Problem-solving abilities of radiography students at a South African university

T Pieterse,[1] MTech (Radiography); **H Lawrence**,[1] DTech (Radiography); **H Friedrich-Nel**,[2] PhD (Health Professions Education)

[1] *Department of Radiography, University of Johannesburg, South Africa*

[2] *Central University of Technology, Bloemfontein, South Africa*

Corresponding author: *T Pieterse (traceyp@uj.ac.za)*

Background. Developing the problem-solving skills of student radiographers is imperative for encouraging critical thinking and allowing them to work efficiently in an era of rapidly advancing technology. Students' ability to demonstrate these skills was studied so that the Department of Radiography, at a comprehensive university in South Africa, could develop a more explicit curriculum to facilitate these competencies.

Objective. To assess problem-solving skills of third-year radiography students at a comprehensive South African university.

Methods. The study employed a descriptive exploratory design. The participants' responses to vignettes (in the form of clinical scenarios) were analysed using a Likert scale and action verbs developed for evaluating evidence of problem-solving skills and providing quantitative data. Field notes were made while analysing responses to each question, providing qualitative data.

Results. The findings indicate that the majority of participants demonstrated a minimal ability to problem solve in a vignette. This implies that to improve problem-solving skills of student radiographers, there is a need for curriculum adjustment to nurture and encourage this competency.

Conclusion. Facilitators need to be taught methods to integrate problem solving into the curriculum, and learning material must be adjusted to accommodate problem solving for this skill to become part of the programme outcomes.

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Currently, radiography students are faced with the challenge of having to learn factual information, while being taught how to interpret the information available to them to problem solve and reflect on their judgement within a given clinical context.[1,2] Problem solving is a vital competency for healthcare professionals in an era of rapidly advancing technology.[3,4] It requires critical thinking, and improves the quality of a clinical service offered and the efficiency of delivering such a service.[5] Therefore, enabling students to problem solve will in turn improve clinical competence.[4]

To improve problem-solving skills of radiographers, problem-based learning (PBL) has been incorporated in the radiography curriculum in certain institutions in Africa, one of which is the Makerere University in Uganda. PBL was first introduced into medical education in the 1960s in Ontario, Canada for physicians.[2] It is a popular teaching method, utilising problem-solving skills, and has been used successfully for some radiography, nursing and paramedic curricula.[6,7] However, a gap still exists in the literature on the assessment of problem-solving abilities in radiography.

The skill can be defined as the student's ability to use objectives and operations to reach a specific goal within certain constraints.[8] It requires inference, involving the identification of factors to come to reasonable conclusions.[3,9] A student who demonstrates good problem-solving skills considers relevant information to deduce judgements, inferences, statements, beliefs and opinions. This competency encompasses the ability to query evidence, present alternatives and draw conclusions.[9]

Freeman and Lewis[8] highlight four components of problem solving, i.e. goal (the solution), objects (what can be used to reach the goal), operations (permitted actions in reaching the goal) and constraints (limitations). In addition, they identify the concept of well-defined problems (all necessary information is given) and ill-defined problems (little or no information is given). In the health sciences, most problems fall into the latter category.[8]

The competency requires critical thinking, which causes individuals to constantly improve their skills for personal and professional growth, thus enabling healthcare workers to make more informed decisions in the clinical environment.[4,10] Therefore, teaching students to problem solve allows the practitioner to integrate theory and practice, improves clinical reasoning and addresses the needs of the patient owing to clinical efficiency and better patient care.[4,5,10]

The South African Qualifications Authority (SAQA) added a new dimension to teaching, learning and assessment with the publication of the critical cross-field outcomes that students need to attain in addition to the programme outcomes. Critical thinking and problem solving are listed among the 12 outcomes. Although the publication dates back to 1995, it is valid to question the ability of third-year radiography students to attain these specific outcomes, as information in this field in a radiography context is lacking.[11]

In the South African context, problem-solving skills among radiography students have not been assessed. The ability of the students to demonstrate problem-solving skills needed to be explored so that the Department of Radiography could develop a more explicit curriculum to facilitate these competencies.

The aim of this study was to evaluate the problem-solving skills of third-year radiography students at a comprehensive South African university.

