CHAPTER 8

Future-Proofing Healthcare Skills Education: Technology-Enhanced Collaborative Learning and Peer Teaching Strategies for Large Student Cohorts in Anatomy Practicals

Arkendu Sen and Lakshmi Selvaratnam

Teaching is the Highest Form of Understanding.

–Aristotle (384–322 BC)

Background

Understanding human anatomy and the organisation of body structure is an integral part of becoming a skilled doctor. It requires hands-on learning of the three-dimensional, visually complex human body and its

A. Sen (✉) · L. Selvaratnam
Jeffrey Cheah School of Medicine & Health Sciences, Monash University Malaysia, Subang Jaya, Malaysia
e-mail: arkendu.sen@monash.edu

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internal organs, typically explored in practical laboratory settings. Globally, with the introduction of integrated medical curricula, there has been a marked shift away from cadaveric dissection-based anatomy study traditionally carried out for centuries. Practical anatomy is now increasingly taught to medical and healthcare students in non-dissection settings, as in Malaysia—due to cost, scarcity of cadavers, various socio-cultural taboos and the advent of increasingly sophisticated digital technologies (Patel et al., 2015; Sugand et al., 2010). At the same time, crowded curricula and insufficient expert medical teachers have resulted in sizeable student cohorts during anatomy practical sessions with fewer timetabled opportunities to master complicated body structures or practise related clinical anatomy skills, resulting in an alarming deterioration in effective learning (Singh et al., 2015; Sugand et al., 2010). The recent Covid-19 pandemic has also caused global disruption in healthcare education with an almost overnight transformation to virtual or online learning for anatomy curriculum delivery (Evans & Pawlina, 2021).

Healthcare education has seen rapid changes this past decade, driven in part by significant technological advances impacting medical research and patient management and disruptive transformations in the global information technology landscape. The next-generation health workforce must possess adequate knowledge and skills to negotiate the complex digital health domain now emerging to ultimately improve health outcomes (Wong et al., 2021). The educational goals for training healthcare professionals have increasingly shifted to include embedding learning technology during essential knowledge acquisition, in improving psychomotor skills and team training (Guze, 2015). Thus, the fundamental requirement of incorporating education technology in medical education has been an overarching factor in the design and development of our Anatomy practical curriculum delivery. The authors are also mindful that inappropriate selection of digital technologies may adversely impact higher education goal achievement (Lacka et al, 2021). Furthermore, any education programmes involving teamwork should provide learning opportunities that are practical and authentic to participants (Pawlina & Drake, 2016), and so, experiential learning has formed a significant hallmark of our practical strategies. According to Crawford

L. Selvaratnam
e-mail: lakshmi.selvaratnam@monash.edu

et al. (2011) experiential learning allows students to apply knowledge that comes from doing something and that the reflective practice associated with it encourages active learning (Harvey et al., 2016; Lucas, 1997). In addition, experiential learning enables students to apply concepts to experiences that they may confront in their professional career (Dellaportas & Hassall, 2013).

One of the critical changes in modern healthcare delivery is the adoption of multi-disciplinary or multi-speciality approaches for managing patients in hospital settings. Effective teamwork involving a diverse group of healthcare professionals is recognised as a significant element of patient care that improves patient safety and health outcomes (Buljac-Samardzic et al., 2020). The complexity of modern hospital healthcare for patients highlights the need for doctors and other healthcare professionals to collaborate and communicate clearly with each other (Eddy et al., 2016). Thus, collaboration skills need to be instilled early in medical students' career, especially in the preclinical phase of undergraduate medical education. In this regard, collaboration starts with the articulation of self-constructed meanings (Stahl, 2000) by describing the problem situation using one's prior knowledge and self-reflection. Subsequently, it evolves into the co-construction of meanings among the group members where they build on others' ideas and thoughts (Mercer, 1996) through the processes of negotiation of shared meaning, mutual explaining and reasoning and elaboration.

Hence, whilst embracing the interactive technology of the twenty-first century, any new practical approaches being developed in healthcare education must focus on instilling lifetime learning through active participation within the collaborative learning environment.

Aims

To overcome the above challenges, innovative strategies sought by the authors aimed to:

Enhance students' core knowledge, competencies in anatomy and prepare for future clinical teamwork, through a series of guided collaborative learning and peer teaching-demonstration activities, with the support of a multimedia learning lab. This includes building in attributes of a competent medical graduate to be developed during basic medical training, as required by the Australian Medical Council (www.amc.org.au).

Design and Preparation

Designing Collaborative Active Learning Strategies in Anatomy Practicals

The anatomy practical education approach was planned and organised according to various stages: pre-practical, in-class (or in-practical) and post-class (or post-practical). Two original and award-winning, key in-practical methods for practical teaching and learning of Anatomy, referred to as Guided Collaborative Learning (GCL) and Student Peer Teaching-Demonstrations (SPTD), were pioneered and iteratively developed from 2008 onwards at our Medical School. These practical activities were conducted within a network supported learning laboratory—the Medical Anatomy and Pathology E-Learning (MAPEL) Lab, co-developed by the authors (https://www.monash.edu.my/jcsmhs/facilities/mapel-lab). The MAPEL Lab was designed and formally launched in 2012 and further adapted for its current purpose-built location in 2014 as a state-of-the-art learning space and campus showcase. This Lab provides an ambient learning environment that incorporates a wide range of physical learning resources, learning software, integrated multimedia and education technology enhancements. The GCL and SPTD practical strategies for learning human anatomy were designed to actively engage mass student cohorts (ranging between 130–160 students) in clinical contexts and professional practice correlations and to ensure our graduates workplace readiness, as required by the medical accreditation bodies for both Malaysia and Australia.

