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Radiologic technology students' technical skills in simulation and actual chest X-ray imaging as measured by competency evaluation: Indicative of radiologic technologists' supervisory performance

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ABSTRACT

This study sought to determine the relationship of radiologic technology students' level of competency in cognitive skills, affective skills, and psychomotor skills and further find out if these variables were significantly determinants of their technical skills in chest x-ray imaging. This inquiry likewise sought to measure the relationship of students' technical skills in simulation and actual chest x-ray imaging. The results showed that the levels of competency of students' cognitive skills, their affective skills, and their psychomotor skills were determined to be competent. The overall mean scores in determining the levels of competency of students' technical skills in simulation, and actual chest x-ray imaging, were also determined to be competent. There was a significant relationship between students' cognitive skills and affective skills. A significant correlation was also determined between students' cognitive skills, and psychomotor skills. There was a significant correlation between students' technical skills in simulation and actual chest x-ray imaging. The students' affective skills, their psychomotor skills, and their cognitive skills in the aspects of radiographic positioning, image quality, and radiographic anatomy identification, were found to be significant determinants of their technical skills in chest x-ray simulation. The students' affective skills were found to be the best determinants of their technical skills in the performance of actual chest x-ray imaging.

KEYWORDS: students' technical skills, chest x-ray imaging simulation, actual chest x-ray imaging, competency evaluation, supervisory performance.

INTRODUCTION

Interest in undertaking this study had been influenced by the personal observation that, oftentimes, the deficiency of radiologic technologists performing chest x-ray procedures could endanger a patient's life. The students' lack of technical competence veers away from this line of specialization and could unnecessarily lead to wrong diagnosis of the patients' state of health condition; thus, compromising their health, well-being, and quality of life. Any inappropriate or defective supervision of students in the clinical area could probably produce less capable students of medical diagnostic radiography; hence, the competence in technical skills of students could be highly dependent on the supervisory performance of Radiologic Technologists. The incompetence demonstrated in the performance of radiographic examinations could unduly constrain the primary objective of the Diagnostic Radiology Department in achieving higher quality x-ray images that could contribute to or aid in restoring a patient's health. Such incompetence could also result in unnecessary radiation exposures of the patient and provide unreliable data to the attending physician. As a professional discipline, chest radiography occupies one of the prime positions in clinical medicine. Probably, it is the single most commonly performed radiological investigation in the world and forms an integral part of the routine examination or diagnosis of individual patient's case, along with the required physical examination and laboratory investigations. Admittedly, the cornerstone of radiological diagnosis of the chest diseases is chest radiography (Thulkar & Srivastava, 2005). The quality of chest images generated by any skilled and competent radiologic technologists plays a crucial part in the diagnosis of a patient's disease or illness. Martensen (2011) previously reported that the accuracy in positioning and compliance with technical factors could affect the diagnostic value of the image. It has been estimated that, in the United States, about 68 million chest imaging procedures had been performed each year to evaluate the patients' lungs, heart, and thoracic viscera, as well as other diseases such as pneumonia, heart failure, pleurisy, and lung cancer. Sometimes, practitioners would ask whether they should consider how the appearances of these structures differed, when based on preventable positioning and technical errors. Probably, it would take only two or three degrees of rotation to affect the appearance of the lungs, causing differences in density along the lateral borders of the chest image. There were even previous incidents wherein the rotation of posterior-anterior chest projection resulted in different heart plane into profile; thus, compromising the diagnosis. According to the World Health Organization (1985), many errors in diagnosis were often due to the result of faulty radiographic technique, especially in chest radiographs. In some cases, the technical faults might only mimic the disease. Cases of bad positioning, incorrect exposure, poor inspiration, and failure to stop breathing could unnecessarily lead to errors in interpretation of the radiographs. This observation implies that the lack of skills of radiology personnel in producing optimum chest images could lead to errors in diagnosis and, consequently, could result in failure to detect the patient's disease and unduly cause the loss of the patient's life. The conduct of this inquiry was anchored on the study of Adler and Carlton (2007) which reported that the development of the students' technical skills in radiologic technology clinical education settings could be influenced by the interplay of the three domains of learning in radiologic technology, namely: cognitive, affective, and psychomotor factors. Egestad (2008) opined that the culture of the imaging department stress that the technical aspect should be regarded as the most important part of the function and practice of radiography. The ideal radiography practice is to be highly effective in performing the tasks with a high degree of accuracy. The expert radiographer might be described as a radiographer who takes good care of the patient while also handling the technical side adequately.

