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Experiential Learning, Spatial Visualization and Metacognition: An Exercise with the "Blank Page" Technique for Learning Anatomy ☆

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Abstract

Purpose: Undergraduate students in the allied health science disciplines are normally required to complete a human anatomy course in their first year. Such courses, while popular, present challenges in that the content requires students to engage different approaches to learning. Recent literature reflects an increased interest in active, experiential learning activities to improve the learning of anatomy and physiology, but activities that focus on the development of metacognitive skills and visual-spatial thinking have been lacking. To address these inadequacies we developed a plasticine modeling and drawing activity in a tutorial room devoid of resources and visual cues referred to as the "blank page" room. The purpose of this manuscript is to communicate the merits of this intervention as an instructional technique used to facilitate the learning of anatomy for undergraduates of allied health disciplines.

Method: During anatomy laboratory sessions we randomly allocated student groups to the activity of plasticine modeling and drawing (blank page technique) or the completion of written review questions. We compared the grades achieved by students who had been exposed to the blank page intervention with the grades achieved by students who were given standard review questions. We also collected qualitative feedback in the form of questionnaires that required participating students to rate the learning efficacy of the activities.

Results: Students performed slightly better on assessment quizzes after the blank page activity compared with the review questions. Student feedback indicated that the blank page activity had greater learning value and promoted stronger engagement in the learning tasks.

Discussion: The blank page activity has merit in student engagement and facilitation of the learning of anatomy by broadening the scope of instruction to encompass multimodal learning preferences, metacognition and visual spatial thinking.

Keywords: Learning anatomy; Metacognition; Visual-spatial thinking; Anatomy laboratories; Clay modeling

☆Ethical approval was granted under Griffith University Human Ethics Committee MSC01/12/HREC.

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1. Introduction

In Australia, in-depth study of human anatomy is experienced for the most part at post-secondary level. In particular, students destined for careers in allied health are required to study a human anatomy and physiology course as part of their degree program. Most of these first year students have never been exposed to detailed human anatomical studies prior to arriving at university. We deliver a large first year anatomy and physiology course (800+ enrolled students) that is mandatory for a range of allied health programs. Based on student feedback, the course is perceived as relevant and interesting but the most challenging of their first year courses. While there is a broad distribution in grades, it is disappointing to report that many students fail to succeed in this course each year.

Our objective was to improve the success rate for all the students in the course and facilitate the learning of anatomy & physiology by implementing a technique that combines experiential learning (learning from a concrete experiences), visual-spatial thinking (construction of mental images) and metacognition (awareness of one's understanding or cognition). In this report we present an application of our technique and describe its alignment with current educational philosophies. Lecturers of anatomy and physiology, who have limited formal training in education and student approaches to learning, may find this technique beneficial, as well as teachers of secondary level science who are preparing students for university programs in the health sciences.

1.1. Learning anatomy

For students of health sciences, laboratory sessions make the learning of anatomy meaningful and relevant to a student's future clinical setting. Large first year undergraduate anatomy laboratory sessions using cadaveric material, models and plastinated specimens are potentially a rich learning platform for first time students of anatomy. These sessions are designed to promote deep learning by providing opportunities for students to observe and manipulate specimens and experience the texture and interrelationship between anatomical structures in 3 dimensions. In reality, in large undergraduate cohorts of 100–150 students per laboratory session, it can be difficult to allow students the time and opportunity to manipulate individual specimens and discover the details of anatomical structures, or create an active learning environment.

Learning anatomy presents a unique challenge for many students who for the first time are required to exercise visual-spatial thinking and construct mental images to enhance deep learning and long term memory. In resource-rich laboratory settings, based on observation and instruction, without active dissection, students can often become passive, superficial learners, and overwhelmed by content. This is particularly acute in first year students who have been accustomed to the small class and teacher-centered environment of secondary school. It has been established that students' approaches to learning are not fixed but change according to the educational context.[1] In addition, recent reports indicate that many first year students lack metacognitive skills or the ability to self-regulate their learning.[2,3]

Surrounded by visual cues in the laboratory, but lacking in metacognitive skills (an ability to monitor their understanding), it is in our experience that students can develop a false sense of knowing without practicing the deep cognitive processes required to construct the knowledge in their own minds. Practicing deep cognitive processing in order to construct knowledge is aligned with the constructivist educational paradigm. Constructivism asserts that learning is development or construction of knowledge where *active* learners interact with and manipulate their surroundings.[4] Aligned with constructivism and often associated with science education is experiential learning. Experiential learning, formalized by Kolb[5] is an approach to learning where the student engages in a concrete experience and reflects upon that experience, responds to it and then constructs the knowledge anew. In developing our learning activity we have blended elements of constructivism and experiential learning to facilitate the learning of anatomy. In addition, we believe the activity encourages the development of metacognitive skills and visual-spatial thinking.

