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Enhancing Entry-Level Physiotherapy Student Learning in Interpreting Radiology – An Action Research Project

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Abstract

Purpose: In Australia, the ability to interpret orthopaedic x-rays is an entry-level skill for physiotherapists. Yet there is a paucity of evidence in the literature which details effective learning and teaching methods to optimise confidence and competence in x-ray interpretation. The aims of this study were to describe the content contained in an orthopaedic radiology module within an Australian 2-year graduate entry Master of Physiotherapy degree; approaches to learning and teaching used in this module; student satisfaction associated with this module over a 2-year period. Method: The University's framework for quality assurance, which is based on the Plan-Implement-Review-Improve underpinned this action research project. The content of the radiology module was reviewed and feedback was gained from a student focus group and standard university course data. Data were analysed using descriptive content analysis and descriptive statistics to identify areas for improvement. Changes to the module were then developed and implemented, and the effect of these changes were evaluated using a custom-designed survey. Results: It was found that didactic methods of teaching were used in this module that encouraged surface level learning. Students reported feeling stressed during the radiology examination due to the learning tasks and assessment being disconnected, and often reported difficulty transferring knowledge into the clinical placement setting. Constructive alignment was undertaken of learning activities and assessment tasks. An additional non-compulsory tutorial was added to the radiology module, where scaffolding and cooperative learning techniques were used to teach students x-ray interpretation. Students reported that the revised curriculum increased their confidence in interpreting x-rays. Students' competence in x-ray interpretation also increased based on a significant increase in score on their radiology examination. Conclusion: Based on the findings of this study the addition of a tutorial that focused on interpretation of x-ray films to supplement radiology teaching improved entry-level physiotherapy students' confidence and competence in interpreting x-rays and their perceived preparedness for clinical placement in a small entry-level physiotherapy cohort at a single Australian University.

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ABSTRACT

Purpose: In Australia, the ability to interpret orthopaedic x-rays is an entry-level skill for physiotherapists. Yet, there is a paucity of evidence in the literature which details effective learning and teaching methods to optimise confidence and competence in x-ray interpretation. The aims of this study were to describe the content contained in an orthopaedic radiology module within an Australian 2-year graduate entry Master of Physiotherapy degree, approaches to learning and teaching used in this module, and student satisfaction associated with this module over a 2-year period. **Method:** The University's framework for quality assurance, which is based on the Plan-Implement-Review-Improve, underpinned this action research project. The content of the radiology module was reviewed and feedback was gained from a student focus group and standard university course data. Data were analysed using descriptive content analysis and descriptive statistics to identify areas for improvement. Changes to the module were then developed and implemented, and the effect of these changes were evaluated using a custom-designed survey. It was found that didactic methods of teaching were used in this module that encouraged surface level learning. Students reported feeling stressed during the radiology examination because of the learning tasks and assessment being disconnected, and often-reported difficulty transferring knowledge into the clinical placement setting. Constructive alignment was undertaken of learning activities and assessment tasks. An additional non-compulsory tutorial was added to the radiology module, where scaffolding and cooperative learning techniques were used to teach students x-ray interpretation. Students reported that the revised curriculum increased their confidence in interpreting x-rays. Students' competence in x-ray interpretation also increased based on a significant increase in score on their radiology examination. **Conclusion:** Based on the findings of this study, the addition of a tutorial that focused on interpretation of x-ray films to supplement radiology teaching improved entry-level physiotherapy students' confidence and competence in interpreting x-rays and their perceived preparedness for clinical placement in a small entry-level physiotherapy cohort at a single Australian University.

BACKGROUND

Physiotherapy is a profession that aims to provide services to individuals and populations to develop, maintain, and restore maximum movement and functional ability throughout the lifespan. It is concerned with identifying and maximising quality of life and movement potential within the spheres of promotion, prevention, treatment/intervention, habilitation, and rehabilitation.[1] The learning and teaching requirements to become a physiotherapist vary internationally as a result of different legislative requirements and health care systems, as well as the health and social needs of a particular nation. The World Confederation of Physical Therapy (2011), however, states that physiotherapy curricula should consist of content and learning experiences in biological and physical sciences, social/behavioural/technical sciences, clinical sciences, and clinical education experiences that are appropriate to that nation (Figure 1).[2]

