Student Observations Reveal Gaps Between Chest Imaging Theory and Practice

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Purpose To assess whether first-year radiography students observed differences between what they were taught in didactic and laboratory courses and how technologists perform chest imaging procedures during clinical experiences.

Methods This study used a mixed-methods approach with a cross-sectional survey, consisting of 11 quantitative and 11 qualitative items, during the fall 2020 semester. The survey asked participants to evaluate survey statements based on their observations of radiographers' behaviors during chest imaging procedures in relation to the 11 American Registry of Radiologic Technologist clinical competency areas. Participants rated their evaluations based on the degree to which they agreed or disagreed with statements regarding radiographers' behaviors using a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). For each statement, a follow-up, open-ended question asked participants to provide reasons why they thought technologists did or did not exhibit certain behaviors. Data were analyzed quantitatively with differential statistics and qualitatively by thematically categorizing open-ended responses.

Results A total of 19 first-year radiography students (N = 19) completed the survey. Most participants somewhat agreed or strongly agreed with 8 out of the 11 competency statements based on their observations of technologists when performing chest imaging procedures: room preparation (73.7%), patient identity verification (89.5%), examination order verification (79%), patient assessment (79%), equipment operation (52.6%), patient management (100%), technique selection (73.6%), and image evaluation (94.7%). Most participants somewhat disagreed, strongly disagreed, or were neutral with 3 out of the 11 categories: patient positioning, radiation safety, and image processing. Qualitatively, participants responded that technologists only provided lead shielding for pediatric patients, were not instructing patients to take 2 inspirations before making an exposure, and were cropping their images electronically before submitting them for diagnoses.

Discussion Participants reported inconsistencies between what they were taught and what they saw technologists doing during chest imaging procedures related to patient positioning, radiation safety, and imaging processing. Participants' responses stated that these inconsistencies might be because of an increase in technologist responsibilities, patient volumes, and fear of not including relative anatomy on their images.

Conclusion Participants reported the most disagreement with radiation safety during chest imaging procedures. Although lead shielding for abdominal and pelvic procedures is no longer recommended, shielding patients during chest imaging procedures is still recommended. Radiography programs can educate students that inconsistency between task order does not mean there is a gap between theory and practice.

Keywords | *clinical competency, radiography program, radiography students, clinical observations*

According to the U.S. Bureau of Labor Statistics, between 2021 and 2031, the number of individuals employed in health care occupations is expected to grow approximately 13%—much faster than the average job outlook for other occupations.[1] Thus, there is a need for robust education programs to prepare people for these health care positions. The radiography profession, like many health care professions, has structured education programs focused on theoretical and clinical requirements.[2] Botwe et al summarized the theoretical component of health care education programs as the opportunity for students to learn the principles and theories needed for professional performance.[2] In addition, the clinical component provides an opportunity for students to understand the theoretical reasoning that supports clinical tasks while providing them with an opportunity to perform those tasks.[2] Thus, many researchers recognize the clinical component as a vital component in professional education.

The goal for radiography education programs is to provide the foundation of knowledge regarding the role of a radiographer, ensure that coursework is consistent with clinical practices, and that program instruction is applicable to real-world scenarios.[3] However, inconsistencies between what is being taught and what is being practiced can lead to a phenomenon called the *theory-practice gap*. Researchers have defined this phenomenon as the gap between what is learned in the classroom and what is practiced in the clinic.[2,4] Arguably, some professionals have stated that the theory-practice gap can be damaging to health care professions; thus, there is a need to focus more on this phenomenon.[5] Evidence-based practice is at the center of providing optimal care for patients. Core competencies of the health care professional is 1 of the main factors that affect patient safety.[6] Thus, ensuring students obtain, and radiographers maintain, core competencies is vital.

Identifying whether a gap exists in radiography education can be tricky, and assessing how each radiographer performs procedures would be tedious and time consuming. However, approaching this topic from the vantage point of radiography students might provide a glimpse into what the students observe alongside radiographers during clinical instruction. The purpose of this study focused on 2 questions:

- When technologists perform chest imaging procedures, in which areas do first-year radiography students observe differences from what was taught in courses and laboratory classes?
- What do they perceive as the reasons for these differences?

This study also reviews the literature surrounding the theory-practice gap phenomenon in other health care professions.

Literature Review

Health care programs typically incorporate some aspect of clinical experiences for their students. This exposes students to the environment in which they will work and provides them with real-world applications for what they have been taught in the classroom. The combination of the 2 exposes students to a broader perspective and deeper knowledge of what is expected in the profession.

Most commonly, the theoretical components are taught in a classroom, and the clinical components are explored and practiced in a laboratory or clinical setting. Researchers described the clinical rotation experience as the foundation of professional education, as it "provides students with the opportunity for consolidating knowledge, socializing into the professional role and acquiring professional values."[7] Working in real-world health care environments with patients allows students the opportunity to apply what has been taught while exposing them to everyday scenarios in the profession. Researchers found that by having direct contact with patients at health care facilities during their clinical experiences, students were able to apply knowledge and skills they gained from the classroom.[8] Having students work alongside professional radiographers during a clinical rotation helps guide them through their clinical experiences.

Exposure to a clinical setting, however, introduces several variables that might affect a student's education. Students in health care education programs are exposed to professionals, including those in the same discipline, who have varying education backgrounds and experiences.[4] For example, some radiographers who supervise students might be recent graduates themselves, while other radiographers might be more experienced and have worked with students for many years. Exposure to a wide variation in the skills of practicing radiographers can result in inconsistent and possibly inaccurate learned behaviors.