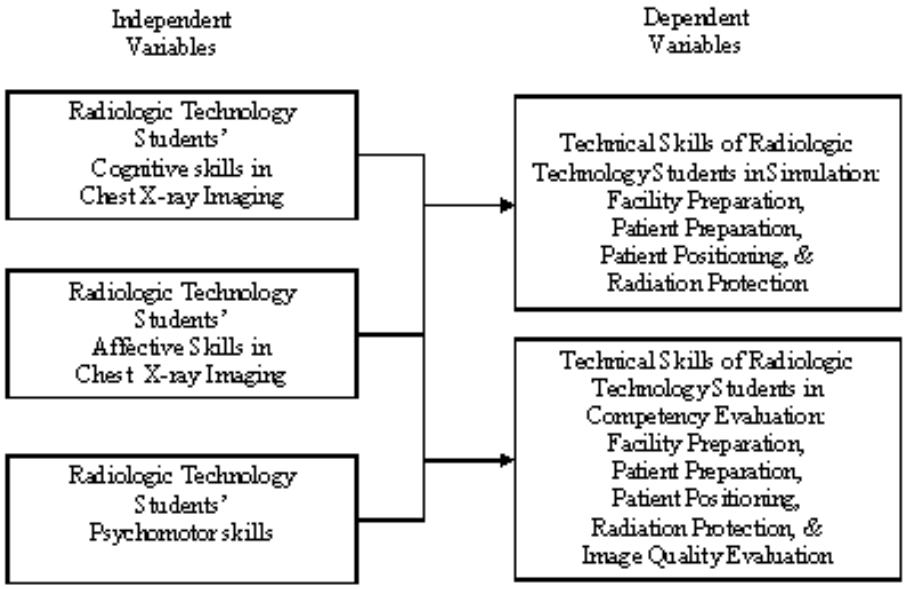

Figure I. The paradigm showing the relationships between independent variables- cognitive skills, affective skill, and psychomotor skills - and the dependent variables- technical skills in simulation and actual chest x-ray imaging as measured by competency evaluation.

The three major domains of learning in radiologic technology, which included cognitive, affective, and psychomotor skills, constituted the independent variables of this investigation, since the interplay of these three domains of learning in radiologic technology could influence the level of students' technical skills in the performance of specific diagnostic x-ray examinations. The dependent variables consisted of the technical skills of students, as measured in simulated chest x-ray procedures to be done without radiation exposure, and in actual chest x-ray examinations through competency evaluation to be done on live patients with the aid of x-ray exposure; the output of which or the resulting image could prove the students' level of technical competence. In the performance of actual chest x-ray examinations, the students' technical skills ought to produce accurate radiographic images; hence, it could be argued that competency evaluation became a higher level of measurement compared to assessment in simulation. The problem of the study focused on the lack of integrated and systematic practice standards that should be instituted into the radiologic technology clinical education program in performing x-ray procedures and in operating diagnostic x-ray equipment that could pose as a hazard to the patients. The problem emerged because there had been no clearly delineated radiologic technology practice standards that could ensure a minimum level of education, knowledge, and skill for the aspiring operators of radiographic equipment expected to eventually reflect the radiologic technologist's ability and empathy in providing the highest quality of patient care. This investigation serves the following objectives: (1) to measure the level of competency of radiologic technology students' cognitive skills in chest imaging, in terms of facility preparation, patient preparation, patient positioning, radiation protection, image quality evaluation, and radiographic anatomy identification; (2) to calculate the level of competency of the radiologic technology students' affective skills in chest imaging; (3) to compute the level of competency of the radiologic technology students' psychomotor skills in chest imaging; (4) to quantify the level of competency of the technical skills of the radiologic technology students in a simulated chest imaging, in terms of facility preparation, patient preparation, patient positioning, and radiation protection; (5) to calculate the level of competency of the technical skills of the radiologic technology students in actual chest x-ray examinations measured through competency