Physiotherapists in Australia are first contact practitioners. The World Confederation of Physical Therapy defines first contact practitioner as a physiotherapist who has completed a physiotherapy professional entry-level programme that equips them to treat clients without referral from a third party such as a medical practitioner.[3] Their ability to conduct an appropriate examination of the client and incorporate additional information from diagnostic tests, such as imaging, is essential to formulate a diagnosis that then directs client management. These skills are paramount not only in Australia, but in other countries where physiotherapists are

primary contact practitioners. Therefore, the knowledge and skills involved with interpreting a range of diagnostic tests must be incorporated into physiotherapy entry-level education curricula.[4]

The focus of this project is on diagnostic imaging related to orthopaedic conditions particularly radiography (i.e. the interpretation of x-rays).[5] In Australia, physiotherapists are able by law to refer clients for x-rays.[6] The Australian Standards for Physiotherapy (2006) which provide a benchmark for knowledge skills and attributes of a safe and effective entry level physiotherapist in Australia state that physiotherapists must have "applied knowledge and understanding of diagnostic imaging such as x-ray, ultrasonography, MRI, and CT…".[4] Despite this, little guidance can be found in The Australian Standards for Physiotherapy (2006) on teaching and assessment strategies that should be used to achieve competence in interpreting imaging.[4]

Literature Review

The international literature has no evidence that describes the appropriate pedagogical approaches and teaching methods for entry-level physiotherapy students to develop competence in interpreting x-rays. However, a study from the United States (US) has described that the majority of contact hours for teaching imaging content in physical therapy professional degree programs the US was in the form of lecture content (59%) with the rest divided mainly through laboratory (15%), and online coursework (17%).[7] The average contact hours spent was 24.4 hours, but this ranged from 2 to 75 hours.[7] Evidence from the medical literature suggests that imaging education has evolved from a "purely didactic, authoritarian model to one that requires informed educational and vocational practice."[8] Teaching theoretical and practical aspects of imaging, including the interpretation of images, tends to add relevance to basic science knowledge, particularly anatomy, and has been shown to facilitate clinical examination and diagnostic skills.[9-11] Radiology teaching should be able to be accessed readily when students need the resources to continue to apply the framework discussed within tutorial based learning.[12] Recent research has shown that a blended, online technique for delivering final year radiology content to medical students was effective in improving student outcomes when evaluating the blended learning module.[13] However no assessment of student learning was evident and evaluation was solely based on the student perception. In summary, there is only a modest description of the teaching and assessment strategies used in imaging interpretation and a lack of evidence on the theoretical constructs underpinning these strategies. Thus, it is not known which strategies are the most effective to teach imaging interpretation.

Theoretical Background

From a theoretical perspective on how adults learn, developing competence in an area requires 1) a deep foundation of factual knowledge, 2) an understanding of facts and ideas in the context or a conceptual framework, and 3) the ability to organise knowledge to facilitate retrieval and application.[14] Applying this theoretical perspective to the teaching of x-ray interpretation requires students to have:

1. An understanding of the basic radiological theoretical knowledge (e.g. the frequently used x-ray views for orthopaedic conditions, structures that can be viewed by x-ray);
2. The ability to appropriately apply a framework to guide the interpretation of x-rays irrespective of the anatomical location of the image;
3. An understanding of what constitutes a "normal" image; and
4. Skills in identifying pathological deviations from the "normal" image.

The teaching technique "scaffolding" could be used to achieve competence in the interpretation of x-rays (at an entry-level practitioner level). Scaffolding is defined as a learning and teaching tool that provides sufficient support to the student to allow them to complete a task independently.[15] Scaffolding could facilitate deeper levels of learning that promote the understanding and application of concepts required for problem solving in unfamiliar contexts, such as during clinical practice.[16] This could be achieved by the internalisation of knowledge and its application to various contexts.[14] When interpreting x-rays, students are required to internalise "normal" images and recognise the aspects that suggest an x-ray is "abnormal." This is an important process, as students are required to understand the principles used to describe a "normal" x-ray, which can then be applied to any x-ray taken throughout the body. Moreover, co-operative learning, where students learn in small groups to achieve pre-defined outcomes, could be used to decrease the scaffold provided by academic staff members, by using student interaction to assist with the development of skill competence.[17] Practice of x-ray interpretation therefore, can be considered a key component of achieving competence and then eventually mastery.