Nielsen et al reported that nursing students occasionally were exposed to situations for which they might not have learned the theoretical or clinical components beforehand.[9] They also discovered that when students work with nurses without targeted goals, their learning outcomes during the clinical experience can be inconsistent and unclear.[9] Extrapolating from nursing students' experiences, radiography students also can be exposed to scenarios for which they have not learned the theoretical components and could observe the behaviors of radiographers during these situations. Depending on the education background and previous experience of the radiographer with whom a student is working, this situation can lead to a conflict between theory and clinical practice when the student learns the theoretical component later in their education program. This could lead to several issues in a profession dedicated to producing images of people in which diagnoses are given such as radiography.

Based on nursing education research, incongruent clinical experiences might occur for radiography students who work with radiographers having various educational backgrounds, little or no experience working with students, or unfamiliarity with current radiography procedures and safety standards.[4] Therefore, what is being taught theoretically in the classroom or laboratory might be inconsistent with what is being practiced by some radiographers. Thus, students might emulate these observed behaviors, whether they are accurate according to American Society of Radiologic Technologists (ASRT) and American Registry of Radiologic Technologists (ARRT) standards.[4] Thus, strategic and intentional clinical experiences are vital to the clinical components of radiography education.

Many parallels can be drawn between research that has been conducted in nursing education and radiography, as both are clinically-based education programs. Hussein and Osuji stated that a big challenge to the theory-practice gap is the shortage of experienced clinical instructors, as well as the heavy workloads that nursing professions often experience.[10] Hanberg and Brown offered a critical argument that the presence of a gap between theory and practice largely can result from a lack of attentiveness to the theories that underlie clinical work.[11] This argument helps identify a reason for the discrepancy between theory and practice. An inability to connect theoretical teachings from the classroom setting to what is being practiced clinically is a valid point. However, attributing the theory-practice gap solely to the inability to connect the classroom teaching to clinical practice is too focused; many factors could be at fault.

Literature has established that the theory-practice gap, especially in nursing, might be because of components rather than a lack of understanding of the theory.[4,8,10,11] For example, the argument is that more research is needed to help identify gaps between theory and practice. The time it takes for research to be conducted, tested, and identified as a new standard of practice is lengthy. The cyclical relationship between theory and practice is guided and led by research. Students might observe new methods being practiced clinically, yet those methods might have been made into theoretical teachings as the new standard of practice.

One component Hussein and Osuji suggest that could be widening the theory-practice gap is the accessibility of knowledge in the clinical setting.[10] Their study states that health care professionals perceive their colleagues to be more readily accessible, so when questions are raised, health care professionals resort to asking their colleagues. Depending on the accuracy of the advice or education the colleague provides, this situation could lead to the spread of incorrect information. Nurses in the study reported that they would use their colleagues for guidance more than a text-based reference—even when the text-based reference is proven to be most accurate.[10]

As educators in radiography programs, ensuring that all content is current and relevant is important. Programs consider the education requirements set by ARRT, accreditation standards set by JRCERT, and the practice standards and curricula documents produced by ASRT when developing their own programmatic curriculum. However, the way programs assess students' competencies and knowledge levels is strictly the responsibility of faculty and program directors. This leads to several ways of implementing, or perhaps offering, a program that complies with national requirements and standards for radiography programs.[12-14] Comparatively, inquiring into what students observe during their clinical experiences might provide another perspective into their clinical education.

According to the ARRT's *Didactic and Clinical Competency Requirements* for radiography, students must demonstrate competence in these 11 keys areas when performing any imaging procedure[12]:

- patient identity verification
- examination order verification
- patient assessment
- room preparation
- patient management
- equipment operation
- technique selection
- patient positioning
- radiation safety
- imaging processing
- image evaluation

Technologists should exhibit behaviors consistent with theoretical teachings for each of these 11 areas while performing patient examinations. When students are educated on how to perform these in the classroom setting, there should be consistencies when working alongside technologists during their clinical education experiences. Any inconsistencies between what is being taught and what students observe being performed might identify a theory-practice gap.

The arguments presented highlight the potential existence and causes of a theory-practice gap in health care education. Although many of the studies focused on nursing practice, similarities can be drawn to radiography education. Research focused on identifying the presence of a gap between theory and practice in radiography education from the perspectives of students should be explored. Although students are not subject matter experts, their unique perspective can help examine the clinical component of radiography education programs by providing insight regarding current practices by radiography professionals.

Methods

The purpose of this study was to survey first-year radiography students and obtain their perspectives on the theory-practice gap between what they observed being practiced during their clinical rotations and what they were taught in a Midwestern university bachelor's degree radiography program. To assess their perceptions of this gap, the researcher collected student observations of technologists during chest imaging procedures. Approval by the Northern Kentucky University Institutional Review Board (1117) was granted for this study.

Participants

This research study was the initial attempt to analyze the theory-practice gap from the perspective of students, thus the researcher only chose to sample first-year radiography students. The Midwestern university bachelor's degree radiography program included 1 year of general education courses followed by 3 years of radiography-specific courses. These students began their first year of the radiography program during the summer semester, which is where they learned chest radiography procedures. Second- and third-year students were not sampled because the first-year students had most recently completed chest radiography procedures in comparison to the other 2 groups of students.