Methods

A descriptive exploratory research design was used to collect both quantitative and qualitative data. The study design was selected to explore, identify and describe themes and patterns in the data, which were then used to judge the students' problem-solving skills.[12]

Students were asked to pose a solution to a scenario-based vignette, constructed by the researcher, and tailor made for radiography students to extract problem-solving skills in a radiography context. The participants' skills were then assessed using a rubric designed by the researcher (Appendix 1) after a literature review to obtain information on current and popular data collection tools used in the assessment of this competency in higher education. The rubric consisted of a list of attributes integral to problem solving, supported by concepts found in the literature. These included understanding of the problem, planning of an appropriate solution, ability to carry out the plan correctly and logically, and ability to evaluate the result.[3]

Each vignette was assessed by assigning a score from 1 (not at all) to 4 (to a large extent), and this information was used to generate the quantitative data. In addition, the researcher wrote extensive field notes, indicating the thought processes of the participants for each attribute identified as integral to problem solving. By reading participants' responses to each vignette, as advocated by Creswell,[13] the researcher reflected on the data, reread the participants' responses and assigned a value according to the Likert scale as well as attributes identified for each vignette. In addition, the researcher made notes inductively on the thought processes relating to the participants' responses to the specific vignette, thus generating qualitative data. The quantitative data were therefore further supported by the qualitative data.

The vignette designed to extract the critical thinking skills of problem solving used in this study was as follows: 'A 36-year-old female patient presents to the imaging department with a 5-day history of numbness and pins and needles in her right arm. The patient is 8 weeks' pregnant. The referring physician has requested a radiograph of the lumbar spine. Apply your knowledge to the above scenario and hypothesise what you would do in the above situation.' The attributes integral to problem solving were then assessed.

The cohort for this research study consisted of third-year radiography students (*N*=73) at a South African university. A single-stage sampling design was used as a sampling frame, which could be developed from the number of students registered. Furthermore, a non-probability sampling approach was used for convenience, the researcher's access to the third-year radiography students and their availability. The study sample consisted of 59% (*n*=43) of the total cohort of registered students.

Ethical clearance was given by the Ethics Committee of the Faculty of Health Sciences of the university concerned. Permission to conduct the study was obtained by the Head of the Department of Radiography at the university where the study was conducted. Participants were recruited once informed consent was obtained and confidentiality was ensured by assigning numbers to participants.

The researcher gave the problem-solving vignette to the students, who were instructed to respond in writing. Participants were reminded of their voluntary participation, and responses to the problem-solving vignette were collected by the class representative and handed back to the researcher. The vignette was handed to the participants once the researcher was assured that they had gained the theoretical knowledge and had attended the practical demonstration relating to the topics of the problem-solving vignette. To ensure that participants did not discuss their answers, the vignettes were handed out in an assessment environment, in the presence of an invigilator.

On completion of the vignette, the researcher assessed the problem-solving skills of participants using the 4-point Likert scale according to the attributes identified for problem-solving skills. Detailed field notes of each participant's response to the vignette were compiled.

To ensure the validity of the vignettes, a field expert was consulted to verify the suitability of questions used prior to data collection. The self-designed measurement rubrics used in this study were also verified by a field expert. This ensured that the use and measurement of the problem-solving vignette were appropriate and applicable to problem-solving skills, and based on the theoretical and practical knowledge that the student had gained to answer the vignette. In addition, triangulation of data by statistical analysis and the generation of themes,[13] as well as the use of an independent coder, further ensured validity of the research process.

Reliability was ensured through consultation with an independent coder to review students' responses to vignettes, only after the researcher had reviewed and documented the responses. By comparing results with the independent coder, consensus was achieved regarding the rating for a particular student's response, thereby avoiding any bias from the researcher. Observation of 10 subjects or events by an independent coder is considered adequate judgement to ensure inter-rater reliability, as advocated by Burns and Grove.[12]

Another indication of the reliability of a measurement tool is its internal consistency.[14] Statistical analysis of Cronbach's coefficient alpha was performed for problem-solving skills measured in this study, its value achieved being 0.924 with four items on the scale. Dependability was ensured by triangulating data collection, as well as by providing a dense description of the research methods.[15] The numerical data were analysed statistically using SPSS.