evaluation, in terms of facility preparation, patient preparation, patient positioning, radiation protection, and image quality evaluation; (6) to analyze a significant relationship of radiologic technology students' cognitive skills, affective skills, and psychomotor skills; (7) to examine a significant relationship between radiologic technology students' technical skills measured in simulation, and in actual chest x-ray examinations through competency evaluation; (8) to find out the determinants of radiologic technology students' technical skills in terms of simulated chest x-ray imaging procedures; and (9) to compute the determinants of radiologic technology students' technical skills in terms of actual chest x-ray imaging procedures measured by competency evaluation. Based on the research data collected, analyzed, interpreted, and inferred, the researcher recommends the following measures: Since the subjects were competent in cognitive skills evaluation in chest imaging, in the theoretical component of image quality courses, emphasis should be given to radiographic images evaluation to maintain the competence of students in this challenging subject. Faculty should be tasked to enhance the cognitive skills of radiologic technology students in image quality assessment in order to produce high-definition radiographic images leading to accuracy in physician's effort to diagnose patient's diseases. The competence of radiologic technologists applied in patient care and management of clients would provide a modeling effect to students to better train them in the process of applying quality radiologic care because one of radiologic technology practices is the development of an individual's core values in handling patients in all aspects of radiologic examinations. The core values of radiologic technologists specified in the Code of Professional Ethics, encourage practitioners to provide the highest level of technical expertise in the performance of radiographic work, employing courtesy, empathy, compassion, and privacy to the patient or client and his/her family. To produce proficient radiologic technology graduates, the three domains of learning in radiography, namely: cognitive, affective, and psychomotor, have to be harnessed and developed among the students. Cognitive skills monitoring and evaluation of didactic faculty in the licensure subjects, such as in Radiographic Technique and Film Processing Analysis I and II, should be given higher priorities to advance the cognitive skills of radiologic technology students in assessing the quality of x-ray images leading to accuracy of physician's interpretation of patient's diseases. Consistent monitoring and evaluation of affective skills of radiologic technology students in licensure subject entitled Patient Care and Management in Radiography, should be applied to raise the radiologic technology graduates' level of empathy to the patients who will receive radiologic care under various diagnostic and therapeutic imaging procedures for the eventual restoration of the patient's health and well-being. Empathy applied in Diagnostic X-ray Imaging means that a radiologic technologist who has the heart is able to care and position the patient properly, he/she is able to shield patient from unnecessary radiation exposure, while at the same time, he or she can produce high quality x-ray images leading to physician's precise interpretation of the patient's medical condition. The correctness of psychomotor skills assessment of didactic faculty among radiologic technology students taking up the board subjects such as Radiologic Physics and Equipment Maintenance, and Basic Radiographic Positioning, should be monitored and regularly evaluated to equip the graduates with the needed skills of radiographic equipment manipulation and control that would objectively result in minimizing radiation exposure to the patient and the imaging staff. Radiologic technology faculty who are in-charge of teaching licensure subjects such as Radiographic Positioning and Radiologic Procedures, Radiologic Contrast Examinations, Patient Care and Management, should integrate simulations into their periodic evaluations in order to evaluate effectively the technical skills and readiness of students in handling the actual diagnostic procedures. A thorough evaluation of student interns' clinical competency, in the individual level, in the final year of clinical education II program, using simulations as procedural evaluation tools, should be encouraged to virtually determine their technical competencies in performing all routine diagnostic x-ray examinations in order to enhance the proficiency of students in handling diagnostic imaging examinations after passing the Board of Radiologic Technology licensure examinations. The areas of Radiologic Technology licensure examination which are vital for students' technical skills development

such as, Human Anatomy & Physiology, Radiographic Positioning & Radiologic Procedures, and Radiographic Technique & Film Processing Analysis I & II, and Radiologic Physics, Equipment and Maintenance I & II, should be constantly monitored and evaluated, by the academic institutions offering the course in radiologic technology. The evaluation of students' performance in the aforementioned licensure fields should be based on internationally accepted radiography practice standards or competency protocols of monitoring, evaluating, improving, and sustaining students' technical skills in performing various diagnostic imaging examinations.

