Lap Ki Chan
Wojciech Pawlina
Editors

Teaching Anatomy

A Practical Guide

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"To my parents, Laura, and my teachers and students, from whom I have learned much"

Lap Ki Chan

"To my anatomy teachers who guided me to the threshold of my optimism: Kazimierz Pawlina, MD my father and first anatomy teacher; Franciszek Jugowski MD, PhD from the Jagiellonian University, Lynn H. Larkin, PhD from the University of Florida; Stephen W. Carmichael, PhD from Mayo Clinic; and to my past, present and future students."

Wojciech Pawlina

Preface

The title of this book, "Teaching Anatomy: A Practical Guide," deserves some explanation. The word *teaching* has unfortunately become an unpopular word in educational writing. It is often associated with passive learning with the teacher playing the role of the "sage on the stage." Knowledge is seen as packages transferrable from the teacher to the students, whose role is only to be receivers of the packages. But to us, teaching involves all activities that a teacher does to help students learn. It involves being both a "sage on the stage" and a "guide on the side."

With the current trend toward a system-based approach to medical education, a book that focuses on the teaching of *anatomy* may seem old fashioned. After all, over the past few decades, anatomy has become increasingly integrated into the wider curriculum and is less of an isolated subject. However, this shift in the curriculum and educational philosophy has not destroyed anatomy's long history as a distinct discipline. Anatomy, especially gross anatomy, still plays a unique role in many healthcare programs: it has frequently become the only practical course that students will experience in the early part of the medical curriculum. Students oftentimes learn gross anatomy from possibly one of the most mystical teaching aids: their first "patients," the cadavers. Cadaveric dissection provides a unique opportunity for students to be introduced to issues of life, death, and suffering and to learn the "soft" skills of medicine. Through working together in the dissection laboratory, students learn skills like reflection, teamwork, communication, professionalism, and ethics, which are all important to their future healthcare careers.

This book aims to be *a practical guide* and not an exhaustive reference on educational theories as applied to anatomy teaching and learning. We understand that anatomy teachers work in diverse educational environments, including professional healthcare and undergraduate programs, teaching students with different kinds and levels of preparation. They may need to work within the confines of a set syllabus or designing their own course. They may have preferences for high or low tech materials and have few resources or many. Their backgrounds may be clinical or academic. They often need to convey a large body of knowledge to students in a short time and integrate it into the wider healthcare curriculum. They may need to take part in highly specialized pedagogies, such as problem-based learning, team-based learning, and e-learning. Moreover, since curriculum structures vary among schools, integrating anatomy into the curriculum must be flexibly done.

To help teachers to tackle these challenges, we edited this guide book, which gives practical advice to both novice and experienced anatomy teachers in the diverse educational situations that they commonly encounter. We are the first to admit that we do not know it all, so each chapter is written by an expert on its topic. The aim is to help teachers to give the best learning experiences to their students. We also understanding that anatomy teachers, like most other teachers in tertiary institutions, need to divide their time between teaching, research, administrative duties and sometimes even clinical work. We have invited the expert authors of the chapters to write concisely and in simple language. Text boxes are provided to bring out the key points, to stimulate reflection on the reader's own situation, or to provide additional practical tips. Educational theories, though not the focus of this book, are selectively included in order to explain the theoretical foundation underlying practical suggestions, so that teachers can appropriately modify the strategies described in the book to fit their own educational environments.

As anatomy teachers, we often hope our students will gaze in awe at the inner universe of the human body, as we once did and, hopefully, still do. The induction of our students to this inner universe is a privilege for us. It deserves to be done well. We sincerely hope that this book can help you to help your students to learn. Learning should be fun. And so should teaching, especially anatomy.

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Lap Ki Chan is an Associate Professor in the Institute of Medical and Health Sciences Education (IMHSE) and the Department of Anatomy at the Li Ka Shing Faculty of Medicine at The University of Hong Kong, where he is also the Deputy Director of IMHSE and the Assistant Dean (Pedagogy). After receiving his medical education at The University of Hong Kong, he completed his doctoral studies at the Department of Biological Anthropology and Anatomy at Duke University, on the comparative anatomy of the shoulder in primates. He then returned to Hong Kong where he completed his training in orthopedic surgery. Since 2007, he has been working exclusively in medical education. His research interests include innovative pedagogies in anatomy education, problem-based learning, and language issues in medical education. He is also involved in faculty development. He is the codirector of the Staff and Professional Development Program at his own school. He is also a Visiting Professor at Zhongshan School of Medicine and an educator for the Asia Pacific region for the *AO Foundation* (*Arbeitsgemeinschaft für Osteosynthesefragen*), primarily offering services in faculty development. His teaching excellence has been recognized by such awards as the *Thomas Henry Huxley Instructorship* from Duke University, and most recently, an *Outstanding Teaching Award* from The University of Hong Kong. He serves as an associate editor for *Anatomical Sciences Education*.

Dr. Wojciech Pawlina is a Professor of Anatomy and Medical Education at Mayo Clinic College of Medicine in Rochester, Minnesota, USA. He earned his medical degree from the Jagiellonin University Faculty of Medicine, formerly Copernicus Medical School in Krakow, Poland, where he was appointed as instructor in the Department of Descriptive and Topographical Anatomy and completed his residency in Obstetrics and Gynecology. Since 1986 he worked as a Postdoctoral Associate at the University of Florida College of Medicine before joining the faculty of the Department of Anatomy and Cell Biology as an Assistant Professor. In 1999 he relocated to Mayo Clinic in Rochester, Minnesota and currently serves as the Chair of the Department of Anatomy and Director of the Procedural Skills Laboratory. He has extensive experience in teaching gross anatomy, histology, and embryology to undergraduate, medical and dental students, as well as residents and fellows. From 2007 till 2013 he was appointed as an Assistant Dean for Curriculum Development and Innovation at Mayo Medical School. He received numerous teaching awards from both the University of Florida and Mayo Clinic and recently he was named 2014 Distinguish Mayo Educator. His research interest in medical education is directed toward strategies of implementing innovative teaching methodologies, teaching professionalism, leadership, and teamwork in early medical curriculum. He serves on several editorial boards of scientific journals and is also Co-Editor-in-Chief of the *Anatomical Sciences Education*, a journal of the American Association of Anatomists.

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Part I

Teaching and Learning Anatomy

1 Elements of Successful Adult Learning

Lap Ki Chan and Miriam Uhlmann

This book is mostly about how teachers can design teaching and learning activities that engage their learners, so as to give them the best anatomy learning experiences. The activities may take many forms, in various settings, and use different methods and tools. Despite these variables, there are some common elements that may lead to better learning experiences. This chapter discusses these elements in general.

To understand the elements, it is important to know how adults learn. Adult learning theory (also called "andragogy"), in the tradition of Malcolm Knowles [1], is defined as "the art and science of helping adults learn." It is based on four assumptions about adult learners:

1. Adults need to know why they need to learn something.
2. Adults need to learn experientially.
3. Adults approach learning as problem-solving.
4. Adults learn best when the topic is of immediate value to their training or work.

Knowles [1] contrasted andragogy with pedagogy, which he defined as "the art and science of teaching children" (note that it is different from the general usage of the term nowadays) wherein the learners are assumed to be more dependent on the teachers in determining what and how they learn, have little personal experience to bring to the learning process, have learning needs largely determined by someone other than themselves, and are more subject centered. However, andragogy and pedagogy should be considered as two separate sets of assumptions that can sometimes be applied to learners of any age under different situations [1].

For adults to learn successfully, educational activities usually need to match their learning needs, motivate by triggering their internal drivers, provide clear goals or outcomes that they are expected to achieve, engage through active learning, stimulate reflection, and create connections with existing experiences. One element that is missing in adult learning theory is feedback, which will also be discussed in this chapter.

Based on Needs

A theory of motivation based on human needs was described by Abraham Maslow and is known by many as Maslow's pyramid/hierarchy of human needs [2]. This defined the term "need" in a broad general sense of human biological and psychological requirements. The relation to education was described by Knowles in 1980 [1]: "These basic needs have relevance to education in that they provide the deep motivating springs for learning, and in that they prescribe certain

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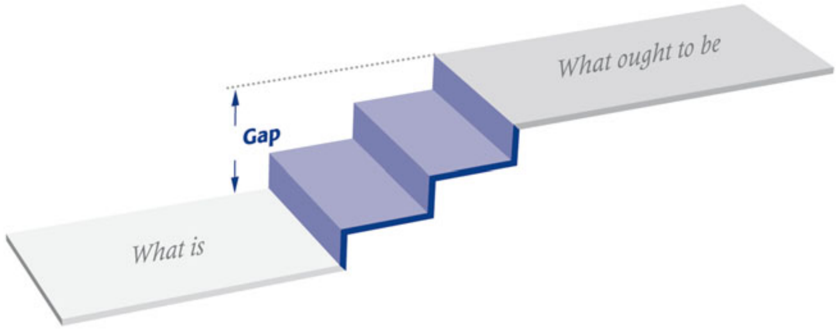

Fig. 1.1 The elements of needs (adapted from Fox and Miner [4])

conditions that the educators must take into account if they are to help people learn…. An educational need, therefore, is the discrepancy between what individuals (or organizations or society) want themselves to be and what they are; the distance between an aspiration and a reality."

In other words, the educational need can be described as a gap between the present level of an ability (what is) and the desired level of the same ability (what ought to be) required for effective performance as defined by the learners, their organization, or society (Fig. 1.1).

Clarification of who the target learners are, their needs, and their environment is crucial to assure that learning takes place. Kern et al. [3] outlined several methods to assess learners' needs (Table 1.1).

Motivation

Motivation to learn arises from an educational need. Perception plays a major role in motivation and "…is the cornerstone of understanding why health professionals may have different levels of motivation related to similar topics and programs…" [4]. It is important to understand that the gap that affects each learner's motivation is always the gap between the perceived present level of ability of the learner and the desired level of ability and that the extent of discrepancy one perceives between these two affects the extent to which one is motivated to learn. The interactions between perceived and actual needs are summarized in Fig. 1.2.

The best situation is where we find a high perceived need and a high actual need, which results in the learner being highly motivated to learn. On the other hand, very large discrepancies are associated with a high anxiety level, which may lead to feelings of aversion rather than attraction and therefore a lack of motivation to learn. The most difficult situation is when learners believe that their performance is close to the standard but it is not, so the perceived need is low but the actual need is high. In such a situation, the learners will not see any need to learn. The question is now how we can motivate these learners.

Table 1.1 Advantages/disadvantages of several need assessment methods (adapted from Kern et al. [3])

Method	Advantages	Disadvantages
Informal discussion	Convenient, inexpensive, rich in details	Lack of methodology, interviewer bias
Formal interviews	Standardized, quantitative, and qualitative information	Needs trained interviewers, costly
Focus group discussions	Efficient, learn about group behavior, qualitative data	Needs skilled facilitator, time, and financial costs
Questionnaires	Standardized questions, quantitative and/or qualitative data, easy to use (especially online), large samples possible	Question-writing skills needed, response rate issue, time intense for data collection and analysis
Direct observation	Best method for assessing skills and performance	Time-consuming, development of guidelines
Tests	Objective measure of knowledge or skills	Requires time, effort, and skill to construct valid test questions

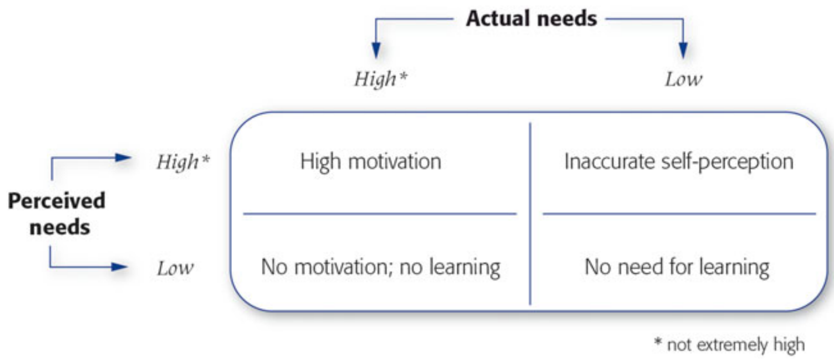

Fig. 1.2 Perceived vs. actual needs (after Fox and Miner [4])

For adults, it is also important to be self-directed and to decide how they want to close an identified gap. Fox and Miner stated that "Motivation to participate in a specific learning activity will be greatest when the physician perceives strong or many goals, that those goals are important, that participating in the specific learning activity is personally satisfying, and that participating will result in achieving goals" [4].