In summary, there is a paucity of evidence on the effectiveness of various methods to teaching the interpretation of x-rays at an entry-level to physiotherapy students. A considerable body of evidence currently exists on theoretical approaches to develop competence. Thus, this descriptive study contained elements of action research aimed to describe the

1. content contained in an orthopaedic radiology module within an Australian 2-year graduate entry Master of Physiotherapy degree;

2. approaches to learning and teaching used in this module;
3. student satisfaction associated with this module over a 2-year period

CASE PRESENTATION

Context

This study was undertaken at Griffith University, a large multi-campus university located in south-east Queensland, Australia. The physiotherapy program, which has been in existence for over a decade in various formats, is a 2-year full time, accredited, entry-level master's degree (Australian Qualification Framework level 9), with an intake of 70 to 80 students annually. The orthopaedic component of the program is offered in the second of a total of five semesters, and consists of a 13-week course, Clinical Science I. This course consists of university-based teaching (including the radiology module) as well as a 5-week full time orthopaedic clinical placement, where students must demonstrate graduate competence, as assessed by the Assessment of Physiotherapy Practice (APP) instrument.[18,19] Other assessment items include a radiology short answer written examination, an end of semester written examination, and a practical examination. The learning outcomes of Clinical Science 1, the methods of assessment that address the learning outcomes and the weighting of each assessment task are outlined in Table 1. This constructive alignment pedagogy allows students to see the direct alignment between the learning outcomes, learning tasks and the assessment.[20]

Table 1. The learning outcomes, method of assessment and weighting of assessment for Clinical Science I

Learning Outcomes:		
1. Demonstrate your knowledge and understanding of orthopaedic physiotherapy assessment, treatment and planning using an evidence-based approach.		
2. Demonstrate that you understand the role of the physiotherapist and other health care providers involved in the patient-centered and holistic management of a client.		
3. Demonstrate professional behaviour appropriate to physiotherapy practice in accordance with ethical and legal requirements as per the Australian Physiotherapy Board Standards.		
Assessment Item	**Weighting**	**Learning Outcome**
Radiology Examination	10%	1
End of Semester Written Examination	20%	1, 2
VIVA Practical Examination	30%	1, 2, 3
Clinical Unit 2 - Orthopaedics	40%	1, 2, 3

The motivation to undertake this study was underpinned by feedback received from the standard university Student Experience of Course Survey, which was conducted at the end of the course in 2012. This survey, which is administered online, is anonymous and seeks to ascertain student experiences and their satisfaction with the course. In 2012, 15% of students (11 out of 72) reported difficulty applying the strategies outlined in radiology lectures to interpreting x-rays both during the radiology examination and while on clinical placement. Based on this issue, this study was undertaken in the context of the University's framework for quality assurance, which is based on the Plan-Implement-Review-Improve (PIRI) (Figure 2).[20] Specifically, we 1) reviewed the radiology module; 2) analysed findings to identify areas for improvement; 3) planned changes to the radiology module; 4) implemented these changes; and 5) reviewed the effect of these changes. Ethical approval, from the Griffith University Ethics Committee (PES/44/12/HREC) was gained prior to eliciting data from students.

Phase 1 - Review of the radiology module

Content, approach to teaching, assessment and outcomes

The content of the radiology module addressed Learning outcome number 1, as described in Table 1. Content analysis of the radiology module, delivered in 2012, revealed that it consisted of two 2-hour didactic lectures, covering the indications for imaging, radiation exposure and patient safety, approaches to reviewing radiographic images, the different projection techniques for each area of the body, positioning of patients, the angle of the central ray and common presentations in the upper limb, lower limb, and spine. Students were provided with a framework to review orthopaedic x-ray images and given examples of frequently occurring presentations and shown how to interpret them.

Assessment was focused on addressing the radiology-learning outcome (Table 1) while developing skills that would be of benefit for the clinical education placement. The assessment task was specifically developed to assess students' competence of interpreting images, as this is a skill required during their orthopaedic clinical education placements. It is also a component of the APP instrument, which is used to evaluate student competence at entry level and is used to evaluate student performance at the end of the clinical placements.[18,19] A 1-hour written examination was therefore used to assess knowledge and skill of x-ray interpretation. Students were shown five radiographic images (one every 10 minutes) and were required to address short answer

questions relating to 1) image view; 2) description of patient position; 3) observations and findings; 4) likely diagnosis; and 5) likely aetiology/pathology or mechanism of injury. The students were then given a final two minutes per image to review. The 2012 cohort of students (n=70) achieved a mean mark of 77% (Interquartile (IQ) Range: 71 to 83%) for the radiology examination.