The sample for this study included a first-year bachelor's degree radiography cohort during the fall semester of 2020, equaling 19 students (N = 19). Questions about age, gender, and race were not included, as these items could lead to identification of participants due to the small sample size. In addition, participants were not asked to report their names, and no electronic tracking of survey data was collected, resulting in anonymous reporting. Excluding this information did not impede data analyses as the data were centered around the participants' observations and not on who reported these observations or where these observations occurred.

The researcher taught 1 didactic course to the first-year radiography cohort and discussed the intention of the research study before the survey was administered. However, to further eliminate a position of power from the researcher and the participants, the survey link and additional information was sent solely by the director of the School of Allied Health at the university.

A recruitment email providing general details, goals of the research study, and a link to the survey in Qualtrics was developed and sent to each of the first-year students during the fall semester of 2020. After students clicked on the weblink, the first part of the survey reminded students that their participation was completely voluntary and that there were no incentives for submitting it. In addition, the survey explained that all information obtained would be completely anonymous and that by submitting it they were providing their consent.

After a period of 2 weeks, the director for the School of Allied Health sent a reminder email with the survey link, allowing more time for participants to voluntarily complete the survey. After 4 weeks, the data were exported from Qualtrics into Microsoft Excel for analysis. The data were analyzed after the semester ended to further protect the standing of the participants in their courses and the program in the unlikely event that they provided identifying information in their responses.

Instrumentation

After a thorough review of literature failed to reveal an appropriate means to assess a student's perspective of the theory-practice gap in radiography, the researcher developed a survey. Because of the large scope of practice in which radiographers operate, for the purpose of this study, a narrow and direct focus was needed. Based on their observations, participants were asked to evaluate statements of radiographers' behaviors concentrated on the 11 ARRT clinical competency areas as they related to chest imaging procedures.

This study used a mixed-methods approach via an electronic survey consisting of 11 quantitative and 11 qualitative items. The survey items were reviewed by program faculty to assess face validity, but no survey testing was conducted before administering to the participants as the survey was meant to only capture data regarding their general observations. Participants rated their evaluations based on the degree to which they agreed or disagreed with statements regarding radiographers' behaviors using a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). In addition, for each statement item, a follow-up, open-ended question asked participants to provide reasons why they thought technologists did or did not exhibit certain behaviors (see **Table 1**). This helped keep the participants focused on the same topic before moving forward in the survey.

Data Analyses

The survey data were exported from Qualtrics into a Microsoft Excel spreadsheet, and irrelevant information was removed (eg, progression percentage, survey duration). The researcher created separate tabs for each of the 11 competency areas and separated data from the initial data set accordingly. This method allowed the researcher to review and analyze each competency individually without crossover from other areas.

First, the frequency of student responses for each competency area was tabulated quantitatively. For the open-ended questions, the researcher reviewed the participants' responses and created categories based on what participants stated they saw during their clinical experiences. In addition, the researcher evaluated these categories and identified larger themes. **Table 2** provides an example of participants' responses to open-ended questions for 3 of the competency areas and of the coding process the researcher used. To validate these themes, the researcher asked an external auditor (ie, other faculty from the radiography program) to review all data and provide an objective assessment of the qualitative data analysis.

Results

All surveys distributed to first-year radiography students were completed and submitted (N = 19). The frequency of participants' responses was reported regarding their level of agreement or disagreement with each of the 11 ARRT clinical competency statements (see **Table 3**). Responses to the open-ended question were analyzed qualitatively and categorized into themes.

Room Preparation

The first statement in the survey focused on room preparation. Fourteen (73.7%) students responded with strongly agree or somewhat agree. Three (15.8%) students responded with somewhat disagree, and 2 (10.5%) students were neutral. Although most students agreed with the statement, 15 students reported that technologists did not clean or prepare examination rooms every time before beginning a chest imaging procedure with patients. The reasons students provided in the open-ended question were categorized into several unique categories: amount of responsibilities the technologists had (ie, their workload), assumption that the room was cleaned by a previous technologist (or student),

Table 1

Survey Statements and Open-Ended Questions per American Registry of Radiologic Technologists (ARRT) Clinical Competencies

Clinical competency	Statement	Open-ended question: "From your perspective, describe what you saw and provide some reasons why technologists did not…"
Room preparation	The technologists ensured the x-ray room was cleaned and prepped before patients were brought in for the procedure.	always have the room clean and prepped before the patient was brought in for the procedure.
Patient identification verification	The technologists verified 2 forms of identification with patients before the procedure.	verify 2 forms of identification with patients before the procedure.
Examination order verification	The technologists confirmed physician's orders and procedures with patients before they began.	confirm the order or procedure with patients before they began.
Patient assessment	The technologists took detailed patient histories and explained the procedure thoroughly to patients before they began.	take detailed patient histories or explain the procedure thoroughly to patients before they began.
Equipment operation	The technologists verified source-to-image distance (SID) using equipment indicators or tape measure on all in-room and portable x-ray machines.	verify the SID distance using equipment indicators or tape measure on all in-room and portable x-ray machines.
Patient positioning	The technologists did not instruct patients to take 2 full inspirations for every x-ray exposure.	instruct patients to take 2 full inspirations for every x-ray exposure.
Radiation safety	The technologists protected patients appropriately with lead shields for each x-ray exposure.	protect patients appropriately with lead shields for each x-ray exposure.
Patient management	The technologists made accommodations or modifications based on the patient's needs.	make accommodations or modifications based on the patient's needs.
Technique selection	The technologists selected appropriate radiation techniques for each x-ray exposure.	select the appropriate radiation techniques for each x-ray exposures.
Image evaluation	The technologists evaluated each x-ray exposure for accurate positioning and reviewed exposure indicators after each x-ray exposure.	evaluate each x-ray exposure for accurate positioning or review exposure indicators after each x-ray.
Image processing	The technologists did not use electronic collimation (image cropping) before sending to the radiologist or PACS.[a]	use electronic collimation (image cropping) before sending to the radiologist or PACS?