MATERIALS AND METHODS

This study followed the descriptive-correlational research design that attempted to explore the relationship between the students' cognitive skills, affective skills, and psychomotor skills, with their technical skills in chest x-ray simulated imaging and actual chest x-ray examinations. The assessment of technical skills of students of radiologic technology was based on their demonstrated competence in simulated imaging in a laboratory setting, and competency evaluation in a medical or hospital setting. This design was used to measure whether or not the students' cognitive skills, affective skills, and psychomotor skills were significantly associated with the technical skills of students the practicing radiologic technologists had taught and supervised while on training. Descriptive statistics employed were the means and standard deviations. Inferential statistics used were the *Pearson's product-moment correlation* (Pearson's *r*), and *Stepwise Multiple Linear Regression Analysis* set at .05 alpha level. To measure the cognitive skills, affective skills, psychomotor skills, and technical skills of students in simulations and competency evaluations in chest imaging, the researcher prepared the research instruments based on the Second Edition of the Radiography Procedure and Competency Manual, published in 2008. On reliability and validity of the instrument, Biedrzycki (2008) clarified that the manual conformed to the validity and reliability requirements set by both the Joint Review Committee on Education in Radiologic Technology (JCERT) and the American Registry of Radiologic Technologists (ARRT). JRCERT has been the only agency recognized by the United States Department of Education to accredit educational programs in radiologic technology. ARRT is the only national certifying agency recognized by the American Society of Radiologic Technologists (ASRT) and the American College of Radiology (ACR). The data gathering procedure includes the following radiographic protocols: Step 1, concerned the measurement of psychomotor skills of students in handling diagnostic x-ray equipment and devices, which is a preparatory procedure prior to routine chest x-ray imaging simulations ; Step 2, focused on the measurement of students' technical skills in chest x-ray imaging simulations, which follows after the psychomotor skills evaluation, simulation is a preparatory procedure before the performance of actual routine chest x-ray imaging examinations; Step 3 embraced the measurement of students' technical skills in actual chest x-ray imaging procedures which followed after a simulated chest x-ray imaging examinations; Step 4 focused on the measurement of students' affective skills in chest x-ray examinations, an evaluation which is done during the performance of actual chest x-ray imaging; and, finally, Step 5 was the last measurement of this inquiry that concerned the evaluation of students' cognitive skills in chest x-ray imaging by asking each student intern on the aspects of diagnostic physics and equipment, radiographic techniques, and radiographic anatomy.

RESULTS AND DISCUSSIONS

To obtain the overall level of competency of radiologic technology students in all the five sets of evaluation, the researcher computed and categorized the mean ratings as follows:

Table 1: Mean Ratings, Descriptive Ratings, and Description of Radiologic Technology Students' Level of Competency

Mean Rating	Descriptive Rating	Description

3.50 – 4.00	More Competent	Performance always showed complete understanding or application of the requirements of radiologic technology practice.
2.50 – 3.49	Competent	Performance showed an understanding or application of the requirements of radiologic technology practice.
1.50 – 2.49	Less Competent	Performance showed minimal understanding or application of the requirements of radiologic technology practice.
1.00 – 1.49	Least Competent	Performance showed no understanding or application of the requirements of radiologic technology practice Inferential Data Analysis.

