 students in Control Group B graduated from the nursing program with a 100% pass rate on the NCLEX exam. The retention rate for Experiment Group A was 85.7%, which exceeded the national average of 75% to 80% for the 2012 and 2013 calendar years (NLN, 2015). The retention rate for Control Group B was 31.9%, which was far below the national average. These results illustrated differences in the characteristics of the control and experiment groups.

Implications for Social Change

The current study is critical because measuring the success of PBL in the development of critical-thinking and problem-solving skills will help educators determine whether incorporating PBL in nursing curricula will be beneficial to allied health students in helping them formulate, develop, and exercise their thinking abilities. The present study may promote social change by providing evidence of approaches, other than traditional lecture, that help students to appropriately apply knowledge and to develop critical-thinking and problem-solving skills that will contribute to improving the quality of healthcare. The results of this study can further impart a foundation for nursing instructors to modify the curriculum to refine students' critical-thinking ability. Lastly, this study can guide nurse educators to be "improvement oriented about their own clinical judgements and to develop strategies to support student reasoning" (Sharp, Reynolds, & Brooks, 2013).

Recommendations for Action

Advances in health care and technology have steadily grown over the past century. The general public has become more knowledgeable about diseases through the use of the large number of technical devices that are available. With the touch of a button, through the use of social media, information can be accessed and distributed immediately. It is no longer acceptable for healthcare providers to limit themselves to knowing only how to perform a skill. They must now know what the skill is, when and where they can perform the skill, how they can perform the skill, why they are using the skill, and what alternatives exist (Khosravanic & Memarian, 2005). Communities consist of individuals who demand and expect more from healthcare providers now than they did in the past. Meeting the expectations of community stakeholders will require healthcare providers to possess critical-thinking and problem-solving abilities. The path to acquiring these skills begins in the classroom. Critical-thinking is at the forefront of nursing programs in response to a world of accelerating change and informal logic. Educators are constantly seeking ways to improve the delivery of information, capture and hold students' attention, stimulate a desire in students to excel beyond the minimum expectations, and help students retain information that can be recalled and used to provide swift, appropriate action in any given situation.

With critical-thinking skills, the allied health nurse can approach a myriad of scenarios with a scientific foundation (Nugent & Vitale, 2012). Without competent critical-thinking skills, some allied health nurses are likely to rely on rote memorization of a step-by-step template and may not be able to provide solutions to situations that deviate from the norm (Nugent & Vitale, 2012). The tendency to adhere to traditional learning methods such as lecture is not easily bypassed because change is not easy to implement.

Given the importance of critical-thinking skills in nursing, the exploration of PBL as a potential avenue to foster the development of this skill in nursing education may yield countless benefits. Education is the key to transforming society and resolving societal problems (Singer & Pezone, 2003). Hargreaves (2003) stated that one of the greatest tasks that educators face today is to help build a dynamic social movement that precipitates positive change in education.

Recommendations for Further Study

More research is needed to specifically address the techniques that are effective in producing positive and progressive changes in students' critical-thinking and problem-solving ability. To produce nurses who are knowledgeable and equipped with the critical-thinking and problem-solving skills needed to provide safe and effective care, nursing schools must first address attrition and improve the retention rate in nursing programs. Competent and effective delivery of healthcare is driven not only by quality, but also by quantity (NLN, 2012). PBL uses everyday problems to stimulate learning and to promote critical-thinking and problem-solving skills, and this learning approach is gaining attention in the context of increasing challenges faced by nurses (Chen et al., 2001). As educators continue their journey to find ways to help students gain and retain knowledge, wisdom, and understanding, PBL should not be considered a *seasonal approach*. The brain is one of the most effective natural tools. It is a tool that can be used to fine tune critical-thinking and problem-solving skills, with an abundance of discernment that will serve the members of the general public in meeting their healthcare needs.

Conclusion

Despite the large number of students admitted to nursing programs each year, the number of graduates continues to be comparatively small (Alfaro-LeFevre, 2004). At SSCC, the attrition rate was consistently between 30% and 70% from 2006 to 2013 (J.