[a] *PACS (picture archiving and communications system) is now known as* MIMPS (medical image management and processing system).

technologists not making an effort, and varying cleaning or prepping routines between technologists.

The most common responses were related to the assumption of examination rooms being cleaned by a previous technologist or student. Six of the 15 total responses were categorized into this area. For example, 1 student stated, "[technologists] expected students to do it, assumed previous tech cleaned room." Another student stated:

> *From my observation, it was the student techs that were always told to clean and prepare the rooms. I observed when first arriving the rooms were a total mess, it was obvious the techs did not clean the room,*

Table 2

Coding and Thematic Analysis for a Sample of Students' Open-Ended Responses for 3 of the ARRT Clinical Competencies

Clinical competency	Response	Researcher's codes	Researcher's identified themes
Patient positioning	"All the techs I worked with usually give the instruction 'take in a breath and hold it.' I think the reason for this is to move quicker."	Only 1 inspiration Busyness	Efficiency
	"They probably feel like it takes too much time."	Efficiency Busyness	Amount of responsibilities
	"Depends on the tech, I say half do it the correct way."	Inconsistent routines	Inconsistent routines
Radiation safety	"Lack of time and forgetting to grab the lead shielding."	Forgetfulness Busyness	Amount of responsibilities
	"They don't always shield; I think they mainly do not shield for older people."	Age-appropriate shielding	Age-appropriate shielding
	"Only under a few circumstances do I see techs use shield, when imaging a child or a younger woman. I think that techs do not think it is necessary otherwise."	Shield pediatric patients Shield young women	Age-appropriate shielding
Image processing	"To make sure they don't over collimate."	Reduce repeat exposures	Efficiency
	"...because they were in a hurry or forgot or just didn't care."	Busyness Forgetfulness	Amount of responsibilities
	"I think most crop before sending to PACS, so they don't have to retake the image."	Reduce repeat exposures	Efficiency

> *at least during night shift. The day shift would not worry about it until the students came in.*

Another student responded that "most of the techs will only clean the room if the patient was touching a lot of things or was sick in any way (or suspected of being sick)." Three students provided responses that were in this category. One student, who strongly disagreed with this statement regarding room preparation, stated:

> *Technologists did not always clean the room after each patient, making the room unclean for the following patient to have imaging done. Although I did see some techs clean the room often after patients, majority of them did not. I would say this just wasn't a part of their routine.*

This indicates that the belief of preparing examination rooms was not a part of the technologists' routine, as illustrated by the inconsistent cleaning behaviors between technologists that students observed. Another student stated that:

> *Some techs prepare the room and thoroughly clean it after each patient, and some techs do not have the room prepped well for the next patient. It has varied between clinical sites, rotations, and techs.*

The cleaning and preparing routines of technologists seemed to vary a great deal and might even be unique to each shift (day shift vs night shift).

The second largest category of students' responses were grouped based on the technologists' workload. The busier the department or unit, the less likely

Table 3
Frequency of Students' Responses to Survey Statements (N = 19)

	Responses, n (%)				
Statement (clinical competency)	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
The technologists ensured the x-ray room was cleaned and prepped before patients were brought in for the procedure. (room preparation)	-	3 (15.8)	2 (10.5)	11 (57.9)	3 (15.8)
The technologists verified 2 forms of identification with patients before the procedure. (patient identification verification)	-	1 (5.3)	1 (5.3)	1 (5.3)	16 (84.2)
The technologists confirmed physician's orders and procedures with patients before they began. (examination order verification)	-	1 (5.3)	3 (15.8)	5 (26.3)	10 (52.6)
The technologists took detailed patient histories and explained the procedure thoroughly to patients before they began. (patient assessment)	-	2 (10.5)	2 (10.5)	11 (57.9)	4 (21.1)
The technologists verified SID using equipment indicators or tape measure on all in-room and portable x-ray machines. (equipment operation)	2 (10.5)	3 (15.8)	4 (21.1)	9 (47.4)	1 (5.3)
The technologists did not instruct patients to take 2 full inspirations for every x-ray exposure. (patient positioning)	7 (36.8)	1 (5.3)	2 (10.5)	1 (5.3)	8 (42.1)
The technologists protected patients appropriately with lead shields for each x-ray exposure. (radiation safety)	6 (31.5)	3 (15.8)	8 (42.1)	1 (5.3)	1 (5.3)
The technologists made accommodations or modifications based on the patient's needs. (patient management)	-	-	-	3 (15.8)	16 (84.2)
The technologists selected appropriate radiation techniques for each x-ray exposure. (technique selection)	-	1 (5.3)	4 (21.1)	9 (47.4)	5 (26.3)
The technologists evaluated each x-ray exposure for accurate positioning and reviewed exposure indicators after each x-ray exposure. (image evaluation)	1 (5.3)	-	-	3 (15.8)	15 (78.9)
The technologists did not use electronic collimation (image cropping) before sending to the radiologist or PACS. (image processing)	3 (15.8)	6 (31.6)	4 (21.1)	5 (26.3)	1 (5.3)

technologists were to clean and prepare the room before the next patient. One student said, "It depended on how busy the tech was. If they weren't very busy, the room would be prepped appropriately." This implies that when they were not busy the room would be prepared appropriately. Another student stated:

> *If there were multiple patients coming in 1 after another, they would just clean it after all the patients were done. The room would typically be set up before each patient, and they would always change sheets on tables.*

Placing sheets on the examination tables seemed to be a means of preparing the room before bringing in the patient for their procedure.

