Effect of CR Lab Equipment on ARRT Image Acquisition and Evaluation Scores

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Abstract

The adoption of digital imaging in medical radiography included the addition of computed radiography (CR) equipment. To provide students with the best possible instruction, radiography programs implemented CR equipment into the laboratory settings to enhance the education students were receiving in the clinical setting. This study compared the scores on the imaging acquisition and evaluation section of the American Registry of Radiologic Technologists (ARRT) national examination for two radiography programs in Texas before the implementation of CR equipment and after to determine if the addition of equipment had an impact on student scores. After the addition of CR equipment in the laboratory setting at the university, the scores on the imaging acquisition and evaluation portion of the ARRT national examination declined. During the same time period, the national average on the same portion of the examination also declined, not as dramatically, but there was still a reduction. The community college, however, demonstrated a slight increase in scores. Based on the decline of the national average on the imaging acquisition and evaluation portion of the ARRT national examination, it is necessary to investigate the cause of the decline.

Effect of CR Lab Equipment on ARRT Image Acquisition and Evaluation Scores

Digital imaging has been part of diagnostic medical imaging since the 1970s with the introduction of computed tomography (CT) and the digitization of fluoroscopy (Carter & Veale, 2014). Widespread adoption of digital imaging in radiography with computed radiography (CR) systems began in the mid- to late-1990s (Imaginis, 2008). Computed radiography systems produce a radiographic image electronically using data that have been digitized and sent to a computer screen for viewing (Carter & Veale, 2014). Prior to the use of digital imaging, medical imaging was performed using film-screen image receptors, which used physical film requiring chemical processing to obtain an image. Film-screen required radiologic technologists to be proficient at selecting correct technical factors, such as kVp and mAs, to achieve a diagnostic quality image while limiting radiation dose to the patient. In film-screen imaging, these factors have a direct effect on image quality.

While it is still the duty of the radiologic technologist to obtain a diagnostic quality image with the least amount of radiation possible, digital imaging offers more flexibility in technical factor selection to assist in the reduction of patient dose (Carter & Veale, 2014). Technical factors in digital imaging do not have a direct effect on contrast and density the way they did in film-screen imaging, offering technologists the ability to reduce patient dose without compromising image quality (Johnston & Fauber, 2016). However, there are many challenges with digital imaging that were not an issue with film-screen, such as a loss of visual cues to the technologist and dose creep, making proper training imperative.

The American Registry of Radiologic Technologists (ARRT) is the national credentialing body for radiologic technologists. The ARRT national examination for radiography tests the students on their knowledge and cognitive skills in the areas of radiation protection, equipment operation and quality control, image acquisition and evaluation, imaging procedures, and patient care and education (ARRT, 2014).

In an effort to augment the education of students, many radiologic technology programs have incorporated CR equipment into the laboratory settings to supplement the training received in the clinical setting. CR equipment is expensive, so not all programs have incorporated it or were able to incorporate it in the same timeline as medical facilities. The purpose of this research study was to determine if the addition of CR equipment in the laboratory setting in two Texas undergraduate radiologic technology programs had a significant effect on the students' scores on the image acquisition and evaluation portion of the ARRT national examination. This is important because radiologic technologists are expected to evolve with the technology and equipment being used; if having additional equipment available for training increases the cognitive skills of the technologist, this can enhance the education of future technologists.

Literature Review

Competency and Role of the Radiologic Technologist

The transition from film-screen to digital imaging and the rapid technological advancements in radiology departments requires radiologic technologists to be knowledgeable, up-to-date, and efficient (Andersson, Christensson, Fridlund, & Brostrom, 2012; Farajollahi, Fouladi, Ghojazadeh, & Movafaghi, 2014). Williams and Berry (1999) conducted a survey of radiographers to determine role and competency level. "The primary role of a radiographer is to care for the needs of the patient whilst producing high quality diagnostic images" (Williams & Berry, 1999, p. 225). Included in caring for the needs of the patient was the knowledge of radiation dose, safety, and protection (Williams & Berry, 2000). A result of the same survey by Williams and Berry (1999) described associated roles and responsibilities of the technologist including professionalism, health and safety, clinical competence, interpersonal skills, professional knowledge, patient care, technical ability, administrative duties, and teaching and learning.

