Learning to look : evaluating the student experience of an interactive image appraisal activity

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http://dx.doi.org/10.1016/j.radi.2019.02.011

Introduction

Through a process of experience the brain creates percepts; representations of objects, enabling them to be recognised when encountered again. Experienced radiographers appraise images quickly and may appear to work instinctively, when in fact they are relying on percepts that they have acquired over time. There is an absence of literature on how adults develop percepts for new visual tasks and whilst efforts to understand errors in medical image interpretation are evident, the cognitive processes remain poorly understood.[1,2] While visual tasks are inherent to medical imaging there is limited evidence of how professionals acquire the skills underlying these actions[3,4] and much of the evidence focuses on outcome rather than cognitive process. Learners become more efficient in visual tasks over time[5–10] with experts able to make inferences from an image much more rapidly than novices.[5,6] It is thought that exposure to visual stimuli improves recognition,[7,11] thus the observer becomes perceptually tuned to image features.[12] Experts take for granted their ability to make sense of information once they are proficient and this can inhibit their ability to educate others.[13]

Frameworks for clinical competence identify the stages a practitioner must progress through to arrive at expert status; the ability to work intuitively by incorporating theory into practice.[14,15] These frameworks are the basis of clinical education, enabling students to apply content in context, during which co-construction of knowledge with supervisors plays a crucial role.[16–18] Whilst the process may begin with knowledge acquisition, clinically relevant assessment, feedback and facilitation feature heavily. Clinical placement should enable radiography students to refine positioning technique and exposure parameter setting through a feedback mechanism based on appraisal of the resultant image. This experiential learning permits a cyclical application of knowledge, feedback, reflection, and planning, thus enabling the learner to consolidate skills over time; facilitation is crucial to this process.[19] Despite taking this approach, module evaluations and the outcome of clinical assessments strongly indicate that students struggle with image appraisal.

The purpose of this study was to investigate if a workshop activity had the potential to support the development of image appraisal skills in a cohort of undergraduate students.

Materials and Methods

All level 4 students from a single cohort took part in a scheduled skills lab, an explanation of this workshop follows to provide background to the focus group discussion. Data generated by the skills lab activity was not retained or analysed for this study. The motivation for this study was to record their opinion of the activity, via focus groups, rather than measure their performance. The HEI granted ethical approval for this study (HSCR14/115) and this included participant observation during the activity, field notes, audio recording of focus groups and retention of transcript data.

Workshop: Image Appraisal Activity

Innovative use of technology can be effective for developing problem solving and decision making skills; both of which are crucial for image appraisal.[20–23] Anonymised images (Postero-anterior chest) of varying technical quality were compared to a reference image and rated as equal, better, or worse according to specific appraisal criteria derived from key texts;[24,25] *Table 1*.

Minimal field to include both apices and both costo-phrenic angles.
Minimal field to include the soft tissues lateral to the ribs.
There is sufficient inspiration to visualise 10 posterior ribs.
The sagittal plane is perpendicular to the image receptor: Medial end of clavicles are equidistant to the spinous process and the length of the right and left corresponding posterior ribs is equal.
The thorax is demonstrated without foreshortening in the coronal plane: approximately 2.5cm of apices visible superior to the clavicles; the patient is neither lordotic or kyphotic.
Both scapulae are positioned clear of the lung field's: the patient's arms are sufficiently rotated.
There is sufficient penetration: the outlines of the thoracic vertebrae are seen through the mediastinum and the lung markings are visible behind the heart.
There is adequate contrast: The ribs, diaphragm, heart, descending aorta are demonstrated and the lung markings are visualised from hilum to periphery.
There is no movement un-sharpness: The lung markings and the cortical outlines of the ribs are sharp.

Table 1: Criteria used for image appraisal in the activity

Students worked in self-selected groups of no more than 3 and were encouraged to discuss their ideas to arrive at a shared decision. After judging all 10 images, the students viewed their group response alongside an expert opinion. A traffic light system of red, amber and green indicated areas of agreement with the expert for each criterion. Students were encouraged to look for trends, discuss discrepancy and identify future learning and development opportunities where there was disagreement with the expert opinion.