Another critical strategy was combining the social elements of peer learning with two important aspects of modern anatomy learning within one sizeable, open plan technology-supported learning space, i.e. the MAPEL Lab. The first aspect is to combine peer learning with access to both digital resources such as high-speed internet access and anatomy education software—which clearly attract our 21st-century digital natives (Prensky, 2001). The second aspect is to combine peer learning with physical resources such as human anatomy models and plastinated (dry human cadaveric) specimens—which the students can physically hold, manipulate and explore. Thus, the lab environment was purposefully designed with multiple large oval tables, comfortably seating 6–8 students on swivel chairs. Models and specimens are placed on these tables for hands-on study, together with integrated microscopes and desktop computers for accessing the Internet and digital anatomy resources; all these allow interaction of students within small groups, facilitated by tutors rotating within the networked MAPEL Lab equipped with full video and audio multicast facilities.

The workflow in learning anatomy involving lectures, pre-learning resources, GCL and STPD and post-practical reviews/assessment is summarised in Fig. 8.1.

During active learning, students are usually engaged in building and understanding facts, concepts, and skills by completing tasks and activities. However, in healthcare education, this is often limited to adopting interactive techniques and applied learning (Swanwick et al., 2019). Acquiring knowledge through social interactions and cognitive discussions is central to teaching and learning in medicine (Duit & Treagust, 1998; Swanwick et al., 2019). In a similar vein, the active learning pedagogical strategies are based on constructivism that posits people build knowledge by acting and reflecting on incidents and experiences around them (Wright et al., 2019). Therefore, there is a strong emphasis on social interactions and cognitive discussions over individual study (Chi & Wylie, 2014; Gibbs, 1994). For practical skills learning, peers working in collaborative groups offer alternative solutions, sustain reasoning activities, and assist in the integration of knowledge (Vygotsky, 1978), thus forming the basis of designing Group Collaborative Learning (GCL). The design of Group Collaborative Learning (GCL) incorporated collaborative learning where student peers, during the discussions in the practical, offered alternative solutions, sustain reasoning activities, and assist in integrating knowledge (Vygotsky, 1978).

To incorporate such principles of social interaction in GCL, the Medical Anatomy and Pathology E-Learning (MAPEL Lab) infrastructure, multimedia computers and furniture were innovatively designed, making it one of the pioneering teaching spaces of its kind in this part of the world and routinely showcased as an exemplar practical classroom (Sen & Passey, 2013). To incorporate such principles of social interaction, the MAPEL Lab infrastructure and furniture were ergonomically designed so that seating arrangements at the oval tables and easy access to learning resources such as models and specimens facilitated various types of seamless interaction: student peer to peer, student peers with resources, student/peers with tutors etc. The Lab creates a space where the lecturers can better support students in deeper learning through facilitation, technology support and foster small group collaboration (Brooks, 2012),

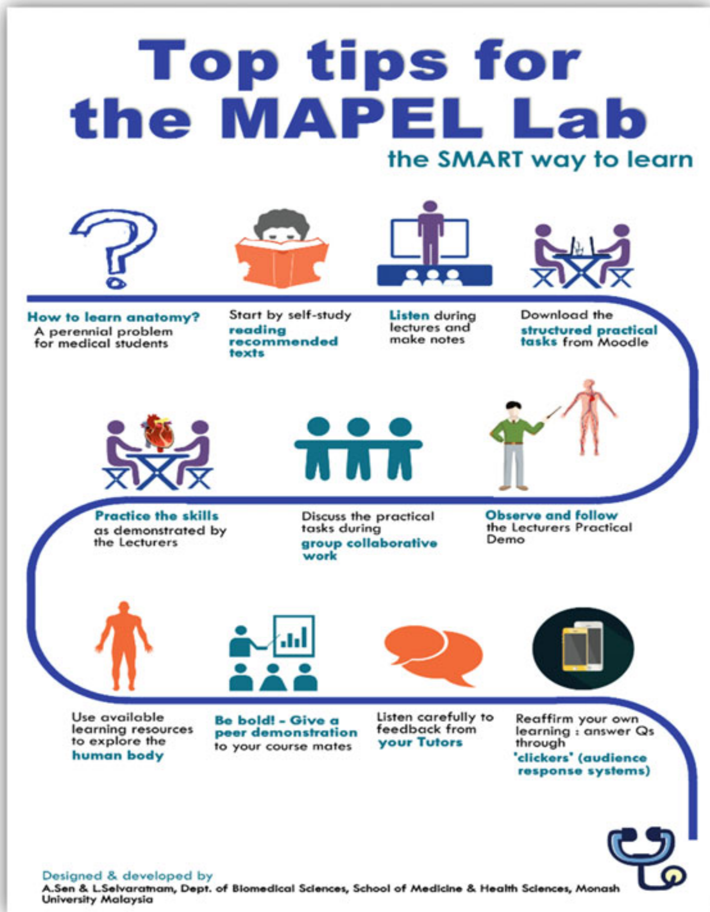


Fig. 8.1 Summary of workflow design for anatomy practical learning in the MAPEL Lab (infographic by Lakshmi Selvaratnam [2015])