Jans, personal communication, August 7, 2013). This situation led to a shortage of qualified graduate nurses to provide quality healthcare to a community that has grown continually from 2001 to 2011 (American Hospital Association, 2014; Bureau of Labor Statistics, 2012). As the nursing shortage increases, so does the complexity of diseases and the advancement of technology. Critical-thinking is necessary for professional nurses to make competent and sound clinical judgements (Bittencourt & Crossetti, 2013).

Educators constantly seek effective teaching methods to help students develop and use critical-thinking and problem-solving skills. PBL is a teaching method that has increased in popularity in an attempt to help nursing students achieve the level of knowledge and competence needed to successfully pass nursing programs (Duffy, 2009). Through this study, I sought to determine the effect PBL had on 200 LPN and RN nursing students' development of critical-thinking and problem-solving skills. The results of this study showed a positive correlation between students taught with PBL and an increase in critical-thinking and problem-solving ability. Although this research was not a true pretest-posttest design, the results cannot be dispelled. Many research studies continue to yield mixed results regarding the effectiveness of PBL in the development and use of critical-thinking and problem-solving in nursing education. This fact indicates that ongoing research is imperative to find an instrument to help nursing students foster critical-thinking and problem-solving abilities. Facione (2012) described critical-thinking as a cognitive engine that drives problem-solving. This same engine can be used as the driving force to promote social change by facilitating educational outcomes that align with the mandates of nursing education governing bodies and the higher level of care demanded by the communities served, thereby improving the quality and delivery of healthcare.

Nursing educators are now required to teach and assess critical-thinking and problem-solving ability in nursing students (NLN, 2012). For many years, researchers argued that critical-thinking in nursing is inherently different from critical-thinking in nonnursing and nonhealth professions (Bittencourt & Crossetti, 2013; Chan, 2013; Kim, 2010; Miller & Babcock, 1996; Polit & Beck, 2010). If this is true, the challenge for future research lies in developing alternative teaching strategies that are specific to the discipline of nursing, and that will bring a level of consistency in nursing programs graduating a higher number of nurses who can provide quality patient care.

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Appendix A: Certificate of Completion for Ethics Training

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that Yvette Jackson successfully completed the NIH Web-based training course "Protecting Human Research Participants".
Date of completion: 03/20/2014
Certification Number: 1433002

Appendix B: Sample of Information Listed on ATI Comprehensive Report Outcomes

Group Performance Summary Table

Predicted Probability of Passing the NCLEX-RN®	Number of Students at Probability of Passing	RN Comprehensive Predictor Form B Individual Score
99%	16	80.0% - 100.0%
98%	11	77.3% - 79.3%
96% - 97%	5	74.0% - 76.7%
94% - 95%	2	72.0% - 73.3%
91% - 93%	4	70.0% - 71.3%
89% - 90%	0	68.7% - 69.3%
84% - 87%	0	66.7% - 68.0%
80% - 82%	0	65.3% - 66.0%
73% - 78%	0	63.3% - 64.7%
59% - 71%	0	60.0% - 62.7%
31% - 56%	0	54.0% - 59.3%
1% - 28%	0	0.0% - 53.3%

Individual Mean-National 68.1%	Individual Mean-Program 68.8%
% of Group Above Individual Mean-National 100.0%	% of Group Above Individual Mean-Program 100.0%

Individual Scores

Individual Mean-National = 68.1% **Individual Mean-Program = 68.8 %**

Adjusted
Probability of Percentile Rank Individual
ID # Passing NCLEX National score Score

