DIGITAL RADIOGRAPHY IN THE EDUCATION OF RADIOLOGIC TECHNOLOGY STUDENTS

A Thesis

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By

Seth A. Sivard, B.S., R.T.(R)

The Ohio State University
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Master's Examination Committee: Approved by
Philip Beckley, Ph.D., Advisor
William Finney, M.A. 
Nina Kowalczyk, M.S. 

Advisor

School of Allied Medical Professions
ABSTRACT

This study was conducted to ascertain the amount of preparation radiography students are receiving in the subject of digital radiography as compared to film/screen radiography, both in the didactic setting and in the clinical education setting. Surveys were sent to 196 radiography schools listed as accredited schools by the ARRT. The respondents were evaluated as a whole and as categories starting with less than 500 total didactic hours up to 2000 total didactic hours at increments of 500 total didactic hours. The results demonstrated that film/screen radiography dominated in both settings. However, radiography students spent 44.8% of their time in a clinical education setting which utilized digital radiography. The study also indicated that the majority of the radiography schools didactically taught digital radiography as part of a course, not having a course dedicated to digital radiography.
DEDICATION

I would like to dedicate this project to my wife. Without her love and support, I would not be where I am today.
ACKNOWLEDGMENTS

I would like to take this opportunity to thank several individuals. First, I would like to thank Dr. Philip Beckley. I appreciate you keeping tabs on me throughout my program. Thank you for being ready to help me when I had any problems and for answering any questions that I had. Next, I would like to thank Mr. William Finney. I truly appreciate all that you have taught me and for all the chats that we had in your office. I wish you well in your retirement. Next, I would like to thank Ms. Nina Kowalczyk for all of your support and advice throughout the process of developing this project. It was truly appreciated. Finally, I would like to thank Ms. Jill Clutter for being with us throughout the steps of this project. Your ideas and advice were truly valued.
VITA

August 10, 1976 ........................................... Born – Marietta, Ohio

1998 ......................................................... B.S. Allied Medicine, The Ohio State University.

1998 – Present ........................................... Imaging Technologist,
Department of Radiology, The Ohio State University

2004 – Present ........................................... Instructor, Department of Radiologic Science,
University of Charleston

PUBLICATIONS

FIELDS OF STUDY

Major Field: Allied Health Education
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CHAPTER 1

INTRODUCTION

Background of the problem

The field of radiologic technology has entered a dynamic and exciting time of great growth and change. Radiology departments are performing more and more procedures due to the fact that the baby-boomer generation is aging and are in need of radiology services for their healthcare (Olivi, 2002). This is putting a greater demand on technologists to perform a larger number of procedures everyday. This increased demand is compounded by the fact that the profession of radiologic technology is experiencing a large personnel shortage. That shortage has been predicted to only get worse over the next few years before things turn around and more technologists enter the field (Olivi, 2002).

There have been several advances in radiography due in large part to advances in computer technology. Many departments are moving toward a filmless environment. In order to make this transition, several components must be installed to create a filmless environment. These components are a digital radiography system, a radiology information system (RIS), and a picture archival and communication system (PACS). The digital radiography system, whether it is computed radiography or direct
radiography, allows the radiologic technologist to acquire an image digitally. The RIS attaches the patient’s information to the image. The PACS allows clinicians to view radiographic images on high-resolution computer monitors instead of looking at hard-copy film radiographs. Radiology departments are moving toward this technology for several reasons. These include overall cost savings in time, increased productivity of staff, faster reporting time on examinations, and a reduction in dose to patients due to decreased film repeat rate.

The trend for radiology departments to install some type of digital radiography will continue until it is the norm. The market is driving down prices of the equipment making this technology more affordable and attractive to departments. Agfa Healthcare states on their website that their company can design a digital system to fit the needs and budget of various healthcare facilities (www.agfa.com/healthcare/content/index.php?table=NAVCLINSOL&rootguid=&navguid=08BABA99BF12D8B619306AA209F53144). There are several manufacturers of digital radiography equipment in the market place including Agfa Healthcare, FujiFilm Medical Systems USA, and Eastman Kodak. According to the FujiFilm Medical System USA website, there are 1,200 Fuji CR systems installed in the U.S. and over 12,000 worldwide (www.fujimed.com/medical/cr_whyfuji.html).

Need for the study

Today’s radiologic technology graduates are working in departments in which they may not be totally prepared to function. It has been documented that there is a learning curve for radiologic technologists when using digital radiography (Reiner et al,
and the department has the responsibility of teaching the technologist about digital radiography. The American Society of Radiologic Technologists (ASRT) is currently revising their radiography curriculum guide to include additional content on digital imaging. However, the radiography curriculum currently in use, which is the recognized and accepted curriculum by which the Joint Review Committee on Education in Radiologic Technology uses to evaluate programs, does not deal with digital radiography in great detail. Until the revised curriculum guide goes into effect, the schools are not obligated to spend a designated amount of time on the subject of digital radiography. The amount of time spent on teaching digital radiography is based on each school’s own discretion. Also in a review of literature, there was no a study found to indicate the average amount of education radiologic technology students obtain in the field of digital radiography. So at this time there really is no way to know how much exposure to digital radiography today’s radiologic technology graduates have when they enter the radiology department to work as a radiologic technologist. The purpose of this survey was to obtain information regarding the amount of didactic instruction and clinical experience today’s radiologic technology students are receiving in the subject of digital radiography.

**Research Questions**

This descriptive study attempted to determine the number of hours of education specific to digital radiography that radiologic technology students receive in various programs. This study also attempted to determine the percentage of programs that have some type of digital radiography in their clinical sites.
The actual questions this study answered were:

1. How many didactic contact hours are radiography students receiving in the subject of digital radiography?

2. In what way is the subject of digital radiography taught didactically in various programs, is it a course of its own or is it incorporated into other courses?