1.2. Learning styles for anatomy

It is now widely accepted that students display multimodal learning preferences[6–8] and when specifically learning anatomy, it has been reported that students who integrate a number of learning methods, demonstrate better long term knowledge retention.[9] As instructors of a large cohort of allied health first year students, we needed to diversify the instructional design of the anatomy laboratories to incorporate different learning styles and encourage deep cognitive processing by the students. The impetus for change to diversify the learning experience was based on our observations that

many students were performing poorly on laboratory assessment quizzes *and* expressing disbelief at their poor performance. We also observed students as passive learners in the laboratory setting.

From this we identified three areas in need of improvement based on desired learning outcomes from the anatomy laboratory experience. First, we wanted the sessions to be more active to enhance engagement and deep learning; second, we wanted to develop students' metacognitive skills to assist self-regulation of their learning; and third we wanted to create opportunities for students to develop spatial visualization skills.

1.3. "Blank page" technique

In 2011, we developed, piloted and reported on an activity to promote metacognition in the learning of anatomy called the "blank page" technique[10] and embedded the activity into our first year anatomy course. In short, the blank page technique requires students to build (using plasticine) or draw (on white boards) anatomical structures in a tutorial room devoid of visual cues; a room that represents a metaphorical "blank page". In contrast to active dissection or observing prosected human cadavers, in the blank page room students are required to make *something* from *visual memory*, relying on their own mental images for recalling the required detail. The blank page exercise compels the students to become active in creating a visual representation of their knowledge as opposed to passive observers. In addition, it provides an opportunity for experiential learning. Students have reported that the exercise is "fun" and "assists their learning". Here we discuss further merits of the blank page technique as informed by the current literature and describe a study where we evaluated its efficacy as a learning tool based on performance on an assessment item.

2. Materials and methods

2.1. Context

Two hundred and thirty-nine first year students volunteered to participate in this study and signed informed consent forms in accordance with University Ethical guidelines. The first year anatomy and physiology course is offered to students of allied health disciplines including Medicine, Biomedical Science, Pharmacy, Dentistry, Physiotherapy and Exercise Science and Nutrition. The student enrollment in the course was greater than 800. Students from all disciplines are mixed together to take three hours of anatomy laboratory per fortnight for 14 weeks (21 h in total). The laboratory sessions are composed of 120–150 students who are arranged in groups of 15–18 to rotate through 6–8 stations. One station takes place in a tutorial room devoid of any resources and referred to as the "blank page" room where students have the opportunity to use plasticine or drawing to recreate particular anatomical structures as suggested by the tutor. Students leave textbooks and other resources aside when they enter the "blank page" room (Fig. 1). Then they are encouraged to recreate an anatomical structure which they feel is challenging for them to construct. Otherwise, the tutor suggests a structure for the student to construct. The students are encouraged to try to recreate the structure without referring to resources for 3–5 min. Only after a genuine attempt are they then given an opportunity to refer to resources for assistance. Once students actually engage in the task, most find it challenging and need to refer to resources after the initial 5 min (see Fig. 4a and b). The total time spent in the "blank page" room is 15–20 min before rotation to the next station. While they are in the "blank page" room, students are guided by the tutor to be aware of their thought processes and are encouraged to recall as much information as possible from their own mentally constructed images. The "blank page" learning environment is relaxed and non-threatening. The entire 3 h session of 6–8 stations ends with a 10 min assessment quiz on the material covered throughout the session.

2.2. An investigation using the "blank page" technique

In the four weeks of musculoskeletal and nervous system laboratory sessions we offered some groups the

Fig. 1. The tutorial room devoid of visual cues represents a metaphorical "blank page".

opportunity to complete the laboratory textbook review questions while they were in the "blank page" tutorial room instead of the plasticine modeling/ drawing activity. For example, Monday sessions would take the "blank page" technique of drawing and modeling, while Tuesday sessions would take the review question activity, the groups would then rotate the following weeks for 4 weeks. The groups were rotated so that they were exposed to each activity for an equal amount of time.