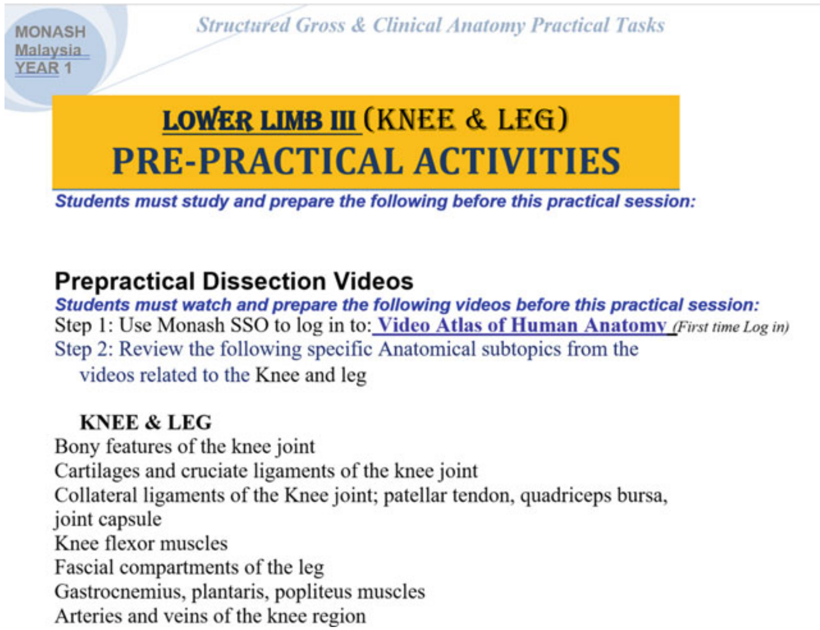
which emphasises that learning and knowledge construction are affected by interaction and collaboration in line with the social constructivist learning theory (Krange & Ludvigsen, 2008).

This enabling Lab environment facilitates the multimodal representation of content, instructional procedures, student-centred discovery and various types as well as multiple foci of student interactions at the various student group tables. The conducive and comfortable setting makes for a positive student experience while producing more effective gains in higher-order learning. The varied formats of visualisation make anatomy learning attractive, motivating and support deep learning.

Pre-Practical Activities

For pre-practical learning activities, these included lecture materials in the form of uploaded PowerPoint slides from face-to-face (synchronous) lectures or video-recorded lectures (asynchronous), accessed through links in the Moodle learning management system at our university. These lecture materials were developed by anatomy tutors from our Medical School and included critical conceptual information for both gross anatomy and clinical anatomy. Other pre-learning materials comprised a variety of learning resources ranging from textbooks/reference books, online websites and computer-aided learning resources (e.g., 3D rotatory anatomy images, links to augmented reality anatomy objects, Fig. 8.2).

As part of the active learning methods used for GCL and SPTD, e-workbook activities in the form of Gross and Clinical Anatomy Practical (GCAP) tasks were designed by the authors to purposefully incorporate practical activities harnessing visual, auditory and kinaesthetic learning modalities as well as embed educational objectives based on cognitive process domains (such as 'remember, understand, apply, analyse, evaluate & create') (Anderson & Krathwohl, 2001). Although the value of learning styles has garnered some debate (Pashler et al., 2008), there is also evidence that interactive/non-interactive multimodal learning aids are preferred by undergraduate medical students and are particularly important for the visuospatial understanding of anatomy (Hernández et al., 2020; Samarakoon et al., 2013). Overall, the practical tasks were formatted to include pre-practical, in-practical and post-practical activities and were hosted on the Moodle learning management system in a timely manner. However, research has shown that certain personalities and learning styles may prefer the high-technology learning environment (Ellis, 2016) while others are not mentally prepared to do so or they may engage at a different pace (Nicol et al., 2018). In a similar vein, Carvalho and Santos (2022) caution on the unexpected technical issues


MONASH
Malaysia
YEAR 1

Structured Gross & Clinical Anatomy Practical Tasks

LOWER LIMB III (KNEE & LEG)
PRE-PRACTICAL ACTIVITIES

Students must study and prepare the following before this practical session:

Prepractical Dissection Videos

Students must watch and prepare the following videos before this practical session:
Step 1: Use Monash SSO to log in to: Video Atlas of Human Anatomy (First time Log in)
Step 2: Review the following specific Anatomical subtopics from the videos related to the Knee and leg

KNEE & LEG
Bony features of the knee joint
Cartilages and cruciate ligaments of the knee joint
Collateral ligaments of the Knee joint; patellar tendon, quadriceps bursa, joint capsule
Knee flexor muscles
Fascial compartments of the leg
Gastrocnemius, plantaris, popliteus muscles
Arteries and veins of the knee region

Fig. 8.2 Sample GCAP tasks with pre-practical activities with reference to bite-sized videos on cadaveric dissection

like lecturers and students not having experience to deal with digital technologies, the Internet connection problems and teaching and learning in a totally remote learning environment, which may have a negative impact of some students' ability to cope with unexpected and challenging situations happening during collaborative learning tasks.

As in GCAP tasks, the structured practical tasks are intentionally designed so medical students can learn both core and applied anatomy skills and facilitate their learning through various visuospatial and kinaesthetic learning aids. Multimodality supports a universal design for learning by communicating concepts in the most effective ways and making sure everyone obtains exactly what they need. According to the cultural psychology research findings, individual learning differences may emerge from cultural factors like thinking style (Lun et al., 2010) and learning style (Joy & Kolb, 2009). Multimodal resources also add interest and break up routine styles of learning. The rationale for adopting multimodal methods for our practicals was twofold: 1) to capture the students' different learning styles and 2) for reinforcement of concepts and learning across different modes. Such an experiential approach inspires medical students as they see how their learning of human anatomy translates into real-world clinical practice. The multimodal approach also has been shown to produce more effective gains in basic and higher-order learning (Rosen & Salomon, 2007) and improve retention rates (Kozma, 2003).

The GCAP tasks utilised multimodal approaches and clinical scenarios for understanding a topic such as anatomy of the knee: for instance, this would include using one's haptic senses of touching, orientating and exploring depth in a knee model or cadaveric specimen (Fig. 8.3a), identification of key structures of the knee, visual comparison with clinical/radiological images of a patient's knee (Fig. 8.3b), palpating/feeling the knee as during clinical examination (on consenting student peers) and listening (audio) for abnormal sounds (crepitus) due to knee disease through studying video/audio links.

In-Practical Activities

Group Collaborative Learning (GCL)

The social affordances (Valenti & Gold, 2010) of GCL include both face-to-face interactions and technology interactions (via table desktop computers or students' BYOD (Bring your own device). This allows for a bidirectional relationship between technology use and creation of a social space for group members. The resultant conducive environment serves to motivate student learning through increasing participation, engagement, interactivity and collaboration (Jeong & Hmelo-Silver, 2016).