For practical application, it is crucial to consider the following two points to motivate your learners:

1. Help your learners to realize their gaps in knowledge and performance by, for example:
   - Online self-assessments: Based on your defined outcomes, ask your learners about their perceived present level and their desired level. This can easily be done with an online survey tool. It is important that learners can see their results to recognize their gaps.
   - On-site small group discussions: During small group discussions, you can find out about the present level of knowledge, and you can help learners to understand where they are and where they should be. This is important in situations where learners think they already know a lot (although they in fact do not) and would therefore not be highly motivated to learn.
   - Reflection (see also section on "Reflection"): Reflective practice helps learners to identify their gaps.
2. Help your learners to stay motivated by using a variety of teaching methods:
   - Use interactive methods for teaching such as interactive lectures and small group discussions.
   - Use new technologies to allow for self-directed learning, e.g., provide online resources such as readings or recorded lectures/webinars.
   - Provide learners with clear goals and outcomes.
   - Provide time and opportunities for reflection.
   - Blend traditional strategies with technology, e.g., self-assessment tests can be completed online and linked to discussion forums.

Outcome Driven

Many teachers declare the objectives before starting a teaching and learning activity. However, these are often the objectives of the teacher: "in the next hour, I am going to tell you ABC, then do DEF…." Such objectives may give learners an idea of what the teaching/learning process will be like. A clear articulation of the learning product, i.e., what the learners are expected to be able to do after the activity, would be more helpful to learners. These expectations, written from the perspective of the learners, are called the intended learning outcomes.

There are several models to help teachers to develop learning outcomes. One is the SOLO (Structure of Observed Learning Outcomes) taxonomy [5], which describes several levels of complexity in the learner's understanding of a subject: prestructural (learners have unconnected information), unistructural (learners are able to make simple and obvious connections between facts), multistructural (learners see more connections but miss the significance to the whole), relational (learners appreciate the significance of the parts to the whole), and extended abstract (learners make connections beyond the subject and are able to generalize). Another model is the revised Bloom's taxonomy [6], which identifies six subcategories in the cognitive domain of learning activities: knowledge, comprehension, application, analysis, synthesis, and evaluation. Whether these six subcategories are hierarchical is debatable, but the subcategory "knowledge" here is defined as remembering and recalling (not knowledge in the general sense) and is usually considered the simplest level of intellectual activity. Miller's pyramid can also help teachers to formulate learning outcomes for their learners (Fig. 1.3) [7]. The pyramid shows the ideal stages of the development of clinical competence but can also be applied to learning in other areas. The first stage is that the learner knows what to do; then he/she knows how to do it (i.e., he/she can describe the process but might not be able to do it). The next level is that the learner shows how it can be done in a safe environment, and the highest level is to apply it in actual practice. Similar to Bloom's taxonomy, Miller's pyramid also distinguishes learning that consists of memorizing facts (declarative knowledge) from learning that enables one to apply procedural knowledge in real-life situations.

After teachers have decided on the intended learning outcomes, they plan backward. They need to decide on the teaching/learning activities that will best help learners achieve the outcomes. They also need to decide on the assessment methods and standards with the intended outcomes in mind. Such an alignment of teaching/learning activities and assessment with the outcomes is called constructive alignment [8] and will be discussed in much greater detail in Chapter 4. If the

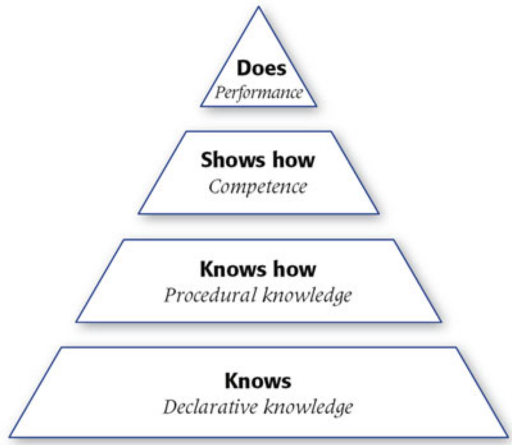

Fig. 1.3 Miller's pyramid. Framework for clinical assessment (after Moore [7])

outcomes are not met by the learners, the teachers may need to reconsider and adapt the teaching/learning activities and the assessment the next time they engage in the same activity, until the intended learning outcomes are achieved to a satisfactory level (Fig. 1.4).

In an outcome-based approach to learning, the intended learning outcomes take a central role. If the outcomes are not properly articulated, it will not be clear what the teaching/learning activities are trying to help the learners to achieve and what the assessment will be measuring. Thus, the articulation of the intended learning outcomes must be carefully done. Each outcome should begin with a verb that describes an observable and assessable action. The action indicates not only whether the learners are able to do certain things but also at what level they are expected to do it after the teaching/learning activity and under what conditions. For example, "describe" and "hypothesize" are appropriate verbs in outcomes since they both indicate not only whether the

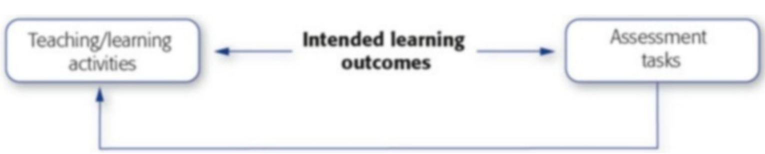

Fig. 1.4 Aligning teaching/learning activities and assessment tasks with the intended learning outcomes

learners are able to understand certain content but also the levels the learners are expected to understand the content (lower level for "describe" than "hypothesize"). Assessment can also be focused on these actions. On the other hand, "understand" will not be an appropriate verb, because it is not observable and can only be indirectly assessed. If it was used in an intended learning outcome, the teacher may have difficulty designing the appropriate teaching/learning activity that will help the learners to achieve it, because it is not clear how much understanding is expected of the learners. The learners will also not know how, and to what level, they will be assessed on that outcome.

An outcome-based approach sets clear goals for learners. If the learners perceive a gap between their current level of ability and the goals, they will be more motivated to take part in the learning activities if they believe the activities have been designed to help them achieve the goals. An outcome-based approach also helps teachers and administrators to cooperate to achieve the same goals, especially if the activity involves more than one teacher. It ensures that the right products are delivered. It is particularly important in the healthcare field because the amount of knowledge learners are required to know is rapidly expanding, while the length of healthcare training programs remains more or less the same [9]. An outcome-based approach ensures that the teaching/learning activities in a program will produce graduates with a set of intended competencies. This approach also encourages debate over the set of intended competencies because the teachers now need to explicitly articulate it [10, 11]. Doing so also enhances the transparency and quality assurance of healthcare training programs.

Active Learning

There is evidence that adults learn better with active learning, which can generally be defined as a learning process in which the learners are engaged in meaningful activities in the classroom and are mindful of what they are doing [12, 13].

The design of a teaching and learning activity determines the tasks that the learners need to engage in and how much active learning is possible. A traditional lecture, which is delivered in a unidirectional manner without interactions between the teacher and the learners, is often used to illustrate what learning is like when active learning is absent. In this kind of learning, the learners passively receive knowledge in a form already determined by the teacher. There are no tasks that the learners need to be involved in. In fact, the learners do not even need to be there for the lecture to take place. In active learning, the learners do not just sit and passively receive information. They are engaged in such activities as discussion in small groups, think–pair–share activities, short writing exercises, debate, or gaming. Some of these activities can be integrated into lectures, thereby introducing some element of active learning into this relatively passive form of teaching and learning. But the lecture format makes these active learning opportunities difficult. Other activities that have been specifically designed to stimulate active learning include collaborative learning [14], cooperative learning [15], and problem-based learning [16], and active learning can be integrated into most other activities, including anatomical dissection (see Chapter 23).

Tasks that stimulate active learning are those that encourage learners to take ownership of the learning, which stimulates them to think critically and creatively in order to accomplish certain tasks. By engaging in these tasks, learners reflect on their prior or newly acquired knowledge, identify gaps in their knowledge, seek out relevant information, assess current problems, analyze facts and opinions, etc.

Although the main responsibility of learning rests with the learners in active learning, the teacher also has a very important role to play. The teacher should cease to be the "sage on the stage" as in a lecture and should become a "guide on the side" by providing a safe and inquisitive environment for the learners to explore and construct knowledge. A friendly and supportive environment encourages the learners to articulate their thoughts and to ask and answer questions in front of others without the fear of feeling embarrassed when they make any mistakes.

Reflection

People learn from experience by reflecting on it. Reflection is thus an integral part of learning. Before a meaningful discussion can proceed, "reflection" must first be defined because this term is used in everyday life and has different meanings in specific circumstances. Moon [17] defined it as "a form of mental processing with a purpose and/or anticipated outcome that is applied to relatively complex or unstructured ideas for which there is no obvious solution," while Boud et al. [18] defined it as "a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to a new understanding and appreciation." A more inclusive definition is given by Sanders [19]: "Reflection is a metacognitive process that occurs before, during and after situations with the purpose of developing greater understanding of both the self and the situation so that future encounters with the situation are informed from previous encounters." It is thus considered a process of thinking about thinking (metacognition) that involves not only the acquisition of new knowledge or skills but also an understanding of both the self and the situation, so that the learner will respond differently in future encounters.

The significance of reflection can be described using Kolb's cycle or the learning cycle [20]. The cycle consists of four stages (Fig. 1.5). Experience is just one of the four stages, and it alone is not sufficient for learning to occur. One needs to reflectively observe the experience ("reflective observation") and then formulate and integrate the new "skills, knowledge, attitudes and values with the learners' cognitive framework" [21] ("abstract conceptualization"). Based on the new cognitive framework after reflection on a previous experience, the learner will respond differently when he or she encounters similar situations in the future ("action"). The new response is itself an experience that the learner can reflect on, leading to further modification of the cognitive framework.

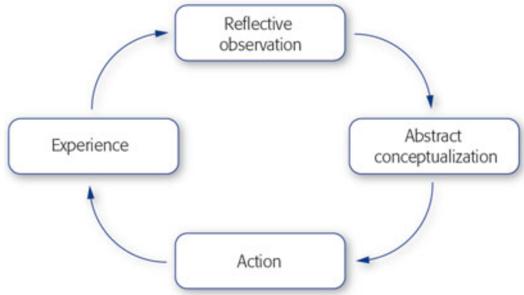

Fig. 1.5 Kolb's cycle (after Kolb [20])

Learners going through the stages in Kolb's cycle are more likely to achieve deep learning because numerous links are formed between the new facts and ideas and their existing cognitive framework, in contrast to surface learning, in which new facts and ideas are isolated and unconnected [22]. The linking process also gives more meaning to the new knowledge, skills, attitudes, and values by relating them to the larger context.

Given the important role of reflection in learning, it is surprising that it does not spontaneously occur as often as desired and needs to be actively promoted. Moon [23] pointed out that learner reflection can be promoted when the tasks are challenging and ill structured (e.g., real-life examples), demand ordering of thoughts (e.g., following exposure to disorganized data), involve evaluation, and require integration of the new into previous learning. Chapter 23 illustrates how teaching and learning around anatomical dissection can be structured to promote reflection.

Feedback

Feedback is an essential part of medical education. It is "…specific information about the comparison between a trainee's observed performance and a standard, given with the intent to improve the trainee's performance" [24, 25]. It helps learners to maximize their potential at different stages of their lifelong learning path, raise their awareness of strengths and areas for improvement, and identify actions to be taken to improve performance. Therefore, the purpose of feedback is to improve performance [26] and reflection [25], not to criticize or judge.