206753	98%	N/A	93	92	79.3%
25661	99%	N/A	99	99	90.0%
	92%	N/A	64	59	70.7%
	99%	N/A	98	98	83.3%
	99%	N/A	99	99	87.3%
	97%	N/A	86	85	76.7%
222112	98%	N/A	90	89	78.0%
	93%	N/A	66	62	71.3%
	99%	N/A	97	97	82.7%
	98%	N/A	91	91	78.7%
	99%	N/A	94	93	80.0%
	97%	N/A	86	85	76.7%
	99%	N/A	96	95	81.3%
231331	99%	N/A	98	98	83.3%
	93%	N/A	66	62	71.3%
	98%	N/A	88	87	77.3%
	99%	N/A	94	93	80.0%
	98%	N/A	93	92	79.3%
	96%	N/A	80	78	74.7%
214344	99%	N/A	95	95	80.7%
	99%	N/A	99	99	90.0%
	99%	N/A	94	93	80.0%
	98%	N/A	88	87	77.3%
223535	94%	N/A	69	66	72.0%
213455	98%	N/A	91	91	78.7%
	98%	N/A	91	91	78.7%
204411	92%	N/A	64	59	70.7%
	99%	N/A	97	96	82.0%
	98%	N/A	90	89	78.0%
	98%	N/A	91	91	78.7%
	99%	N/A	96	95	81.3%
	99%	N/A	94	93	80.0%
	96%	N/A	80	78	74.7%
	97%	N/A	84	83	76.0%
202302	99%	N/A	95	95	80.7%
	98%	N/A	91	91	78.7%
219998	95%	N/A	75	72	73.3%
28785	99%	N/A	97	96	82.0%

Appendix C: Example of ATI Comprehensive Score Interpretations

Group Score: This score is determined by adding all of the individual scores from the group and dividing the sum by the number of individuals in the group. This group score describes how, on average, the students within the group performed on the assessment (or within a designated sub scale).

Sum of Individual Scores Within the Group ÷ Number of Individuals in the Group = Group Score

For example:

40.7% + 53.2% + 69.4% + 70.8% + 82.1% ÷5 Individuals in the Group = 63.2%

Group scores can be interpreted through "criterion-referenced" or "norm-referenced" measures. Criterion-referenced measures are best used to determine if an established standard has been met (e.g., % of students achieving a particular score or probability of passing). Norm-referenced measures can be useful for comparing performance to other students or groups.

Pretest Items: There are 30 unscored pretest questions throughout the assessment, and 150 scored questions. The pretest questions are used for research purposes.

Topics to Review: Based on the questions missed on this assessment, a listing of content areas and topics to review is provided. A variety of learning resources may be used in the review process, including content, images, animations and videos in ATI's Content Mastery Series® Review Modules, online practice assessments, and a focused review that is individualized to the questions missed.

To learn more about additional ATI NCLEX® prep products visit www.atigreenlight.com.

Comprehensive Predictor® 2013 individual scores to NCLEX-RN® performance for a sample of RN students. As can be seen from the table, higher Predictor scores tend to indicate a higher probability of passing the NCLEX-RN®. However, students should use caution when interpreting the table because numerous factors can influence the performance on both the Predictor and the NCLEX-RN®. The expectancy table pertains only to individual scores and not to group scores.

Criterion-Referenced Measure – Probability of Passing NCLEX- RN®: The following expectancy table was developed by comparing RN

RN Comprehensive Predictor® 2013 Expectancy Table

RN Comprehensive Predictor® 2013 Individual Score	Predicted Probability of Passing the NCLEX-RN®
80.0% - 100.0%	99%
77.3% - 79.3%	98%
74.0% - 76.7%	96% - 97%
72.0% - 73.3%	94% - 95%
70.0% - 71.3%	91% - 93%
68.7% - 69.3%	89% - 90%
66.7% - 68.0%	84% - 87%
65.3% - 66.0%	80% - 82%
63.3% - 64.7%	73% - 78%
60.0% - 62.7%	59% - 71%
54.0% - 59.3%	31% - 56%
0.0% - 53.3%	1% - 28%

For example, note that a student with a score of 69.3% correct would be expected to have a 90% chance of passing the NCLEX-RN® on the first attempt. Although this is a high probability of success, it is not a guarantee. For every 100 students with this score, 90 are predicted to pass and 10 are predicted to fail.