RELATIONSHIP AMONG THE RADIOLOGIC TECHNOLOGY STUDENTS' COGNITIVE SKILLS, AFFECTIVE SKILLS, AND PSYCHOMOTOR SKILLS

Table 10: Relationship among the Radiologic Technology Students' Cognitive Skills in Chest X-ray Imaging, Affective Skills in Chest X-ray Imaging, and Psychomotor Skills in Handling Diagnostic X-ray Machine and Devices

Students' Competency	**Cognitive Skills**	**Affective Skills**	**Psychomotor Skills**
Cognitive Skills		.389*	.379*
Affective Skills	.389		
Psychomotor Skills	.379*		

* p<.05

Table 10 shows that between affective skills and cognitive skills the obtained r = .389 with sig (2-tailed) =.001 < p-value of .05, revealed that there was a significant relationship between affective skills and cognitive skills in chest x-ray imaging, thus the null hypothesis was rejected. This finding is similar to the study of Ugwu, et al. (2010) which proved that affective skills of students in radiography were significantly related to their cognitive skills. Students' attitude and interest in radiography were significantly related to their academic competence. This result is also similar to the study of Adler and Carlton (2007) which explained the development of skills of students in the clinical education settings could be influenced by the interplay of the three domains of learning in radiologic technology, namely: cognitive, affective, and psychomotor. Table 10 likewise shows that between psychomotor skills and cognitive skills, the obtained r = .379 with sig (2-tailed) =.002 < p-value of .05, revealed that there was a significant relationship between psychomotor skills and cognitive skills; thus, the null hypothesis was rejected. This finding is supported in the inquiry of Egestad (2008), which concluded that good radiography practice could be characterized by the combination and integration of technical competence including but not limited to x-ray machine manipulation or psychomotor skills, and patient-oriented actions or empathy towards patients that fell within the affective domain of practicing radiologic technologist. Radiologic technologists should be concerned with the patient's experience throughout the course of the imaging procedure; they should focus on the patient while skillfully dealing with the technical side of the examination. They should operate machinery and technology adequately in accordance with requisition forms and place the patient in the correct projection and position in order to produce optimal x-ray images. These actions should be performed in a manner that the patients experience satisfaction and comfort. This is a triple challenge; they should be technically skillful, they should treat the patient well, and integrate technology to the best interest of the patient. All of this should be integrated in the same "operation". The analysis showed that the difference between the radiologic technology practitioners lay in their treatment and care of their patients. This finding is also supported by the inquiry of Reed (2011) which explained that students in radiologic technology should possess the knowledge and skills in using the x-ray equipment in the manner for which it is designed and intended.

Their ability to detect malfunctions, broken parts within the equipment and any hazards in the area is critical to ensure the treatment and safety of patients. This finding is also related to the inquiry of Giordano and Greathouse (2008) which reported that the clinical evaluation in radiologic technology should typically include all three domains - cognitive, affective, and psychomotor- because an integral part of educating competent radiologic technology professionals would include the development of professional attitudes and excellent technical skill.

RELATIONSHIP BETWEEN RADIOLOGIC TECHNOLOGY STUDENTS' TECHNICAL SKILLS IN SIMULATION AND COMPETENCY EVALUATION

Table 11: Relationship between Radiologic Technology Students' Technical Skills in Simulated Chest X-ray Imaging, and Actual Chest X-ray Examinations by Competency Evaluation

Technical Skills	Simulation	Competency Evaluation
Simulation		.320*
Competency Evaluation	.320*	

* p<.05

Table 11 shows that between chest imaging simulation and actual chest x-ray imaging measured by competency evaluations, the obtained r = .320 with sig (2-tailed) =.010 < p-value of .05, revealed that there was a significant relationship between students' technical skills in chest x-ray imaging simulation and the performance of actual chest x-ray imaging through competency evaluations; thus, the null hypothesis was rejected. This finding is similar to the study of Adler, et al. (2007) which discussed that a simulated clinical procedure could gradually improve the student's ability to handle the actual performance of radiographic procedure as the weeks and months proceeded with the clinical education program. Almohiy and Davidson (2011) study also justified that simulated imaging could be important for developing technical skills and for improving clinical training outcomes. Simulated imaging could provide the students with the opportunity to practice radiography skills in a structured, predictable and safe learning environment, so that during actual performance of x-ray examinations, students could further develop their skills in situations that were unable to be simulated in the laboratory sessions. The respondents recommended the use of radiographers, rather than lecturers, as evaluators during the Objective Structured Clinical Examination (OSCE) to ensure that it is conducted realistically by people who practice the profession on a regular basis. Almohiy and Davidson (2011) study has bearing on the present investigation because the assessment of the technical skills of students was measured in a simulated clinical procedure. The study measured if there was a significant relationship between x-ray procedures in simulation, and those investigations performed in actual, or real life x-ray examinations.