A common model for giving feedback in clinical education settings was developed by Pendleton [27]. Pendleton's rules consist of the following steps:

1. Check if the learner wants and is ready for feedback.
2. Allow the learner to give comments/background to the material that is being assessed.
3. The learner states what was done well.
4. The observer states what was done well.
5. The observer states what could be improved.
6. The teacher states how it could be improved.
7. An action plan for improvement is made together.

Pendleton's rules are structured in such a way that the positives are highlighted first (steps 3 and 4) in order to create a safe environment. In addition, step 3 forces the learner to reflect on his/her action. This is followed by the observer reinforcing these positives and adding some more if needed. "What could be done differently?" is then suggested, first by the learner and then by the observer. Again, it gives the learner the opportunity to reflect and to decide what to do next time. The advantage of this method is that the learner's strengths are discussed first. Avoiding a discussion of weaknesses right at the beginning prevents defensiveness and allows reflective behavior in the learner. The most crucial step is step 7, the action and follow-up plan, where the learner agrees with the observer on changes he/she will make for the next time.

Although this model provides a useful framework, there have been some criticisms of its rigid and formulaic nature, and a number of other models have been developed for giving feedback in a structured and positive way. One of these is the "sandwich" model, which starts with identifying the learner's strength, is followed by identifying the learner's areas in need of development, and concludes by reinforcing the strengths again.

Elements of Effective Feedback

- Provide a culture of giving feedback between learners and teachers. Feedback should be given **frequently**.
- Give feedback only when asked to do so or when your offer is accepted.
- Schedule formal feedback sessions that are convenient for the learner and the teacher, and adequate time should be given for both parties to prepare. Give feedback in a **timely** manner (not too soon or too late after the event).
- Select a location that is as private as possible.
- Measure the learner's performance against **standards** and well-defined goals and objectives.
- Provide **specific** and **accurate** information, including examples, not generalizations.
- Focus on the **positive**.
- Focus on **behaviors** that can be changed, not personality traits.
- Be **sensitive** to the impact of your message. Feedback is for the recipient, not the giver.
- Consider the content of the message, the process of giving feedback, and the congruence between your **verbal and non-verbal messages**.
- Encourage **reflection**.
- Be clear (have a goal) about what you are giving feedback on, and link this to the learner's **overall development** or intended program outcomes.
- Do **not overload**—identify two or three key messages to outline at the end. Be sure that the learners themselves identify the changes they want to make.

Summary

To promote effective learning, teachers need to understand the needs of learners and to motivate them by enabling them to perceive any gaps that exist between their present level of ability (what is) and the desired level (what ought to be). Learners can be motivated to learn better if they are informed regarding the specific learning outcomes of the activities and how achieving these outcomes will help them to bridge their gaps. Teaching and learning activities and assessment methods and standards should all be designed to help learners achieve these outcomes. Learners should be actively engaged in the learning process, instead of passively receiving information. They should be given frequent, accurate, and specific feedback at the appropriate time and be given time and opportunities for reflection.

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2 Learners of a New Generation

Camille DiLullo

It has been proposed that learning is expedited when clearly defined "learning outcomes" are stipulated in advance. This concept and an approach for implementation are more fully addressed toward the end of this chapter. To exemplify the process, I am providing two outcomes you should expect to attain after completion of this reading. The anticipated outcomes to be acquired are the ability to (1) identify issues that can impact learning of the next generation and (2) coordinate content delivery that can facilitate next-generation learning.

The Learner Persona

Differentiate the Constituents of Multigenerational Learning Cohorts

Learner cohorts in higher education are more likely to be comprised of individuals from multiple generations as compared to the learner cohorts in K-12 education which are predominantly composed of individuals from a single generation. Whether a particular cohort is comprised of learners from one or more than one generation, it can be predicted that individual learning cohorts will include people with varied learning characteristics. Strauss and Howe [1] defined distinguishing characteristics for specific generations of the twentieth century in the USA. The authors proposed that identifiable generational traits are in part shaped by global, national, and societal events that occur during the time period of the previous generation. It is likely that generalized traits of individual generational cohorts from other countries can also be defined but will vary based on their respective national and societal events. When examining charts that delineate generational descriptions, individuals commonly feel they do not personally possess every characteristic assigned to their particular generation or alternatively that personality traits assigned to previous or later generations are more apropos. Appreciation of how your personality reflects the attributes associated with your own generation can help elucidate the premise that learners within any generational cohort are not a clonal population. The exercise provided in Table 2.1 is designed to help you ascertain how in synch you believe your personality traits are with those categorized for a single generation. Peruse the characteristics listed in Table 2.1 for four American generations. If you are an American, select the generational cohort to which you belong. If you are not part of an American generation, select the group which has a majority of

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Table 2.1 Attributed generational traits

1925–1942 Silent generation	**√**	**1943–1960 Baby-boom generation**	**√**
Adaptive		Antiestablishment	
Cautious		Confident	
Conformist		Entrepreneurial	
Due process oriented		Free spirited	
Fair		Idealistic	
Hard working		Individualistic	
Mediator		Independent	
Nonviolent		Personal growth	
Reserved		Revolutionary	
Risk averse		Self-directed	
Socially conscious		Self-indulgent	
Solitary		Self-motivated	
1961–1981 Generation X	**√**	**1982–2003 Millennial generation**	**√**
Cynical		Accepts authority	
Detached		Achiever	
Determined		Civic	
Enigmatic		Considered special	
Informal		Family oriented	
Pragmatic		Happy	
Quick		Pressured	
Reactive		Optimistic	
Realistic		Protected	
Self-protective		Self-assured	
Self-reliant		Service minded	
Street smart		Team player	

traits that you consider most appropriately represent your particular generation. In the column to the right of the group you selected, check how many of the listed traits you feel characterize your persona. Now examine the traits in columns of other generational cohorts with which you did not identify. Again, in the right column check those traits which you believe can fairly be ascribed to your persona. You may not feel strongly bound to distinctive traits attributed to the group with which you primarily identified. Alternatively, you may feel closely aligned with traits linked to other generational cohorts. Members of any generation may possess many of their generations' ascribed traits, but they are just as likely to possess traits typical of other generational cohorts.

Appreciate Individual Learner Characteristics

It is essential that we view generational traits as trends in a given learner cohort rather than as inflexible characteristics. It is incumbent upon educators to tease out what traits charged to the newest generation of learners might influence their learning keeping in mind that many of these things might impact learners of previous generations as well. Global evolution has created the culturally diverse and technologically rich environment in which the millennial generation has been raised. Millennial learners come from a multitude of cultural, religious, and socioeconomic backgrounds [2]. They have grown up in a world dominated by digital communication both in their personal lives and in their educational experience. Diversity and engagement with technology will be factors that affect the success of millennial as well as next-generation learning into the foreseeable future. Societal circumstances have also been suggested to affect millennial generation learning including the protected nature of their upbringing, the way they have all been made to feel special, the pressure they have been put under to become high achievers, and the tendency for them to engage in team activities. In our global environment of competition with goals for ever-increasing productivity and efficiency, many traits that have been ascribed to the millennial generation are likely to remain the same for next-generation learners. Despite overarching trends in generational traits, learning cohorts will encompass individuals with unique personalities. In the process of learning, that which we are inherently interested in or excited about we learn best. Guiding learners to explore new knowledge through the lens of their distinctive professional passions within real-world contexts, which I refer to as interrelational learning (IRL), will more deeply engage students in the learning process.

Much has been written regarding the transformation in learning style of the millennial generation [2–5]. Suggested learning style changes include multitasking, a preference for learning using technology and working in groups as well as the elimination of reading. Alternative views assert that the learning style of the millennial generation may not be as radically different from previous generations as is often proposed [6, 7]. Studies have shown that many millennial learners continue to be engaged with traditional teaching methods and do read although it may be with e-books rather than textbooks [8]. While individual learners can absorb information in multiple ways, they generally demonstrate a learning style preference. In other words, they learn more easily in one particular modality as compared to others. Learners process information in one of several ways and can be defined as visual, aural, read/write, or kinesthetic [9]. Individuals will vary in their predilection for specific modalities so within any learner cohort there will be a mix of preferred learning styles.

Support Varied Learning Styles with a Balanced Educational Approach

The recognition of different learning styles [10, 11] has advanced in tandem with the evolution of available educational resources. For centuries, learners had to adapt their learning style to the resources that were available. In the last century, resources included primarily lecture, handouts, books, films, personal notes, and a physical library. The technological explosion has exponentially increased the overwhelming array of educational resources beyond the traditional to include digital pedagogy, lecture capture, computer animation, YouTube, e-books, web searches, virtual programs, a digital library, blogs, e-communities, and so on. This vast assortment can substantially support a greater variety of learning styles. It may now be more appropriate to view the need for evolution in teaching modalities to be an outcome of the increased selection of educational resources rather than the inherent learning differences of next-generation learners. The pedagogical pendulum has for centuries been shifted toward using traditional teaching methodologies that favor aural and read/write learners. Collectively, our expanded learning resources offer more opportunity to directly engage visual and kinesthetic learners. However, the introduction of innovative delivery methods with the concurrent elimination of traditional pedagogy could swing the pendulum to the other extreme and limit the learning environment for aural and read/write learners. Facilitation of learning must take a balanced approach in content delivery that incorporates multiple and varied learning paradigms to accommodate learners of all types. Some educators have embraced the idea that each learner should have a special curriculum designed exclusively for them to meet their particular learning needs [12, 13]. Embracing a comprehensive approach to content delivery would eliminate the need for custom learner curricula. Next-generation learners would have the opportunity to self-select instructional modalities that provide them optimum success in developing expertise.

Ensure Learner Competence with Innovative Technology

Millennial generation learners sometimes referred to as digital natives [14, 15]—individuals whose development has been infused with technology—have had extensive experience with digital exploration, gaming, and communication and are purported to be adept with user-friendly digital devices. Despite the pervasive use of technology by this generational cohort, data indicates that their proficiency with commonplace digital devices does not necessarily translate into an aptitude for educational technology [16, 17]. Educators should not presume that all next-generation learners, let alone learners from previous generations, will be skilled in the use of educational technology such as integrated educational content platforms, anatomical simulators, and virtual anatomy programs. Sufficient instruction must be available to appropriately prepare learners in the use of technology that is employed to deliver content. Time management is crucial to millennial generation learners who feel under great pressure to achieve and are always attempting to expedite successful completion of their requirements. Clear directives on the use of educational technology will maximize learner engagement with and benefit from these resources. Upfront instruction on technological applications can reduce invested effort and help learners facilitate time management.

Keep Learners Focused with Active Learning and Frequent Feedback

The incessant simultaneous use of multiple digital devices by millennial generation learners has them convinced they are capable of unrestrained multitasking. They are consistently in the habit of rapidly switching tasks. The nature of multitasking frequently manifests in learner dispositions that are easily distracted and have difficulty maintaining focus. Millennial learners have little difficulty in overlapping texting, web surfing, and gaming tasks. However, data indicates that while multitasking may not appreciably impact activities such as gaming that can be classified as habit learning [18, 19], it is likely to significantly disrupt the acquisition of knowledge aimed toward subsequent integration and reasoning [20–24]. Learners must be sufficiently engaged to maintain their focus on learning. The use of active learning and a broad variety of content delivery paradigms is likely to promote more consistent engagement for learners of all styles. Sustained focus on learning can also be encouraged with the provision of frequent feedback. Feedback that triggers discovery and reflection of personal strengths and weaknesses allows learners to target areas where improvement would benefit overall success. In addition to feedback from formative and summative testing, learners should be directed to gain feedback through interactive social discourse. As millennial learners are already adapted to collaboration in teams, feedback via group interaction whether physical or virtual will stimulate enhanced learner motivation.