Focus Groups

All Level 4 students were timetabled to attend the image appraisal workshop but participation in the focus group was voluntary. Students were offered the opportunity to withdraw from the study at any time, but it was made clear in the participant information letter that it was not possible to withdraw their anonymised focus group data as this may compromise understanding of the

transcripts. All students gave written consent. This was agreed within the scope of the application for ethical approval.

Focus groups are valuable in exploratory research, when seeking to gain insight into new phenomena,[26] or when existing knowledge is limited.[27] Focus groups offer potential value over individual interviews because they allow discussion between subjects enabling them to explore and clarify their opinions[28] and alternative views may be introduced that would not have been considered by an individual. Unlike quantitative research where random allocation of subjects is recommended, it was considered beneficial for students to form a focus group with their familiar peers, recognising the potential for micro-cultures;[29] these naturally occurring groups can provide valuable insight because peers may reflect on their previous interactions or challenge each other, adding different perspectives to the data.[28] Focus groups therefore occurred immediately after regular skills labs which took place over 2 days; day 1 AM (N= 7 students) and PM (N= 8 students), day 2 AM (N= 8 students). Twenty-three students took part in focus groups representing 43% of the cohort.

In an attempt to limit bias students were encouraged to speak freely, in confidence and with no fear of judgement from the researcher, who was also their tutor. Additional data consisted of field notes made during the focus groups and observational 'jottings'[30] taken during the workshops. This enabled validation of results if for example, participants answered questions in a way that they thought might appeal to the researcher or to the rest of the group when the opposite actions and opinions were observed in the workshop.

How are they learning how to appraise images now / currently?
What did they think of the appraisal activity?
Eg; having 3 choices, making a decision, number of images to appraise, the images themselves?
What did they think about the use of specific criteria?
How did they find working in a group?
Will the activity help them learn?
When do they need this activity?
Any other comments?

Table 2: Focus group questions.

A guided but unrestricted interview (content, ordering of questions; *Table 2*) was audio recorded for each focus group and transcribed by an administrator; the researcher performed a sense check on the transcription. No students who took part in the focus groups withdrew from the study. One student offered non-verbal communication only, failing to offer any comments of their own, all other participants provided a verbal contribution.

Data Analysis

Data analysis followed an inductive approach derived from multiple authors;[31–34] *Table 3*. Close reading of the text and listening to the recorded focus group enabled recognition of when a participant was speaking as an individual or with agreement from the group and the tone of the discussion. This generated a series of attitudes and potential points to explore. Following this, each component of the focus group was coded with a summary of key points and/or meaning; this resulted in a combination of emergent codes that used the participants own language and a descriptive summary of the main topic of that section of script.

Stage 1	*Read each transcript through to develop general impressions of what is being said, note any immediate thoughts and any attitudes expressed by the participants.*
Stage 2	*Apply codes to sections of text, emergent or descriptive.*
Stage 3	*Organise codes identifying similarities or themes.*
Stage 4	*Final reduction of data into meaningful discussion points.*

Table 3: Stages of data analysis.

Throughout the coding process, comparison of all three transcripts ensured that the codes were relevant to all groups. The different groups had adopted their own common language but the essence of what they were saying was the same and recognising this made for more efficient organisation into themes. Connections between codes led to organisation into several hierarchy tables. For example, a broad theme was 'Participants exposure to image appraisal' under which multiple data sets might include 'recognition of being taught', 'in skills labs', 'associated with assessment', 'exposure in clinical placement' and, 'potential barriers in clinical placement'.

These methods present findings from the subject perspective[30,35] and enable not only a record of student opinion but also some appreciation of the underlying concepts leading to those opinions. Observational jottings and field notes complemented the analysis of the transcription data and enabled clarification of some of the comments made by students.

Results and Discussion

Final reduction of the data was organised under 2 major headings; *Table 4*.