Students from both groups were invited to complete a short questionnaire while completing either activity. Question 1: *"How confident do you feel in your ability to complete this task?"* required students to rank their confidence of performing the activity task before commencing the task on a Likert scale of 1–5 (1 = very unconfident; 5 = very confident). After completion of the task, students were required to answer Question 2*:* "*Do you feel this exercise assisted your learning*?" and to rank the degree to which it assisted their learning on a Likert scale of 1–5 (1 = strongly disagree; 5 = strongly agree).

The student groups were categorized by the activity they completed (modeling and drawing or review questions) for each of the laboratory sessions. After four weeks, the average quiz scores achieved for the student groups who completed each of the activities were compared to determine if the blank page activity had an impact on student performance on the assessment quiz. The average quiz scores between the two groups were analyzed using an independent *t*-test, as the student groups who completed the assessment quiz each week were not exposed to identical conditions i.e., the quiz and the activity was different each week.

The quiz assessments were composed of 10 slides with images from the textbook laboratory manual and other comprehension style questions related directly to the specimens covered in the laboratory session. The quizzes were compiled by the course convenor who was chief investigator of this study (H.L.N.). The quiz was designed to provide formative assessment of students' recall and understanding of anatomical structures covered in the session and their related functions.

Qualitative data were collected in the same manner as our previous pilot report where students circled the descriptive terms that most closely matched their experience of the activity (see Fig. 3). Descriptive terms listed (fun; challenging; relevant to lecture material; boring; tedious; stimulating; made me think) were taken from an international study of undergraduates perspectives on laboratory sessions.[11]

3. Results

Our results show that students who complete the blank page technique by drawing and modeling structures instead of review questions performed slightly better on the assessment quiz ($p < 0.05$, see Table 1). This confirms other research reports supporting the use of multiple learning approaches in particular kinesthetic approaches to learning anatomy and retention of knowledge.[9,12–15]

We also collected student's self-reported confidence at attempting each of the tasks (see Table 1, Q1). Confidence judgment is a component of metacognitive awareness,[16] and our results show that students felt more confident attempting the modeling/drawing activity than answering review questions ($p < 0.001$).

Student's self-reported learning value of each activity was collected and analyzed. Results show that students rate the plasticine modeling and drawing activity ("blank page" technique) as more valuable as a learning tool ($p < 0.01$) (see Table 1, Q2. and Fig. 2).

Table 1
A comparison of student experience (Q1 and Q2) and performance on assessment quiz for student groups who completed the "blank page" activity with student groups who completed standard review questions.

Quantitative parameters	Review questions $n = 126$ Mean ± SD	Modeling/drawing $n = 113$ Mean ± SD	*p-value*
Q1. (Confidence level)	2.39 (±0.84)	3.15 (±0.81)	< 0.001
Q2. (Learning value)	3.64 (±0.75)	3.91 (±0.59)	< 0.01
Quiz score/40	28.62 (±7.66)	30.51 (±6.76)	< 0.05

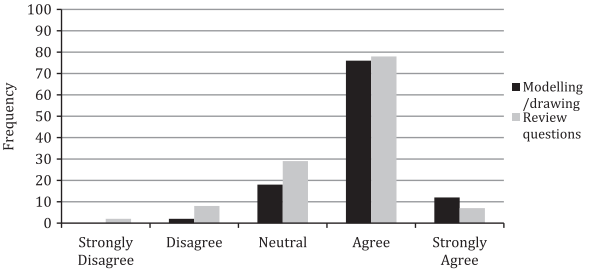

Fig. 2. Learning value of plasticine/drawing activity compared with review questions as rated by participating students. Likert scale frequency of responses to Question 2: "Do you feel this exercise assisted your learning?".

Qualitative responses show students find the "blank page" technique of modeling and drawing less challenging than the review questions, but more stimulating. For both activities "made me think" was equally popular as a response. Student responses of "fun" indicate a higher degree of engagement in the "blank page" activity. The response pattern was similar to that from our pilot study where "fun" "stimulating" and "made me think" ranked highly for the modeling activity. "Fun" and "stimulating" ranked lower as a preferred descriptor for the review questions, whereas "challenging" and "made me think" ranked higher than modeling/drawing activity as a preferred descriptor (Figs. 3 and 4).