It is well recognised that different media forms have different affordances (Jeong & Hmelo-Silver, 2016; Laurillard, 2002). Hence, Group Collaborative Learning as practised by students utilises many media forms to provide rich and varied learning experiences (Sen & Selvaratnam, 2012): *Narrative media*, e.g. image/description of an anatomical structure or clinical anatomy case scenario; *Interactive media*—computer-assisted anatomy modules (under institutional licence) accessed online; *Communicative media* that facilitate exchanges between teacher and student; *Adaptive media*—for annotating pictures/histology virtual slides and *Productive media* e.g. production of schematic diagrams or PowerPoint slides/mini-video presentations for sharing. According to Hakkinen and Hamalainen (2012), this is important because the current learning

(a) 3. KNEE JOINT

3.1. Functionally knee joint is a modified hinge joint – Explain how concerning shifting of its axes of movement

3.1.1. Briefly discuss the key factors that contribute to the stability of the knee joint.

- REVIEW interactively the overview of structures of the Knee here (3.1) – click on each component to know the details
- Review the layered dissections of the Knee joint in Recommended CAL (Computer Assisted Learning) Resource (Lower Limb module, "System") Nos. 12 – 14 to perform the following:

3.2. Identify the **knee joint line**

3.2.1. What is the normal "Q" angle of the Knee joint ?

3.2.1.1. How does it differ between sexes?

3.3. List & identify the **muscles that flex and extend the Knee** joint.

- REVIEW interactively the locking (7.1) /unlocking (7.4) of Knee here :

3.4. Demonstrate and explain on an articulated knee, the **locking and unlocking of the knee joint**.

3.4.1. Which muscle is involved in unlocking?

- Perform a virtual dissection in the recommended CAL (Computer Assisted Learning) Resource to explore the knee region: Right knee joint (frontal view) module

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(b) 7. RADIOLOGY

- Refer to radiological images in textbooks, & the following radiological websites here

7.14. Identify and correlate the key features of the distal end of femur and proximal Tibia and Fibula in the following

7.14.1. Plastic embedded sagittal section of the Knee joint

7.14.2. X-ray of the Knee joint (AP & Lateral views)

7.15. Study the following:

7.15.1. Review interactively X-ray of the Knee joint here (AP & Lateral views)

7.15.2. MRI of the Knee joint: Coronal and Axial images

7.15.3. Fractures of Tibia & Fibula

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Fig. 8.3 (a) Sample GCAP task with in-practical activities involving hands-on manipulation of self/peer volunteers and reference to interactive digital resources. (b) Sample GCAP task with in-practical activities involving visual/multi-modalities integrating applied clinical/radiological correlations and links to physical and digital resources trajectories take different formats (formal—informal, physical—virtual) and they are supported by the communication media and informational media.

Student Peer Teaching-Demonstration (SPTD)
Student Peer Teaching-Demonstration (SPTD) comprises an adaptation of an active learning method (Johnson et al., 1998), more specifically of peer instruction involving active learning that engages students in solving problems, sharing ideas, giving feedback and more importantly, teaching practical skills to each other. The crucial role of teaching in learning, including peer teaching, has been immortalised in Aristotle's words that "Teaching is the highest form of understanding" and this forms a key element of our practical strategy and still holds true today. In the modern context of higher education, knowledge integration and extension occur through teaching and practice applications within learning communities which support active learners and critical thinkers (Boyer, 2004; Lee, 2014). Furthermore, these peer teaching demonstrations reinforce knowledge and skills learnt by students in GCL and aim to attain a higher level of competency by teaching and demonstrating to their peers in keeping with the medical graduates' attributes as practitioners and health advocates involved in improving healthcare quality whilst working in professional teams (Australian Medical Council, 2012; Myron et al., 2018). The impact of peer teaching on student learning compared to traditional, tutor-related didactic teaching has reported improvements in student mastery of both conceptual reasoning and problem-solving (Crouch & Mazur, 2001). However, for peer instruction to be effective in active learning, educators' ability to adapt innovative teaching methods and evidence-based implementation is paramount (Schell & Butler, 2018). Furthermore, during peer instruction, students are in control of their learning, and they self-regulate the discussion (Arico & Lancaster, 2018). As such, they must be empowered to seek clarification for better understanding in relation to their prior knowledge and finally reconstruct meanings in their own terms (Green, 2019).

Our novel GCL and SPTD methods support various modes of active learning (Naismith et al., 2004; Graffam, 2007) relevant for the future evolving needs of the medical profession, particularly in a post-pandemic world (since these methods are readily translatable into online synchronous and asynchronous formats which our team has adapted and conducted for 2 years since the Covid-19 outbreak in early 2020). Typically, however, teaching and learning activities have been designed to be hands on and experiential so that students within our technology-enhanced learning lab are motivated to follow *behaviourist learning* through real-life clinical scenarios highlighted by tutors during the clinical/anatomical demonstrations streamed in real-time from the demonstration console and; collaborative *learning* whereby student groups manipulate physical resources and digital content.

Team Teaching by Professional Practice Experts, Facilitation and Feedback

The social constructivist theory emphasises the importance of social interaction between students and teachers to stimulate effective learning (Bandura, 1977). Group collaborative learning also requires quality facilitation by expert tutors. To ensure clinical knowledge/skills integration with basic medical sciences (Standring, 2009), clinical anatomists and practising/active surgeons have been employed as anatomy tutors to facilitate our practicals. These expert tutors have multiple roles. For one, they give valued input as needed to student teams during their GCL discussions of practical tasks. These tutors also conduct live demonstrations to identify high-resolution, detailed features of plastinated human specimens or lifelike anatomy models to the whole cohort via videocasting utilising large TV displays/ceiling-to-floor screens from the demonstration console/podium at the front of the MAPEL Lab. Furthermore, during peer teaching demonstrations (SPTD) by selected student groups to the class, tutors give valuable and immediate feedback on student presentations or demonstrations and highlight the relevance of anatomy in future clinical practice and authentic settings. The use of SPTD which is an active, collaborative learning approach enables the students to learn together and the tutors to facilitate their learning (Carstensen et al., 2020) by providing immediate feedback for procedural learning and delayed feedback for tasks well within the students' capability (William, 2011).