The Way They Learn

Using "CER" Cycles to Develop Expertise

The concept of "teaching around the cycle" is founded on the premise that in processing information learners proceed sequentially through the following specific phases: (1) concrete experience, (2) reflective observation, (3) abstract conceptualization, and (4) active experimentation [25]. However, it can also be theorized that learners initiate the intellectualization of new knowledge with the "conceptualization" of information and follow this by related "experience" and "reflection." A cyclical progression of *c*onceptualization, *e*xperience, and *r*eflection designated "CER cycles" can prepare learners for interactive experimentation in the development of expertise. Learners advance through multiple CER cycles before participating in relevant interactive experimentation. The concept of "CER cycles" differs from that of "teaching around the cycle" in the learners' approach to the assimilation of new content. For "teaching around the cycle," learners would be absorbed with continuous sequential participation in the aforementioned phases of learning. For "CER cycles," learners would be engaged in prescribed cyclical phases of conceptualization, experience, and reflection prior to a phase of interactive experimentation. Programs can deliver CER cycles through (1) provision of content [conceptualization], (2) experiential challenges to apply conceptualized knowledge [experience], (3) opportunity to reflect upon acquired knowledge [reflection], and periods of simulated or actual real-world scenarios [interactive experimentation]. CER cycles can be created for defined blocks of information that are sequentially arranged to build programmatic knowledge. Progression through a CER cycle is exemplified with the learning outcome in the following text box.

Learning Outcome—Obtain a Blood Pressure Measurement with a Blood Pressure Cuff

- **Conceptualization**
Individual learner appreciation of critical arm anatomy as well as the relationship of individual arm structures one to another
- **Experience**
Independent learner examination of (1) discreet arm structure and surface anatomy relationships, (2) brachial artery pulse localization, and (3) blood pressure cuff operation
- **Reflection**
Group review of pertinent information in a laboratory setting, a relevant case-based session, or a personal study group
- **Interactive Experimentation**
Engagement in a team exercise in which students practice taking their partner's blood pressure with a blood pressure cuff

Conceptualization and Unistructural Understanding

During the initial phase of a CER cycle, "conceptualization," learners absorb new information. They acquire isolated facts that they may not necessarily link together. It is a one-dimensional understanding of information. In terms of Biggs' "Structure of Observed Learning Outcomes" or SOLO taxonomy, this would be considered unistructural understanding [26]. The disparate nature of newly conceptualized information is often more obvious at the beginning of a course or program. The fragmented understanding of new information learned in the conceptualization phase of a CER cycle may be masked by accumulating knowledge. However, information conceptualized at the beginning of any CER cycle will be integrated into prior knowledge during the remaining "experience" and "reflection" phases of that cycle. Generally, focused conceptualization of information occurs independently rather than in a group format.

In an unfamiliar learning environment, each learner commonly approaches conceptualization of knowledge in ways, whether visual, aural, read/write, or kinesthetic, that they have determined from previous experience best facilitates their learning. For example, the initial steps in learning how to take a blood pressure measurement would involve conceptualization of basic facts. Learners on their own, depending upon their options, may choose to attend a lecture, watch a podcast or animation, read a text, study an atlas, etc. They will continue to review this information until they believe it is adequately understood. Frequent opportunity for independent self-quizzing will provide feedback that can illuminate for learners areas in which they may be weak. Independent self-quizzing immediately after initial conceptualization has been shown to improve long-term retention of information [27–30]. Actively directing learners toward alternative styles of learning with which they might not be as familiar can provide a form of early intervention which may guide students toward enhanced conceptualization of information they find confusing and could improve success in assimilating program content.

Experience Through Real-World Contexts

In the second phase of a CER cycle, "experience," learners independently relate their newly acquired knowledge to contextual scenarios. This experiential application of conceptualized knowledge supports the development of expertise as learners are stimulated to connect acquired knowledge to practical situations. Learners begin to recognize the significance of how initially disparate pieces of information are interrelated to each other as well as to real-world applications. In this phase, new knowledge can be linked to knowledge acquired through previous CER cycles. Learners begin to develop a two-dimensional or multistructural understanding of information. The experiential application of new knowledge, like initial conceptualization, generally occurs independently. In general, the types of individual experiential learning in which students can participate are multimodal. Visual and kinesthetic learners might gravitate toward using physical or virtual cadavers and laboratory specimens to help them connect various aspects of their conceptualized knowledge. Aural and read/write learners may be more engaged using podcast demonstrations and online or paper-based case problem solving with self-quizzing.

Reflection Through Interactive Discourse

Reflection is the final phase in a CER cycle. Once learners have independently acquired knowledge through conceptualization and experience, they need time to reflect on what they have learned. The reflection that completes a CER cycle is reflection that determines how successful the phases of conceptualization and experiential learning have been rather than reflection on personal feelings on individual experiences. In this phase of the cycle, learners should participate with others in interactive discourse. Interactive social discourse provides direct feedback from others that affords opportunity for learners to validate that their comprehension of assimilated knowledge is both accurate and adequate. Learners can identify information that they may have overlooked or not have fully understood. With reflection, learners will advance to more fully integrating facts, concepts, and principles and evolve a more three-dimensional or relational perspective of knowledge. The knowledge will become more interrelated. Ample opportunity within each CER cycle for reflection and personal authentication of learning can effectively prepare students for successful engagement in the next CER cycle. Both group study and team activities offer face-to-face social interaction that can promote reflection on learning. Subsequent to a program-defined number of CER cycles, learners will be prepared to engage in interactive experimentation through which they can utilize their accumulated learning in real-world contexts.

"CER" Cycle Success Will Vary By Learner

Figure 2.1 provides a visualization of the progressive advancement of learner knowledge through sequential CER cycles. The graph illustrates a projected series of CER cycles in a prescribed learning period designed to lead to attainment of all defined program learning outcomes. The 45° stepped line represents programmatic CER cycles that are sequentially presented to learners throughout the prescribed program learning period. Four individual learners are represented by unique shapes that symbolize their individuality. The color changes for each learner indicate at what point along the program timeline they have successfully integrated a specific percentage of program learning outcomes. It is expected that on average learners will progress through programmatic CER cycles within the prescribed program learning period. However, learners begin the prescribed learning period with disparate prerequisite knowledge in addition to having varied learning style preferences and academic proficiency. These among other factors can influence variable learner progression. On the graph, the individual slope of each learner indicates the rate at which they successfully pass through the series of CER cycles. Most learners will advance through the defined CER cycles in a relatively predictable pattern and successfully attain all expected program learning outcomes using the entire prescribed learning period. However, even among these cohorts, learners will vary to some degree in how quickly they acquire learning outcomes (learners 2 and 3). The slope of their lines will be clustered but may not be identical. A learner slope that is significantly different than the 45° stepped line indicates learner divergence from average. Some will quickly grasp information and make connections among program content and concepts allowing them to rapidly advance through CER cycles to succeed in mastering the prescribed learning outcomes (learner 1). Others may struggle with one or more CER cycles, delaying their integrated understanding of program content and achievement of program success (learner 4).

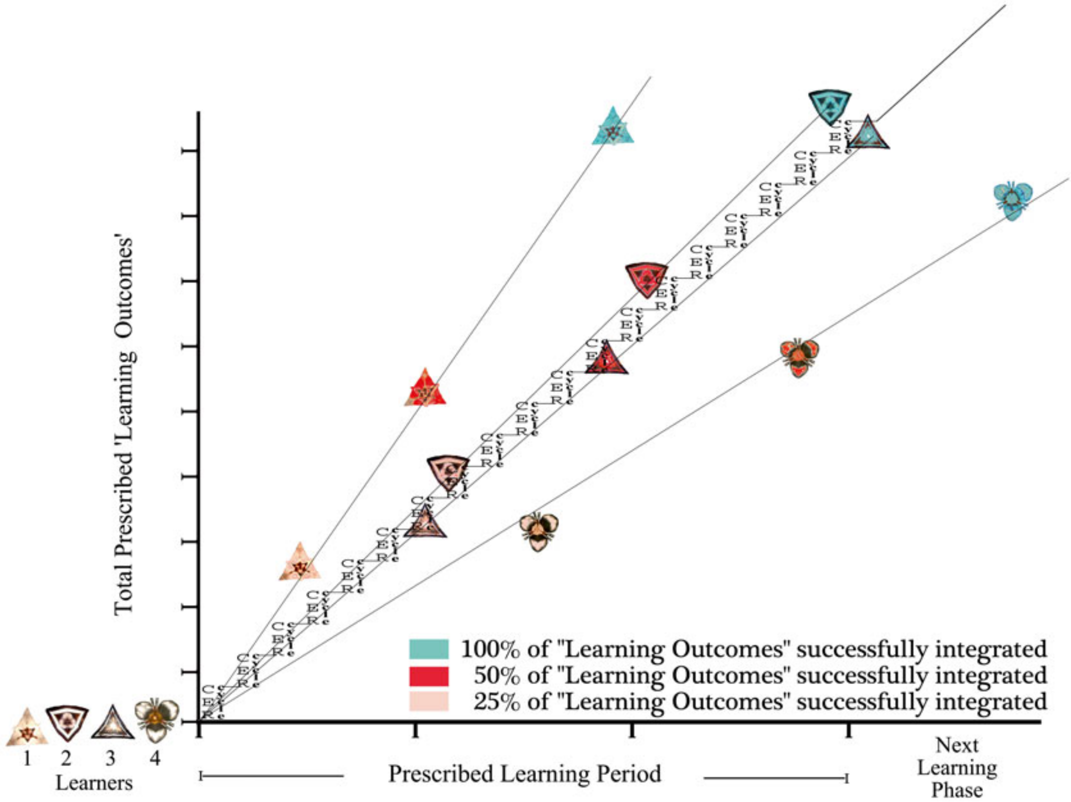

Fig. 2.1 This figure illustrates the progression of four individual learners through a prescribed program period. The four learners (1–4) are represented by unique shapes that symbolize the variability of learners that can exist within a particular learner cohort. The program timeline is delineated along the *x*-axis. Contiguous with the "prescribed learning period" is inserted the "next learning phase." The total "prescribed learning outcomes" are represented along the *y*-axis. Sequential programmatic CER cycles that are projected to facilitate learner acquisition of "prescribed learning outcomes" are represented in relation to time with a 45° stepped line. The color changes for each learner indicate what percentage of expected program knowledge the learner has attained [*peach* = 25 %, *red* = 50 %, *turquoise* = 100 %]. Factors specific to individual learners will influence the pace of successful progression through the program. Average progression through the program will produce a learner slope line that is similar to the 45° stepped CER cycle line. The progression slope of the majority of learners should be clustered around this CER cycle line. A learner slope that is significantly different than the 45° stepped line indicates learner divergence from average

Strategies to Facilitate Success in Next-Generation Learning

Communicate Clearly Defined Learning Outcomes

Subsequent to the determination of appropriate content, clear definition and communication of expected learning outcomes is the next major step in facilitating learning. Unequivocal documentation regarding the knowledge that is to be acquired will keep learners focused and promote effective time management. The terminologies "learning outcomes" and "learning objectives" while often considered to be synonymous can be defined as distinctly different entities. "Learning objectives" generally list what knowledge will be covered within a specific block of learning. "Learning outcomes" details demonstrable results learners are expected to manifest at the completion of the course of study [31, 32]. In the context of interrelational learning, learning outcomes should reflect intended real-world applications of successfully assimilated knowledge. Learning outcomes should be written using active and measureable verbs such as *align*, *correlate*, *trace*, *connect*, and *predict* which can suggest appropriate assessment methodologies. Ideally, assessments should be directly correlated to the stated learning outcomes [32, 33].

The difference between a "learning outcome" and a "learning objective" can be illustrated in anatomy using a typical heart learning module. "Understand the structure and function of components in the four chambers of the heart" would be a "learning objective" which informs learners about what information should be studied. Learner efforts would be focused on memorizing the names of all the heart structures that are stipulated. Using the "learning outcome"—"correlate normal and abnormal heart sounds with typical and atypical heart structure and function"—for the same module would guide learners toward a deeper understanding of how heart structure can impact heart function. Learner efforts would be guided toward better integrating heart structure as it relates to patient auscultation and cardiac function in an authentic context.