Appendix D: SPSS Data for Experiment Group A and Control Group B

ID	Year	Group	Pretest	Postest	Difference	Treatment	filter_$	Dummy_Treatment
1	###	Experiment	85	95	10.00	1.00	1	1.00
2	###	Experiment	65	85	20.00	1.00	1	1.00
3	###	Experiment	72	82	10.00	1.00	1	1.00
4	###	Experiment	70	80	10.00	1.00	1	1.00
5	###	Experiment	72	82	10.00	1.00	1	1.00
6	###	Experiment	72	76	4.00	1.00	1	1.00
7	###	Experiment	72	83	11.00	1.00	1	1.00
8	###	Experiment	80	90	10.00	1.00	1	1.00
9	###	Experiment	62	71	9.00	1.00	1	1.00
10	###	Experiment	73	93	20.00	1.00	1	1.00
11	###	Experiment	78	75	-3.00	1.00	1	1.00
12	###	Experiment	68	77	9.00	1.00	1	1.00
13	###	Experiment	78	79	1.00	1.00	1	1.00
14	###	Experiment	72	76	4.00	1.00	1	1.00
15	###	Experiment	73	82	9.00	1.00	1	1.00
16	###	Experiment	78	78	.00	1.00	1	1.00
17	###	Experiment	72	80	8.00	1.00	1	1.00
18	###	Experiment	75	79	4.00	1.00	1	1.00
19	###	Experiment	68	78	10.00	1.00	1	1.00
20	###	Experiment	78	79	1.00	1.00	1	1.00
21	###	Experiment	72	78	6.00	1.00	1	1.00
22	###	Experiment	82	90	8.00	1.00	1	1.00
23	###	Experiment	68	78	10.00	1.00	1	1.00
24	###	Experiment	73	80	7.00	1.00	1	1.00
25	###	Experiment	85	89	4.00	1.00	1	1.00
26	###	Experiment	60	70	10.00	1.00	1	1.00
27	###	Experiment	73	79	6.00	1.00	1	1.00
28	###	Experiment	68	75	7.00	1.00	1	1.00
29	###	Experiment	75	85	10.00	1.00	1	1.00
30	###	Experiment	73	77	4.00	1.00	1	1.00
31	###	Experiment	72	81	9.00	1.00	1	1.00
32	###	Experiment	72	78	6.00	1.00	1	1.00
33	###	Experiment	78	79	1.00	1.00	1	1.00
34	###	Experiment	68	80	12.00	1.00	1	1.00
35	###	Experiment	78	85	7.00	1.00	1	1.00
36	###	Experiment	73	77	4.00	1.00	1	1.00
37	###	Experiment	80	86	6.00	1.00	1	1.00

38	###	Experiment	75	80	5.00	1.00	1	1.00
39	###	Experiment	78	80	2.00	1.00	1	1.00
40	###	Experiment	68	75	7.00	1.00	1	1.00
41	###	Experiment	73	79	6.00	1.00	1	1.00
42	###	Experiment	88	88	.00	1.00	1	1.00
43	###	Experiment	94	96	2.00	1.00	1	1.00
44	###	Experiment	88	90	2.00	1.00	1	1.00
45	###	Experiment	77	83	6.00	1.00	1	1.00
46	###	Control	71	73	2.20	2.00	0	.00
47	###	Control	70	67	-3.00	2.00	0	.00
48	###	Control	86	87	.50	2.00	0	.00
49	###	Control	67	65	-1.70	2.00	0	.00
50	###	Control	78	73	-5.00	2.00	0	.00
51	###	Control	69	68	-1.00	2.00	0	.00
52	###	Control	89	88	-.70	2.00	0	.00
53	###	Control	76	77	.70	2.00	0	.00
54	###	Control	70	73	3.30	2.00	0	.00
55	###	Control	60	62	1.70	2.00	0	.00
56	###	Control	65	67	1.70	2.00	0	.00
57	###	Control	79	82	2.70	2.00	0	.00
58	###	Control	81	82	.60	2.00	0	.00
59	###	Control	67	68	1.30	2.00	0	.00
60	###	Control	89	92	2.60	2.00	0	.00
61	###	Control	60	62	1.60	2.00	0	.00
62	###	Control	83	83	.30	2.00	0	.00
63	###	Control	84	85	1.00	2.00	0	.00
64	###	Control	74	75	1.00	2.00	0	.00
65	###	Control	74	75	1.00	2.00	0	.00
66	###	Control	62	65	3.40	2.00	0	.00
67	###	Control	75	77	1.60	2.00	0	.00
68	###	Control	79	82	3.00	2.00	0	.00
69	###	Control	65	65	.00	2.00	0	.00
70	###	Control	76	73	-3.00	2.00	0	.00
71	###	Control	63	68	5.30	2.00	0	.00
72	###	Control	68	72	4.30	2.00	0	.00
73	###	Control	84	87	2.60	2.00	0	.00
74	###	Control	60	63	3.00	2.00	0	.00
75	###	Control	61	61	-.30	2.00	0	.00
76	###	Control	56	57	.80	2.00	0	.00
77	###	Control	80	82	1.50	2.00	0	.00
78	###	Control	71	73	1.70	2.00	0	.00
79	###	Control	60	64	4.00	2.00	0	.00