Student perceptions of the radiology module

A focus group was conducted in 2012 with the aim of eliciting student perceptions of the radiology module, as standard university data derived from the Student Experience of Course (SEC) questionnaire. Qualitative comments indicated that students experienced difficulty transferring theoretical imaging knowledge into the interpretation of x-rays during their clinical education placement. All physiotherapy students in the 2012 first year cohort, who had completed the module and received their grade for the course, were invited to participate in a 1-hour focus group, which elicited information on the radiology content and delivery, through a series of pre-defined questions and open discussion. Students were able to present their own ideas and responded to ideas on possible improvements to the course and its delivery that were proposed by the researcher (CC). Those students who agreed to participate in the focus group signed a consent form, prior to data collection. The focus group was audiotaped, and then transcribed. Descriptive content analysis was used to identify common themes.

Five students (4 female, 1 male) with a range of grades from a credit to high distinction participated in the focus group. Students reported that there was disconnect between the lectures and the assessment of their competence in interpreting x-rays. They suggested that a link between the radiology theory and the practical aspects of x-ray interpretation was required. They proposed that a small group tutorial would enable them to practice interpreting x-rays in an open, safe environment. Students thought that this would assist them to prepare for their examination, as well as to be work-ready for their clinical placement.

Phase 2 – Identification of areas of improvement

From a theoretical perspective, although the content of this module met accreditation standards, the approaches to learning and teaching encouraged surface learning; that is rote learning of principles and x-ray presentations particularly for examination purposes.[22] There was a noticeable lack of radiological interpretation tuition, where students practiced the application of their radiological knowledge to interpret x-rays, within a structured and supportive environment. This was identified from both the analysis of the content of the module as well as by the students. This type of practice has been shown to promote deeper learning, as well as to increase student confidence associated with x-ray interpretation.[20,23,24] Moreover, the approach used for assessment, a written examination which required interpretation of x-rays, has been shown to be stressful.[25] Students reported that the lectures were disconnected from the assessment approach, which also potentially contributed to their stress. It was concluded that approaches to teaching, which focused on reducing student stress, e.g., scaffold content and co-operative learning, and may improve student confidence and competence in interpreting x-rays.[14,17]

Phase 3 – Planned changes to the radiology module

Two 1-hour, non-compulsory small group tutorials were developed to enable students to apply the knowledge gained in the lectures to interpretation of radiographic images in a safe and collegial environment where they would be able to gain feedback on their progress, thus providing a scaffolding step in their learning. These tutorials were designed based on the theory of Bransford et al of developing mastery and Kagan's work on co-operative learning.[14,17] The tutorials also added in the constructive alignment of the course.[20] Specifically, the tutorials were designed so that students would apply their theoretical knowledge gained from the radiology lectures to interpretation of x-rays. Students would work in small groups, where it was expected that they problem-solved with their peers. They would be provided with four images and accompanying targeted questions to complete in 40 minutes to simulate an environment similar to the examination process. The tutorial questions were designed to be similar to those encountered in the radiology examination and during clinical education placements, thus providing the link between theory and the practical application. In the remaining 20 minutes of the tutorial, the tutor highlighted frequent misconceptions or errors and discussed model answers for each image. Each of the images was systematically dissected using the question categories described previously. Model answers were made available to students following the tutorial to allow them to focus on tutorial discussion.

Phase 4 – Implementation of the changes and Phase 5 – Review of the effect of these changes

The tutorials were introduced in 2013. All enrolled Master of Physiotherapy students (n = 70) attended both of the optional tutorials. A short survey was designed to elicit information on student perceptions on how the lectures, tutorials, and assessment influenced their understanding of radiographic interpretation (five 7-point Likert scale questions), as well as advantages and limitations of the new curriculum (2 open-ended questions). The survey was administered after the results of the radiology examination were released to students. Content analysis was used to identify common themes and their frequencies on the responses to the open ended questions, whereas data gained from the 7-point Likert scales were collapsed into three categories: "agree," "neutral," and "disagree" and percentages calculated for each category.

Fifty-nine of the 70 enrolled students completed the survey (response rate = 84%). Students reported positive experiences associated with the radiology module. All students (n=59) felt that the radiology lectures were effective in presenting the radiology content, the tutorials were helpful in consolidating the content learnt within the radiology lectures, and the tutorials were helpful in preparing for the radiology examination. Ninety-five percent of students (n=56) reported that they felt prepared for the radiology examination whereas 93% of students (n=55) reported that they felt confident interpreting x-rays after attend the radiology module (Table 2).