Patient Identity Verification

The second statement in the survey concentrated on patient identity verification. Seventeen (89.5%) students responded with strongly agree or somewhat agree with this statement. One (5.3%) student provided a neutral response, and another (5.3%) student responded with somewhat disagree.

The open-ended question yielded 3 responses. Two of them stated that technologists obtained 1 patient identifier. A student responded by saying, "Most of the times they used 2 [identifiers], but a few times they would only use 1," and the other student said, "Sometimes they ask for a DOB [date of birth], other times not." Because these students might only hear or see technologists verbalize or interact with a patient, the students might not be aware of other methods technologists use to verify patient identity. For example, the other response provided by a student stated that, "Some patients aren't always awake or able to answer simple questions like that so they would just trust that they were in the right room." In cases of emergency, patients who are not responsive can be verified by their wristband, which has all the pertinent information needed to verify them before beginning the chest imaging procedure. Thus, a technologist could have reviewed the patient's wristband and verified the patient without saying a word, and student would have been unaware of this.

Examination Order Verification

The third statement in the research survey concerned examination order verification. Fifteen (78.9%) students responded with strongly agree or somewhat agree with this statement, 3 (15.8%) students were neutral, and 1 (5.3%) student responded with somewhat disagree.

Of the 19 students who completed the survey, 6 provided responses to the open-ended question regarding the presence or absence of verification for chest imaging orders. These responses resulted in several distinct categories: assuming the order was input correctly, technologists' workload, and varying routines between technologists.

Some of the responses students provided regarding the perceived reasons that technologists did not confirm the chest imaging procedure order included, "they were trying to be fast," and the technologists "very rarely ask patient to confirm [physician's] orders." The amount of responsibilities have caused technologists to work quickly and without an established routine, which can lead to not verifying the order. Another student stated,

> *A tech may not always discuss what was order[ed] by the doctor to the patient. This may be due to the fact of simply forgetting to, or sometimes the tech will just go and do what the order says without discussing it with the patient.*

Assuming the imaging requisition was input accurately into the medical record system leads to simply performing procedures as they are ordered. However, medical errors might occur. Patients might be able to provide insight into what their doctor ordered and why.

Patient Assessment

The fourth statement in the survey was focused on patient assessment. Fifteen (78.9%) students responded with strongly agree or somewhat agree with this statement, 2 (10.5%) students responded with somewhat disagree, and 2 (10.5%) students were neutral.

Although almost 80% of the students reported that technologists recorded detailed histories and explained chest imaging procedures to patients, there were many responses to the open-ended questions on what the students observed when these were not completed. Based on the students' responses, what they saw and described were categorized into these reasons: technologists' workload, cursory patient history recorded, and procedure vaguely explained.

Most examples students provided reflected the perception of the increased workload of technologists, leading to some tasks being forgotten or neglected. Among the 11 students that provided responses, 5 (45.5%) students stated that technologists did not record detailed patient histories or explain the chest imaging procedure thoroughly because of the department or unit being busy. One student stated that it was because of "a lack of time," while another student said:

> *I have seen techs go into great detail about patient history and discussing the procedure to a patient, but other times they do not. This was due to how busy the hospital is, they may have just want[ed] to get the patient in and done real quick.*

This further supported the assumption that because of a busy department or unit, technologists felt rushed or hurried to ensure patients' chest imaging procedures could be completed and reviewed by a radiologist. The increased volume of patients, patients' levels of consciousness, communication barriers (ie, non-English speaking or an inability to speak), and the urgency of a patient's condition might add to the workload of the technologists or their feeling of being rushed in the radiology department or unit.

Although workload was the largest category for student responses, others observed that technologists might not have obtained detailed histories or explained chest imaging procedures to patients. For example, 1 student stated:

> *I see majority of the techs asking a patient history, although some techs have forgotten to do so for some exams. Most techs just tell the patient what to do/give instructions on positioning and not thoroughly explain to each patient what is going to be happening.*

This suggests that technologists simply forgot to take detailed patient histories and vaguely described chest imaging procedures before positioning patients. Another student said, "Not all histories are extremely detailed and not all procedures are explained. There's always a history taken but if it's an easy scan they won't explain." This response indicated that although histories were recorded, the level of thoroughness was not what first-year students expected. In addition, there were inconsistencies between technologists, as some provided a thorough explanation of the procedures to patients and others did not.

Equipment Operation

The fifth statement in the survey represented the equipment operation competency. A total of 10 (52.6%) students responded with strongly agree or somewhat agree with this statement. However, 5 (26.3%) students responded with somewhat disagree or strongly disagree, and 4 (21.1%) students had a neutral response.

Out of the total sample of 19 students, 5 did not answer or provide examples of when technologists did not verify source-to-image distance (SID). Most students stated that technologists did not verify SID when performing a portable chest imaging procedure. Seven (50%) out of the 14 students who provided responses gave this as a reason. Other examples were categorized by technologists simply guessing, improper equipment maintenance, and urgency of procedure.