80	###	Control	71	72	.80	2.00	0	.00
81	###	Control	54	52	-1.80	2.00	0	.00
82	###	Control	61	63	2.70	2.00	0	.00
83	###	Control	85	85	-.20	2.00	0	.00
84	###	Control	84	85	.70	2.00	0	.00
85	###	Control	56	55	-.50	2.00	0	.00
86	###	Control	46	43	4289.10	2.00	0	.00
87	###	Control	56	57	.70	2.00	0	.00
88	###	Control	85	87	1.60	2.00	0	.00
89	###	Control	55	55	-.10	2.00	0	.00
90	###	Control	50	53	3.20	2.00	0	.00
91	###	Control	65	68	2.90	2.00	0	.00
92	###	Control	80	82	2.30	2.00	0	.00
93	###	Control	71	76	4.60	2.00	0	.00
94	###	Control	63	63	.40	2.00	0	.00
95	###	Control	60	52	-8.40	2.00	0	.00
96	###	Control	70	77	6.60	2.00	0	.00
97	###	Control	59	62	2.70	2.00	0	.00
98	###	Control	72	75	3.00	2.00	0	.00
99	###	Control	77	80	3.00	2.00	0	.00
##	###	Control	71	79	8.00	2.00	0	.00
##	###	Control	69	72	3.10	2.00	0	.00
##	###	Control	83	82	-1.20	2.00	0	.00
##	###	Control	77	76	-1.20	2.00	0	.00
##	###	Control	74	75	.60	2.00	0	.00
##	###	Control	63	65	2.00	2.00	0	.00
##	###	Control	79	79	-.10	2.00	0	.00
##	###	Control	66	68	2.00	2.00	0	.00
##	###	Control	73	75	1.70	2.00	0	.00
##	###	Control	76	76	.30	2.00	0	.00
##	###	Control	76	76	.30	2.00	0	.00
##	###	Control	72	75	2.70	2.00	0	.00
##	###	Control	72	74	1.80	2.00	0	.00
##	###	Control	77	76	-.70	2.00	0	.00
##	###	Control	71	72	.40	2.00	0	.00
##	###	Control	69	70	1.30	2.00	0	.00
##	###	Control	83	81	-2.30	2.00	0	.00
##	###	Control	77	78	1.40	2.00	0	.00
##	###	Control	74	74	-.30	2.00	0	.00
##	###	Control	63	66	2.50	2.00	0	.00
##	###	Control	79	77	-2.20	2.00	0	.00
##	###	Control	66	68	2.60	2.00	0	.00