Learning Outcome Versus Learning Objective

- **Learning Outcome**
  Correlate normal and abnormal heart sounds with typical and atypical heart structure and function.
- **Learning Objective**
  Understand the structure and function of components in the four chambers of the heart.

A multimodal exercise to fulfill the stated learning outcome would be one in which learners actively correlate normal and abnormal heart sounds with appropriate cardiac structure/function through animations, audio files, radiographic imaging, and anatomical specimens. The learning outcome directly suggests an assessment strategy through the active verb *correlate*. A typical assessment could be based on evaluation of learners correlating normal and abnormal heart structure with normal and abnormal heart sounds. Unequivocal direction with learning outcomes will assist learners in efficient navigation throughout their educational journey.

Challenge Learners Through Multimodal Learning Paradigms

Recognizing that multiple learning style preferences exist within our student cohorts, we should ensure that learners have a variety of content delivery modalities from which to choose. It is important to advance learning through a multimodal approach which will provide opportunity for individual learners, whether visual, aural, read/write, and kinesthetic, to self-select the educational paradigm which most readily facilitates their learning. Various resources will support different types of learning. Cadaver dissection, videos, animations, models, plastinated specimens, and virtual dissection will favor visual learners. Lecture [in-class, podcasts, or lecture capture] as well as small group discussion may be more suited to aural learners. Reading assignments, lecture [note-taking], and writing assignments will benefit read/write learners. Simulation workshops, virtual reality programs, simulated patients, cadaver dissection, models, and anatomical or plastinated specimens are effective for kinesthetic learners. Some content delivery paradigms will be equally effective for different learning styles. For example, physical or virtual dissection can engage both visual and kinesthetic learners.

However, to enhance lifelong learning skills, it is most advantageous for the learner to be able to assimilate information in any modality that might be encountered. Therefore, in addition to learning in their preferred learning style, it is important for students to learn with modalities in which they feel less adept. Learners should be encouraged if not required to acquire information in ways that are a "match" as well as a "mismatch" to their learning style preferences. Advancing skills in absorbing information from a wide range of communication modalities will advance learner proficiency for information integration and enhance the prospect for success with future independent learning.

Provide Guidance for Identification of Authenticated Information

In the process of conceptualizing information, learners are challenged by the overwhelming number of educational resources available to them. In addition to traditional resources, there has been a proliferation of creative digital resources and various technologies that can be utilized to facilitate learning including e-books, podcasts, lecture capture, animations, videos, virtual programs, audience response systems, simulators, course management systems, e-portfolios, and social media. In addition to required resources, learners usually search for supplemental resources that can facilitate their learning. Learners invest significant effort in attempting to ascertain which learning resources will best serve their needs. Educators can provide guidance to learners in sorting through the countless available choices by designating a targeted collection of resources that will best explicate the program-defined learning outcomes. Expeditious selection of auxiliary educational material that will most appropriately support an individual's knowledge acquisition can positively impact effective time management and optimally facilitate learning.

Next-generation learners are accustomed to exploring digital resources in order to identify information they believe will advance knowledge comprehension. They are, however, often naïve about the quality of the resources they uncover [34–37]. Beyond the educational environment, individuals will frequently be expected to self-select reliable information germane to any number of topics. Within the context of the educational program, learners should receive appropriate instruction to cultivate their ability to independently search for new authoritative information. They should be directed away from resources that may be inaccurate or unvetted. Learners must be prepared to recognize the subtle messages conveyed in digital communication known as second-order information [38]. Understanding how to evaluate indirect cues like the purpose of a web page or the source of information can guide learners in evaluating the objectivity of content. Proficiency in information literacy will provide another facet in the progression of learning that can facilitate knowledge acquisition, further successful time management, and enhance lifelong learning skills.

Offer Opportunity for Interactive Social Discourse

Next-generation learners, who have routinely received frequent feedback both in and out of the educational environment, continue to look for feedback in learning. Generally, feedback is crucial in helping identify areas of strengths and weaknesses which once recognized can be addressed. Using formative and summative testing, as well as course instructor feedback, learners attain fundamental information regarding their success with tested or queried knowledge. However, learners can obtain more dynamic feedback through interactive social discourse. The penchant that next-generation learners have for working in groups makes interactive feedback very effective. Learners can construct a personal learning network (PLN) [39] sometimes referred to as a professional learning network. The PLN is a place for individual learners to consolidate social interactions that offer the most productive feedback to advance their learning. The interactive social discourse engaged in through the PLN provides committed periods for learners to pass through the final reflective phase of a CER cycle. Educators should guide learners in the selection of participants for their particular PLN.

A variety of educational delivery paradigms including problem-based learning and team-based learning can support social discourse and be included in the students' PLN. More recent methodologies like the flipped classroom also require students to independently conceptualize information delivered digitally and then subsequently discuss it in a more interactive forum.

Study groups in which learners participate after independent conceptualization and experiential learning become part of the learners' PLN. The learners' PLN can be expanded with online venues such as Facebook, particularly a Facebook site linked to the educational institution. Communication avenues in which learner content can be critiqued by others like small group discussions, discussion boards, blogs, e-learning communities, e-portfolios, Twitter, and Pinterest can act to support interactive educational social discourse. As part of linking knowledge acquisition to real-world scenarios and individual learner professional interests in the context of interrelational learning, ongoing professional extracurricular activities can also generate interactive discussion which can corroborate learning and contribute to a learners' PLN.

Conclusions

Next-generation learners are engaged by a variety of learning styles in the process of absorbing information. Programmatic content delivery should be designed utilizing the broadest possible array of learning modalities to facilitate knowledge acquisition for individual learners. Innovative methodology and digital technology blended with traditional pedagogy can be used to create advancing sequential cycles of conceptualization, experience, and reflection which will advance the learner in the development of expertise. To maximize efficient learner time management, enhance their learning experience, and foster academic success, the following educational practices should also be integrated into the instructional paradigm: (1) identification of clearly defined learning outcomes correlated to real-world applications, (2) adequate instruction for technology platforms and programs, (3) guidance in the use of learning resources, (4) provision of frequent feedback including appropriate assessments and evaluations linked to learning outcomes, and (5) opportunity for interactive social discourse.

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3 Learning Styles in Anatomy Teaching and Learning

Barry S. Mitchell

Anatomy has been taught for centuries. Most would agree that there has been little significant change in topical content of courses, and additionally there has been little change in teaching style. Rembrandt's painting "The Anatomy Lesson of Dr. Nicolaes Tulp" (Fig. 3.1) illustrates the point: a group of earnest-looking students crowded around the cadaver and the teacher, with a textbook to hand, is a scene that could easily be transferred to a contemporary medical school. However, more recently there has been recognition that the learning style of students varies, and this impacts on the ease with which students acquire their anatomical knowledge. Perhaps only recently has this been recognized as a factor in the design of anatomy courses. With greater attention to learning style, perhaps anatomy might be learned for centuries too!

Warnings of a decline in this cornerstone subject of clinical medicine [1] have added impetus to attempts to modernize anatomy teaching. Now, in some institutions plastic anatomical models, imaging, and computer-based learning are the hallmarks of contemporary methods of teaching gross anatomy rather than the traditional dissection-/prosection-based courses. Some medical schools are giving less time to anatomy education, so much so that examination of anatomical cadaveric material has been abandoned altogether. Substantial problems may arise because of the diminished time allocation for anatomy and also because of the declining number of sufficiently experienced anatomy teachers.

In this chapter, some of the research findings of the learning styles of medical undergraduate students, and also those from other healthcare contexts, have been set out. Some personal observations of anatomy teaching and learning styles are also offered, derived from experience of delivery of a variety of UK undergraduate anatomy courses.

How Do Students Learn Their Anatomy?

Identifying a Style

Different students learn anatomy in different ways. Most adopt a style that is the result of several attempts to develop a successful strategy, in terms of outcome for assessment, and that leads to a consolidated body of knowledge that can be applied successfully in a clinical context. This takes time, and it may not be until well into a second semester that the most successful strategy is identified. Application of the knowledge acquired may have to wait until the clinical phase of the course. Assessment drives learning for a subject like anatomy like no

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Fig. 3.1 "The Anatomy Lesson of Dr. Nicolaes Tulp" (1632) by Rembrandt showing the learning style of students around the teacher and the cadaver, peering at a textbook

other, and the overriding concern of students is that they can master the body of knowledge, the successful outcome of which, in their view, is good marks in any assessment. However, you can tell more about how much students are learning by the questions they ask than by the answers they give [2].

Deep or Superficial?

Many students aim only for superficial learning as they often leave the learning until assessment time is approaching: deep learning is a style adopted by a smaller minority of students. But it is the aim for any educator to lead his or her students to just such an appreciation of their subject, and in any event this leads to a lifelong acquaintance with the subject and therefore a repository equipping for clinical practice.

How Do Students Work in Anatomy Classes?

Group Dynamics

Some students prefer to learn in groups, so they are comfortable in traditional dissecting room work. Equally, some students prefer working in pairs, trios, or even larger groups in prosection-based courses where they find that their preferences are catered for in such environments. In such groups, a hierarchy often exists with a leader who calls the tune. Challenge is a means by which all are enticed into learning, even if this is superficial in the first encounter. These small groups are informal, often "teacher-absent" and safe environments for learners to try out their newly acquired knowledge. Collective wisdom is often employed to determine the understanding of a particular topic.

Individualists

Some students work happily as individuals, rarely turning to their peers for help. This may be because they do not trust others, that they believe that there is no advantage to be gained from collaboration or teamwork, or that they are unprepared for the medical school experience, one not previously encountered prior to entry.

Maturity in Learning

Often graduate students will approach anatomy irrespective of their prior knowledge with a degree of professionalism that is not only impressive but indicates a strategic approach to learning. In other words, they take the material presented very seriously and aim to "do it properly," something that less mature learners sometimes fail to do.

Career Choice

Some students of anatomy have already decided that they wish to pursue a career in surgery; thus, acquiring knowledge of anatomy is a step they take with relish. In any event, students who appreciate the competitive career pathway of clinical medicine will take every opportunity to get to grips with their learning and to ensure that their future career choice remains open to them or even be enhanced.

Self-Help Groups

Some learners prefer to study in their own time away from scheduled classes. This may involve self-help groups that develop in student residences. This style is often effective for much of the curriculum, but it does not allow the benefits of the dissection-/prosection-based material to illustrate topics. However, while that may have once been true, easy access to online material, podcasts, etc., means students are able to view images, illustrations, and guided texts whenever they wish, whenever they need. Many students bring laptops or iPads into lectures so that they can access material to facilitate their learning. Indeed, they expect such material to supplement the material supplied by staff. Often students entering higher education for the first time struggle with the style of the lecturer as they are not aware of the best strategy to benefit from what is offered. Learning from lectures therefore is something that depends in part on students' prior experience.

How Does the Topic Affect Anatomy Learning Style?

Different topics in anatomy lend themselves to particular approaches. Some topics are theoretical, for example, the autonomic ganglia in the head. Embryology is another theoretical subject, even though it has obvious benefits in understanding topographical anatomy if the learner is persuaded to persist. Working out the movements of a joint is an example of where a problem-solving approach in a group offers opportunities to encourage collaborative thinking and for learning team dynamics. Learning topics such as the brachial plexus is aided by practical activity such as model making. Surface anatomy is aided by recourse to body painting provided students are agreeable to this.

What Is the Optimal Learning Environment for Anatomy?

Setting the Tone

The environment of the learning space, whether a dissecting room, a prosection laboratory, or an IT classroom, should be stimulating. There is evidence that the learning approach is influenced by the learning environment set by the teacher. For example, in science classes in a range of Australian universities where teachers describe their approach to teaching as having a focus on transmitting knowledge, students are more likely to adopt a surface approach to the learning. In classes where teaching staff utilize approaches to teaching that are more student oriented, students adopt deeper approaches to learning [3].