DETERMINANTS OF RADIOLOGIC TECHNOLOGY STUDENTS' TECHNICAL SKILLS IN SIMULATION

Table 12: Determinants of Radiologic Technology Students' Technical Skills in a Simulated Chest X-ray Imaging Procedure

Model	R	R Square	R Square Change	B	t	Sig.
(Constant)				1.709	4.01*	.000
Affective Skills	.301	.090	.090	.309	2.45*	.017
Psychomotor Skills	.387	.150	.059	.326	2.50*	.001

Cognitive Skills in						
Radiographic Positioning	.469	.220	.070	-.253	-2.63*	.011
Image Quality	.524	.275	.055	.272	3.01*	.004
Radiographic Anatomy	.573	.328	.054	-.188	-2.15*	.036

*p < .05

Table 12 presents the significant predictors of students' technical skills in a Simulated Chest X-ray Imaging Examination (Simulation). The R Square values of .090 means that 9 % of the variations in Chest X-ray Imaging Simulation could be attributed to students' affective skills, .150 means that 15 % of the variations in Chest X-ray Imaging Simulation could be attributed to their Psychomotor Skills, .220 means that 22 % of the variations in Chest X-ray Imaging Simulation could be attributed to their cognitive skills in radiographic positioning, .275 means that 27.5 % of the variations in Chest Imaging Simulation could be attributed to their cognitive skills in image quality evaluation, and .328 means that 32.8 % of the variations in Chest X-ray Simulation could be attributed to their cognitive skills in radiographic anatomy. Chest X-ray Imaging Simulation was regressed on the five variables, affective skills, psychomotor skills, and cognitive skills in radiographic positioning, image quality, and radiographic anatomy by Stepwise Multiple Regression Analysis. Results demonstrated that affective skills in chest imaging, psychomotor skills in diagnostic x-ray machine operations, cognitive skills in radiographic positioning, image quality evaluation, and radiographic anatomy are significant predictors of students' technical skills in Chest X-ray Imaging Simulation. This result is validated in the study of Giordano and Greathouse (2008) which explained that the formative evaluation of radiologic technology students' clinical performance in the affective, cognitive, and psychomotor domains could be critical to the development of their technical skills and professional competencies. Giordano and Greathouse (2008) reemphasized that the clinical evaluation in radiologic technology should typically include the cognitive, affective, and psychomotor domains because an integral part of educating radiologic technology professionals to a level of competency should include the development of professional attitudes and excellent technical skills. This finding is supported in the study of Sanders (2011) which argued that simulation education should allow students to integrate their communication, and patient assessment skills with their technical abilities in handling diagnostic x-ray equipment and devices. The portable chest radiography simulation involves the realistic presentation of various reproducible clinical conditions for the purpose of evaluation and assessment. The simulation experience affords the students with the opportunity to practice, and perfect their patient care skills, build confidence in their abilities, and work as a team member in a safe environment. The strength of the radiography simulation experience for students is measured effectively in the confidence that students demonstrate upon entering the clinical rotation. The result is also related to the inquiry of Kowalczyk and Leggett (2008) which reported that experienced radiographers did indeed make their professional duties appear simple, but higher-level reasoning skills are required to integrate the knowledge of radiologic science, imaging technology, and disease processes needed to perform competently the diagnostic x-ray procedures in a modern imaging department. The study of Kowalczyk, N. and Leggett, T.D. (2008) also suggested that cognitive skills elements, like critical thinking and problem solving in image quality evaluation, can be crucial in radiologic technology and needed to be developed and strengthened in radiography students early in the educational process. Radiologic technology students must demonstrate sound critical-thinking skills to function as competent professionals in handling diagnostic x-ray examinations in today's health care environment. The findings are related to the inquiry of Nol and associates (2003) which reported that radiographers' positioning techniques are associated with their technical skills in the performance of chest x-ray procedures. The study revealed that more than 30% of the repeats were for chest x-rays, and the