The use of digital radiography makes visual interpretation for image quality slightly more difficult when compared to film-screen radiography. In film-screen, it was evident to the technologist when an image was not of diagnostic quality. There were visual cues, such as an image being too dark or too light, to indicate to the technologist what was wrong with the film and how to correct it (Uffmann & Schaefer-Prokop, 2009). The amount of radiation needed to produce a quality film was dependent on the film, screen, and processor (Odle, 2008). In digital imaging, these visual cues are no longer available because the computer automatically adjusts the brightness and presents an overall acceptable image with a wide range of exposures. This makes the role of the technologist more difficult and increases the need for proper training and knowledge to interpret the image for diagnostic quality beyond the visual cues. It is also easier to unknowingly administer an increased radiation dose because of the numerous variables with digital imaging (Uffmann & Schaefer-Prokop, 2009).

Methodology

Archival data of student scores on the imaging acquisition and evaluation portion of the ARRT national examination were obtained. National average scores on the same portion of the examination for the same date range were obtained directly from the ARRT in the public Annual Report of Examinations provided by the organization (ARRT, n.d.). The ARRT scores were chosen because the examination measures cognitive ability, which was the focus of this study. The purpose of this study was to determine if the additions of CR equipment in the laboratory settings at the aforementioned institutions had a significant effect on the students' scores on the image acquisition and evaluation portion of the ARRT national examination. Permission to conduct the study was obtained and granted by both Institutional Review Boards (IRB). The community college approval was issued on October 5, 2015 with no approval number issued; the university approval number is 15092501.

Subjects

The subjects used for this study were graduates of undergraduate radiologic technology programs at a public two-year community college in north central Texas and a medium-size public university in northwest Texas between the years 2006 and 2014 who completed the ARRT national examination. There were 252 student scores obtained from the community college and 395 student scores obtained from the university, for a combined total of 647 student scores. All scores were obtained from the ARRT and provided to the researchers by each institution for their respective students with no student identification information attached. All subject data were archived and anonymous.

Data Collection

Once IRB approval was obtained from both institutions, the researchers requested the scores from the imaging acquisition and evaluation portion of the ARRT examination from the program directors of both institutions. Upon inquiry, both institutions revealed computed radiography (CR) equipment was implemented in the laboratory settings at their institutions in 2007, which would affect the students completing the examination in 2009. This gave the researchers a pre-equipment date range of 2006-2008 and a post-equipment date range of 2009-2014 to compare the data. Once the data were received, it was organized in a database by institution, year, and score. Upon receipt of the institutional data, the researchers obtained the national average scores from the ARRT public report for each year and added the scores to the database containing the institutional data.

After the data were organized into one database, the researchers coded the data for analysis. The date ranges were separated into pre-equipment (1) and post-equipment (2) categories; the institutions were designated by the institutions; the examination scores were separated by institution and pre-equipment and post-equipment date ranges; and the ARRT national average scores were separated into pre-equipment and post-equipment date ranges.

Data Analysis

The primary hypothesis, that the addition of CR equipment in the laboratory setting will provide a significant difference in student scores on the imaging acquisition and evaluation portion of the ARRT examination, was tested using two independent-sample *t* tests followed by an analysis of variance (ANOVA). The data were input into SPSS and an independent-sample *t* test was performed to compare overall pre-equipment scores to overall post-equipment scores for both institutions combined. A second independent-sample *t* test was calculated to compare the national average of the imaging acquisition and evaluation portion of the examination in pre-equipment and post-equipment date ranges, excluding institution data. Finally, an ANOVA was performed to determine the effect of pre- and post-equipment date ranges on the imaging scores by school. The alpha level of .05 was used to determine statistical significance for all tests.