4. Discussion

4.1. Review questions versus "blank page" technique

Traditionally, laboratory manual review questions are the most popular study tool to assist students in consolidating key learning objectives from laboratory sessions. Indeed, many instructors of anatomy would have used this method of review themselves, and endorse it for their students. According to the VARK learning mode preferences,[6] this style of learning, while valuable, caters for learners who fit well into the read/write category. Plasticine modeling and drawing as incorporated in the "blank page" technique offers alternative modes of learning, i.e., kinesthetic and visual learning. In addition, this kinesthetic approach increases student engagement and perception of "fun" in the laboratory (Fig. 3).

When compared with the activity of completing laboratory manual review questions, our results indicate that the "blank page" technique is equally effective

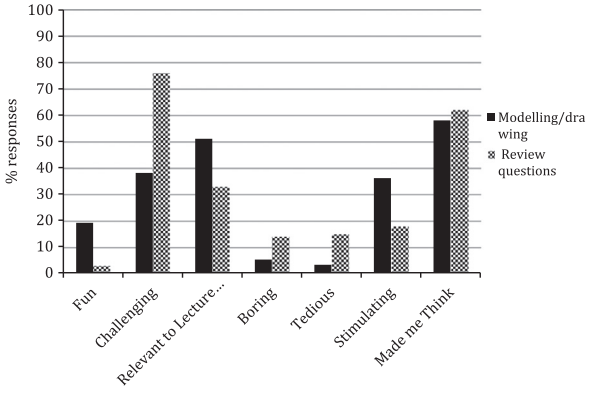

Fig. 3. Plasticine/drawing activity compared with review questions, qualitative responses. Frequency of circled responses represented as a percentage of total responses.

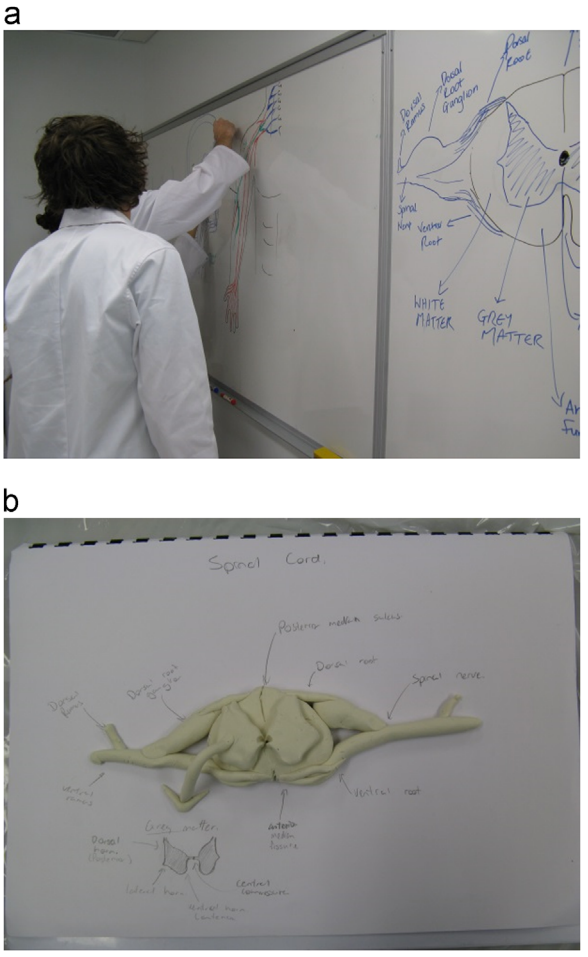

Fig. 4. (a) Students at work in the "blank page" room. (b) Student's plasticine model of spinal cord in cross section.

for preparing students for assessment quizzes based on identification of structures and recall of anatomical detail (Table 1). Indeed, our data support findings in a similar study by Bareither et al.[12] in which clay modeling and written module interventions were compared among students of different learning styles. In their study, evaluation of the effectiveness of the interventions, based on assessment performance, showed no significant differences. However, qualitative responses indicated greater student engagement in the clay modeling intervention.[12]

Of the visual, aural, reading/writing, and kinesthetic (VARK) learning preferences[17] the "blank page" technique supports visual and kinesthetic approaches, while review questions are suited to read/write learners only. Reading the textbook and summarizing lecture material is a common learning mode offered to first year undergraduates of Health disciplines, but with increasing student enrollments and educational backgrounds, the

learning styles of the student population are becoming more diverse.[7,18,19] Hence, there is a need to offer new and diverse activities to optimize student success in first year anatomy courses. Moreover, the "blank page" technique is likely to encourage deeper learning and long term retention when used in conjunction with review questions as the combined activities support multiple approaches to learning.[7,12,20] Long term retention of knowledge in conjunction with this specific technique requires further investigation.