positioning errors were largely associated with junior radiographers. This indicates that the problem might be due to lack of imaging experience, training, and improper supervision of section heads and senior members of the radiology technical staff. The following are the results of this investigation: The levels of competency of radiologic technology students' cognitive skills in chest x-ray imaging, their affective skills in performing chest x-ray imaging procedures, and their psychomotor skills in handling diagnostic x-ray equipment were found to be competent and the responses were also consistent as shown by the small standard deviation. The overall mean ratings for determining the level of competency of radiologic technology students' technical skills in performing simulated chest x-ray imaging procedures, and their technical skills in performing the actual chest x-ray imaging procedures measured by competency evaluation, were found to be competent and the responses were also reliable as shown by the small standard deviations. There was a strong positive significant relationship between the radiologic technology students' cognitive skills and affective skills in the performance of chest x-ray imaging procedures. A strong positive significant correlation was also found between the radiologic technology students' cognitive skills in chest x-ray imaging, and their psychomotor skills, in terms of manipulating the diagnostic x-ray equipment and devices. There was a significant relationship between the radiologic technology students' technical skills in a simulated chest x-ray imaging procedures and the actual chest x-ray imaging procedures as measured by competency evaluations. The radiologic technology students' affective skills in chest x-ray imaging, their psychomotor skills in handling diagnostic x-ray machine and devices, and their cognitive skills in chest x-ray imaging, in the aspects of radiographic positioning, image quality, and radiographic anatomy identification, were found to be significant determinants of their technical skills in the performance of simulated chest x-ray imaging procedures. The radiologic technology students' affective skills in chest x-ray imaging procedure were found to be the best determinants of their technical skills in the performance of actual chest x-ray imaging procedure measured by competency evaluation.

CONCLUSIONS

The following conclusions were formulated on the basis of the findings: Since the radiologic technology students were competent in the cognitive skills evaluation, they could make use of their knowledge, reason and judgment in chest imaging that would ultimately help them analyze the value of diagnostic images for quality control purposes leading to satisfactory interpretation of physicians of the patient's underlying medical problems in the chest cavity. The radiologic technology students' performance in affective skills assessment showed their complete understanding or applications of practice standards in handling patients during diagnostic x-ray procedures of the chest. Competency in this aspect of evaluation will bring comfort and safety to patients or clients in the diagnostic imaging department because the students had developed the core values of an ideal radiographer which are competent, compassionate, and caring. The result of psychomotor testing to the subjects of the study indicates that the radiologic technology licensure course on Radiologic Physics, Equipment and Maintenance should be evaluated consistently and systematically to develop the necessary skills or competency among radiologic technology students in the aspects of x-ray equipment manipulation with the foremost objective of reducing the radiation exposure of patients, clients, and imaging staff. The proficiency in this aspect of x-ray equipment manipulation ensures that patients or clients are given safe exposure techniques to help reduce radiation exposure and occurrence of repeat examinations to clients and imaging professionals. Therefore, the holistic approach in enhancing the proficiency of radiologic technology students in performing diagnostic x-ray procedures needs the development of the three interrelated competencies namely: (1) cognitive skills which concern the applications of stock knowledge and critical thinking in x-ray imaging to better assess the quality of x-ray images, (2) affective skills which embrace the applications of quality patient care to clients, and (3) psychomotor skill involving the manipulation of radiographic equipment and x-ray devices to effectively reduce radiation exposures during diagnostic examinations. A simulated imaging could be important for honing the technical skills of radiologic technology students,