3. What percentage of radiography programs have digital radiography in their clinical sites?

4. How many clinical contact hours are radiography students exposed to digital radiography?

Definition of Terms

**ARRT**- The American Registry of Radiologic Technologists. The national certifying body of radiologic technologists. The ARRT certifies radiologic technologists through tests and continuing education requirements.

**ASRT**- The American Society of Radiologic Technologists. It is the world’s largest radiologic science organization. According to the ASRT’s website, the ASRT is responsible for establishing standards of practice, educational curricula, and entry-level standards for the profession.

**COMPUTED RADIOGRAPHY (CR)** - Radiography system using phosphor plates in an imaging cassette that is then scanned by a plate reader to produce a digital image.

**DIGITAL RADIOGRAPHY**- Consists of both computed radiography and direct radiography.
DIRECT RADIOGRAPHY (DR) - Radiography system that uses image receptors that will produce and process a digital image displaying it directly on a computer monitor. The receptor does not need to be scanned by a phosphor plate reader.

JRCERT- The Joint Review Committee on Education in Radiologic Technology. The national body that programmatically accredits radiography programs.

PACS- Picture Archival and Communications Systems. Computerized system that makes it possible to electronically store, manage, distribute, and view images.

RIS- Radiology Information Systems. Computerized system that makes it possible to electronically store, manage, distribute, and view medical information.
CHAPTER 2

REVIEW OF LITERATURE

Healthcare is in a state of change due, in part, to technological advances and changing patient demographics. This leads healthcare educators to question whether our educational programs are keeping pace with the current healthcare environment. “The future belongs to those who are anticipating, shaping, and influencing change even as they are immersed in it” (Selker and Broski, 1991). However, research indicates that changes and trends in the healthcare environment occur well before they are included in the academic preparation of students. “Dr. Markley Boyer of Tufts University has characterized the educational environment in U.S. medical schools as a long period of innovation without change” (Wilson et al, 2000). In the Journal of Allied Health, Wilson et al state that there is “lag time in translating current health care changes into academic coursework” (Wilson et al, 2000). This lag time has caused experienced practitioners, who work with new graduates, to challenge the academic preparation of the students for the current health care environment (Adamson et al, 1997).

Computers are in all aspects of healthcare, and it is important that graduates from healthcare programs have computer skills. A study in the Journal of Nursing Education concluded “…that integrating information technology content into undergraduate nursing
curricula is imperative to help nursing students gain the necessary skills for successful employment. Students need both traditional computer skills, such as searching databases, and specialized computer skills, such as bedside charting. Possessing these skills will allow new nurses to better help their patients” (McCannon & O’Neal, 2003). New graduates of nursing schools are filling nursing positions that are very technical or computer based. However, these nurses may not be totally prepared to work in these positions because “many undergraduate nursing programs do not require any information technology courses in their curricula” (McCannon & O’Neal, 2003). This is a major disadvantage for the new graduates because “with the supply of nurses failing to meet the projected demand, nurses need to be competent in the initial job skills required because current work environments do not provide nor promote lengthy orientation for new employees” (McCannon & O’Neal, 2003). It has also been demonstrated in a study from England that half of the nurses used computers, but “training in basic information technology skills appeared to be minimal because less than 5% of the nurses had received training” (McCannon & O’Neal, 2003). Studies have shown that there is a need for information technology concepts, skills, and tools to be included in nursing curricula. However, the inclusion of these skills into the curricula has been slow “and no consistent curricula for nursing information technology exist in nursing education programs” (McNeil et al, 2003). McNeil’s study demonstrated “...the need for additional education of nursing directors and faculty specifically addressing the importance of information technology for supporting evidence-based health care” (McNeil et al, 2003). “The challenge for nursing programs will be to close the ever-widening gap between education and practice” (McNeil et al, 2003). A study performed by Haque and Gibson
demonstrated "...that the present-day healthcare delivery systems have become increasingly technology-dependent, and that there is a growing need for training in the use and applications of computers in healthcare" (Haque & Gibson, 1998).

The field of radiography is currently facing a shortage that is only projected to become worse, as mentioned in Chapter One. Therefore similar to nursing, radiography students will be depended on to be productive members of the radiology department once they graduate. With the increased movement toward digital radiography, the question is, "Do radiography students possess the necessary information and skills to be fully productive in a digital radiography department?" The studies eluded to in the previous paragraph demonstrate the trend that education is not keeping up with practice and that graduates are not fully prepared to be productive members of the healthcare team.

The education in the subject of genetics is another issue for allied health educators. The Human Genome Project has brought about a new understanding of disease (Burton & Stewart, 2003). This new understanding may lead to classifying diseases by their molecular pathology instead of their clinical criteria. Also, this new understanding may bring "new options for prevention and treatment of disease" (Burton & Stewart, 2003). Knowledge in the subject of genetics will be of particular importance to nurses. "A nurse may be the person to whom concerns about a family history of cancer or heart disease are first raised" (Burton & Stewart, 2003). Nurses will need to be able to explain to patients genetics for their patients so that they understand. Also, nurses "will need to understand and be able to communicate about how genes and the environment interact and use this knowledge to influence appropriate lifestyle changes in their patients" (Burton & Stewart, 2003).
In New Zealand, a study was conducted to evaluate the teaching of genetics in undergraduate nursing programs. The study investigated “how much genetics is taught in the bioscience component of the three-year Bachelor of Nursing degree offered by 16 tertiary education institutes in New Zealand” (Nicol, 2002). The reason for the study was the new information in genetics and its role in healthcare. The authors state that “in order that nurses may perform effectively in their role it is paramount they receive a thorough grounding in both the biology of genetics and clinical genetics during their undergraduate program”. The results of the survey demonstrated that on average 250-350 hours were spent teaching biosciences. However, 66% of the programs reported spending less than 10 hours teaching genetics, and none of the programs reported spending more than 20 hours on the subject. Also, through use of a Likert scale, the instructors indicated a strong agreement to the statement “genetics will have a major impact on healthcare over the next five years (Nicol, 2002). The respondents “are aware of the importance of genetics and the impact this branch of biology will have on healthcare, but it is not reflected in the curriculum” (Nicol, 2002).