Results

An independent *t* test was conducted comparing overall imaging scores separated by pre- and post-equipment date ranges, with a total $N = 647$ individual imaging scores, pre-equipment ($n = 225$) and post-equipment ($n = 422$). The data for pre- and post-equipment imaging scores for both institutions combined are presented in Tables 1 and 2. Levene’s test for equality demonstrates a nonsignificant result (p = .286), so equal variances can be assumed between pre- and post-equipment scores. While the overall result of the effect of adding CR equipment to the laboratory setting across both schools was a negative result, it was statistically significant (p = .000).

A two-way ANOVA was conducted that examined the effect of the addition of CR equipment by school on imaging scores. The data for the ANOVA calculations are presented in Tables 3 and 4. Levene's test for equality demonstrates a significant difference between groups (p = .018) that indicates a violation of homogeneity between groups. There was a statistically significant interaction between the effect of the addition of CR equipment on imaging scores, $F(1, 643) = 23.45$, $p = .000$, as well as a statistically significant interaction between the effect of the addition of CR equipment by school on imaging scores, $F(1, 643) = 25.38$, $p = .000$. However, there was no statistical significance between schools, $F(1, 643) = 1.30$, $p = .254$. A profile plot representing the estimated marginal means of imaging scores is demonstrated in Figure 1. The community college demonstrated a mean slightly higher than the university (.06). The community college also had a slight increase in scores of 0.01 after the addition of CR equipment, while the university had a noteworthy decrease of 0.57.

In the second independent *t* test, the national average was separated by the same pre-equipment and post-equipment date ranges used with the institutions and compared with a total N = 9, where N is the national average per year for the nine years studied, pre-equipment (n = 3) and post-equipment (n = 6). The data for national averages are reported in Tables 5 and 6. Levene's test for equality demonstrates a nonsignificant result (p = .296), so equal variances between pre- and post-equipment date ranges can be assumed. There was an overall decrease of .05 after the addition of CR equipment; however, the decrease was not statistically significant (p

= .516). A profile plot representing the estimated marginal means of national average is demonstrated in Figure 2.

Discussion

Since there is not currently other literature published that investigates the effect of adding CR equipment in the laboratory setting, there is nothing to compare these results to or a basis to speculate the reasoning behind them. The researchers had to draw from their own observations and experience to attempt to interpret the results from this research. When looking at the comparison of overall imaging scores between the two institutions before the CR equipment was installed and after the equipment was installed, the decline is likely due to the declination in the university scores, because the community college demonstrated a slight, nonsignificant increase in scores. While schools were not delineated in this particular test, results in other calculations lead to that hypothesis.

The decline in the imaging scores at the university after the addition of CR equipment suggests including the equipment in the learning process for the students might have had a negative impact on their learning process. However, there is more to be considered here. Clinical settings used in the two programs studied had removed film/screen equipment from their facilities, which could have been detrimental to the students' knowledge about film/screen radiography. This could have been the reason for the decline, rather than the addition of the CR equipment. The faculty members at the university had only ever worked in the field using film-screen equipment at the time of implementation, according to the program chair. None of the faculty were familiar with the digital imaging content added to the curriculum. As mentioned previously, there are distinct differences in the processes and principles between film-screen and digital imaging. Switching from film-screen to digital imaging was a true paradigm shift in the field of radiology and involved a great learning curve for all technologists, faculty, and students. Future research will explore the effect of this faculty learning curve on student scores.

The decline in imaging scores in the national average that correspond with the pre- and post-equipment date ranges, while not statistically significant, was found to be relevant to the researchers to possibly offer another explanation for the decline in scores at the university. However, it is likely the data are skewed because of the small sample size. Since the national average also declined, while not as much, it could indicate the test as a whole was increasingly more difficult, with the addition of more digital imaging questions added from 2006 to present, or the paradigm shift in the field was difficult for other schools to teach effectively as well, creating a slight decline nationwide, as well as at the university. The lack of decline at the community college might have been because of a difference in students, more knowledgeable faculty, or even better preparation for the examination because of smaller cohorts of students.