Post-Practical Activities

Peer Group Evaluations of SPTD Presentations

These evaluations were designed to be conducted weekly by non-presenting student groups who assessed the presenting groups carrying out SPTD (Fig. 8.5). The authors developed a rubric consisting of 7 elements with an evaluatory range to streamline feedback evaluation of student teamwork and assess the quality of their oral presentations/hands-on demonstrations (Hafner & Hafner, 2003). This peer group evaluation rubric was shared with all groups to understand the learning process, its participatory culture and to appreciate tutor expectations (Kollar & Fischer, 2010). Results were collated after the Part B components of each practical and cumulative scoring per group could be calculated for the whole academic year.

Preparation of Assessment Process: Objective Structured Clinical Anatomy Review (OSCAR)

Student assessment is helpful to gain an objective measure of knowledge, comprehension and skills and attitudes. The challenge then was to devise the most appropriate tool for reviewing Anatomy understanding using an integrated yet practical assessment approach through proper incorporation of multimedia technology with anatomy learning resources. The Objective Structured Clinical Anatomy Review (OSCAR) was thus designed as a novel formative assessment strategy with the following aims: to test student comprehension of key anatomy principles and relevant clinical anatomy; act as an anatomy revision aid at the end of each body systems-based study module and to provide prompt learning feedback on student competence in applying anatomical principles in future clinical settings. Formative assessment in anatomy enables students to identify their strengths and gaps in knowledge and contributes to deeper learning, at the same time allowing the educators to revise their teaching when required (Evans, 2020). The OSCAR is usually conducted as a practical assessment in the MAPEL Lab, still it can be switched to a fully online format, especially relevant during the Covid-19 pandemic (Sadeesh et al., 2021).

Preparation for the OSCAR involved designing station questions (up to 30 per circuit; both first and second-order type) to test anatomy topics covered that same semester and crafted to embrace visuospatial, and interactive learning aids particularly relevant in medical practice. A detailed floor plan with OSCAR stations (represented by tables and computers/laptops) including the route of students with bell timing was drawn up.

Before the OSCAR, plastinated specimens and models were placed on the planned stations, tagged appropriately with marker labels and double checked by the tutor team. Stations could also include tagged clinical case photos, radiographs and images from anatomical software. Arrangements for sequestering students before the OSCAR and quarantining afterwards had to be planned, to ensure the validity of the formative practical assessment.

Implementation

The practical activity-based approaches that we designed are implemented in the following format on a biweekly basis per year cohort across Years 1–2.

Student Groupings

Anatomy practicals are conducted twice a week for Year 1 and 2 cohorts, each comprising 130–160 medical students. To maintain effective interaction and team dynamics, all students are pre-assigned to groups of 10–12 students, the same groups as those for their problem-based learning sessions, and each headed by a student leader. The pre-assigned groupings allow for the University equity policy to be maintained, such that the groups are based on having an even mixture of gender, international and domestic students, high and low achievers etc. According to Zhang et al. (2016) and Lou et al. (1996) heterogeneous grouping is more effective in obtaining information from other group members due to different knowledge base when compared with homogeneous grouping.

- Students are expected to study and prepare topics in the Practical Guide before each practical session. Practical tasks highlight key gross anatomy concepts and applications relevant to their future clinical practice, topics which are commonly assessed.
- For each Student Group, a leader is chosen. He or she will then distribute topics/activities amongst the members. The leader is rotated weekly.
- Each Student Group should ensure members bring adequate textbooks and atlases (print copies or e-books) or other learning resources.
- Individual student preparedness and active contribution to learning are essential for a group to be effective in collaborative learning.

- Professionalism and MAPEL Lab guidelines are expected to be maintained during practical sessions, including any loan and return of models according to stipulated times.

Pre-Practical Activities

Students will access their Gross & Clinical Anatomy Practical (GCAP) Tasks for each week via the e-Workbook/Moodle Learning Management System. In collaborative learning it is pertinent that students come prepared with their self-constructed meanings of the GCAP tasks so that they can engage constructively in the group discussions. The Moodle Learning Management system allows effective integration of learning resources with e-learning activities (Chia et al., 2017) for practical preparation. They are encouraged to work individually at first and then within their groups to corroborate each other's understanding. Students can review the given practical learning objectives, carry out any suggested pre-practical activities and study from the resources given in the Practical guide and recommended textbooks/validated websites. Members are given the flexibility to share their group learning during face-to-face group discussions and through online discussion groups and collaborative documents via a shared user interface. This is to shift away from a teacher-centred approach where, according to Owens et al. (2020), students may not come prepared, rather, expecting information to be provided.

In-Practical Activities

During implementation, GCL and SPTD activities follow a defined Practical Schedule (Table 8.1) utilising available practical resources—both physical and online—and this is adhered to by students and tutors to maintain appropriate time management.