The Essence of Good Teaching

Good teaching should entice students to explore and to find out for themselves rather than to be the empty vessels awaiting fill from their erudite teachers. This latter approach offers a learning style that is nonnegotiable as it is ultimately only through the self-directed efforts of any learner that any learning takes place at all. Many students have stood around a demonstrator in a dissecting room session listening to the oratory, and however powerful, much is lost as the pace proceeds on to new topics. The penetration of the talk in anatomy demonstrations is quite superficial and can only be seen as a source of guidance for further study. Ideal learning will best take place where students have time to spend examining this material for themselves independently of the demonstrator. This will enable them to consolidate the information, hard won that it often has proved to be. Engagement of learners with learning material is also a requirement for education to take place, and any learning environment that does not cause such engagement fails to bring about the intellectual processing necessary to advance understanding and thence to be able to apply the knowledge.

Study Guides

Clarity in purpose is a prerequisite for any effective learning to take place, irrespective of learning style. For example, guided reading or study guides are very helpful not only in defining the scope of what is expected of student learning, but they can also offer opportunities to lead students though pathways designed to stimulate learning. It can prescribe the examination of prosected material or imaging material, for example. It can ask questions of students so that appropriate learning can be emphasized. It can direct additional reading that is required to complete a learning task. These additional resources have to be designed to be usable by the different learning styles students may utilize.

How Does Assessment Drive Learning?

Any assessment tool must be constructively aligned to the teaching style. In other words, in a program of study where there are elements of practical work, where students are expected to learn to identify structures, their assessments must also be designed in such a way as to test the knowledge that has arisen from the practical examination of the learning material. It would be inappropriate to test knowledge in ways that do not reflect the ways learning has taken place.

How Do Learning Styles Impact on Anatomy Teaching and Learning?

Learning Styles

Work on learning styles has been based on the theory advanced by Kolb [4] and further advanced by Honey and Mumford [5] who suggested that learners utilize four distinct styles or preferences. Thus, individual learners may be categorized by the way they approach a learning task as either “activists,” “theorists,” “pragmatists,” and “reflectors.” If learners understand their own learning style, it will greatly assist their learning of any particular topic. In tackling their studies, it ought to prompt the student to specifically use his or her style of choice, but it also should prompt the learner to utilize other styles too, as they seek to extend their repertoire. Indeed, changes in learning styles of medical students have been demonstrated over time and in relation to different types of curricula [6]. Students from three different medical schools were surveyed using Kolb’s Learning Style Inventory over 2 successive years with either problem-based learning or integrated or hybrid curricula. Significantly, a change in learning style was observed over the

2 years in greater than 40 % of the students in all three curricula.

Style Categories

Activists are those who prefer to learn by activity such as brainstorming or problem solving. They derive much from group discussions or role play and are keen to explore new learning experiences. In contrast, theorists examine the theory underlying observations, actions, or presented information. They are systematic about their studies. Pragmatists are practical people, equally comfortable with experimentation to find a suitable resolution of a problem. They enjoy examination of case studies and will positively involve themselves in problem-based discussions. Reflectors take time to come to conclusions. They need to think about the observations they have made and allow time to consolidate and place these thoughts in a developing framework. They benefit from feedback from others in this process. They are keen participators in observational learning opportunities. Often these students are those that are quiet and are not among the first to offer explanation, theories, or answers in a group situation; and prefer to reflect on what has happened before making a contribution. They may prefer to work on their own or in pairs rather than in the group as a whole.

Predominance of Styles

In a survey among first-year medical students at one UK medical school, the learning style of "reflector" was found to be dominant (40 %) [6]. Over 50 % of the students changed their learning style to "activist" during the course of their studies in the year. This accords with the findings of the survey of medical students studying physiology by Gurpinar et al. [7] in which, significantly, "theorists" achieved higher results in the end of year examination. In a different study, of Pakistani undergraduate medical students [8], 45 % were categorized as "activists," whereas in the population of postgraduate medical students studied, 38 % were "reflectors" and 35 % "theorists." The least common learning style was "pragmatist" among both undergraduate and postgraduate students. These differences in categorization may have as much to do with cultural influence as learning style per se (vide infra).

Identifying Learning Style at Admission

Medical learners are significantly different from the general population in several key learning characteristics, including sensing and judging dimensions as assessed by a type of the Myers-Briggs test [9]. Significantly, their academic success was correlated with various learning styles, principally multimodal, visual, and kinesthetic. Thus, it is clear that account should be taken of the characteristics of students and the style they are likely to employ. Consideration should be given to this as a part of the admission process.

Learning Styles in PBL Curricula

In problem-based (PBL) curricula, students use a variety of learning styles [10] where more self-regulation of learning content is observed and hence development of greater self-confidence can be expected. In a nursing masters PBL course, students changed their learning style, as their confidence grew [11]. In a study where students were categorized as either "activist," "reflector," or of "no specific preference" [12], the "reflective" group showed the best outcome in participation, and the "no preference" group showed the best teamwork in a PBL setting. "Activist" learners had the lowest score in any of the areas tested. Thus, grouping students according to their learning styles may be a useful way of promoting specific learning outcomes.

How Does Culture Affect Learning Style?

The learning preferences of United Arab Emirates University medical students [13] showed students preferred teacher-structured learning experiences dealing with concrete and applied tasks rather than abstract tasks. This cultural influence accords with the work of Mitchell et al. [14] who demonstrated distinction between the learning styles of Chinese and British medical students in their anatomy learning, attributing the differences to cultural influences. Similarly, the impact of culture on learning activities was evident among Jordanian and Malaysian medical students in their use of different anatomical resources [15]. These differences in learning styles are important factors in designing lectures and practical activities for student cohorts which incorporate multinational learners. Especially in times where recruitment drives attract international students, whose cultures are very different from home-based students, more account should be taken of this in selection of pedagogic approach so as to avoid disadvantaging some students.

Learning Styles in Other Contexts

Insight from Other Disciplines

In postgraduate hospitality industry education, it has been argued that a didactic approach is not sufficient on its own and that learning tasks need to play to the individual's learning style where possible [16]. A gender difference in learning style in medical undergraduate physiology has been demonstrated [17] where a majority of male students preferred multimodal instruction; in contrast, a majority of female students preferred single mode.

Insight from Other Professional Education

In a different healthcare profession and studying a different topic (substance abuse), the influence of learning styles preference of undergraduate nursing students was evaluated [18]. "Reflector" learning styles preference was the dominant learning style among the majority of undergraduate nursing students.

Style Affecting Choice of Resources

Choice of type of learning resource is influenced by learning style [19]. First-year osteopathic students who utilized online educational resources described their learning styles as "active," "intuitive," "global," and/or "visual." They were more likely to use such material than those who categorized their style as "reflective," "sensing," "sequential," and/or "verbal."

Use of the VARK (an acronym for visual, aural, kinesthetic, and reading/writing learning styles) inventory [20] has shown that visual learners have a preference for learning through seeing; thus, use of visual aids in lectures would be good examples where this type of learner would be facilitated. Anatomy lectures are by their very nature presentations where photographs and diagrams are often used to explain concepts or details. Auditory learners learn through hearing, examples of which also include use of lectures, but from a different perspective. This serves to emphasize that use of lectures can serve more than one type of learner, and where more practical activity could be incorporated to aid tactile/kinesthetic learners, this only adds to the utility of the lecture approach. Indeed, the preference of the latter type of learner for more practical activity would be well served in gross anatomy practical classes, especially where there is opportunity to examine prosected material or to dissect. In preparing, classes' teachers can consider these aspects in developing their presentations.

McCardle [21] suggests that learners can also be categorized as confident, affective, transitional, integrated, or risk taking.

To Do

- Identify an anatomical topic for a group of students to learn.
- Think of the different learning styles of your students.
- Devise a range of appropriate activities.

Confident learners prefer tasks that have clear aims. Indeed, they may prefer to set their own goals, deciding the direction of their learning and progressing at their own pace. Confident learners may work faster than other students in their cohort, a fact that teachers need to take account of. Group practical work and tutorial opportunities where there is opportunity for discussion in anatomy work well for confident learners.

Affective learners are influenced by their feelings and need reinforcement in their learning, at least by their peers, if not their teachers. They regard their lecturer as an expert for the source of all wisdom and are influenced by him or her. This type of learner is encouraged in learning activities that positively reinforce the process by which they expand their knowledge base. Teachers of this type of learner will recognize that these students strive to fulfill expectations placed upon them.

Transitional learners tend to focus on the particular type of information they are learning and on how that it can be applied. They are happy putting pieces together when to fit in their world at their own pace. Transitional learners may need assurance as they learn.

Integrated learners establish peer-like relationships with their lecturers. These learners know where they want to go, enjoy being responsible for their own learning, and don't need too much guidance. Integrated learners want to use the information they receive; thus, practical exercises or explaining a clinical context facilitates these learners. Working with these learners needs sensitivity on the part of the lecturer.

Risk-taking learners thrive on new learning opportunities, both practical and theoretical. Risk-taking learners will stray from course guidelines and their previous learning practice to gain new knowledge and welcome the opportunity for interactive exercises. These learners will often succeed in the end, even in the face of consternation by their lecturers.

Multiprofessional Perspectives

The learning accomplished by multiprofessional groups of students from across the healthcare disciplines, including medicine, physiotherapy, radiography, nursing, midwifery, and biomedical science, varies, as adjudged by their assessment performance [22], largely according to the professional specialism of the students and their teachers. The culture of the profession required different levels and approaches to the subject of gross anatomy, and this posed challenges for the teachers to ensure that all students were facilitated in their learning and provided with useful information for their subsequent education. Nonetheless, it proved possible to engage the majority of learners, irrespective of their professional program by use of study guides, diagrams, and support for tutors of different professional learners. Despite this, assessment

What Will You Do?

- You are designing a practical session for a class of medical students. You have a tutorial lasting 45 min to plan in which the students will tackle an activity that will aid their learning.
- Describe the anatomy of a region or of some aspect of a body system. An example might be the brachial plexus. You need to think of activities that will enable students to meet their learning outcomes and reflect their particular style of learning. Thus, one activity could be model making; another could be to design a chart; another subgroup could focus on investigating the effects of lesions of the different parts of the plexus and their clinical consequences. Another could discuss the formation of the plexus and draw a whiteboard diagram.
- In these various ways, you have designed a multitask activity that enables the group to function in subgroups and offers the opportunity to change to another activity. This means that particular learning style preferences can be catered for and offer opportunities to learn how to handle a change in style and appreciate any benefit this might bring.

results indicated that those students who perceived that anatomy was a more important subject scored more highly.

Conclusions

The author's experience of how students learn anatomy has been described. In devising anatomy courses, account should be taken of individual student learning styles in anatomy teaching and learning as this will enhance the student experience and facilitate deeper learning. Students learn in different ways: some individually but more often in collaboration. Assessment drives learning, though whether this always encourages deep learning may depend on the student. Design of anatomy curricula ought to take account of learning style so that the optimum learning environment is offered, as well as the opportunity for students to try out different styles, as their style may change over the duration of their studies. The optimal environment for anatomy learning is discussed.

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4 Constructive Alignment: An Outcomes-Based Approach to Teaching Anatomy

John Biggs and Catherine Tang

Outcomes-Based Education and Outcomes-Based Teaching and Learning

In order to improve the quality of student learning, we advocate a form of outcomes-based education. But first, we need to make an important distinction between two kinds of outcomes-based education.

The first refers to broad institutional outcomes, such as averaged student performances, that are used for such purposes as quality assurance, benchmarking, accreditation requirements, and the requests of external stakeholders like employers and policymakers [1]. The question here is for administrators: "How well is the institution performing in relation to its own mission statement and performance indicators and in relation to other institutions?" There is no *necessary* connection here between these externally driven managerial concerns and the quality of the teaching that supposedly produced those outcomes.

The second kind of outcomes-based education is intended directly to improve student learning, so we refer to it as "outcomes-based teaching and learning," which addresses the learning outcomes that students are expected to achieve at both program and especially course levels. The question here is for teachers: "What do I want my students to be able to do as a result of their having learned specified topics?" The intended outcomes not only nominate the topic content but additionally what the student is intended to do with that content. The intended outcomes for any given course may be determined by the individual teacher or the teaching team, together with any relevant external input.