Palliative care is another healthcare practice that affects allied health education. Over the past decade there has been a major shift in the emphasis given to palliative care with over 90% of hospital beds now being occupied by patients with chronic life threatening illness (Lloyd-Williams & Field, 2002). A study performed in the UK demonstrated that nursing diploma students received of 7.8 hours and degree students 12.2 hours of instruction in palliative care, while undergraduate medical students receive 20 hours (Lloyd-Williams & Field, 2002). A study that was performed to evaluate education’s impact on the attitudes of undergraduate nursing students indicated “…that
education can have a positive effect on nursing students’ attitudes toward care of the dying” (Mallory, 2003). Pharmacy schools were also surveyed in regards to education in palliative care. The study indicated that pharmacy students received 3.89 lecture hours per year in palliative care (Herndon et al, 2003).

The amount of education in palliative care is being evaluated for physicians as well. One study evaluating internal medicine house officers indicated that these physicians received 1-5 hours of prior formal training in palliative care, 1-5 hours in pain management, and 6-20 hours in ethics (Clark et al, 2003). The study also concluded that “palliative care knowledge and ease with dying patients were higher in later years of residency but were not associated with prior formal palliative care training. These data highlight the continued need to evaluate and improve training in palliative care and pain management” (Clark et al, 2003). Another study inquired as to how physicians learn to provide palliative care. The results indicated that physicians learn very little through formal education, but mostly on the job and by learning from their mistakes (Schulman-Green, 2003).

There also appears to be a discrepancy between what educators and what practicing healthcare professionals feel should be entry-level competencies (King et al, 2003). One such issue is gerontologic studies. “Rarey’s survey of 835 California radiographers indicated that many of these professionals are not well informed about gerontological issues and are not prepared to meet the needs of patients older than 65” (Sanders & Mitchell, 2003). “Despite the increase in the number of elderly people in the United States, there have been limited attempts to educate the allied health workforce about the merits of a gerontologic curriculum” (Namazi & Green, 2003). These studies
indicate that healthcare is changing, but education is not changing with it. Education appears to be behind, reacting to the environment, instead of anticipating and shaping it.

In the previous five paragraphs, one can see how the practice of healthcare is changing, but education is not keeping up by revising the curriculum in order to keep pace with these issues. A limitation of this study was the fact that the author was unable to locate many articles dealing with radiography student curriculum and education. Therefore, it was necessary to look outside of radiography to other healthcare fields such as nursing where there is much research conducted in their field. However when reviewing the previous paragraphs, other healthcare fields such as pharmacy and medicine were included to demonstrate that education is lagging behind clinical practice for all of healthcare, not just nursing or radiography.

One area of importance in comparing student preparation in radiography education to required clinical skills upon graduation is the continued increase of digital imaging systems in the clinical environment. Current literature supports a movement toward a digital radiography department from a film/screen based radiography department. The savings received from this venture toward a digital radiography department and the improved productivity justifies the initial costs. It was demonstrated in a study performed by Reiner et al that there is a “learning curve” associated with implementing digital radiography. The study evaluated productivity in hospital settings and demonstrated that upon implementation of digital radiography, radiographers’ productivity dropped 10.8%. However, departments which had more than one year experience with digital radiography demonstrated a 27.8% increase in productivity (Reiner et al, 2002). The previous study demonstrates the importance of being educated.
in the subject of digital radiography. The decrease in productivity during the “learning
curve” translates into an increase in the amount of time for the delivery of healthcare to
patients due to their radiographic exams not being performed.

Effects of Digital Imaging

Cost and Efficiency

The initial cost of implementing a digital radiography system into a radiology
department can be quite expensive, but the long-term advantages of a digital system
outweigh the initial costs. Some of these advantages include increased department
productivity, decreased time for reports from radiologists, decreased expenditure on
radiographic film, decreased amount of storage space for films, and reducing the need for
a film library and its staff. A study done by Duerinckx and Grant stated, “... it is
important that the radiology community realize that the purchase of large-scale PACS
and CR systems can be cost-effective. Not only will the system pay for itself in 7-8 years
in most moderately sized hospitals, but also, if the use of radiographic film can be
reduced more rapidly, it may allow the purchase of PACS-CR equipment for less then
half the cost base” (Duerinckx and Grant, 1998). The conclusion is that the quicker a
department eliminates film, the quicker it will recover the cost of implementing a digital
system.

A study at St. Luke’s Episcopal Hospital in Houston, Texas showed the impact of
a DR system. The radiology department stated that during its peak hours they may have
a backlog of up to ten patients needing a radiology exam. After the implementation of a
DR room, it decreased their backlog. The DR system “has reduced our average exam
time from ten minutes to one and a half minutes, not including patient transport time”
This led the radiology department at St. Luke’s to install a DR system in their new emergency department radiology room. They estimate that the benefits gained from this system will allow it to pay for itself in three years.