Guided Collaborative Learning (GCL) (Refer to Fig. 8.4)

1. Part A will focus on key concepts and principles of Gross Anatomy.
2. Students are encouraged to view highlighted dissection videos of the relevant topic and discuss and review any dissections/prosections (as available).
3. During Part B, the practical will be conducted in a similar format but focus on Surface Anatomy, Radiology & Clinical Anatomy. Students

Table 8.1 Practical schedule for gross/clinical anatomy (an exemplar)

Conduct of Activity	*Time (min)*
Part A Session (Gross Anatomy):	120
• Students can view dissection videos	10
• Guided collaborative learning (GCL) with structured practical (GCAP) tasks on critical concepts/basic principles of gross anatomy	70
• Hands-on exploration, identification and manipulation of plastinated specimens/models/virtual dissection software)	
• Tutors will be facilitating the session with respective groups	
• Feedback queries from students on areas of difficulty or clarification	5
• Tutor demonstration of relevant plastinated specimens/models; respond to any queries	35
Part B Session (Clinical Anatomy)	120
• Guided Collaborative Learning (GCL) with structured practical (GCAP) tasks on critical concepts in clinical anatomy including surface anatomy, radiology, procedural and surgical anatomy	70
• Tutors will be facilitating the session with respective groups	
• Tutor's demonstration of relevant plastinated specimens/models/radiographs/clinical or surgical procedure images, animations or videos	10
• Announcement & preparation: student group allocation of tasks	5
• Student Peer Teaching Demonstrations (SPTD) by student groups of selected practical tasks presented live/real-time to the whole cohort	20
• Peer teaching feedback	
• Polling software/audience response system used for questions and answers; with feedback to the whole cohort facilitated by tutors	15

Fig. 8.4 Students in GCL sessions in deep discussion using models, books, multimedia technology etc. with facilitation by clinician tutors (green arrows, right)

should explore clinical anatomy/application resources to address the tasks.

4. Students within each group should explore the GCAP Tasks as far as possible, in the form of self-directed discussion with hands-on models, plastinated specimens, consenting peers etc.
5. Tutors will play a facilitatory role by rotating amongst groups and being available for clarification.
6. Tutors will also clarify concepts and demonstrate any practical skill queries to the whole class by broadcasting from the "Tutor Demonstration Console".

Practical Resources

For the study of bones & joints, muscles, viscera & neurovascular structures students may:

- Use articulated skeletons & bone sets, anatomical models, plastinated cadaveric specimens, fixed/potted specimens, textbooks, atlases and multimedia as available
- Review labelled anatomy posters and images of prosections displayed in the MAPEL Lab
- Review dissection videos or software; digital repository of plastinated specimens and models; illustrated catalogue of models (hard copies/online).

For the study of Surface/Clinical/Procedural anatomy students may:

- Where possible, palpate or map out on themself or on willing and consenting peer volunteers from within their group or on models/plastinated specimens.
- Use dermatographic pencils or washable markers for mapping surface anatomy on consenting volunteers
- Carry out surface anatomy examination in groups of at least 3 persons and strictly follow guidelines for peer examination as laid out in clinical skills.

For the study of Radiology/Cross-sectional Anatomy students may:

- Refer to radiological images (e.g., plain films, CT/MRI scans) in textbooks, atlases, multimedia and real films (as available)
- Refer to plastinated cross-sections/corresponding digital radiographs
- Refer to online (computer-aided learning) resources.

Student Peer Teaching-Demonstrations (SPTD) (Refer to Fig. 8.5)

1. During Part B, student groups will be selected randomly and rotated each week to demonstrate from the Tutor Demonstration Console to the whole class on assigned practical tasks.
2. Student Peer Teaching-Demonstration of tasks by student groups should incorporate anatomical learning resources available, including plastinated specimens, models, bone sets, willing peer volunteers and education technology tools/multimedia (Fig. 8.5). In addition, students need to develop the digital and media information literacy skill, one of the essential twenty-first century skills (Binkley et al., 2012). Such group presentations should integrate the following technology aids, wherever possible:
    - Visualiser
    - Digital whiteboard/drawing tools

Fig. 8.5 Student Involvement in SPTD

- Camera
- Microphones (mobile/cordless)
- Tutor Demonstration Console
- Computers and anatomy software
- Designated websites and databases under Monash University Library
- E-Books (Anatomy textbooks and practical atlases)
- Other audio-visual aids as necessary.

Clockwise from Left:

- Students involved in SPTD sessions using anatomy resources-models/specimens/Atlas and various multimedia technology (visualizer, camera etc.) with facilitation by clinician tutors (green arrow, right).
- SPTD with Surface marking (external representation of internal body) skills on consenting fellow students.
- Live video capture and broadcast of SPTD with students' demonstration of "real world" practical skills
- Student Peer Teaching-Demonstration (SPTD) will involve different members of each group taking ownership to present various tasks based upon specified criteria.
- Student groups should actively work together to produce quality presentations/demonstrations with hands-on use of models/specimens strongly encouraged. In addition, group members are expected to collaborate and assist in answering queries from the floor or from tutors.
- All peer teaching will be moderated and facilitated by the tutors, with clarifications given as needed.

Learning Feedback

According to Winstone et al. (2017) and Timms et al. (2016), for feedback to be effective in supporting learning, students must engage with it by decoding its meaning, translating it into action and recognising its value. In other words, students must develop feedback literacy (Carless & Boud, 2018). Nevertheless, feedback will be provided to students on their learning during each of the following stages of the practicals:

1. Peer and tutor verbal feedback during GCL and self-directed group discussions
2. Tutor verbal and hands-on feedback during SPTD presentations.
3. Peer group feedback on SPTD presentations by non-presenting groups; evaluations displayed concurrently and cumulatively for each practical across the academic year
4. Automated feedback on In-practical knowledge gains using polling software/audience response systems
   - o Using these polling systems, objective questions are posed to the whole cohort involving multiple-choice questions (MCQs), extended matching questions (EMQs).
   - o Topics range from basic practical identification type, second-order questions to the more complex scenario/problem-solving questions.
   - o Students have the flexibility to discuss within their groups before answering.
   - o Tutors ensure clarifications of critical/challenging questions and address misconceptions.