4.2. Experiential learning and metacognition

Experiential learning is where the immediate concrete experience of completing a task leads to opportunities for reflection and abstract conceptualization.[5] In large cohort, resource-rich anatomy laboratories there is often limited opportunity for students to engage in manipulation or dissection of the specimen (kinesthetic learning). In the context of the anatomy laboratory, kinesthetic activities such as dissection, body painting and clay modeling, provide the concrete experience of experiential learning and has been shown to enhance learning and recall.[13,21–23] Experiential learning allows for the development of metacognitive skills (skills to encourage self-regulation of learning) because of its iterative cycle of reflective observation and reaction to errors. The blank page technique of modeling plasticine and drawing anatomical structures from memory incorporates kinesthetic, experiential learning and explicitly teaches an awareness of metacognition (a learner's knowledge of their own cognition or understanding). Metacognitive awareness is heightened because the learning environment where this activity takes place is a tutorial room devoid of resources (see Fig. 1), in contrast to the resource-rich anatomy laboratory. The task creates an opportunity for self-reflection as they realize their lack of knowledge, followed by efforts to build the knowledge by referring to textbooks and resources, making it a more memorable and lasting learning experience.

Confidence judgment is a component of metacognition. We have commenced the practice of asking students to rank their confidence of completing a task as a way of developing metacognitive skills. Interestingly, students felt more confident at completing the drawing/modeling task than completing review questions. Students may perceive the kinesthetic activity as less exacting of their knowledge. In reality, the students who embarked upon the blank page plasticine modeling and drawing activity found that they were not able to complete the task without referring to their textbook or other visual resources. Students' metacognitive judgment in performing cognitive kinesthetic activities and read/write activities in anatomy is another area, which requires further investigation. We are currently working on developing an instrument to measure metacognitive skills in the context of learning anatomy. It can potentially become a central guiding principle for teaching metacognitive awareness in learning anatomy.

4.3. Spatial visualization skills in learning anatomy

Development of spatial visualization skills is important for student understanding of life sciences[24] and anatomical relationships.[25] Visual spatial thinking involves visual perception, and ability to mentally store and manipulate visual spatial representations which can be subsequently recalled in the absence of the visual stimulus.[26,27] For example being able to imagine an organ in three dimensions from a cross sectional view requires highly developed visual spatial cognitive skills.[28] While language support in anatomy is evident in the form of textbook glossaries and in-text definitions of Latin roots of anatomical terms, support for the skillful use of images is something perceived as belonging to art rather than anatomy.[24,27] Observations of textbook images and viewing of prosected cadaveric specimens is a rich support for visualization but students can become dependent on textbook images and fail to construct a stable image in their own mind. Even in a resource-rich anatomy laboratory, there may not be an opportunity to communicate or re-express the knowledge through action such as drawing or modeling. Active reconstruction of the image by drawing or modeling can encourage the development of visual spatial thinking and the formation of robust memory representations.[29,30] The blank page technique assists the learner to reconstruct the image from memory in the absence of visual cues, creating a sense of ownership of the knowledge and guiding the student away from textbook dependency. In future cohorts we intend to encourage students to create image portfolios while in the laboratory setting and evaluate the impact this has on long term retention of anatomical knowledge.

5. Conclusion

In this report we have highlighted the merits of the "blank page" technique in three domains of deep learning relevant to anatomy: (1) experiential learning; (2) metacognition and; (3) visual-spatial thinking. We also report findings that infer that the use of the blank page technique is equally beneficial in preparing students

for assessment quizzes for anatomy when compared to the activity of completion of review questions. Our qualitative data also suggest that the blank page technique engages students in the learning activity and is a non-threatening, valuable learning tool. Moreover, implementation of this technique encourages multimodal learning, which has been shown to be beneficial for long term knowledge retention. The activity satisfies our primary aim which was to facilitate the learning of anatomy, however, it brings to light deficiencies in our course curriculum. In particular, the distinct lack of metacognitive guidance and development of visual-spatial thinking skills. Considering cognitive load for first year students of anatomy and physiology, we believe that new approaches in these areas will promote effective retention of knowledge and student success.

We understand there are limitations to this study in that most of the data are self- reported student feedback, however, we wish to share our findings with instructors of anatomy and teachers of life sciences to encourage development of student skills associated with learning anatomy.

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