Several articles have shown a decrease in the amount of time taken for a report to be generated for a radiography exam. At a Mayo community medicine practice in Rochester that produces about 45,000 radiology exams per year, the interpretation time was reduced for both routine and urgent exams. Through PACS, the images were available for remote soft-copy interpretation. This also allowed for a specialist to view and interpret exams from a remote location (Hangiandreou et al, 1997). A study conducted at the Royal Adelaide Hospital in Australia showed a reduction in reporting times of both chest and orthopedic exams when comparing conventional film radiography versus digital radiography. “The mean reporting times for digital and conventional chest examinations were 17 and 25 minutes, respectively; a significant 8 minute difference. The orthopedic examinations revealed mean reporting times of 8 and 26 minutes for digital and conventional systems, respectively; a significant 18 minute difference” (Lai and Langlois, 1999).

Several studies have also shown a decrease in examination time and increased efficiency in several radiology departments. A study that was performed by the Canon Research Center America at the Cleveland Clinic Foundation showed that DR resulted in workflow savings over traditional film/screen practice. “There is an additional 30% reduction in total examination time using DR with RIS integration” (May et al, 2000). The radiology department at Veterans Affairs Maryland Healthcare System also showed a decrease in technologist examination times in the performance of radiographic exams
The department of radiology at the University of California at San Francisco showed a higher patient volume for digital radiography systems as well as time to image availability for interpretation. “A mean of 10.7 patients were moved through the DR chest room per hour, and 9.2 patients per hour using CR, versus 8.2 patients per hour for the analog device. Measured time to image availability for interpretation is much faster for digital radiography versus screen-film, with the mean minutes to image availability calculated as 5.7 +/- 2.5 minutes for DR, 6.7 +/- 1.5 minutes for CR, and 29.2 +/- 14.3 minutes for screen-film” (Andriole et al, 2002).

Another article by Bickford and Daniels in the journal Radiologic Technology states that two of the biggest expenditures for most radiology departments are film and contrast media. They state that digital imaging can reduce the amount of expenditure on contrast media because studies have shown that digital imaging requires less contrast agent to create a diagnostically acceptable image. Digital radiography, with PACS, reduces the amount of money departments spend on film because there is no need to print the image under normal circumstances. Sometimes, granted, the patient may need the film to take to an outside physician’s office. In this case the film can be printed, but for most cases the films will never need to be printed which will reduce the amount of money spent on film as well as the money spent on film storage. The authors go on to state that “…the long-term savings can justify the initial outlay” (Bickford and Daniels, 1998). The reason being is that departments will increase their productivity and save money on the costs of film and film storage.
Clinical Applications

In one urgent care setting, the care of 215 patients was analyzed. The patients were divided into two groups, where one group’s examination was performed using film-screen radiography and the second group’s examination was performed using digital radiography. “The analysis demonstrated a reduction in time to final diagnosis that was better appreciated during times when a staff radiologist was not immediately available. The data suggests that digital radiography is a useful tool to improve the clinical outcome of patients seen in the acute care setting” (Mattern et al, 1999).

In another study reported by Huda et al in the Journal of Digital Imaging a questionnaire was sent to emergency departments in North America on the subject of digital radiography. The study listed several advantages to digital radiography in the clinical environment. These included prompt availability of images, eliminating lost images, and improving image quality to name a few. Both of the radiology departments and emergency departments, who responded, reported about half were highly satisfied (Huda et al, 1997). Another key point was that there were no respondents who were dissatisfied.

Another study reported by Pathi and Langlois at the Royal Adelaide Hospital demonstrated a significant reduction in the time for availability of images for digital radiography. Thirty patients were included in the group that received conventional film imaging, and thirty patients were included in the group that received digital radiography. The average time to availability for film-screen imaging was 47.9 minutes. The average
time for digital radiography was 14.4 minutes. "The time-motion data indicates a 70% reduction in turnaround times for digital X-ray images compared with conventional films to the requesting doctor" (Pathi and Langlois, 2002).

Studies have also shown a reduction in radiation exposure for patients when using digital radiography as compared to conventional film-screen imaging. There are a couple of reasons for this reduction, but the main reason is the reduction in repeat rates for patients. Digital radiography has significantly reduced the number of repeat films in departments that use digital radiography. A study that was reported by Peer et al showed an overall reject rate of 27.6% in a conventional imaging department and 2.3% in a digital radiography department. The main reason for repeats in the conventional department was exposure, but the main reason for repeats in the digital department was positioning. They stated that "a marked reduction of repeated X rays and consequently reduced radiation exposure of the patient was clearly shown in this study comparing two differently working radiology departments" (Peer et al, 2001). Another study that was reported by Polunin et al also showed a lower repeat rate for digital radiography. The overall repeat rate for conventional imaging was 8.2% and for digital radiography was 4.6%. In this study the repeat rate due to exposure factors was considerably less for digital radiography. For conventional radiography, the repeat rate due to exposure factors was 3.2%. For digital radiography, the repeat rate for exposure factors was 0.6%. This led them to the conclusion that digital radiography "resulted in a reduced retake rate due to exposure factors leading to a reduction in the overall retake rate" (Polunin et al, 1998).

There have been studies done to evaluate how digitally acquired images compare to conventional film images. O'Connor et al reported that "there was a significant
improvement in diagnostic performance for soft-copy formats relative to hard-copy formats” (O'Connor et al, 1998). These results were based on radiologists’ opinions on 115 images. Lu et al did a study that used a contrast-detail phantom. They also had the help of four physicists to help determine a patient’s dose during the study. The purpose of the study was to see if using digital radiography compromised the contrast-detail of an image. Their study “suggested using a higher kVp setting and additional filtration would reduce the patient entrance skin dose without compromising the contrast detail delectability” for digital radiography (Lu et al, 2002). Hamer et al conducted a study comparing digital radiography versus film-screen radiography. Based on images obtained using identical exposure parameters, “the new digital flat-panel detector … appears to be at least equivalent to conventional screen film combinations for skeletal examinations, and in most-respects even superior” (Hamer et al, 2001).