Open-ended questions elicited responses that were mostly directed at the tutorials. Students reported to like the approach to learning in the tutorials, as the tutorials were presented in examination format: "*It was a mock exam question style which was great in helping us prepare and see what the exam would look like."* Students also reported that the tutorials assisted them to consolidate and apply their theoretical knowledge (n = 10): "*Just getting used to looking at x-rays and describing what you see."* The tutorials also provided opportunities for peer assisted / collaborative learning (n = 9): *"Time to discuss findings with classmates,"* as well as example answers (n = 6): *"Good to get explained examples rather than just questions and answers".* Students also suggested that extra tutorial sessions should be provided (n=13, 22%). Although nine students (15%) reported that the lectures were effective in delivery theoretical content, a further six students (10%) felt that these lectures were not sufficiently detailed, particularly "the mechanism of injury should be more explained in more detail."

An independent sample t-test was conducted to compare the radiology examination for the two cohorts. Students in this cohort (2013) achieved a higher mean mark of 83% (IQ Range: 72 – 86) compared to 77% (IQ Range: 71 to 83) for the 2012 cohort ($p<0.05$) with variances between the groups being similar ($F = 0.032$, $p=0.86$).

The SEC scores reflected the change in the learning approach style for the radiology examination. Students commented

"Interesting, radiology tutorials were great!"

"The tute classes for radiology were also really helpful"

"The extra x-ray tutorials, without these I'm not sure how I would have gone on the first assessment piece."

The overall satisfaction of the course improved from 3.7 (out of 5.0) in 2012 to 4.3 to 2013.

Table 2: Student Statements on the Radiology Module on 7-point likert scale

Statements	Overall
I felt that the Radiology Tutorials were helpful in consolidating the content learnt within the Radiology Lectures.	6.61
I felt that the Radiology Tutorials were helpful in preparing me for the Radiology Examination.	6.59
I felt that the Radiology lectures were effective at presenting the Radiology content.	6.24
I felt prepared for the Radiology Examination.	5.86
I feel confident in interpreting x-rays after attending the Radiology Lectures, Tutorials and Assessment.	5.76

DISCUSSION

The ability to interpret radiological films, in particular x-rays, is considered an integral part of an Australian physiotherapist's toolkit.[4] This action research study is the first to our knowledge that has reported the outcomes associated with implementing a scaffolded collaborative learning approach to teaching radiology to entry-level physiotherapy students.[5,14,17] This project is also the first to report the content contained in an orthopaedic radiology module within an Australian entry-level physiotherapy degree, approaches to learning and teaching used in this module, and the student satisfaction associated with this module.[5] Students reported that a didactic style lecture assisted them to learn the underlying principles for interpreting x-rays but fell short when applying these principles to address practice-based scenarios.[8] Students reported that they lacked confidence in the application of radiological knowledge. Despite a paucity of evidence on how to teach radiology to physiotherapy students, this finding is in agreement with studies on other entry-level health professional students.[8-11] For example, medical students preferred interactive case-based teaching sessions to didactic learning of this content.[26] The previous method of teaching radiological content seemed to be inadequate in preparing students for clinical placement and ultimately the work place.[8]

An evidence-based approach was used to the redevelop the curriculum, including the incorporation of co-operative learning and scaffolding.[16,17] Scaffolding has been described as providing clear direction and purpose, keeping students on task, offering assessment to clarify expectations, pointing students to worthy sources, reducing anxiety, surprise, and disappointment, delivering efficiency, and creating momentum.[16] In addition, the advantages of co-operative learning include learning with social interaction in meaningful contexts.[17] Through these experiences, students begin to internalise the concepts and assume responsibility for the development of their skills in x-ray interpretation.[14] Engaging in the newly designed subject matter with peers and gaining information from various sources (including peers, academic staff members, and resources) led to a documented increase in

student confidence and competence in interpreting x-rays. Students reported that they were subsequently better prepared for their clinical placement and more work ready.

These results need to be interpreted with care due to the study involving two cohorts of students at one Australian university. Thus care is required when generalising the results to contexts that may differ from this study.[27] Future research could involve following up future cohorts of Griffith University Master of Physiotherapy students to determine the appropriateness of the approaches to learning used in the radiology module and the congruence with the accreditation requirements. This would involve a further action research cycle.[5] To increase the generalisability of the findings further work would involve using the action research cycle at other institutions to evaluate and further develop contemporary methods to teach radiology to entry–level physiotherapy and other health professional students.

CONCLUSION

Based on the findings of this study the addition of a tutorial that focused on interpretation of x-ray films to supplement radiology teaching improved entry-level physiotherapy students' confidence and competence in interpreting x-rays and their perceived preparedness for clinical placement in a small entry-level physiotherapy cohort at a single Australian University.

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