While the results were not expected by the researchers, the hypothesis was supported by a statistically significant difference in scores following the addition of CR equipment in the laboratory setting for the schools selected for the study. The difference was not expected to be a negative one; however, this suggests a need for further research into the reasons why this occurred, as well as a need for a follow up analysis to see if the decline in scores continues after 2017 when film/screen content is removed from the national examination. Additional research comparing other schools' test results from this time period, 2006 -2014, could lead to other conclusions and offer more insight into the impact adding CR equipment had on a regional or national level.

Conclusion

The shift from film-screen to digital imaging in the field of radiology created the need for more diligent and thorough training of students and technologists. The ability for a technologist to make assessments about the quality of his or her film using visual inspection is no longer possible with digital imaging. The technologist must be trained to use other criteria such as exposure indices and subtle image components to determine diagnostic quality, as well as how to avoid the propensity of dose creep, or steady increase of patient dose over time, with digital imaging.

This transition to digital imaging also brought about a drastic curriculum change with a steep learning curve in the education of students from a faculty standpoint. While the basic concepts remain the same, the principles and qualities of imaging that technologists and faculty members had known to be truth for decades was quickly altered. This could possibly have played a role in the negative findings of this study. After the addition of CR equipment in the laboratory setting at the university, the scores on the imaging acquisition and evaluation portion of the ARRT national examination declined. During the same time period, the national average on the same portion of the examination also declined, not as dramatically, but there was still a reduction. The community college, however, demonstrated a slight increase in scores.

Some possible limitations of this study include a violation of the homogeneity of groups in the ANOVA calculations, limited data provided as an explanation for results obtained, and differences in students and faculty at the two institutions. Another factor to consider is while the content is the same at both institutions, the course the students take to cover image acquisition and evaluation could differ slightly as well in delivery or even comprehension of the material.

Suggestions for Future Research

Because there is no research on the effect of the addition of CR equipment in the laboratory setting of radiography programs, further research may be warranted to determine if other schools experienced a decline in scores with initial adoption of CR equipment. Based on the decline of the national average on the imaging acquisition and evaluation portion of the ARRT national examination, it is necessary to investigate the cause of the decline; perhaps the examination became more difficult or the content and specifications were not sufficient to inform educators what the students are being tested on with the addition of digital imaging or the continued inclusion of film/screen content. It is necessary to revisit this study after 2017 when all film/screen content is removed from the national examination. It is also possible there was not enough time for institutions to properly prepare and implement curriculum to include the new technology implementation.

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Table 1 – Independent *t* test of Pre- and Post- Equipment Imaging Scores

Group Statistics					
	Pre/Post Equipment	N	Mean	Std. Deviation	Std. Error Mean
Imaging Score	Pre-Equipment	225	8.7324	.66518	.04435
	Post-Equipment	422	8.3905	.71489	.03480

Table 2 – Independent *t* test of Pre- and Post- Equipment Imaging Scores

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Imaging Score	Equal variances assumed	1.142	.286	5.934	645	.000	.34192	.05762	.22878	.45507
	Equal variances not assumed			6.066	486.650	.000	.34192	.05637	.23116	.45268

Table 3 – ANOVA Descriptive Statistics

Descriptive Statistics				
Dependent Variable: Imaging Score				
Pre/Post Equipment	School	Mean	Std. Deviation	N
Pre-Equipment	BHC	8.6000	.72141	92
	MSU	8.8241	.60941	133
	Total	8.7324	.66518	225
Post-Equipment	BHC	8.6113	.63206	160
	MSU	8.2557	.73000	262
	Total	8.3905	.71489	422
Total	BHC	8.6071	.66467	252
	MSU	8.4471	.74146	395
	Total	8.5094	.71628	647

Table 4 – ANOVA Statistics

Tests of Between-Subjects Effects						
Dependent Variable: Imaging Score						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	32.443[a]	3	10.814	23.257	.000	.098
Intercept	41323.797	1	41323.797	88870.114	.000	.993
PrePost	10.906	1	10.906	23.455	.000	.035
School	.607	1	.607	1.306	.254	.002
PrePost * School	11.805	1	11.805	25.388	.000	.038
Error	298.989	643	.465			
Total	47180.940	647				
Corrected Total	331.432	646				
a. R Squared = .098 (Adjusted R Squared = .094)						