Summary

The information provided in this literature review demonstrates that healthcare is changing both technologically and in terms of patient demographics. However, it appears that education is falling behind in regards to educating students regarding current and future healthcare practice and that this lag may be present as radiography departments are moving from film/screen based radiography to digital radiography. In a reviewing the literature, a study evaluating the amount of education radiography students receive in the subject of digital radiography was unable to be discovered. Therefore, there appears to be a need for a study to ascertain the amount of education radiography students receive in the subject of digital radiography, and it would also be beneficial to determine the amount of clinical education time radiography students spend in a clinical education
setting which utilizes digital radiography. The latter would demonstrate the amount of exposure the students have to actually seeing digital radiography being practiced in the healthcare environment along with its effects on the delivery of care to patients.
Research Methodology

The methodology used for this thesis was descriptive survey research. The process for selecting the radiography schools for the survey was a simple random process where each school had an equal chance of being selected. The sample for the survey was randomly selected from the list of accredited radiography schools on the ARRT website, excluding radiography schools located outside of the United States. Either the JRCERT or their respective regional accrediting body accredits these radiography schools. The graduates of these programs are eligible to take the national accreditation exam given by the ARRT. Given these conditions, there were a total of 619 radiography schools on the list. The random sample had a $P = 0.5$, a confidence level $= 95\%$, and a precision level of $\pm 7\%$. To fit these criteria, the random sample included 196 schools. This number was determined with the equation used to calculate sample size as presented in Introduction to Research in Education by Ary et al.

The radiography schools that were included in the sample received a survey questionnaire (Appendix B). The questionnaire was developed and piloted among various allied health educators. Their responses helped shape the final draft of the
questionnaire. The questionnaire consisted of nine questions relating to various aspects of the radiography school. It requested background information of the radiography schools included in the study as well as data on the amount of time spent on the subject of digital radiography. The radiography schools were asked to provide information on how the subject of digital radiography is taught and how much time is spent on the subject during the length of the program. The schools were asked to estimate the amount of time spent in hours due to various schools being either on semesters or quarters.

The issue of non-response was handled by an attempt to contact a random sample of the non-responding schools by phone and briefly conduct the survey on the phone. To reduce non-response error, the surveys were coded so that it could be determined which radiography programs did not respond, and the schools are asked to provide their name and address on the questionnaire. The data was collected and presented in way to attempt to answer all of the research questions that are listed in Chapter One. They were as follows:

1. How many didactic contact hours are radiography students receiving in the subject of digital radiography?

2. In what way is the subject of digital radiography taught didactically in various programs, is it a course of its own or is it incorporated into other courses?

3. What percentage of radiography programs have digital radiography in their clinical sites?

4. How many clinical contact hours are radiography students exposed to digital radiography?
CHAPTER 4

RESULTS

Data Analysis

There were a total of 196 surveys mailed to randomly selected radiography schools in the United States. A total of 105 responses were gathered with 103 being useful. The 103 returned questionnaires gave a response rate of 53%. The total number of fully completed surveys was 85, which was a rate of 43%. The data was analyzed using the SPSS software package. The data was analyzed as a collectively and also as eight categories with the total number of didactic hours for each school being the determining variable. The categories were as follows: schools with less than 500 hours of didactic instruction, schools with greater than or equal to 500 but less than 1000 hours of didactic instruction, schools with greater than or equal to 1000 but less than 1500 hours of didactic instruction, and schools with greater than 1499 but less than 2001 hours of didactic instruction. The radiography programs were asked to respond to nine questions regarding the instruction of digital radiography in their program.
All Responding Programs’ Data

The radiography programs were asked to respond to five questions regarding the instruction of digital radiography in the didactic setting. The calculated mean of the total number of didactic hours for all schools was 807 hours. The calculated mean of didactic hours that were spent teaching digital radiography was 20 hours. The calculated mean of didactic hours that were spent teaching film/screen radiography was 49 hours. (Figure 4.1) Of the responding programs, 88% (n=91) reported that there was not a dedicated course to teaching digital radiography in the program. Twelve percent (12%) (n=12) reported that there was a course dedicated to teaching digital radiography in the program. When asked if the instruction of digital radiography was included in another course, 1% (n=1) of the responding programs reported that digital radiography was not included in another course, while 99% (n=102) reported that it was included in another course. (Table 4.1)

The radiography programs were also asked to respond to five questions regarding the subject of digital radiography in the clinical education setting. The calculated mean of the total number of clinical contact hours was 1821 hours. The calculated mean of the number of hours in which a student is in a digital radiography environment was 816 hours. The calculated mean of the number of hours in which a student was in a film/screen environment was 1020 hours. (Figure 4.1) Of the responding programs, 3% (n=3) reported that none of the clinical education sites utilized digital radiography. Ninety-seven percent (97%) (n=100) reported that digital radiography was utilized in the clinical education sites. However, 14% (n=15) of the programs reported that not all of their students attended these clinical education sites. In contrast, 85% (n=88) of the
programs did report that all of their students attended the sites that utilized digital radiography. The radiography programs were also asked if the students were required to perform equipment competencies of the digital radiography equipment. Of the responding programs, 44% (n=45) reported that the students did not have to perform digital radiography equipment competencies while 56% (n=58) reported that students did have to perform the competencies. (Table 4.1)

Figure 4.1: Mean educational hours for all reporting programs.
### All Radiography Programs

