Using a clinical computer system to assess student anatomical knowledge and understanding: A pilot

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Abstract

Introduction: Although anatomy is baseline knowledge for radiation therapists, students often do not see its clinical relevance. Radiation therapists need to interpret the anatomy visualised on computed tomography (CT) images for planning and treatment verification purposes. The Bachelor of Radiation Therapy at the University of Otago combines anatomy with imaging concepts in a first-year academic paper. Teaching includes using a treatment planning system (TPS), which permits students to make the connection between textbook anatomy and CT images. This project explored the use of a TPS as an assessment tool for anatomy.

Method: The anatomical knowledge of two small cohorts of first- and second-year radiation therapy students was assessed using a treatment planning system. Semi-structured focus groups were conducted with each cohort to capture the students' experience of the assessment.

Results: Students performed no worse in this assessment compared with a similar traditional assessment. In addition, the assessment promoted student engagement with the material. Students could demonstrate their knowledge and understanding in a manner reflective of clinical practice. Concerns regarding lack of familiarity in using the planning system and fear of technological failure on the assessment day were identified, as well as a general discomfort with the absence of a "correct answer" for certain scenarios.

Conclusions: This study shows that a TPS can be used to teach and assess anatomical knowledge. Students found the TPS assessment to be more clinically relevant and were able to make connections between topics and clinical experience. Future assessments utilising a TPS should ensure students are familiar with the system prior to those assessments.

Keywords: assessment; computer systems; anatomy; computerised tomography; evaluation.

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Introduction

The study of anatomy is common to a wide range of health professions. Although cadaveric dissections have traditionally underpinned anatomical teaching for medical students, allied health professions have used a variety of other approaches. Over time, for example, studies have examined the development of clinical skills alongside anatomy learning (Monkhouse, 1993; Philip, Unruh, Lachman, & Pawlina, 2008), using a case-based system of teaching anatomy (Drake, 2007) and debated the use of cadavers or medical imaging to support anatomical learning (Gunderman & Wilson, 2005). The various approaches are influenced by the specific needs of different professions, the resources available and the pedagogy of those delivering the courses (Johnston, 2010; McCuskey, Carmichael, & Kirch, 2005). Radiation therapists (RTs) use their anatomical knowledge to facilitate the planning and delivery of a course of radiation therapy to (mainly) cancer patients. Medical images play a key role in treatment planning and treatment delivery. Anatomical knowledge supporting the interpretation of medical images, therefore, forms a significant component of the Bachelor of Radiation Therapy offered by the University of Otago. Historically, anatomy textbooks have provided the backbone of factual anatomical information for RT students. At the time this pilot study was conducted, there was no textbook that specifically addressed the anatomy visualised in medical images in the context of radiation therapy.

Clinically, computed tomography (CT) images produced by radiation therapy treatment planning systems (TPSs) are used to generate and optimise treatment plans. The University of Otago has been using a TPS to teach the skills and concepts associated with plan generation and optimisation in the relatively safe and stress-free classroom environment since 2007. The TPS used for learning activities is identical in function and appearance to that found in clinical practice. The University of Otago was the first tertiary institution in the world to have a TPS purely for classroom use. The author has personally observed several institutions in Australia and the UK that are also now using a TPS to teach planning concepts.

A TPS demonstrates anatomy using CT datasets. Cross-sectional images across all physical planes offer a three-dimensional representation of anatomy.

By using the TPS, students enjoy a classroom experience similar to the clinical setting with respect to applying their anatomical knowledge. Anecdotally, using the TPS to support anatomy teaching has had a positive reception from students and the clinical staff supervising students on placement in two ways. First, students regarded using the TPS to be a more engaging way to learn and spend time in the classroom. Second, learning anatomy using the TPS and then spending time in clinical placement improved the connection between theory and practice.

While other institutions use a TPS to teach planning concepts, to my knowledge, using a TPS to support anatomy teaching is unique to the University of Otago. It should also be noted that at the time of the pilot study, the combination of anatomy with image interpretation was a relatively new academic module developed as part of a revised curriculum.