1. Data relating to participant preparedness for image appraisal activities.
2. Data relating to how this activity might contribute to skill development.

Participant preparedness for image appraisal activities	***For Analysis?***
Using check list for what to include *Rote learning of checklist* *Recognise problems of relying on checklist* *Evidence of being exam driven: items on checklist align with marks awarded*	**Surface learning. This is not image appraisal, it is not applied* **Only became apparent later / after attempts* **Reflects exam results, lacking depth.*
Reflection on own learning strategies: *Using images from internet but no feedback provided* *Working alone / working with other students* *It's a verbal task but not practicing verbally* *Problems with lack of feedback.*	**Much of this appears to be related to testing remembrance of the checklist only. We need to be more explicit, directing to projection specific criteria*
Reflections, awareness of depth of learning / knowledge / ability *Feeling of disappointment*	**Apparent after testing / formal activity and feedback received* **Potential to harness motivation*
Exposure to learning: *Inequitable exposure to detailed image appraisal in clinical* *Feel silly having to keep asking for clarification and do not question supervisor decisions on images* *Not recognising teaching and learning in academic* *Problems with where to find information*	**Needs further investigation* **Barriers in clinical learning: education / awareness for supervisors?* **What are we doing wrong? Needs re-branding? Do we need to change delivery?* **Review reading lists? Are we signposting? Are we using the most appropriate texts/resources?*
Activity potential contribution to skill development	***For Analysis?***
Reinforces knowledge *Identified learning needs* *Provision of expert opinion was a positive feature* *Feel more confident with chest image appraisal*	**Feedback is crucial*
Opportunity to clarify meaning / make sense of *Constructing knowledge with peers* *Felt comfortable to discuss in this forum*	**Through discussion* *(issues with over bearing group members inhibiting discussion also noted)*
Enjoyed the activity, had fun *Felt motivated to learn*	**Consider potential for learning?*
Positive learning environment, learn more just being the skills lab *Preferred over lecture format*	**Benefits of clinical simulation?* **Adopt appropriate teaching and learning strategies for the task*

Some criteria were difficult to judge as equal/better/worse *Some criteria were not understood by participants and some anatomy not identified correctly*	**Agree, only became apparent during the activity. Need a resource to explain this before they start.* **Need to consider how we are delivering this information initially.*
3 grading choices was appropriate *Reference image was considered useful although this wasn't fully explored* *Viewing multiple images of same anatomy – helped to identify normal appearances in population*	**Minimise subjectivity, easier for everyone to agree a decision* **Is there any evidence base?* **Is this related to evidence on pattern recognition? Might this help with learning anatomy? Might this help with applying knowledge of criteria?*

Table 4: Final reduction of data.

The following issues related to learning were common to all three focus groups and disctate the basis of the discussion:

- Knowledge: Students struggled to identify radiographic anatomy and / or use this knowledge effectively when evaluating patient position or exposure.
- Experience: They expressed that exposure to image appraisal had been variable: but they didn't always recognise opportunities that were available to them.
- Feedback: When provided, may not have been effective or at the appropriate time.

Knowledge and approach to learning

When asked how they were currently learning image appraisal, there was a consensus across all focus groups that they learnt a checklist by rote. This checklist, *Table 5*, outlines generic features and questions that should be addressed in every image and is used as an aide memoire.

AREA OF ASSESSMENT	CRITERIA
Name the projection:	
ID:	Correct name: DOB: Correct dept ID: Date of examination
Markers & annotation:	Has the correct aspect marker been applied? Has it been applied pre or post processing? Is it in an appropriate position? Is there an appropriate annotation?
Position:	Is it the correct projection? Assess patient position. Justify decision and suggest corrections required. Name correct centring point. Make a judgement about the centring point used. Other factors relating to positioning to be considered.
Collimation / shuttering:	Has all the relevant anatomy been included? Name upper/lower/lateral limits. Is the collimation field too large/ too small? Can that decision be made or has the image been shuttered?