<table>
<thead>
<tr>
<th>Feature</th>
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<th>Percent = Yes</th>
<th>N = No</th>
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<tr>
<td>Dedicated DR Course</td>
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<td>11.7%</td>
<td>91</td>
<td>88.3%</td>
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<tr>
<td>DR Incorporated Into Another Course</td>
<td>102</td>
<td>99.0%</td>
<td>1</td>
<td>1.0%</td>
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<tr>
<td>Has Clinical Education Sites Utilizing DR</td>
<td>100</td>
<td>97.1%</td>
<td>3</td>
<td>2.9%</td>
</tr>
<tr>
<td>All Students Attend A DR Clinical Education Site</td>
<td>88</td>
<td>85.4%</td>
<td>15</td>
<td>14.6%</td>
</tr>
<tr>
<td>Require Students To Perform Competencies On DR Equipment</td>
<td>58</td>
<td>56.3%</td>
<td>45</td>
<td>43.7%</td>
</tr>
</tbody>
</table>

*Table 4.1: All radiography programs descriptive data.*
Programs With Less Than 500 Didactic Hours

Seventeen schools that responded stated that the program had less than 500 total didactic hours. The calculated mean of the total didactic hours for these programs was 332 hours. The calculated mean of didactic hours that were spent teaching digital radiography was 10 hours. The calculated mean of didactic hours that were spent teaching film/screen radiography was 42 hours. (Figure 4.2) Of these programs, 94% (n=16) reported that there was not a dedicated digital radiography course in the program. Six percent (6%) (n=1) reported that there was a dedicated digital radiography course in the program. One hundred percent (100%) (n=17) reported that the subject of digital radiography was incorporated into another course. (Table 4.2)

The calculated mean of the total number of clinical contact hours was 1588 hours. The calculated mean of the number of hours in which a student was in a digital radiography environment was 412 hours. While the calculated mean of the number of hours in which a student was in a film/screen environment was 1176 hours. (Figure 4.2) All 100% (n=17) reported that digital radiography was utilized in the clinical education setting. Eighteen percent (18%) (n=3) reported that not all of the students in the program attended the clinical setting that utilized digital radiography. Eighty-two percent (82%) (n=14) reported that all students did attend the clinical setting in which digital radiography was utilized. Fifty-nine percent (59%) (n=10) of the programs reported that the students were required to perform equipment competencies on the digital radiography equipment. (Table 4.2)
Figure 4.2: Mean educational hours for radiography programs with less than 500 didactic hours.
Radiography Programs With Less Than 500 Didactic Hours

<table>
<thead>
<tr>
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<tr>
<td>DR Incorporated Into Another Course</td>
<td>17</td>
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<tr>
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<td>17</td>
<td>100.0%</td>
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<tr>
<td>All Students Attend A DR Clinical Education Site</td>
<td>14</td>
<td>82.4%</td>
<td>3</td>
<td>17.6%</td>
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<td>Require Students To Perform Competencies On DR Equipment</td>
<td>10</td>
<td>58.8%</td>
<td>7</td>
<td>41.2%</td>
</tr>
</tbody>
</table>

Table 4.2: Radiography programs with less than 500 didactic hours descriptive data.
Programs With Greater Than or Equal to 500 But Less Than 1000 Didactic Hours

Forty-three radiography programs are represented in this category. The calculated mean of the total number of didactic hours for this category was 741 hours. The calculated mean of the number of hours spent teaching digital radiography was 19 hours. The calculated mean of the number of hours spent teaching film/screen radiography was 40 hours. (Figure 4.3) Eighty-six percent (86%) (n=37) of these programs reported that there was not a course dedicated to digital radiography in the program. However, 14% (n=6) of the radiography programs reported that there was a course dedicated to digital radiography. All 100% (n=43) reported that the subject of digital radiography was included in another course. (Table 4.3)

The calculated mean for the total number of clinical education hours was 1901 hours. The calculated mean for the number of hours in a digital radiography environment was 1055 hours. The calculated mean for the number of hours in a film/screen environment was 880 hours. (Figure 4.3) Ninety-eight percent (98%) (n=42) of the programs reported that digital radiography was utilized in the clinical education setting. However, 16% (n=7) reported that not all of the students attended a setting in which digital radiography was utilized. This leaves 84% (n=36) of the programs where all of the students attended a clinical education setting in which digital radiography was utilized. Fifty-six point eight percent (56%) (n=24) of the programs required the students to perform digital radiography equipment competencies, while 44% (n=19) did not require the competencies. (Table 4.3)
Figure 4.3: Mean educational hours for radiography programs with greater than or equal to 500 but less than 1000 didactic hours.
Radiography Programs With Greater Than or Equal to 500 But Less Than 1000 Didactic Hours

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<td>42</td>
<td>97.7%</td>
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<tr>
<td>All Students Attend A DR Clinical Education Site</td>
<td>36</td>
<td>83.7%</td>
<td>7</td>
<td>16.3%</td>
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<tr>
<td>Require Students To Perform Competencies On DR Equipment</td>
<td>24</td>
<td>55.8%</td>
<td>19</td>
<td>44.2%</td>
</tr>
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</table>

Table 4.3: Radiography programs with greater than or equal to 500 but less than 1000 didactic hours descriptive data.
Programs With Greater Than or Equal to 1000 But Less Than 1500 Didactic Hours

Twenty-one radiography programs are represented in this category. The calculated mean of the total number of didactic hours for this category was 1137 hours. The calculated mean of the number of hours spent teaching digital radiography was 41 hours. The calculated mean of the number of hours spent teaching film/screen radiography was 68 hours. (Figure 4.4) Eighty-six percent (86%) (n=18) of these programs reported that there was not a course dedicated to digital radiography in the program. Fourteen percent (14%) (n=3) reported that the program had a dedicated course for the subject of digital radiography. All 100% (n=21) reported that the subject of digital radiography was included in another course. (Table 4.4)