ISSN 1442-1100

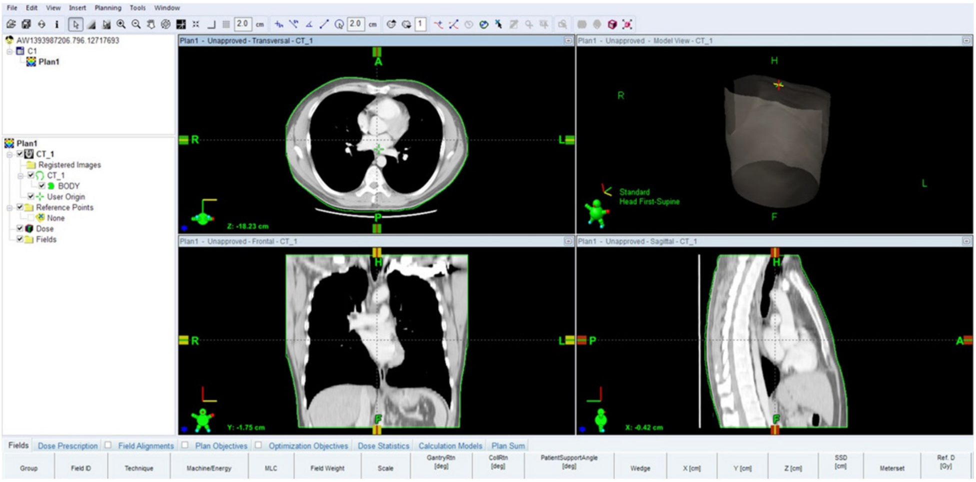

Figure 1. Screenshot depicting the way in which the treatment planning system presents cross-sectional anatomy via CT images.

Although the TPS was used in the teaching and learning of anatomy, this was not reflected in the assessment of this module, which was divided into four written tests and one final written exam. Instead, imaging questions have consisted of single, printed CT images included in written tests. Students were asked to identify particular structures indicated on those images. The marks attributed to these questions accounted for less than 10% of the marks available across the entire paper. Previous studies have indicated the value of tasking students with assessments that encourage engagement and represent value (Boud, 1990; Boud & Falchikov, 2006). More significantly, the extensive work of John Biggs on constructive alignment has outlined the merits of aligning teaching and learning activities with assessment tasks (Biggs & Tang, 2009). Other than being mentioned in routine student evaluations, no formal data around the use of a TPS as a teaching or assessment tool of anatomical knowledge had been collected. Therefore, this pilot study aimed to investigate the use of a TPS in assessing the anatomical knowledge of RT students. The specific objectives were to measure student performance, capture the student experience of completing the TPS assessment and assess the logistics of using a TPS for assessment from the students' perspective.

Method

This pilot study employed a methodology with both quantitative and qualitative aspects. All Year 1 and 2 students (n = 49) were invited to participate by a group email. The email included a participant information sheet outlining the project and the format of the pilot assessment.

The students' performance in the pilot assessment, administered after all summative assessment had been completed for the year, was measured quantitatively. The timing was chosen to reduce the risk of over-assessment, and students knew that the results from the pilot assessment would not affect their academic record. Students were provided with two computed tomography (CT) datasets presented in the TPS. They

ISSN 1442-1100

were asked to electronically annotate 30 anatomical structures on the images for the first dataset. A tool in the TPS allows the creation of annotations that have definitive three-dimensional coordinates within the physical volume represented by the images. Each student was able to save these annotations against their own dataset for later marking by the tutor. Students were then asked to identify 15 structures pre-annotated on the second dataset, which had the editing rights disabled. Students were free to use the full range of TPS tools to manipulate images, such as enlargement, contrast, brightness, windowing, level, etc. The order in which students attempted the tasks was not specified. Students were awarded a mark for each correct annotation (dataset 1) and each correct identification (dataset 2), and the total score for each student was recorded.

Qualitative data was obtained via two focus groups attended by all students who completed the assessment—one group for each year group. The focus groups were conducted in a seminar-type room and facilitated by an independent researcher, unknown to the students and not involved in the program. A series of prompt questions was provided, but discussion was allowed to follow the direction taken by the two groups (Table1). The focus group discussions were audio recorded, transcribed and coded using thematic content analysis. Coding was done on a line by line basis, and themes were identified from those codes. Comparative coding and analysis was performed by an independent peer. Themes were discussed by email and in a single face-to-face discussion to reach agreement (Liamputtong, 2009).