The students who stated technologists did not verify the SID during portable chest imaging procedures provided detailed examples. One student said, "I've noticed that with portables, they don't really check the SID, they just estimate. Some techs have just straight up said that the SID didn't matter too much." Another student stated:

> *I have never seen a tech use a tape measure on the portable x-ray machine, most of the time they just do a guess on the SID. Most of the time they do make sure they are at the correct SID on the in-room machines.*

These examples suggest that technologists verified the SID while performing chest imaging procedures in the department or units but did not during portable procedures. One student mentioned that "[technologists] always check in the room, never on portables, but our portable machine does not have a tape measure." The tape measure is the main way to measure and indicate proper SID when performing portable imaging procedures. Thus, based on this student's response, the portable radiography system was missing a piece of vital equipment, which would not allow the technologist to verify the SID during a chest imaging procedure.

Patient Positioning

The sixth statement in the survey focused on patient positioning. A response of strongly agree or somewhat agree indicated that technologists did not instruct patients to take 2 full inspirations before the chest imaging procedure, while a response of strongly disagree or somewhat disagree means the technologists did.

For this statement, 9 (47.4%) students strongly agreed or somewhat agreed with this statement. A total of 8 (42.1%) students responded with somewhat disagree or strongly disagree, and 2 (10.5%) students were neutral.

A total of 16 students provided responses to the open-ended questions asking for them to provide examples or to describe what they saw technologists do. All 16 of the students provided examples of behaviors that indicated technologists did not instruct patients to take 2 full inspirations before chest imaging procedures; instead, the technologists instructed them to perform 1 inspiration. One student stated, "I've never heard a tech tell the patient to take 2 breaths," and another student reported that the technologist "just tells them to hold their breath." In addition to this being the most common response, several students provided additional examples. One student responded, "It depends on the tech—I say half do it the correct way." This suggests there are inconsistencies between technologists regarding patient instructions during a chest imaging procedure.

Radiation Safety

The seventh statement in the survey addressed radiation safety. Two (10.5%) students responded with strongly agree or somewhat agree with this statement. However, 9 (47.4%) students responded with strongly disagree or somewhat disagree, and 8 (42.1%) students were neutral.

The responses that students provided varied in reasons why technologists did or did not protect patients with a lead shielding. Many of the examples students provided were categorized into age-related shielding, technologists' workload, forgetfulness, varying shielding routines between technologists, and technologists not making an effort.

Nine (52.9%) out of the 17 students who provided responses gave examples of when technologists would protect patients with a lead shield based on the age of the patient. For example, a student responded, "Only under a few circumstances do I see techs use a shield—when imaging a child or a younger woman. I think that techs do not think it is necessary otherwise." Another student stated, "Sometimes if the patient is below the age of 30 and a female they will shield, when possible, but most of the time they do not shield." Conversely, 1 student stated, "I have not seen them shield patients for any exposure. Most of our patients are postmenopausal or over the age of 60, but even the younger patients don't get shielded." That student's comment suggests that during this student's clinical rotation, none of the patients were protected with lead shielding during a chest imaging procedure regardless of their age.

Although most students' observations reflected age-related reasons, several students provided other observations. One student said that the reasons technologists did not protect a patient with a lead shield was because of a "lack of time, and forgetting to grab the lead." Furthermore, another student stated, "I do see techs making efforts to shield proper patients, but some techs forget or don't always make the effort." Another student stated that, "They [technologists] are in a habit of shielding." This could point to inconsistent routines between technologists as well. These responses further support technologists are forgetting to shield patients, routines are inconsistent, and technologists are not making the effort to shield.

Patient Management

The eighth statement in the survey focused on patient management. All 19 (100%) students agreed with this statement; 16 (84.2%) students strongly agreed, while 3 (15.8%) students responded with only somewhat agree."

One student provided a response to the open-ended question regarding why technologists did not make accommodations for patients. This student reported, "[Technologists] were trying to be fast and get the exam done as quickly as possible." This response can be interpreted in various ways. Technologists might have been rushed because of the urgency of the patient or there were other patients needing to be imaged. Technologists might have finished quickly so they could take a break. Because this was all the information the student provided, assumptions were not made.

Technique Selection

The ninth statement in the survey focused on technologists' technique selection. Fourteen (73.6%) students responded with strongly agree or somewhat agree with this statement. Four (21.1%) students were neutral, and 1 (5.3%) student responded as somewhat disagree.

Although most students agreed with this statement, 10 (52.6%) of the students provided examples of contrasting behaviors by technologists regarding technique selection. Six out of these 10 students, stated that the technologists used preprogrammed techniques that the radiography system prescribed. Making modifications to the automated technical factors prescribed by the system to account for varying patient sizes and ages was another response that students provided. One student stated, "A lot of techs rely on the automated technical factors that are used when selecting a position, mostly the tech will adjust if the patient is larger or smaller than average." "Typically, the techs will trust the automatic numbers based on the exam. I have seen them change them manually for certain body types," responded another student. Thus, having an accurate technique preprogrammed into each console is highly important because of technologists' behaviors around technique selection.

Several other students alluded to differences in technique selection based on the technologist's age and experience. For example, 1 student stated, "Older techs typically change the technical factors for every exam, but some only do it if the patient is much larger than average." This suggests that older or more experienced technologists might prefer to modify the techniques rather than rely on the preprogrammed technical factors set on the radiography system.