for advanced clinical training outcomes. The radiologic technology students who are competent in performing a simulated clinical procedure indicate that their prior knowledge in radiologic technology licensure subjects such as equipment maintenance, radiographic positioning techniques, and patient care are satisfactory in developing the technical skills needed to perform the procedure both in humans and diagnostic x-ray equipment. The cognitive skills and affective skills applied in the performance of diagnostic x-ray procedures are always interrelated. Results of better analysis of the processes involved in creating high-definition diagnostic images, and a caring radiologic technologist who is compassionate to patients would likely produce good quality x-ray images since empathy in radiologic care indicates that at the end of the process, the radiologic technologist is able to yield good radiographs. The study of Ugwu and associates (2010) confirmed that affective skills of students in radiography are significantly related to their cognitive skills in the performance of x-ray examination procedures. This study also found out that there was a significant relationship between the radiologic technology students' cognitive skills and psychomotor skills in the performance of chest imaging procedures; therefore, the interplay of cognitive skills and psychomotor proficiency in the performance of x-ray examinations is confirmed. The inquiry of Egestad (2008) explained that competent radiography practice could be characterized by the combination and integration of technical knowledge, including but not limited to, x-ray machine manipulation. Radiologic Technologists who precisely operate the diagnostic x-ray equipment and technology would objectively place the patient in the correct projection or position in order to produce the finest x-ray images; such technical practices would likely minimize repeat examinations that could potentially increase patients' radiation dose. A significant relationship between the radiologic technology students' technical skills in a simulated chest x-ray imaging procedures and actual chest imaging examinations measured by competency evaluations was also confirmed in this inquiry; therefore, simulated clinical procedure is a reliable testing mechanism that enhances the technical skills of radiologic technology students in the performance of actual x-ray examinations. The significant relationship between simulations and actual performance of x-ray examinations is further confirmed in the study of Almohiy and Davidson (2011) which justified that simulated imaging could be important for developing technical skills and for improving clinical training outcomes evident in actual x-ray investigations. Simulated imaging could provide the students with the opportunity to practice radiography skills in a structured, predictable, and safe learning environment, so that during actual performance of x-ray examinations, students could further develop their skills in situations that were unable to be simulated in the laboratory sessions. The interplay of cognitive, affective, and psychomotor learning areas in the performance of diagnostic x-ray examinations is confirmed in this investigation. It is further validated in the study of Giordano and Greathouse (2008) which explained that the formative evaluation of radiologic technology students' clinical performance in the affective, cognitive and psychomotor domains could be critical to the development of their technical skills and professional competencies. The study revealed that the determinants of radiologic technology students' technical skills in chest x-ray imaging simulation procedures were their affective skills, psychomotor skills, and cognitive skills in positioning, image quality, and radiographic anatomy. Among the enumerated predictors, students' psychomotor skills were established to be very high determinants of students' technical skills in chest x-ray imaging simulation. Therefore, the performance of students in licensure areas in the radiologic technology curriculum such as in Human Anatomy & Physiology, Radiographic Positioning & Radiologic Procedures, and Radiographic Technique & Film Processing Analysis I & II, most especially, in Radiologic Physics, Equipment and Maintenance I & II, should be monitored and regularly evaluated by clinical and didactic faculty members to cultivate the technical skills of the students in Radiologic Technology clinical practice. Radiologic technologists who have the human skills of being compassionate and caring of patients or clients in the imaging department would likely obtain their patients' willingness and cooperation to the diagnostic x-ray procedures ultimately resulting in generating the highest quality diagnostic images, leading to physicians' accurate interpretations of a patient's underlying medical problems. The result of

this inquiry is validated in the study of Giordano and Greathouse (2008) which conveyed that while the evaluation of the affective skills of radiologic technology students was relatively difficult to measure compared to the evaluation in the cognitive domain, it could be critical to the development of technical skills and compassion of radiologic technology professionals toward their patients. The results of the study further explain that the affective skills of radiologic technology students are critical to the development of competency or technical skills of the students in the performance of radiographic procedures. The core values developed and applied by radiologic technology student interns to the patients, in terms of compassion and empathy, resulted in the patients' overall cooperation to actual x-ray procedures because cooperative patients are evidences of the care and compassion of humane radiologic technologists.

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