Table 1
Focus Group Prompt Questions

You have all undertaken the full set of assessments currently used in the anatomy and imaging paper. In those assessments, you were asked to identify anatomical structures from single CT images, which were printed. You couldn't alter those or view the same region from a different view or alter the contrast. Today you were asked to identify and mark a series of anatomical structures on full CT datasets where you could choose the view and manipulate contrast. We want to hear about how the experience today compares with the written tests and exam.	
1	How does the experience of identifying anatomical structures using multiple images on a planning system compare to the same task using paper copies of single images?
2	Which approach do think better reflects your ability to identify structures on images?
3	Which approach do you think relates better to: a. How you were taught to interpret images b. How you experienced image interpretation in clinical placement (understand Stage 1 has had limited time in clinical)
4	How comfortable were you with the time allocated for each assessment type? • In written tests: - 12.6% of total mark from tests, 25 minutes - 6% of total mark from exam, 18 minutes • Electronic test - It is likely 15% of total mark would go on imaging, time limit of 45 to 60 minutes
5	How useful was it that the test was done using a system you were already familiar with and is one used in the clinical setting?
6	Did you find more flexibility with the electronic version of the assessment? How important would that be to you?
7	Can you make any suggestions to improve the experience of the electronic assessment?
8	How did you score on the imaging questions in your tests and exam?

ISSN 1442-1100

Ethical approval for the study was obtained using the University of Otago Human Ethics Departmental Approval process. Participation in the assessment was considered informed consent, as explained on the participant information sheet emailed to the students.

Results

Six students were recruited from the first-year cohort (n = 28) that had just completed the anatomy and imaging paper, and four second-year students (from a cohort of 21) who had completed the same paper in the previous year were also recruited. The second-year students had spent an additional 6 months on clinical placement prior to participating in the pilot study. Each year group completed the assessment in 45 minutes.

Performance

With respect to performance in the TPS assessment, the first-year cohort performed better (average 83, range 60–95) than the second-year cohort (average 62, range 43–74). No direct comparisons could be made between the performance in the TPS assessment and previous similar assessments of individual students due to issues of anonymity. As a broad comparison, statistics for both the first- and second-year cohorts (in their entirety), based on similar questions asked in the traditional manner, were obtained from departmental files. The Year 1 cohort completed the traditional assessment a few weeks prior to the TPS assessment (average 65, range 36–88), whereas the Year 2 cohort completed a very similar assessment a year earlier (average 63, range 41–90). Based on this broad comparison, the students did not perform any worse in the TPS assessment than they did in previous similar traditional assessments, even if that assessment was completed a year earlier.

Focus groups

Four themes were identified from data collected from the two focus groups and are described below.

Making it real

Students reported that completing an assessment that aligned with how they would ultimately apply their knowledge in a clinical setting was a strongly positive experience. This approach seemed logical to the students, and they suggested that this could contribute to greater satisfaction with the learning process. This assessment approach may also facilitate transitioning from understanding textbook representations of anatomy to interpreting medical images.

> *Well, because it's how we view images when we are in clinical practice* (G1P1)
>
> *It's the primary way we look at anatomy, so it seems silly to look at it any other way than how we are going to do it when we are on placement.* (G1P2)

Improved learning

Students reported that using the TPS as a learning and assessment tool could assist forming links between the various papers comprising the program and the type of learning required. This was seen as beneficial to the learning experience and the quality of the learning achieved. Students perceived that performance was not driven by the type of assessment, rather their learning processes leading up to it, reinforcing the

ISSN 1442-1100

idea that quality of learning was perhaps of more significance than they had realised. There was significant discussion around the perceived need to avoid rote learning, as this would be counterproductive when an assessment style required them to problem solve. This seemed to overlap with the idea that the assessment made things "real" and reflected the role they were working towards.

> *There is definitely an advantage in knowing how to do stuff rather than knowing the information.* (G1P2)

> *It would make a difference to my understanding. … It means I would understand the body as a whole a lot better. … Grade-wise, I'm not sure if it would have a, have an impact, which is probably what you would want*. (G2P1)

Motivation

Students reported that the nature of the new assessment had a positive influence on their motivation to study. Embedding assessment in a process connected to the realities of the "real world" and in a manner that makes learning engaging and of better quality gives them greater reason to invest the effort required. Students indicated that improved motivation could also be linked to a perception that the effort required to prepare was directly rewarded by a more significant contribution to the grade achieved overall in the paper.