Post-Practical Activities

Peer Group Evaluations of SPTD Presentations

Evaluations of group presentation/demonstrations during SPTD will be conducted by non-presenting groups and fun prizes awarded for the top groups at the end of the academic year to recognize their teamwork-led efforts. On a scale of 0–5, the evaluation criteria included the following seven items (Hafner & Hafner, 2003). According to Crisp (2012) peer evaluation should cover not just the declarative knowledge, but also on the functional and procedural knowledge components.

(1) Accuracy of the content of the presentation
(2) Cohesiveness and smooth flow of the presentation
(3) Use of specimens and models
(4) Integration of anatomy with clinical correlation
(5) Use of audio-visual aids (microphones, visualiser, camera)
(6) Response to questions
(7) Overall delivery of presentation.

Assessment: Objective Structured Clinical Anatomy Review (OSCAR)

For this formative practical assessment, students were guided into the MAPEL Lab to begin answering station questions on answer scripts as short answers following their designated circuit clockwise. After a minute the electronic countdown timer prompted the students to rotate in an orderly fashion through all stations until the OSCAR was completed. Answer scripts were collected for review by the tutor team before their briefing and feedback session to the whole cohort that followed the OSCAR. Through participation in the OSCARs and the ensuing briefing by the tutor team, students gain valuable formative feedback which provides reassurance, promotes reflection and serves as a guide to their future learning. If so, both the lecturers and students should have a shared understanding of what feedback is and how to use it formatively, particularly, lecturers need to have an insight into students' expectations and perceptions of feedback (Bader et al., 2019). To this end, Poulos and Mahony (2008) concur that for formative feedback to be effective, students have to act on it.

Outcomes

Evaluation of Practical Strategy

Upon implementation of the GCL, SPTD and OSCAR, using Kirkpatrick's methodology (Kirkpatrick, 1994; Rouse, 2011), we evaluated the guided learning and student-led teaching demonstration strategies with a focus on 3 levels which are variously called 'Reaction,' 'Learning' and 'Behaviour'.

- Using Kirkpatricks methodology in combination with 360 evaluations of our practical strategy, GCL/SPTD was assessed quantitatively and qualitatively at levels of (a) "Reaction" through Formal teaching evaluations—University/Faculty-wide unit evaluations (Student Evaluation of Teaching and Units [SETU] Scores and student feedback; (b) Learning (summative exam grades, student evaluation [qualitative & quantitative] of impact on their learning), and (c) Behaviour (student peer assessment using a structured questionnaire and tutor/lecturer reviews [qualitative]).
- Formal Teaching Evaluations

The scores from independently administered SETU unit evaluations across the Faculty of Medicine with its affiliated Schools of Medicine at our Malaysia Main Campus (where we introduced this new practical strategy in our MAPEL lab) and the Australia Clayton Campus were analysed in relation to the key question on 'Lab/Practicals', which typically received a 65% response rate from the total number of students attending the sessions; Unit evaluations demonstrated distinct improvement (by 5 to 18%) after the practicals were implemented over the years at our Main campus. In the first year of GCL/SPTD introduction at Monash Malaysia Main Campus, SETU evaluation scores increased to 4.33/5.00. For the first time, the branch Campus scores ranked higher than the other campuses (same anatomy syllabus and assessment/but traditional anatomy practical teaching). Considering that more than half the practicals for this Unit comprise anatomy, this is indicative of a distinct improvement in the student experience for anatomy practicals.

Furthermore, our own (authors) contribution to the students' Anatomy learning through this practical strategy is exemplified by consistently very high educator evaluation scores, averaging 4.75–4.85 out of 5.00, in Monash Questionnaire Series on Teaching (MonQueST/SETU) evaluations by students in recent years (2020) while delivering the novel practical strategy.

Tutor/Educator Peer Reviews

Formal reviews by senior faculty involved in this course also indicate the effectiveness of the GCL/SPTD teaching innovation. A Consultant General Surgeon (based in Melbourne) and former Deputy Director, Centre for Human Anatomy Education, Faculty of Medicine, Monash University Australia reported that:

> *Learning objectives: very well done; Use of illustrations & examples done well and that students' learning behaviour, attention & interest maintained.... participants' involvement encouraged... students appeared motivated.*

Giving a Malaysian perspective, Consultant Orthopaedic Surgeon and Past-President, Malaysian Orthopaedic Association, while facilitating GCL/SPTD as part of our tutor team observed that:

> *There was a remarkable improvement in the student participation when [this] was introduced. Their activity during the sessions was more focused*

and productive.... they took the peer [teaching] seriously and made sincere efforts in improving their presentation.

Finally, we were extremely encouraged and honoured by comments from a distinguished and most renowned Medical Education pioneer/guru and Editor of 'Medical Teacher': "*This is an excellent approach.... integration of clinical components with team-based learning encourages collaborative learning……a new concept in traditional anatomy practicals*".

Student Evaluations
Most importantly, student feedback demonstrates their engagement and how it translates into effective learning. Typical student comments indicating this connection include the following:

- "*Practical tasks: really good [helps] to look thoroughly [at] the topic. Group Discussion: helps us to clarify any doubts……please continue every week. [The] Peer demonstration helps when I present to the whole class because I make sure I learn my part*".
- *"OSCAR is good" …. "Can we have OSCAR every week?" … "Very very stimulating and increases the desire to study more about anatomy… (tough stuff, though*)"
- "*…ability to keep students engaged in one of medicine's most difficult and complex subjects is exemplary…dedicated, enthusiastic and entertaining…. definitely contributes positively to our learning and development…stimulates my learning by giving us relevant clinical facts; has made anatomy so interesting and fun filled learning process*".