##	###	Control	73	74	.40	2.00	0	.00
##	###	Control	76	76	.30	2.00	0	.00
##	###	Control	76	76	.30	2.00	0	.00
##	###	Control	72	73	.60	2.00	0	.00
##	###	Control	72	73	.80	2.00	0	.00
##	###	Control	77	78	1.50	2.00	0	.00
##	###	Control	71	74	3.00	2.00	0	.00
##	###	Control	69	71	2.00	2.00	0	.00
##	###	Control	83	85	1.70	2.00	0	.00
##	###	Control	77	76	-.80	2.00	0	.00
##	###	Control	74	75	.40	2.00	0	.00
##	###	Control	63	63	-.40	2.00	0	.00
##	###	Control	79	78	-1.30	2.00	0	.00
##	###	Control	66	68	2.00	2.00	0	.00
##	###	Control	73	74	.80	2.00	0	.00
##	###	Control	76	76	.30	2.00	0	.00
##	###	Control	76	71	-4.90	2.00	0	.00
##	###	Control	72	74	1.60	2.00	0	.00
##	###	Control	72	69	-3.20	2.00	0	.00
##	###	Control	77	74	-3.00	2.00	0	.00
##	###	Control	71	74	2.90	2.00	0	.00
##	###	Control	69	70	1.20	2.00	0	.00
##	###	Control	83	81	-2.40	2.00	0	.00
##	###	Experiment	77	85	8.00	1.00	1	1.00
##	###	Experiment	73	79	5.70	1.00	1	1.00
##	###	Experiment	75	78	3.10	1.00	1	1.00
##	###	Experiment	75	87	11.70	1.00	1	1.00
##	###	Experiment	72	77	5.00	1.00	1	1.00
##	###	Experiment	80	89	9.00	1.00	1	1.00
##	###	Experiment	85	87	2.20	1.00	1	1.00
##	###	Experiment	75	76	.90	1.00	1	1.00
##	###	Experiment	73	82	9.00	1.00	1	1.00
##	###	Experiment	72	78	6.30	1.00	1	1.00
##	###	Experiment	88	91	2.70	1.00	1	1.00
##	###	Experiment	75	79	4.20	1.00	1	1.00
##	###	Experiment	88	90	1.40	1.00	1	1.00
##	###	Experiment	73	77	3.60	1.00	1	1.00
##	###	Experiment	67	73	6.00	1.00	1	1.00
##	###	Experiment	73	84	10.80	1.00	1	1.00
##	###	Experiment	83	83	-.10	1.00	1	1.00
##	###	Experiment	82	84	1.90	1.00	1	1.00
##	###	Experiment	79	80	.70	1.00	1	1.00

##	###	Experiment	80	84	4.30	1.00	1	1.00
##	###	Experiment	79	82	3.40	1.00	1	1.00
##	###	Experiment	70	76	6.20	1.00	1	1.00
##	###	Experiment	78	82	3.90	1.00	1	1.00
##	###	Experiment	80	85	5.30	1.00	1	1.00
##	###	Experiment	82	91	8.90	1.00	1	1.00
##	###	Experiment	89	90	1.40	1.00	1	1.00
##	###	Experiment	82	86	3.80	1.00	1	1.00
##	###	Experiment	79	80	.90	1.00	1	1.00
##	###	Experiment	75	76	.90	1.00	1	1.00
##	###	Experiment	73	83	10.00	1.00	1	1.00
##	###	Experiment	86	89	2.40	1.00	1	1.00
##	###	Experiment	78	83	4.70	1.00	1	1.00
##	###	Experiment	82	83	.80	1.00	1	1.00
##	###	Experiment	78	84	5.90	1.00	1	1.00
##	###	Experiment	80	85	5.70	1.00	1	1.00
##	###	Experiment	82	85	2.70	1.00	1	1.00
##	###	Experiment	75	83	8.10	1.00	1	1.00
##	###	Experiment	83	84	.90	1.00	1	1.00
##	###	Experiment	84	88	4.00	1.00	1	1.00
##	###	Experiment	81	86	5.30	1.00	1	1.00
##	###	Experiment	93	96	2.90	1.00	1	1.00
##	###	Experiment	78	81	2.80	1.00	1	1.00
##	###	Experiment	80	84	3.40	1.00	1	1.00
##	###	Experiment	85	88	3.00	1.00	1	1.00
##	###	Experiment	79	82	2.90	1.00	1	1.00
##	###	Experiment	84	89	4.50	1.00	1	1.00
##	###	Experiment	80	87	7.20	1.00	1	1.00
##	###	Experiment	79	79	.20	1.00	1	1.00
##	###	Experiment	82	85	2.60	1.00	1	1.00
##	###	Experiment	69	74	4.80	1.00	1	1.00
##	###	Experiment	85	87	1.80	1.00	1	1.00
##	###	Experiment	70	75	5.10	1.00	1	1.00
##	###	Experiment	72	81	8.70	1.00	1	1.00
##	###	Experiment	80	93	12.80	1.00	1	1.00
##	###	Experiment	83	91	7.80	1.00	1	1.00
##	###	Experiment	70	83	12.60	1.00	1	1.00

Appendix E: Sample Explanation of the Posttest Mean Scores

Experiment Group A Individual Categories Breakdown

Foundational Thinking in Nursing 92.8% Ability to recall and comprehend information and concepts foundational to quality nursing practice.
Clinical Judgment/Critical-thinking in Nursing.