Once the outcomes have been defined, teaching should be designed to engage students in learning activities that are likely to achieve those outcomes. Assessment then addresses how well those outcomes have been achieved by students and is therefore criterion referenced. Such assessment is best achieved by rubrics or statements that specify the standards for different levels of student performance. Assessment tasks should also allow for any unexpected or unintended but desirable outcomes. While unintended but desirable outcomes cannot be specified in advance, they can be allowed for by asking students to place any evidence they think appropriate for their achieving unintended outcomes in a portfolio that is submitted for assessment. In outcomes-based teaching and learning, students should not be assessed according to how their performances compare with each other and then graded according to a predetermined distribution such as the bell curve.

These issues of linking teaching and assessment to achieving the intended learning outcomes

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(ILOs) are specifically addressed in the version of outcomes-based teaching and learning known as constructive alignment, as discussed below.

Constructive Alignment

Some years ago, Thomas Shuell summarized the implications for teaching and learning of cognitive psychology thus [2]:

> If students are to learn desired outcomes in a reasonably effective manner, then the teacher's fundamental task is to get students to engage in learning activities that are likely to result in their achieving those outcomes.… It is helpful to remember that what the student does is actually more important in determining what is learned than what the teacher does.

Embedded in this seemingly obvious statement is a powerful design for teaching that draws on two important principles:

- Knowledge is not transmitted by a teacher but is constructed by students through their own learning activities.
- The intended outcomes of teaching need to be stated upfront, and teaching methods and assessments need to be aligned to what those outcomes require if they are to be met.

These principles are the basis for constructive alignment [3, 4]. Constructive alignment is a form of outcomes-based teaching and learning in which both teaching and assessment are aligned to the ILOs, which specify what the student is expected to do with the content taught. The traditional topic-based curriculum only specifies what content the teacher is to address.

Accordingly, the ILOs need to state not only what the student is intended to learn but how, to what level, and in what context. Thus, if the topic in question is the anatomy of the upper and lower limbs, the learning outcome focuses on what the student is supposed to be able to do with that anatomical knowledge, for example, to *list* the muscles, bones, joints, nerves, and blood supply to the limbs or at a higher level to *explain* how the different anatomical components work and coordinate to produce movement or higher still to *predict* what functional disability will result from a specified injury to a certain part of the anatomy and to *design* a management program or a treatment protocol for such an injury. Thus, the student will not only *know about* the anatomy of the upper and lower limbs but be able to act properly on the basis of that knowledge—which is after all the purpose of professional education.

Good teachers have always taught with a view to what students should be able to do after being taught and how well they should do it—that is one reason why they are good teachers. In constructively aligned teaching, we simply make this explicit.

These verbs in the ILOs are used to prescribe the teaching/learning activity (TLA) the students need to engage in order to optimally achieve the outcome. If the ILO refers to *explain* the functioning of the musculoskeletal system, the TLA would require the students themselves to explain how the system functions, say to another student or in a presentation, not just to listen and take notes from a teacher who is doing the explaining.

The assessment task in turn addresses that verb in the ILO; if the verb is e*xplain*, the assessment is in terms of how well the explanation is carried out. Often, the most appropriate assessment task is the TLA itself, making alignment perfect. This is the case in problem-based learning (PBL), in which the ILO is solving a particular professional problem, the teaching/learning activity is solving the problem, and the assessment is how well the problem is solved.

High-level verbs in the ILO, such as *hypothesize*, *reflect*, *solve unseen problem*, or *create*, leave the outcome quite open. In that case, the assessment task needs to allow for the unexpected, as does an assessment portfolio.

Several writers have mentioned the utility of constructive alignment in teaching different subjects: computing science [5], earth sciences [6], designing e-learning [7], engineering education [8], health sciences [9], plant physiology [10], physiology [11], social work [12], statistics [13], teacher education [14], and veterinary sciences [15]. Typical advantages of using constructive alignment referred to in these studies include:

- Students being able to focus more effectively on the key learning goals
- Fairer and more reliable assessment
- Improved learning outcomes, including critical thinking and depth of student work
- Greater transparency leading to easier and more accurate interuniversity and international comparisons
- Greater coherence in programs and more effective evaluation of modules and courses

The major disadvantages refer to staff and student workloads. The major staff workload is in the initial transition from traditional to constructively aligned teaching, while that for students is often self-inflicted—they work harder in constructively aligned courses.

The principles of constructive alignment are used as frameworks for quality assurance agencies in the UK and Hong Kong [16]. Edström [17] writes: "course evaluation should be regarded as a component of constructive alignment, together with the ILOs, learning activities and assessment." Constructive alignment is widely regarded as a key idea on postgraduate certificates in higher education [18].

There are three main stages involved in applying constructive alignment to the teaching of anatomy: designing the ILOs, designing the teaching/learning activities (TLAs), designing and aligning assessment tasks (ATs), and obtaining a final grade.

Designing the Intended Learning Outcomes (ILOs)

ILOs contain a content topic or topics, action verbs that help specify the level of performance the students are expected to achieve, and a context for the learning to take place. Verbs such as *identify*, *name*, *describe*, *explain*, *predict*, *plan*, *design*, *hypothesize*, *generate*, and *create* are examples of increasing levels of understanding. Thus, to use the verb *understand* itself in an ILO is inadequate because it does not identify the kind or level of understanding required. The ILO verbs give students a clear signpost as to what and how they are to learn and on which they will be assessed. Ideally, there should be no more than five or six ILOs for a one semester course.

The SOLO taxonomy [4] provides a useful guide in deciding the levels of understanding or performance. The first two levels, *unistructural* and *multistructural*, see understanding as a quantitative matter of *knowing more*. The next two levels focus on qualitative changes as understanding deepens. At the *relational* level, students are able to *put things together* by interrelating the multiple aspects to create a structure, while at the *extended abstract* level, students are able to go *beyond the given* and take the argument or application of a principle to a new dimension. When writing ILOs, teachers need to decide what levels of understanding or performance students are expected to achieve and clearly indicate those levels by the ILO verbs. Other taxonomies such as the Bloom taxonomy may also used as a source of verbs, but we have found SOLO more useful as it provides a hierarchy of levels of understanding.

Let us take the example when students are learning the anatomy of the upper and lower limbs. Some of the relevant ILOs could be for the students to be able to:

1. *Identify* and *name* all the muscles, bones, ligaments, joints, nerves, and blood supply to the upper and lower limbs.
2. *Describe* the origin, course, and insertion of the muscles in the upper and lower limbs.
3. *Describe* the courses of the nerves and blood vessels in the upper and lower limbs.
4. *Explain* how movements are produced in the upper and lower limbs.
5. *Compare* and *contrast* the mobility and stability of a ball and socket joint and a hinge joint in relation to their anatomy, using the shoulder joint and the knee joint as examples, respectively.
6. *Predict* what functional disability will result from injuries to a particular anatomical structure of the upper and lower limb.

These ILOs are generic and only meant here to serve as examples: readers will need to design their own (see To Do below).

To Do

- Consider a topic in anatomy that you are going to teach. Design up to 5 ILOs that you intend your students to achieve.
- We will return to these ILOs in later exercises.

When designing ILOs, teachers need to consider the context within which the course is being taught, the aims of the course, the level of the course, the target students, the reasons for which they are taking the course, and the needs of the profession which the students will be engaged in after graduation. Where clinical applications are desirable, ILOs might contain verbs such as *assess*, *diagnose*, *plan (management/treatment program)*, *implement*, *make a prognosis*, and *evaluate*.

Apart from the ILOs that are specified in the curriculum, there may well be outcomes that are a positive outcome of teaching but that weren't intended by the teacher. Teachers need to allow for such unintended but desirable outcomes with open-ended assessment tasks so that the students themselves may provide evidence of such outcomes.

Designing the Teaching/Learning Activities (TLAs)

Teachers need to design activities that will engage students in activating the ILO verbs. The traditional lecture usually provides a one-way transmission and teacher-centered mode of teaching, with little opportunity for student engagement. If students are expected to *explain* how movements are produced in the upper and lower limbs, it is insufficient for the teacher to explain this in a lecture for here the students are not engaged in explaining but in listening, taking notes, and perhaps asking a question. For the students to achieve the ILO *explain*, they need to do the explaining themselves if that is what it is intended that they should be able to do.

Take the example in the previous section when students are learning the anatomy of the upper and lower limbs; to be able to explain, students can acquire the background information from books or other sources, doing dissection in anatomy lab, and then engage in *explaining* to fellow students—in pairs or in a group in class—on how movements are produced, say by using a model skeleton, by pulling on the muscles on a dissected cadaver in the anatomy lab, or by drawing a concept map to explain how the various anatomical components work in producing movements. An assignment would allow the students to explain in written form. These are some aligned TLAs for the ILO *explain*, and teachers can decide on the appropriate ones that would suit the particular teaching sessions.

A higher-level ILO might require students to *predict* what functional disability would result from injuries to a particular anatomical structure of the upper and lower limb. Again, students need to do the predicting themselves. Students doing background reading on relevant information, discussing with fellow students, role-playing the resulting disability, or working on a case study are aligned teaching and learning activities for the achievement of the ILO to *predict*.

Aligned TLAs can be conducted in large or small class situations and can also be either managed by the teacher or students or as self-learning activities, consistent with available resources. There are many suitable TLAs other than lectures and tutorials.

To Do

- Select one ILO from the list you have written in the previous section. Design some TLAs that would engage your student in achieving the outcome.
- When designing these TLAs, you may consider what you need to do as a teacher, but it is more important to consider what your students will be required to do themselves.
- You will also need to consider any required and available resources to implement those TLAs.

To Do

- Using the same ILO that you have designed TLAs for in the previous exercise, design ATs that would be appropriate to assess the student's achievement of that ILO.
- When designing these ATs, you may consider first whether the TLAs used would be appropriate for perfect alignment.
- Also consider any required and available resources for implementing these ATs.

Designing and Aligning Assessment Tasks (ATs)

Assessment tasks (ATs) for a given ILO or set of ILOs are aligned to the target ILO(s) by presenting the student with tasks that require them to enact the verbs in the ILOs—or closely related ones—and provide evidence of the level of performance that they have achieved. The best form of alignment is where the TLA is itself the assessment, as in problem-based learning. There are two steps in designing a suitable assessment task:

1. Selecting a practicable task that embodies the target verb
2. Judging how well that task has been performed

In designing ATs, we need to select practicable tasks that embody the target ILO verb(s), taking into consideration the workload for the teacher and students and the available resources in implementing the tasks. The invigilated examination provides a very restrictive assessment environment that will very likely not be able to address many ILOs, especially the higher-level ones.

Take the two ILOs that we have been using: "*Explain* how movements are produced in the upper and lower limbs," and "*predict* what functional disability will result from injuries to a particular anatomical structure of the upper and lower limb." A written assignment, an oral presentation, a concept map, and a case study are all possible and aligned ATs. Where the TLAs are the assessment tasks, alignment is perfect.

In outcomes-based teaching and learning, assessment is criterion referenced. Student performances can be assessed by judging them against established grading criteria or rubrics, instead of the more usual practice of marking quantitatively by accruing marks bottom-up. In constructive alignment, the logic of assessment is holistic, not analytic. The sample rubrics in Tables 4.1 and 4.2 enable the whole to be assessed and awarded a qualitative assessment category, such as A, B, C, or D. However, for logistic purposes such as obtaining a final grade, a quantitative scale can be allotted to each category or subcategory (see section "Obtaining a Final Grade").