The calculated mean for the total number of clinical education hours was 1982 hours. The calculated mean for the number of hours in a digital radiography environment was 719 hours. The calculated mean for the number of hours in a film/screen environment was 1201 hours. (Figure 4.4) Ninety percent (90%) (n=19) of the programs reported that digital radiography was utilized in the clinical education setting. Ten percent (10%) (n=2) reported that not all of the students attended a setting in which digital radiography was utilized. Fifty-seven percent (57%) (n=12) of the programs required the students to perform digital radiography equipment competencies, while 43% (n=9) did not require the competencies. (Table 4.4)
Figure 4.4: Mean educational hours for radiography programs with greater than or equal to 1000 but less than 1500 didactic hours.
Radiography Programs With Greater Than or Equal To 1000 But Less Than 1500 Didactic Hours

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<tr>
<td>DR Incorporated Into Another Course</td>
<td>21</td>
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<td>Has Clinical Education Sites Utilizing DR</td>
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<tr>
<td>All Students Attend A DR Clinical Education Site</td>
<td>19</td>
<td>90.5%</td>
<td>2</td>
<td>9.5%</td>
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<tr>
<td>Require Students To Perform Competencies On DR Equipment</td>
<td>12</td>
<td>57.1%</td>
<td>9</td>
<td>42.9%</td>
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</table>

Table 4.4: Radiography programs with greater than or equal to 1000 but less than 1500 didactic hours descriptive data.
Programs With Greater Than 1499 But Less Than 2001 Didactic Hours

Four radiography programs are represented in this category. The calculated mean of the total number of didactic hours for this category was 1796 hours. The calculated mean of the number of hours spent teaching digital radiography was 17 hours. The calculated mean of the number of hours spent teaching film/screen radiography was 86 hours. (Figure 4.5) One hundred percent (100%) (n=4) of these programs reported that there was not a course dedicated to digital radiography in the program. All 100% (n=4) reported that the subject of digital radiography was included in another course. (Table 4.5)

The calculated mean for the total number of clinical education hours was 1800 hours. The calculated mean for the number of hours in a digital radiography environment was 1213 hours. The calculated mean for the number of hours in a film/screen environment was 587 hours. (Figure 4.5) All 100% (n=4) of the programs reported that digital radiography was utilized in the clinical education setting. However, 25% (n=1) reported that not all of the students attended a setting in which digital radiography was utilized. This leaves 75% (n=3) of the programs where all of the students attended a clinical education setting in which digital radiography was utilized. Twenty-five percent (25%) (n=1) of the programs required the students to perform digital radiography equipment competencies, while 75% (n=3) did not require the competencies. (Table 4.5)
Figure 4.5: Mean educational hours for radiography programs with greater than 1499 but less than 2001 didactic hours.
### Radiography Programs with Greater Than 1499 but Less Than 2001 Didactic Hours

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<td>DR Incorporated Into Another Course</td>
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<td>100.0%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Has Clinical Education Sites Utilizing DR</td>
<td>4</td>
<td>100.0%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>All Students Attend A DR Clinical Education Site</td>
<td>3</td>
<td>75.0%</td>
<td>1</td>
<td>25.0%</td>
</tr>
<tr>
<td>Require Students To Perform Competencies On DR Equipment</td>
<td>1</td>
<td>25.0%</td>
<td>3</td>
<td>75.0%</td>
</tr>
</tbody>
</table>

Table 4.5: Radiography programs with greater than 1499 but less than 2001 didactic hours descriptive data.
Discussion

The data has shown that radiography programs are providing some instruction on the subject of digital radiography. The overall percentage of didactic hours spent teaching digital radiography is 2% as opposed to 6% on film/screen radiography. In all of the categories more time was spent teaching film/screen radiography than teaching digital radiography. The data also demonstrates that 97% (n=100) of the radiography schools have a clinical education site that utilizes digital radiography. However, 15% (n=15) of the programs report that not all of their students attend a clinical education site that utilizes digital radiography. Some of the categories demonstrated that students spent more time in a digital radiography environment than in a film/screen environment. However, overall the students spent 44% of their time in a digital radiography environment and 56% in a film screen environment. The highest percentage of didactic time that digital radiography received in a category was 4% in the greater than or equal to 1000 but less than 1500 hours of didactic instruction category. The highest percentage of didactic time that film/screen radiography received in a category was 13% in the less than 500 hours of didactic instruction category. Also 12% (n=12) of the responding programs reported that the program had a digital radiography course. However, 99% (n=102) reported that the subject of digital radiography was incorporated into other coursework.

Additional tests

The data was analyzed using some additional correlation tests. The correlation tests were used on the following variables: performance of competencies on digital equipment versus total time in a digital radiography setting, performance of competencies on digital equipment versus total number of didactic hours spent on digital radiography,
and total number of didactic hours spent on digital radiography versus the total number of didactic hours. None of the tests revealed a significant relationship between any of the variables tested.

Limitations of the study

One of the limitations of the study was the large amount of variance between radiography programs, particularly in the amount of hours of instruction, both didactic and clinical, for radiography students. This variance caused large standard deviations which can be seen on the data tables. Another limitation was the fact that only ARRT approved radiography programs that were located within the United States were included in the study. One limitation was the fact that a portion of the surveys were only partially completed. Because some of the surveys were only partially completed when the schools were divided into categories based upon total didactic hours, only 85 of the respondents were used. This was a response rate of 43%, which was lower than the overall response rate of 53%. 