89.5 Ability to use critical-thinking skills (interpretation, analysis, evaluation, inference, and explanation) to make a clinical judgment regarding a posed clinical problem. Includes cognitive abilities of application and analysis.
No of Group Nursing Process Items Score Description.

Assessment 90% Ability to apply nursing knowledge to the systematic collection of data about the client's present health status in order to identify the client's needs and to identify appropriate assessments to be performed based on client findings. Also includes the ability to accurately collect client data throughout the assessment process (client history, client interview, vital sign and hemodynamic measurements, physical assessments) and to appropriately recognize the need for assessment prior to intervention.

Analysis/Diagnosis 88% Ability to analyze collected data and to reach an appropriate nursing judgment about the client's health status and coping mechanisms, specifically recognizing data indicating a health problem/risk and identifying the client's needs for health intervention. Also includes the ability to formulate appropriate nursing diagnoses/collaborative problems based on identified client needs.

Planning 89.5% Ability to apply nursing knowledge to the development of an appropriate plan of care for clients with specific health alterations or needs for health promotion/maintenance. Includes the ability to establish priorities of care, effectively delegate client care, and set appropriate client goals/outcomes in order to ensure clients' needs are met.

92% Ability to select/implement appropriate interventions/INTERPRETATION/CLINICAL JUDGEMENT (e.g., technical skill, client education, and communication response) based on nursing knowledge, priorities of care, and planned goals/outcomes in order to promote, maintain, or restore a client's health. Also includes the ability to appropriately respond to an unplanned event (e.g., observation of unsafe practice, change in client status) or life threatening situation and to routinely take measures to minimize a client's risk.

Evaluation 92.0% Ability to evaluate a client's response to nursing interventions and to reach a nursing judgment regarding the extent to which goals and outcomes have been met. Also includes the ability to assess client/staff understanding of instruction, the effectiveness of intervention, and the recognition of a need for further intervention.

Control Group B Individual Categories Breakdown

Clinical Judgment/Critical-thinking 73% Ability to use critical-thinking skills (interpretation, analysis, evaluation, inference, and explanation) to make a clinical judgment regarding a posed clinical problem. Includes cognitive abilities of application and analysis.

Foundational Thinking in Nursing 72.9 Ability to recall and comprehend information and concepts foundational to quality nursing practice.

Data Collection 72.3% Ability for explanation and ability to apply nursing knowledge to the systematic collection of data about the client's present health status in order to identify the client's needs and to identify appropriate assessments to be performed based on client findings. Also includes ability to ask the client appropriate questions, listen carefully to the client's responses, and respond appropriately. Nurses must continuously use appropriate methods to safely collect comprehensive client data.

Planning 75% Ability for self-regulation and to participate in the development of an appropriate plan of care for clients with specific health alterations or needs for health promotion/maintenance. Includes the ability to contribute to the establishment of priorities and desired outcomes of care that can be readily measured and evaluated.
Implementation/Therapeutic Nursing Intervention,

73.4% Ability to use clinical judgment/INTERPRETATION **a**nd critical-thinking to select and implement appropriate therapeutic interventions based on nursing knowledge, priorities of care, and planned goals or outcomes in order to promote, maintain, or restore a client's health. Also includes the ability to appropriately respond to an unplanned event (e.g., observation of unsafe practice, change in client status) and to routinely take measures to minimize a client's risk.

Evaluation 72.8% Ability to evaluate a client's response to nursing interventions and to reach a nursing judgment regarding the extent to which goals and outcomes have been met. Also includes the ability to assess client/staff understanding of instruction, the effectiveness of intervention, and the recognition of a need for further intervention.
No of Group Priority Setting Items Score Description.

72% Ability to demonstrate nursing judgment/explanation in making decisions about priority responses to a client problem. Also includes establishing priorities regarding the sequence of care to be provided to multiple clients.