Image quality:	Suggest appropriate exposure factors and SID. Is there sufficient penetration to demonstrate the required bony and soft tissue structures? Is there sufficient radiographic contrast to visualise difference between the required bony and soft tissue details? Is there sufficient density to visualise the required radiographic anatomy? Suggest adjustments to exposure factors if required. Is there any unsharpness? Are there any avoidable artefacts? Does the image display an exposure index? If so is it appropriate for the examination?
Anatomy and pathology	Identify the radiographic anatomy. Are there any normal variants? Describe any pathology.
Diagnostic acceptability	Is this radiograph gold standard/acceptable/require a repeat? Discuss further/additional projections required to complete this examination.

Table 5: Image appraisal checklist.

To appraise each image proficiently requires consideration of essential criteria that are specific to each radiographic projection.[24,25] Students had not learnt these or were unable to apply relevant knowledge resulting in fundamental errors. For example, they were observed checking for rotation by using the wrong anatomical structures and lacked appreciation of the criterion for assessing inspiration by counting all ribs, not just those above the diaphragm. Similarly, they felt that the criterion relating to contrast assessment should have been split up so that each anatomical element was evaluated separately, revealing a misconception of contrast assessment.

"one of the questions did involve about three different things to look at so if one was better and one wasn't……. then it was a bit confusing"(FG3 P5)

Radiographic image appraisal is a complex skill requiring assimilated knowledge of anatomy, patient and equipment positioning, and the scientific principles of x-ray exposure selection. These students had studied anatomy and radiographic technique for the appendicular skeleton and chest alongside scientific principles in a single trimester prior to practice placement. It is common for students to adopt a surface approach to learning; choosing to memorise facts in order to cope with large volumes of data[36] but surface learning does not encourage critical thinking[37] and this may be why students struggle to apply knowledge in cognitive tasks such as image appraisal.

Some students stated that they had questioned a supervisors decision regarding diagnostic acceptability, seeming to be frustrated and this was echoed both verbally and non-verbally by others:

"I think if it would be an acceptable image then that's what's important" (FG1 P6)

So, although they are questioning decisions made by supervisors in clinical practice, study data and observations suggest that they are unable to judge the criteria by which that decision is made.

Clinical assessments and this workshop had helped students appreciate that their previous understanding of image appraisal fell short and some attributed this to their reliance on the

checklist. Within academia students are expected to be self-directed and whilst tutors may sign-post them to resources, learning the specific criteria for each image takes time. Our data revealed that many of them don't do this, but we also learned that students were not happy with their current level of understanding. Comments, attitude and the good humour during our activity and focus groups imply enjoyment and this tends to result in higher levels of motivation,[38,39] an individual's propensity to find academic activities meaningful.[40] To ensure that students are motivated to learn and apply essential image criteria, teaching and learning must focus on its relevance to their clinical role. There should perhaps be less emphasis on learning anatomy from diagrams and more reference to how anatomy appears in radiographic images?

Experience and learning from feedback

Some students highlighted apparent inequity in the level of support and time for image appraisal in clinical practice. Further discussion revealed that they may only acknowledge formal activities, often associated with assessment:

> *"that was like the first I really knew of how in depth it had to be and the OSCE was the next week". (FG1 P6)*

Students also raised concerns about exposure to image appraisal in the academic setting but when prompted they recalled and spoke favourably of focused teaching sessions. This raises questions about how students perceived this learning and whether tutors needed to be more explicit about the aim and outcomes of the session.

Some students described their motivation to appraise images from the internet and acknowledged that this was of limited value without model answers. Providing students with the opportunity to clarify any concerns face to face and receive essential feedback is an effective mechanism for driving continued learning[41] but currently students may not be receiving or recognising feedback on their performance until the critical point of assessment; this represents missed opportunity for them to operate more effectively in practice. Provision of feedback was considered a success of this workshop.