What is reassuring is that the impact and practical significance of learning clinical anatomy through our innovative GCL/SPTD strategy has been appreciated by medical students in later clinical years and even beyond as a doctor. This is exemplified by a final year medical student (who went through GCL/SPTD in year 1 and Year 2) recollecting that:

Year 1-2 anatomy teaching is indeed useful…; more so the extra emphasis that is put on clinical relevance/application of theoretical anatomy knowledge—… most useful during clinical years. Clinicians will always be asking questions on clinical anatomy, not [just] only during surgical postings. The anatomy practicals were useful to bring together all the bits & pieces of knowledge and *also consolidate lectures. It was also a fun opportunity to learn as a group, open up & also teach others*

Peer group evaluation of SPTD presentations by non-presenting groups was also very optimistic concerning the overall delivery and accuracy, the use of resources, audiovisual technology and clinical anatomy correlations during presentations (scoring between 3.8–4.7/out of 5).

Student evaluations of GCL/OSCAR indicated their high level (over 80–90%) of support for the strategies and resources that strongly and positively impacted their learning ($n = 92$ students).

Student Grades

A comparison of student achievement based on end-of-year exam scores for Year 1 before and after the implementation of the new program showed that mean scores for gross anatomy improved from 59% (before) to 66% after its introduction, an improvement of 7%, reflecting improved learning amongst student cohorts that was sustained with time.

Publications, Education Awards & Intellectual Property

Our insights into such innovative, practical learning have been shared with the broader educational researchers' community through peer-reviewed publications (Selvaratnam and Sen (2009), Selvaratnam et al. (2012), Selvaratnam et al. (2017), Sen and Selvaratnam (2009); Sen et al. (2016); Sen et al., 2020; Sen & Leong, 2020; Sen & Selvaratnam, 2010a, 2010b, 2010c, 2011a, 2011b, 2012, Wan et al., 2022) especially about Technology Enhanced Learning.

The Lab and novel education strategies framing our anatomy practical curriculum delivery have received recognition through numerous education awards, namely by Australian higher education bodies (Australian Government AAUT/OLT Citation Award [2012] as reported in the government Hansard), Monash University (Vice Chancellor's Excellence in Teaching Citation [2010], Faculty Dean's Award for Excellence in Teaching [2014, 2010] and Pro Vice-Chancellor's [PVC's] Award for Teaching Excellence [2009, 2011, 2014]), international higher education bodies (Ron Harden Innovation in Medical Education Award, 2015, 2011) and as a Malaysian innovation with commercialisation potential (Silver Award ITEX, 2018).

Our novel MAPEL Lab provides a state-of-the-art and conducive learning environment not only for studying anatomy but has also become a multi-usage facility and used by other medical disciplines, for open days showcase, public education and postgraduate surgical training workshops.

The basis of these GCL and SPTD pedagogies has contributed to developing intellectual property for a networked ecosystem of multi touch tabletops in an e-learning resource lab, resulting in the authors being granted a Utility Innovation (patent), a first in the field of Education Technology for Monash University (Utility Innovation IP/Co-inventors: Sen et al., 2020).

Conclusions

This novel technology-enhanced, task-based, collaborative model of GCL/SPTD serves to promote medical students from passive listeners to active problem-solvers and lifelong learners (Rosenberg et al., 2006), translating Aristotle's philosophy "Teaching is the highest form of understanding" into practice**.** Integrating educational technology through PCs, Digital resources, physical models etc. allows a seamless multitude of interactions—peer to peer, peer to tutor, peer to resources—within the same group and across cohorts. The effectiveness of this model is due to the affordances of such interactions within a technology-enhanced laboratory.

The GCL, SPTD and OSCAR model's effectiveness is reflected in the positive outcomes in all our evaluation goals of reaction, learning and behaviour. Student receptiveness towards this practical approach manifested in the overall improvement in student/team-directed learning, motivation and engagement—essential skill sets required later when engaging in regulated continuous professional development as future practising doctors (Yam et al., 2016). Although some senior tutors were initially hesitant to step away from traditional dissection-based approaches, overall, once trained and familiar with the teaching format, tutors readily accepted the new, technology-enhanced methods. The unit evaluation scores showed that the practical innovation, since its inception, has been sustained over time. It also indicates its effectiveness against our main campus following the same curriculum but with a traditional mode of delivery.

Though analyses on technology-enhanced learning and active learning methods in healthcare disciplines have been studied (Dori & Belcher, 2005; Gutmann et al., 2015), the likes of GCL/SPTD have yet to be reported as a proper method of long-term practical training in healthcare education involving team-based approaches within large student cohorts, the practice of GCL/SPTD in our campus has been made possible, due to the innovative and enabling learning environment provided by the integration of authentic learning resources within the technology-supported MAPEL lab. Hence, this practical activity-based approach goes beyond basic peer teaching strategies to focus on the critical visual, haptic and immersive experience of explorations of demonstrations using human body specimens, models and peer volunteers, by student groups to their cohort peers. Improvement of summative scores shows that SPTD reinforces knowledge/skills learnt in GCL. By taking on teaching/demonstrating roles, students can attain a higher level of competency in practical skills (Australian Medical Council, 2012). A key design highlight of this Anatomy practical strategy has been the incorporation of clinical anatomy for each practical guide including tasks that allow competencies in clinical skills to develop during such basic science (Anatomy) practicals—a true example of authentic learning with added skills development during preclinical teaching and learning. Further, these practical activities are facilitated by actual industry players and healthcare professionals—clinician tutors. Integration of authentic tasks and facilitation and input by workplace practitioners or those with prior practice experience should be the aim of educators when trying to design their practical programmes using this model. Whilst this strategy and all its associated activities have sustained well for over a decade of implementation in the physical learning environment of the MAPEL Lab, interestingly these last two years of the Covid-19 pandemic have seen their successful conversion to a fully online format with the same learning outcomes as during pre-pandemic times.

Overall, this multi-award-winning educational innovation could readily be applied as a role model for practical learning and engages students in professional collaborations demanded in today's clinical practice, strongly supporting GCL/SPTD as a future-forward, effective strategy for practical skills training in medical and healthcare education.

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