The qualitative data were analysed as suggested by Creswell,[13,16] by coding the information, generating themes from the codes and interpreting the meaning of the data. This was achieved by reading the participants' responses to each vignette, reflecting on the data and re-reading the responses. This method enabled the researcher to make in-depth field notes inductively while assigning a value (according to the 4-point Likert scale) for each of the attributes identified to rate the participants' responses to the vignette. The field notes were then coded, forming themes, and verbatim quotes were added as supportive evidence.

Results

Measurement of problem-solving skills was subdivided into four attributes (understood the problem, planned an appropriate solution, carried out the plan correctly and logically, and evaluated the result) considered integral for demonstrating problem solving. The attributes were scored on a 4-point Likert scale. The mean score for the participants' ability to demonstrate problem-solving skills was 2.32, indicating a minimal ability to problem solve. Of the 43 participants, 20.4% could problem solve to a large extent, while 29.7% showed no problem-solving skills. It is interesting to note that 46.5% of participants understood the problem, 14% planned an appropriate solution and 11.6% carried out the plan correctly and logically.

Quantitative data

Fig. 1 illustrates the ability of participants to demonstrate the attributes of problem-solving skills. Almost half of the group understood the problem, while the majority were unable to plan a solution and carry out an

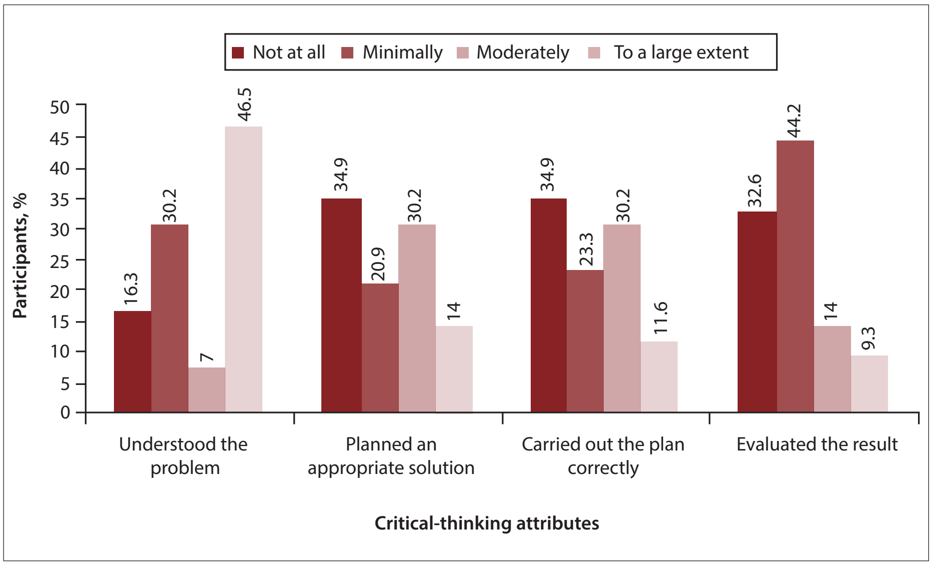

Fig. 1. Participants demonstrating attributes of problem-solving skills.

Table 1. Ability of participants to demonstrate attributes of problem-solving skills (*N*=43)

Attributes for critical thinking skills: problem solving	Mean score (maximum = 4)	Standard deviation (SD)
Understood the problem	2.84	±1.194
Planned an appropriate solution	2.23	±1.088
Carried out the plan correctly and logically	2.19	±1.052
Evaluated the result	2.00	±0.926
Total mean	2.32	±1.065

appropriate plan. Just over 40% of participants in this vignette were able to evaluate the result to a minimal level.

Table 1 indicates the mean score for the attributes demonstrating problem-solving skills. The standard deviation (±SD) ranges from 0.926 to 1.194. Looking at this large variation in SD, and with reference to Fig. 1, one can observe that although the total mean score for participants to demonstrate problem-solving skills was minimal, some participants achieved a moderate score and others a 'not at all' score, proving a greater degree of variability for this skill.