A process of 'spaced education' whereby students are introduced to a topic and revisit it at regular intervals should enable the development of complex skills by providing forums for consolidation and clarification that encourage long term retention [42]. Application should be facilitated in practice placement; these students don't feel that this is happening consistently or with sufficient frequency. Staffing, time demands and the adoption of digital radiography in the clinical environment may be contributors; the impact of which should be considered for further research. Continuous assessment is beneficial for testing knowledge retention, reinforcing facts and introducing new

information[43] so students should be provided with regular opportunities for image appraisal practice in the undergraduate programme. Providing a forum for learning in which students have a positive relationship with their educator is paramount[44,45] and whilst this can be difficult in placement where students work with many radiographers, the skills lab environment at the University is familiar and supporting. The tutor can ask questions to promote discussion and harness the positive aspects of collaborative learning.

Whilst simulation may not replace experiential learning in practice placement, the use of human images has been shown to be of value to our students. One focus group stated that the use of criteria helped them to appreciate that an image can be normal even when it doesn't conform to the stereotypical gold standard representation found in text books:

"so using your criteria to like you said assess what's in front of you not what you think it should look like cos everybody's different" (FG2 P4)

That the elusive 'gold standard' image is not always achievable but a range of appearances are still considered acceptable is an important learning point for student radiographers once again reiterating the value of learning essential criteria.

Without question, research in perceptual tasks supports the notion that increased exposure enables recognition thus suggesting that a novice observer must spend time viewing images to develop their percepts. Ability in visual tasks can be learnt[46] and enhanced with facilitation.[3] For successful image interpretation, the observer compares what they are seeing to their mental picture of 'normal' in order to recognise anomalies; this requires viewing many images from a variety of patients.[9,47] In this respect, this workshop has the potential to improve pattern recognition because students view multiple examples of the same projection in quick succession. If anatomy is easy to spot on one image, the viewer may more readily recognise similar but ambiguous features in another because they know where to look at what to look for.

Image appraisal is a complex visual skill requiring higher-level application and problem solving for which collaborative learning is an effective strategy.[48] Small group work is considered beneficial to decision making according to constructivist models and peer review is thought to encourage deeper learning.[49] Observations during the activity and focus groups demonstrated that students engaged in co-construction of understanding, a recognised mechanism for enabling the development of novice to expert performance.[18] They expressed that they had learnt from each other with some stating that this was better than in practice because they felt silly having to keep asking their supervisor things they should probably understand.

Limitations

A potential limitation of this study was that the subjects knew the researcher; this has been seen to lead to social desirability bias as students answer questions in a way that they think appeals to the researcher.[50] The decision for a tutor to host the focus groups was considered potentially beneficial because they work closely in supporting these students and could facilitate an open, non-judgemental conversation.

Questioning and data analysis was conducted by a single researcher and whilst this may risk bias it can also enable consistency of the interpretation and coding of the data.

Focus groups did not take place at the same time potentially creating opportunities for students in later groups to be influenced by others. At the beginning of each focus group the researcher stressed the importance of confidentiality appealing to students not to repeat discussions outside of the forum.

A single cohort of students completed the study in one institution, limiting generalisation.

Recommendations

Prioritisation and time constraints are recognised as a barrier to clinical education with teaching assigned a lower priority in medicine[51,52] but in order to develop the deep embodied knowledge of the competent practitioner, this knowledge must be applied and tested in action.[53] Further inquiry should focus on developing evidence-based strategies for facilitating clinical learning and these strategies will need to be both time efficient and frequently conducted. In addition, image appraisal combined with eye tracking may help educators appreciate whether students are able to apply the correct knowledge of anatomy and radiographic technique to the image appraisal task.

Conclusion

Students described a positive impact of the image appraisal activity, gaining a better understanding. Educators must not assume that the provision of resources will result in students developing deep knowledge. Teaching and learning strategies that are detailed and task specific are recommended to avoid a surface approach to learning. Spaced education, repetition and appropriate feedback are essential to enable learners to develop the competence and confidence for complex visual tasks, such as image appraisal. These components are identified by education theory as important for the development of clinical competence as they enable the student to utilise increasing levels of cognition as they progress from novice to expert.

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