Table 5 – Independent t test of National Average Imaging Scores Pre- and Post-Equipment

Group Statistics					
	Pre/Post Equipment	N	Mean	Std. Deviation	Std. Error Mean
National Average	Pre-Equipment	3	8.3333	.05774	.03333
	Post-Equipment	6	8.2833	.11690	.04773

Table 6 – Independent t test of National Average Imaging Scores Pre- and Post-Equipment

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
National Average	Equal variances assumed	1.276	.296	.683	7	.516	.05000	.07319	-.12307	.22307
	Equal variances not assumed			.859	6.940	.419	.05000	.05821	-.08790	.18790

Figure 1 – Profile Plot of Pre- and Post-Equipment Imaging Scores by School

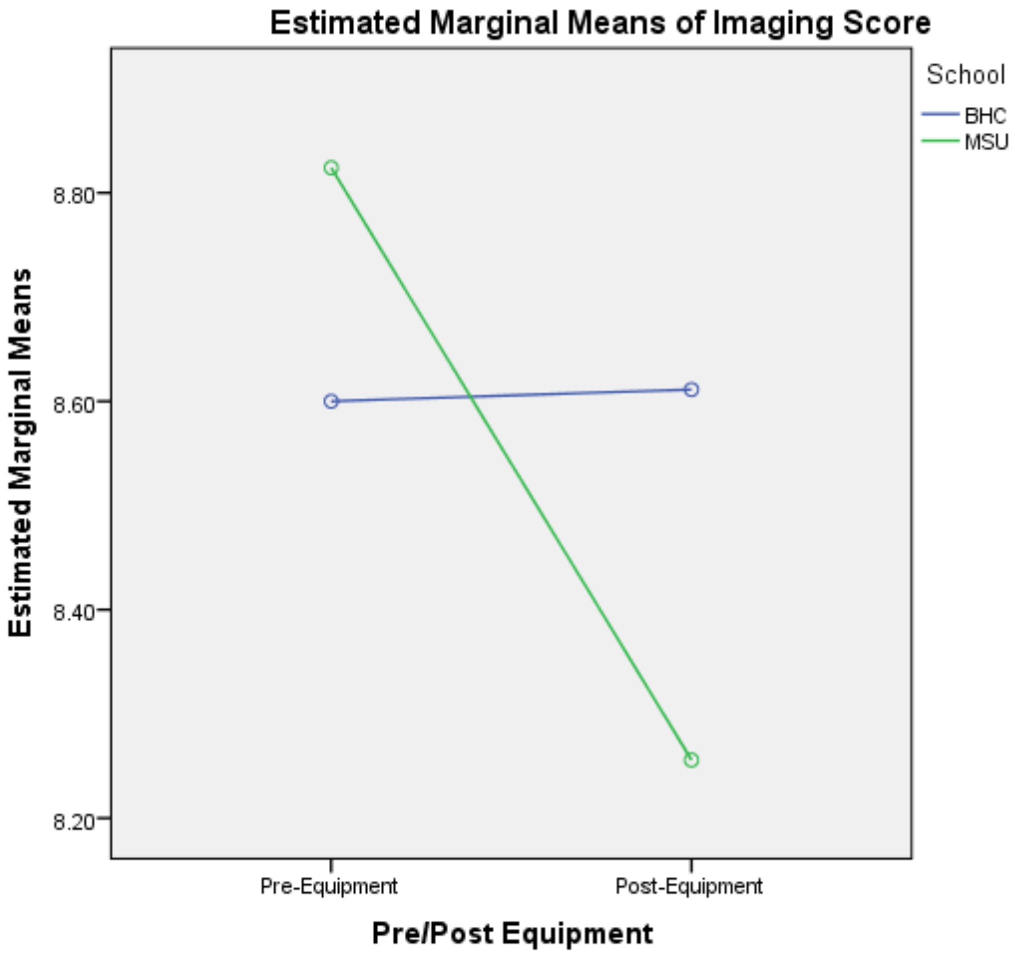

Figure 2 – Profile Plot of National Average