Qualitative data

The quantitative data are further supported by the results of the qualitative data. The vignette called for each participant to demonstrate problem-solving skills by determining that the examination requested did not correlate with the clinical symptoms and providing a possible course of action. Compounding the problem was the fact that the patient was 8 weeks' pregnant. The participants' answers to the vignette led to the generation of the following theme: 'Inability to analyze the problem.' The researcher concluded that participants have the ability to identify problems that may exist in the vignette, but are unable to identify solutions, or they propose solutions that are not feasible in the given scenario.

The following verbatim quotes were extracted from the participants' vignettes to support this theme:

'I would suggest that the patient has an MRI of the lumbar spine . . .' – participant 42.

'First I would advise her to go to another physician for second opinion, if she is willing I would do AP, lateral and oblique views for the lumbar spine, and a AP pelvis . . .' – participant 29.

'Considering that I will never do the lumbar spine I will do only the right arm lateral to see if the pins are still aligned . . .' – participant 35.

'Pins and needles down the arm would be an indication a cervical examination not lumbar. The patient being pregnant will also limit the amount of views . . .' – participant 49.

Discussion

Participants in this study very clearly understood the problem by highlighting the obvious (that the patient was 8 weeks' pregnant), but then neglected to notice that the patient's history did not correlate with the requested radiographic examination. As participants were unable to reflect on the vignette as a whole, their problem-solving ability was limited, with many unable to link the clinical information given and the examination requested – therefore not recognising the problem. Participants who correctly identified the mismatch between the clinical information given and the examination requested were not sure of the correct procedure to follow. This led to some participants being unable to suggest a reasonable solution to the problem and some resorted to refusing to X-ray the patient.

A study by Fero *et al.*[17] on nursing students' critical-thinking skills yielded similar results to those found in the current investigation, revealing that 75% of student nurses did not meet overall expectations relating to a given simulation designed to test for problem-solving ability. Most nursing student errors were associated with problem recognition and reporting findings to the referring doctor. Almost half of the participants in Fero's *et al.*'s study correctly recognised the problem, while 100% were unable to justify their decisions.[17]

In the current study, participants realised that they should not take a radiograph of a pregnant patient, but seemed unable to design an appropriate path to follow. Again, when faced with a problem to solve, participants tended to refer the matter to a qualified radiographer who would instruct them with regard to a course of action, or take over the patient from them, thereby eliminating the student from the problem-solving process. This minimal ability to problem solve could be due to students not being given the opportunity to think for themselves. In busy imaging departments, students tend to step aside when complications arise, and allow the qualified radiographer to take the lead. Very often students might continue with another patient, instead of following through with the initial patient and assisting the qualified radiographer.

The findings of this study are unique to the radiography setting and provide a platform for further studies in problem solving in radiography education. A literature survey revealed that problem-solving skills can be taught to students using various methods that should be integrated into the curriculum.

However, before educators can expect students to demonstrate problem-solving skills, facilitation of these skills must be incorporated into the academic programmes.[3,5,18]

Conclusion

The results of this investigation demonstrate that the majority of radiography students who participated in this study were unable to problem solve to a large extent in a written clinical scenario, and therefore the current students will not have the ability to optimally apply these skills in a clinical setting.

Regretfully, this study has revealed that radiography educators at the university concerned have not adequately facilitated the development of problem-solving skills among third-year radiography students. Therefore, interventions are required to meet the standards stipulated by SAQA.

Implementation of role-play, video-taped simulation sessions, use of case studies, as well as integrated assessments are modalities that should be included in the curriculum to encourage and nurture problem-solving skills and in turn improve clinical efficiency of student radiographers.

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Appendix 1. Problem-solving rubric[8,19]

	1 = not at all	2 = minimally	3 = moderately	4 = to a large extent
• Understood the problem (interpretation, identifies essentials of the goal to be achieved)				
• Planned an appropriate solution (generation, addresses core issues, uses a feasible plan, plan is reasonable for achieving goal)				
• Carried out the plan correctly and logically (strategising, steps in achieving the goal are clearly set out)				
• Evaluated the result (reflection, strengths and weaknesses identified)				