Image Evaluation

The tenth statement in the survey focused on image evaluation. Most of the students, 18 (94.7%), agreed with this statement; 15 (78.9%) strongly agreed, and 3 (15.8%) responded with somewhat agree. One (5.3%) student strongly disagreed.

With most agreeing to this statement regarding image evaluations, students still provided examples when technologists did not display this behavior. Four (21.1%) out of 19 provided reasons in the open-ended question. Among the 4 who provided responses, 3 (75%) were focused on the technologists' workload. For example, 1 student stated, "Because of time, most techs do not evaluate the exposure indicators at any time during an exam." Another student reported that the technologist "did not always view indicators after each x-ray due to timing." This suggests that if the image looks appropriate to the technologist, they assume the proper amount of radiation was used. In addition, 1 student stated the technologist "never looked at exposure indicators" that they knew of." This would imply that evaluating image exposures might not be a part of the technologists' or departments' protocol or routine.

Image Processing

The eleventh and last statement in the survey focused on image processing. A response of strongly agree or somewhat agree indicates that technologists did not use electronic collimation (image cropping) on chest imaging procedures, while a response of strongly disagree or somewhat disagree means the technologists did.

A total of 6 (31.6%) students responded with strongly agree or somewhat agree with this statement. Nine (47.4%) students responded with somewhat disagree or strongly agree, and 4 (21.1%) students were neutral. Regarding the open-ended questions, 11 (57.9%) out of 19 provided their observations.

When assessing and reviewing students' responses, there were many varied examples and reasons why technologists did or did not use electronic collimation. The themes that emerged were based on efficiency, reduction of radiation exposure to patients, visual appearance of images, and inclusion of relative anatomy.

One student stated that some technologists told them it was easier to not collimate when performing chest imaging procedures, as it helped reduce repeat imaging. The student stated:

> *Some techs have told me that it is easier for them to open the collimation to be sure that all anatomy necessary is on the image than to retake the image. Later they will crop all unnecessary space around the anatomy out. I think this is a time issue, techs think this is more efficient than positioning perfectly.*

This suggests that some technologists are not collimating to the appropriate anatomy before imaging and instead are electronically collimating any excessive anatomy after. This observation is further supported by a different student's response that said, "Most techs use postcollimation after the exposure and before sending it [to the radiologist]. They try and keep surrounding anatomy, but some only include what is needed." Because a few students reported these as observed behaviors, these observations might suggest that there are differences in routines between technologists and hospital locations.

Other students reported that although technologists might not collimate before the exposure, they do ensure that all pertinent anatomy is present. The students stated that the technologist indicated to them that by not collimating, unnecessary radiation exposure to patients was reduced. This is illustrated by a few responses students provided. One stated that,

> *I've seen techs crop [electronically collimate] images a lot, simply because they want their image to 'look better' than it was and to avoid the radiologist seeing the patient got too much radiation from a decreased collimation.*

As suggested by the radiation safety survey statement, technologists need to make sure they do not overexpose patients with radiation. According to this student's response, the technologists are fearful that if they submit images containing unnecessary anatomy to radiologists, the technologists will be reprimanded. Electronic collimation gives the appearance that the technologist did not expose unnecessary anatomy of the patient though they might have.

ASRT specifically mentions image cropping (electronic collimation) in the Ethical Issues in Health Care subsection of the radiography curriculum guidelines for educators to teach students appropriate cropping practices.[13] In addition, Ehrlich and Coakes state that image cropping should be used to improve the quality of the displayed image but not as an alternative for poor collimation of the original exposure.[15] They further say that electronically collimating-out exposed anatomy is considered to be beyond the scope of practice for technologists; radiologists make the determination of whether anatomy is relevant or not.[15]

Discussion

The quantitative data in this study showed that among the 11 ARRT clinical competencies, students reported a higher frequency of disagreement on the radiation safety statement. Students provided examples of the behaviors displayed by technologists regarding why patients were not protected with lead shielding during chest imaging procedures. Such examples were fixated on the technologists' workload and forgetfulness. Most students provided statements around age-related shielding. Responses by students stated that most of the patients having a chest imaging procedure were aged 65 years or more and did not require lead shielding.

In radiography education, radiation safety is centered around 3 key areas: lead shielding, collimation, and using the lowest dosage of radiation possible. Disagreement between responses was related to lead shielding. Comments and examples provided in this study indicated that technologists were shielding patients who they considered younger, however subjective that might be. Based on these responses, students indicated that technologists were adhering to proper radiation safety protocols and shielding patients appropriately for their age.

In 2019, the American Association of Physicists in Medicine released a position statement recommending the discontinuation of routine patient gonadal and fetal shielding in x-ray-based diagnostic imaging, and in 2021, the National Council on Radiation Protection and Measurements recommended the discontinuation of routine gonadal shielding during abdominal and pelvic radiography.[16,17] This is an example of how research and practice might be ahead of theoretical teachings and policies. Research is meant to advance current knowledge or develop new ideas and ways of thinking. Textbooks recommend technologists provide lead shielding for the gonads if it will not be in the primary beam[18,19]; however, this is not a requirement. As research further explores lead shielding during radiography procedures, textbooks might take longer to be updated to reflect new, appropriate radiation safety procedures.