CHAPTER 5

CONCLUSIONS

The data answered all of the research questions. The data demonstrated that 12% of the radiography programs have a course dedicated to the subject of digital radiography. The data also demonstrated that in 99% of the radiography programs, the subject of digital radiography is included in other coursework. The data made evident that 97% of the radiography programs had digital radiography in a clinical education setting. Also according to the data, radiography students receive on average 20 hours of didactic instruction and 816 hours of clinical education in the subject of digital radiography. This translates to 2% of the total number of didactic hours dedicated to digital imaging and 44% of the total number of clinical education hours in which students are a clinical education setting that utilizes digital imaging. As for film/screen radiography education for all schools, students receive on average 49 hours of didactic instruction and are in a clinical education setting in which film/screen radiography is utilized for an average of 1021 hours. These numbers translate to 6% of the total number of didactic hours being dedicated to film/screen radiography and 56% of the total number of clinical education hours in which students are in a clinical education setting that utilizes film/screen radiography.
The group that had the greatest difference in percentage of didactic hours dedicated to digital radiography and film/screen radiography was the category of programs with less than 500 didactic hours. The percentage of didactic hours dedicated to digital imaging is 3%, whereas the percentage of didactic hours dedicated to film/screen radiography is 13%. The distribution of clinical education hours between digital radiography and film/screen radiography for this group was different than that for all radiography schools. The percentage of clinical education hours in which digital radiography was utilized is 26%, and the percentage of clinical education hours in which film/screen radiography was utilized is 74%.

The group that most closely matched the percentages for all radiography schools was the greater than or equal to 500 but less than 1000 didactic hours. The percentage of didactic hours dedicated to digital radiography and film/screen radiography are 2% and 5% respectively. The percentage of clinical education hours in which digital radiography was utilized is 55%, while, the percentage of clinical education hours in which film/screen radiography was utilized is 46%. This group was also somewhat surprising because although more of the students’ clinical education time was spent in a digital radiography environment, more didactic time was spent on film/screen radiography.

Another interesting result from the data was that out of all of the respondents only three reported dedicating more didactic hours to the instruction of digital radiography than to the subject of film/screen radiography. All others reported that the subject of film/screen radiography received more didactic hours than digital radiography.

The data showed that the subject of digital radiography is present in both the classroom and in the clinical education setting. However, film/screen radiography is still
dominate in both settings. It is recommended that the study be repeated in a five years to evaluate any change in the didactic setting or the clinical education setting in the subject of digital radiography. It is recommended that a study to ascertain reasons as to why more time is not spent on the didactic instruction of digital radiography should be done when radiography students spend 44% of their clinical education hours in clinical education settings where digital radiography is utilized. It is also recommended that a study should be done to determine the type of training for digital radiography and the amount of time spent on this training that radiology departments, which utilize digital radiography, present to new radiography graduates employed in the department.
APPENDIX A

LETTER TO RADIOGRAPHY PROGRAMS

Seth A. Sivard  B.S.  RT(R)
Graduate Student of The Ohio State University
4 Rockland Drive
Williamstown, WV 26187

To: Radiography School Program Director

I am currently a graduate student of The Ohio State University working on my thesis project which deals with digital radiography in the radiologic technology program's curriculum. The reason that I have chosen this subject is because of the trend of many healthcare centers across the United States to implement this technology into their radiology departments. The purpose of the study is to try to ascertain the amount of time digital radiography is getting in the classroom and clinical education sites. Your radiography school has been randomly selected to be a participant in this study. I ask that you please take a few moments to answer the brief survey that is enclosed with this letter and mail it back to me with the enclosed pre-addressed stamped envelope. It should only take a few minutes to complete. If your program grants more than one type of degree (i.e. associate’s or bachelor’s), please answer the questions for the type in which the most
students complete. I ask that you answer the questions in regards to the last class that
graduated from your program. Also please answer the questions regarding hours in actual
contact hours not credit hours or semester hours. The survey is coded to help with the
issue of non-response error. I am also asking that you include the name and address of
your program. The purpose of this is to also help with the issue of non-response error.
I thank you in advance for your participation.

Sincerely,

Seth A. Sivard  B.S. RT(R)
APPENDIX B

SURVEY INSTRUMENT

DIGITAL RADIOGRAPHY IN RT CURRICULUM SURVEY

Instructions: If your program grants more than one type of degree (i.e. associate's or bachelor's), please answer the questions for the type in which the most students complete. Please answer the questions in regards to the last class that graduated from your program. Also please answer the questions regarding hours in actual contact hours not credit hours or semester hours. The purpose of including the name and address of your program is to help reduce non-response error only. The survey will be coded to help with the issue of non-response as well.

1. Does your program have a didactic course dedicated to digital radiography?

2. Does your program incorporate digital radiography into another course?

3. What is the total number of didactic contact hours that a radiography student in your program receives?

4. Please estimate the number of didactic contact hours that digital radiography is taught during a student's time in your program. The number of didactic hours film/screen imaging is taught.
   Digital Radiography: 
   Film/screen Radiography: 
   _______ hours 
   _______ hours
5. What is the total number of **clinical** contact hours that a radiography student in your program receives?

6. Do any of the clinical education sites for your program utilize digital radiography?

7. Do all of the students in the radiography program rotate through these sites?

8. Please estimate the total number of clinical hours during which students can earn ARRT competencies that are in a digital radiography environment? Please specify if the answer is in actual hours.

   ________ hours

9. Are students required to earn equipment competencies on digital radiography equipment (i.e. manipulation of contrast, cassette identification with patient’s information, rotate image, etc.)?

Name and Address of Program (optional):

THANK YOU FOR YOUR PARTICIPATION
REFERENCES


**Websites used:**

[www.arrt.org](http://www.arrt.org)  [www.asrt.org](http://www.asrt.org)

[www.jrcert.org](http://www.jrcert.org)  [www.fujimed.com](http://www.fujimed.com)