> *I felt like I needed to know everything, like I needed to know where vessels were and what they went to and what they did, as opposed to … memorizing the round circleness of where they were*. (G2P5)

> *It actually makes it seem a lot more relevant, a lot more worth my while*. (G2P4)

Student anxieties

Some anxieties were expressed by students, best classified as logistical concerns or interpretation concerns. Concern was expressed about being disadvantaged by varying degrees depending on the student's level of confidence using the TPS to do the assessment as well as anxieties about the TPS breaking down on the day. It was suggested that students could be given more opportunities to become familiar with the TPS before doing the assessment and that clear backup plans in case of technological failures on the assessment day were in place.

> *It would have been nice if my images had saved … at least we will know for the next time*. (G1P1)

> *Obviously, there's a whole element of if you know how to work the system really you are going to have an advantage but if everyone's taught the same thing then I guess that's how it goes.* (G1P1)

Some anxiety was expressed about the perception that, for many assessment items, there was no absolute correct answer or solution. For example, many of the structures could be identified on multiple CT slices. While they understood the merits of the rudimentary problem solving approach encouraged by the assessment, many students were worried that their solution would not be acceptable, essentially a fear of failure due to differences in interpretation.

> *You had to like pick your own reference point to represent that tissue which I guess is a little bit harder and could be more scrutineered? Is she pointing at the liver, is she pointing at the hepatic vein, what is she doing?* (G1P1)

ISSN 1442-1100

Discussion

Overall, this study shows that it is feasible to use a TPS to assess anatomical knowledge. Students performed well in the assessment; they found the assessment to be more clinically relevant; and they were able to make connections between topics and clinical experience.

Even though the number of students participating in this pilot study was small (n = 10) and constituted only 20% of the student cohorts, the group was representative of a typical year group with respect to gender, age, ethnicity and academic achievement. Students did not score worse than they themselves and their peers did in similar questions assessed in the traditional way. Further research with larger numbers of students is warranted in order to verify these results in a statistically meaningful way.

Focus group data showed that the assessment provided a means of connecting information from various papers taught during undergraduate study and would positively affect the nature and amount of study participants would do in preparation for it. Biggs and Tang (2009) described how differences between surface and deep approaches to learning affect the depth and understanding of factual and applied knowledge. Surface learning often results in linear progression through a course of study, whereas deep learning allows for integration of knowledge and understanding of concepts accumulated over a longer period of time and from different sources. This would be especially important for knowledge and understanding deemed to be core to the skillset of newly qualified radiation therapists. It is interesting, therefore, to note that students commented that the nature and quality of their study should determine their score rather than the assessment type.

Logistical concerns from a student point of view reinforce the wisdom of piloting any significant change to an assessment (McCann, 2010). Using technology can both enhance and hinder learning. Technology needs to be reliable and properly supported so that students are not disadvantaged by failing infrastructure. There is the risk that the focus of an electronic assessment will become using the tool and not the learning being assessed. Both potential issues can be readily addressed. The TPS used for the assessment is a commercially available, well-established software package with a raft

Table 2
Logistical Issues Identified by the Lecturer

Number of computers	· One machine per student with a total of 19 machines; larger classes need to be split into two groups
Timetabling issues	· Double time required for one assessment for classes >19 · Extra time required to facilitate changeover of groups if classes >19 · A 1-hour time period will be enough to allow the required number of assessment elements to be comfortably completed by most students
Technological issues	· Need to have alternative dates arranged to accommodate potential technological breakdown · Students must be reminded both verbally and in written form to save work regularly

ISSN 1442-1100

of support mechanisms in place. The main pitfall of the TPS is that its intended use did not include assessing anatomical knowledge. Reflections are given in Table 2. As a result of this pilot study, the author has engaged with the system manufacturer about the feasibility of developing an educational version of the TPS. The concern around familiarity with the TPS should not present significant challenges as the students use TPS in other modules of the program. Introducing students to the TPS at an earlier point in the program's timeline may further minimise this concern.