Another competency area students reported in their open-ended responses focused on image processing. Students were asked to report their level of agreement on whether technologists avoided electric collimation (cropping). According to the responses, technologists were not collimating the area that exposed patients, or collimated very little, as a means of reducing repeat exposures. However, exposing irrelevant anatomy adjacent to relevant anatomy is still considered unnecessary exposure to the patient. The fear of collimating anatomy that is considered relevant should not deter technologists from collimating. One research study that examined collimating behaviors in 2 health care facilities showed poor collimation habits by its technologists throughout all radiology departments.[20] After providing the results of their research study to the participants involved, the technologists argued that their main concern of collimating was the fear of missing pertinent anatomy.

This research study provided an opportunity for first-year students to give examples of inconsistencies they observed. For example, technologists' workload was reported in the open-ended questions for several clinical competencies as the observed reason technologists behave inconsistently compared with what the students had been taught. The technologists' workload was reported by students as a reason why technologists did or did not display certain behaviors for these 8 clinical competencies:

- examination order verification
- image evaluation
- image processing
- patient assessment
- patient management
- patient positioning
- radiation safety
- room preparation

This reason would imply that the stress of being busy causes technologists to forgo standard practices to keep up with increased patient volumes or to simply forget altogether.

Another common theme reported by students was technologists' inconsistent adherence to routines. Varying routines between technologists led to inconsistencies between cleaning and preparing examination rooms before the patient arrived, verifying orders with every patient, protecting patients with lead shielding, and manually selecting a technique vs using the preprogrammed selections on the radiography system. Task order (order in which tasks are performed) by technologists could be a reason why students reported inconsistencies or varying routines between technologists. However, inconsistencies between routines or various reasons students provided does not necessarily mean there is a gap between theory and practice. Examples such as these should be addressed with first-year students as they might interpret these behaviors as gaps in their learning and experiences.

Limitations

This research study was the first time the survey was administered to first-year students. Although the survey items were assessed by program faculty members before the survey was administered, further validity and reliability testing should be conducted. For future research, reviewing each item and ensuring that they match appropriately to the 11 clinical competencies is important. Rewording items or creating more items to increase the instrument's reliability before administering it again might also be important.

The results of this study provide a vantage point or glimpse into the minds of first-year radiography students. Radiography programs would benefit by investigating the perspectives of each cohort of students separately to obtain a deeper understanding. Because first-year students are newly exposed to their clinical experiences, their perceptions might change during a prolonged period. With more education and experience, their abilities to report accurate information will increase. In addition, after data are collected from other cohorts of students, a comparison throughout the entire program of students could be conducted. Obtaining such information might identify similarities, differences, or trends. Furthermore, each incoming group of first-year students should be researched. This would permit a direct comparison between groups of students who were at the same level of progress in their radiography coursework.

Examining these various groups of students from different cohorts and periods might aid radiography programs in closing gaps that are identified. Moreover, students in different cohorts might identify the same competency areas as having gaps, and students might respond differently as they progress through the program. The amount of hours students spend in a clinical setting could affect the ratings and responses they provide. A longitudinal study throughout several years would provide a more robust means of assessing the validity and reliability of this survey. These questions might be answered if data were collected during a prolonged period, as well as between the years in which students have progressed in their radiography program (ie, first-year students, second-year students, third-year students).

Although this study gathered data regarding chest imaging procedures, another study could determine whether students reported the same or different results for other imaging procedures. In addition, fluoroscopic procedures regarding radiation safety could be explored. Appendicular vs axillary imaging procedures also might differ in technologists' behaviors. Furthermore, outpatients vs inpatients or trauma patients might present unique results as well.

The data for this study were provided based on first-year students' observations and memories when they trained with radiographers. Reporting general observations from memory is a research limitation. Obtaining data that required participants to self-report information from memory might lead to memory-based errors.[20] Thus, based on Mora's recommendation, the survey was developed and administered to help minimize these errors.[21] Students completed the survey during the semester they were completing their clinical rotations. Each survey item was specific enough so that the students could reflect on their own experiences. Furthermore, all open-ended questions directly followed the accompanying statement for which they indicated their rating so that they could refer to how they answered previously at any point.

Research studies conducted to analyze gaps between theoretical teachings and clinical practice in radiography education should look to expand its participant sample. For this study, an initial inspection of current teaching and practice behaviors was explored. Thus, researching first-year student perspectives on the theory-practice gap was the avenue chosen. However, to further explore this phenomenon, a longitudinal research study with a validated instrument that includes first- and second-year students for associate degree radiography programs, as well as third-year students for bachelor's degree radiography programs should be considered.

Lastly, the period in which the data was collected presented challenges. In the fall semester of 2020, the COVID-19 pandemic affected higher education. During this time, first-year radiography students were still permitted to attend their clinical experiences at this university if they wore N95 masks (or appropriate ventilators) continuously throughout the day. Nevertheless, the physical, emotional, and mental stress of the pandemic could have affected students and technologists. The students might not have remembered correctly, and the technologists might not have been performing at their best. Thus, the survey data might not be indicative of typical practice.

Conclusion

Education, research, and clinical practice have a cyclical relationship. This study is an early attempt to examine student perspectives and observations in radiography education programs. As new areas are explored and innovative ideas become standard, research regarding the theory-practice relationship in radiography education will also need to be explored. As research in this phenomenon expands, as different techniques are discovered, and as policies change, radiography education programs will have to adapt. Continuing to explore the theory-practice relationship in radiography education will strengthen radiography as a profession. Many avenues for future research can be explored regarding the theory-practice gap in radiography education.

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