Students expressed concerns around there not being a "right answer" in some scenarios. The need for a "right answer" may be a direct consequence of surface learning (Balasooriya, Toohey, & Hughes, 2005; Biggs & Tang, 2009; Ramsden, 2003). Students commonly memorise large chunks of factual information. This approach does not adequately prepare for the absence of a "right answer", especially in the context of health care provision. There is instead the concept of best practice, which is evidence-based and will change depending on the latest published research. In addition, no two situations or patients are the same, so best practice often centres on the ability to problem solve, which is rooted in deep-learned knowledge (Rosenberg & Donald, 2015). The piloted assessment seemed to force students to problem solve, moving them away from a rote learning approach into the realms of deeper learning and, thereby, understanding. It is of interest that the students identified the "carrot and stick" nature of the assessment. The carrot was the fun and realistic way in which they could apply theoretical knowledge and the latitude to deduce responses rather than recall items from memory. The stick was the absence of definitive answers, acknowledging that they had to give a best-case solution based on their knowledge and experience. Course and assessment design can confront students with this "carrot and stick" issue, and their response and performance will ultimately depend on their learning strategy, their ability to embrace the carrot and stick issue and their personality (Chakravarty et al., 2005).

The amount of time spent and the nature of any study will be a reflection of the time devoted to the topic by the teacher and the way in which the topic is taught (Boon, Meiring, & Richards, 2002; Gibbs & Simpson, 2004). Teaching should encourage understanding rather than memorisation and recall, and the assessment strategy must reflect this and give a valid measure of what has been achieved whilst encouraging learning to continue into the future (Gibbs & Simpson, 2004). It seemed apparent to the students in this pilot study that the assessment, and by definition the teaching leading to the assessment, demonstrated where their anatomical knowledge fit into the wider picture of being able to plan a course of radiation treatment and allowed them to make connections between anatomy and imaging, and other topics in their program of study.

Motivation is a key determinant of the success of learning and assessment (Boud & Falchikov, 2006). The perceived clinical relevance of material studied is a prime motivator. The four Year 2 students, who had completed 6 months of clinical placement, were particularly convinced of the value of making the assessment an experience closely tied to clinical practice. To them, this was a significant benefit of the assessment and a strong motivating factor to devote study time and energy to this topic. The six first-

ISSN 1442-1100

year students had just completed the anatomy and imaging paper. They thought that this pilot assessment gave them a better understanding of the clinical significance of anatomical knowledge, and this would have made them study harder.

This "motivation to study based on perceived clinical significance" perspective reinforces the principles of constructive alignment. If aligned teaching and assessment is provided in an engaging manner, with an emphasis on clinical relevance, students should be able to make connections between learning tasks at an earlier point and recognise the value of deep learning (Biggs & Tang, 2009; Boud & Falchikov, 2006). This does not only apply to the teaching of anatomy; it could also make a useful contribution to the maturation of students into accomplished lifelong learners.

Limitations and further development

Running this pilot study for a small cohort of students has provided useful information on how to proceed with developing future roll-outs and evaluation of the assessment.

The quantitative data collected in this study was, at best, rudimentary. Any study aiming to measure change in performance by students in a statistically meaningful way would require a more extensive quantitative dataset of several student cohorts. Information about student perceptions of the assessment experience could be compared to their performance. Additionally, input could be sought from clinical tutors and supervisors to see if there is correlation between a better learning experience and more effective application of the learning in the clinical setting.

Many qualitative designs seek data saturation. This necessarily requires large numbers of participants; however, follow up interviews after further study or clinical practice, where time has allowed reflection and adjustment to learning strategies, may give more substance to the notion that a more meaningful study experience correlates with better clinical practice. Focus group data is often well-complemented by other data collection methods and follow up interviews or surveys (Morgan, 1996). Inevitably, the study depended on the volunteer participants who turned up. It is possible that another cohort may have presented other views. Due to time restrictions, in this pilot study, no feedback was obtained from the group to check if the analysis captured the tone of the discussion.

One aspect of the assessment that this pilot did not fully address was the likely resourcing needed to set up and mark an assessment of this nature for an entire class. While not definitive, there was some indication of logistical considerations with respect to students being familiar with the TPS system and backups for potential technological failure on the day of assessment. A complete roll-out of this assessment as part of summative assessment and further evaluation has already taken place and will be reported on separately.

Conclusions

This pilot study showed that it is possible to use a treatment planning system (TPS) for assessing the anatomical knowledge of a small group of first- and second-year radiation

ISSN 1442-1100

therapy students. A total of eight out of ten students scored at a similar or higher level than the average score for the combined cohort for similar questions assessed in the traditional manner. Focus groups with the participating students revealed that this assessment tool gave them a better insight into the clinical significance of studying hard and performing well in this type of test. It also allowed them to make connections between the anatomy paper and other papers in their course of study. Concerns that need to be addressed in future studies include giving students enough time to familiarise themselves with the TPS and a need to plan for technological breakdown.

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