These criteria are made clear prior to the assessment process to all parties involved in assessment, students, teacher, and any other parties such as the assessment panel or external

Table 4.1 Example of rubrics for *explain* (this is only a generic example. Rubrics for "explain" in a particular content need to be developed in context)

	Subgrades (scale score)	Evidence
A	A- A A+ 3.7 4.0 4.3	As in "B" but also provides views on possible alternative causes and/or results depending on changes of conditions Able to link current reasoning to situations in real-life and/or professional contexts
B	B- B B+ 2.7 3.0 3.3	Able to identify a full range of relevant points with details. Support by relevant literature Points are organized to provide a comprehensive and cohesive reasoning or causality
C	C- C C+ 1.7 2.0 2.3	Able to identify a number of relevant points with some details Use these points to provide a fair reasoning of causality, but little or no evidence of a comprehensive overview of reasoning or causality
D	1.0	Able to identify and briefly write about limited points Very little evidence of using these points to provide reasoning to why they are interrelated
F	0.0	The information is sparse and is mainly inaccurate Explanation lacks relevant reasoning or is based on irrelevant information

Table 4.2 Example of rubrics for *predict* (This is only a generic example. Rubrics for "predict" in a particular content need to be developed in context)

Grade	Subgrades (scale score)	Evidence
A	A- A A+ 3.7 4.0 4.3	As in "B" but also provides a comprehensive and holistic view on how and why the prediction has been made
		Able to provide possible implications of prediction to situations in real-life contexts
		Evidence of attempting to provide suggestions for intervention to amend or counteract any possible adverse effects as a result of the prediction. In the case of medical and allied health students, this may be suggestion of any possible management or treatment programs (the merits of which need to be considered in relation to the level of study of the students)
B	B- B B+ 2.7 3.0 3.3	Prediction is accurate and realistic
		Able to identify a full range of relevant points to support the prediction
		Evidence of integrating the details in a cohesive manner with some evidence of a comprehensive overview of various factors or reasons leading to the prediction
C	C- C C+ 1.7 2.0 2.3	Prediction is largely accurate
		Able to provide some details of relevant information to support the prediction
		Evidence of providing a fair reasoning to support the prediction but little or no evidence of a comprehensive overview of various factors or reasons leading to the prediction
D	1.0	Prediction is incomplete
		Able to provide limited information
		Very little evidence of using the information to support the prediction
F	0.0	Information is sparse and mainly inaccurate
		Prediction is inaccurate and irrelevant to the context given

assessor. Examples of rubrics for assessing the two ILOs for *explain* and *predict* are provided in Tables 4.1 and 4.2, noting these are generic examples and such criteria need to be developed in the context of the content area and the discipline concerned.

Traditionally, the teacher has been the sole party responsible for assessing and grading the student performance. Research has shown that students could be involved in the assessment process [19, 20]. Students assessing their own work (self-assessment) or assessing their peers' work (peer assessment) can be used as a TLA or an AT. To be able to assess either their own or their peers' work, students need to be very clear beforehand about the ILO(s) that the ATs address and the criteria with which the performance is to be assessed, thus reinforcing their own understanding and enabling them to better achieve the ILOs. Making a judgment about whether a performance meets the given criteria is vital for reflective professional practice, when professionals need to judge their own and their peers' performance and to identify how their performance can be improved. These are important lifelong learning skills that many professionals say are most lacking in their undergraduate education [21].

Obtaining a Final Grade

Individual assessments of a student's different performances need to be combined to form a final grade for the course. Qualitative assessments can be converted into a number scale that can then be dealt with arithmetically to yield a final grade. Thus, in Tables 4.1 and 4.2, a quantitative number may be allocated to each category and subcategory: thus, A+ is given 4.3, A 4.0, and A− 3.7. There is a larger gap across categories than within categories: B+ is 3.3, that is, 0.4 difference from A− rather than 0.3 as within categories (these figures are taken from the policy of one university). The final grade can thus be determined by averaging these figures, and when the average has been computed, it can be converted back to the nearest letter grade.

To Do

- Now try to develop rubrics for the ILO that you have selected and used in the previous exercises.
- If you have selected the same ILO that we have used in this chapter (explain/predict), you will need to consider how the sample rubrics need to be modified to suit the content and context of your teaching.
- You will also need to consider any required and available resources to implement them.

Alternatively, it is possible to derive an *a priori* system by which the final grade is awarded according to a predetermined pattern of letter grades. For example, the final grade of A is awarded if most other performances are A grade with none lower than B; a similar procedure is sometimes used to award the class of honors in an undergraduate program.

If a pass/fail system is used, then the teacher needs to decide what minimal levels of outcome are needed to meet the particular professional requirements.

Conclusions

We have outlined here a design for teaching that is eminently suited to teaching anatomy. Clearly, the statements of ILOs will be specific to a particular course and the purposes for which it is being taught. We have given examples of TLAs and ATs for two different ILOs, *explain* and *predict*, in the hope that readers will be able to construct their own ILOs and align suitable TLAs and ATs to them. Further details about the theory, and examples of implementation of constructive alignment from several disciplines, are available [4].

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5 Competencies for Teaching Anatomy Effectively and Efficiently

John F. Morris

Introduction: "What Is Needed, When It's Needed"

The ideas and suggestions put forward in this chapter are the result of about 40 years of "teaching" anatomy to medical and science students, first in Bristol then in Oxford. This has involved both school-leaver and graduate-entry medical students, the training of demonstrators for practical classes and—when asked or required for validation—guidance for junior lecturing staff, and numerous postgraduate courses. In both universities, the undergraduate medical courses have had the traditional arrangement of a preclinical followed by a clinical component, the former based in primary university facilities and the latter in hospitals. Those with extensive experience of "integrated" courses may disagree, but I suspect that the fundamental principles I shall attempt to outline are universal. What is more, it is essential that the "preclinical" parts of a course have a clear understanding of what the "clinical" parts will expect and that many of the illustrations used in "preclinical" teaching are of a clinical nature. The reverse should also be true but in practice seems to be harder to achieve.

"Teaching" in its widest sense is not something that is done *to* the students or staff, but rather "helping students or staff to understand and learn," i.e., a much more interactive educative process. What this means is that there is not a single group of competencies involved—they will differ for school-leavers and graduates; they will differ for the high fliers and for those who find themselves struggling; they will differ at different points in the course. The first competency is therefore to assess carefully what it is that the students need to understand and to learn *at any particular point in their course* and to tailor what is offered to that need. This of course implies an understanding of the entire course; one common failing in busy teaching staff, pressed hard to produce innovative research, is that they think of their contribution in isolation rather than as part of a continuing course and intimately related to what went before and what will come after. This is where strong course committees can help.

> The first priority is to assess what students need to understand and to learn at any particular point in the course and to deliver that material effectively.

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Gross Human Anatomy Is the Product of Evolution and Development

The gross anatomical structure of an adult is the result of a process of development and can only be understood properly if that development is also understood. It is also a product of a long evolutionary process, and the understanding of many parts of anatomy is facilitated when its evolution is considered. Without these two backgrounds, gross anatomy becomes simply a descriptive exercise. An essential competence for teaching anatomy is therefore a clear understanding of the development and evolution of the human body, even if that background material is not presented to the students with the gross anatomy. Students will often ask “why is it like that?” of some curious item of anatomy. Only with that background knowledge will teachers be able to give a reasoned explanation.

> Staff involved in teaching gross anatomy must acquire a clear understanding of those aspects of the developmental process and evolution that has led to the anatomy of modern humans.

Anatomy Is Both a Science and a Preparation for Clinical Medicine

Both science and medical/dental courses will require a sound understanding of the general principles involved in the organization of the human body. For both, gross anatomical structure is part of a continuum that stretches through microscopic and cellular to molecular structure. Whereas a science course can deliver the understanding of general principles without dealing with every part of the body, a medical course should arguably give a comprehensive cover, particularly because some details irrelevant to anatomical science are of considerable clinical significance (e.g., the surface projection of the fundus of the gall bladder, the position of the great saphenous vein in relation to the medial malleolus). Arguably science courses may wish to devote more time to the understanding of developmental mechanisms and evolutionary processes and their interrelationships.

> Anatomical teaching material should be designed specifically to achieve the somewhat differing requirements of medical and science courses.

Medicine is, of course, underpinned by science, which needs to be understood early on. For this reason, gross anatomy is often presented in the first year of medical courses, well before students in many courses will spend much time in clinical studies. To address this problem, undergraduate anatomy education in the Oxford medical curriculum is provided in two separate courses. The first-year course concentrates on scientific aspects, linked with histology, development, and genetics and is presented on a *systematic* basis to complement systematic studies of physiology and biochemistry. At the end of the third preclinical year and just before clinical school, students undertake a 3-week, full-time “Principles of Clinical Anatomy” course, which has a more *regional* approach. This course refreshes year 1 material but in particular focuses on aspects of anatomy needed for examination, diagnosis, and simple procedures that students will shortly encounter. Of course, year 1 students find that understanding and learning are motivated and easier when examples of clinical dysfunction are presented. The same is often true for science students.

> If possible, the teaching of scientific aspects of gross anatomy should come early in a medical course; specifically, clinical aspects should be positioned close to the clinical components of the course.

Anatomy Teaching Works Best if It Starts with Function

One of the principal concerns of students (and junior staff) is that "anatomy has an overwhelming amount of detail to learn," and it is true that a huge amount of detail is now available. However, anatomical structures in general have evolved to fulfill certain *functions*. It is my experience that starting with the function of an anatomical element, analyzing what that function involves, and then discussing only the amount of detail of the gross structure, histology, molecular structure, etc., that is needed to explain that function is the best way to overcome this problem. If one tries to progress in the opposite direction, *from* the structure *to* the function, the question remains what of the mass of our present detailed knowledge of the structure do the students really need; which should they concentrate on? In clinical practice, students and staff will be presented first with some dysfunction and will then have to explain and diagnose what is wrong in terms of disordered structure, physiology, or development.

> Always start by considering function; present only such anatomical detail as is required to understand normal function and common dysfunctions.

Anatomy Teaching Should Stress Understanding and Concepts Rather Than Individual "Facts"

As already noted, there is a potentially overwhelming amount of anatomical "facts." The danger is that these are taught/learned as separate items, to the detriment of understanding of real functional anatomy. A good example is the presentation of somatic muscles. Often they are presented as separate named entities, starting with their origin (arguably in detail the least important fact), insertion, nerve supply, and their "action" (usually only the prime mover function) at the end. In reality, individual named muscles never act alone, but as groups, often with a common innervation from spinal segments and peripheral nerves and often contribute to a variety of different actions. I therefore recommend that it is much better to start with the *groups* of muscles as defined by their functions (e.g., elbow flexors), to give only the information about their attachments that is needed to explain this, and then to spend more time on their peripheral and root nerve supply and where that might be compromised, because this is the most common cause of a localized dysfunction. In my experience, students find it much easier to go from the group (general) to the specific rather than vice versa. Similarly for spinal nerves, peripheral nerves and even major arteries start with the broadest description of what they supply (dermatomes, muscle groups, functional compartments) and only then deal with the specific components. If the essential concepts are well understood, there is much less chance that a detail will be misremembered.

> Start with generalities, groupings of function and supply, and only then go into carefully selected details within those generalities and groupings. Concepts and understanding should have priority over factual detail.

What Detail Should the Teacher Present? "Core" Knowledge

Having acknowledged that in gross anatomy (as in other disciplines) there is a wealth of detail, it is also essential that the anatomy educator enables a graduating medical student to acquire a certain amount of knowledge to be a competent junior doctor. Defining that "core" is a key problem. When designing the "Oxford Textbook of Functional Anatomy" [1], the late Dr. Pamela MacKinnon and I went systematically through gross anatomy and asked at every point "is this piece of detail essential for understanding, or something that they might need to have readily available in their mind to deal with common clinical conditions and especially those that they might encounter in emergencies?" If the detail did not fit either criterion, it was downplayed or ignored. Similarly, a group from the (UK & Ireland) Anatomical Society undertook a similar exercise and produced a “core document” [2]. Of course, in any teaching presentation, it can be very important to present other “non-core” material to illustrate, explain, or provide evidence, but this should always be with reference to the “core” information we wish students to learn and retain.

> Defining an agreed “core” of essential factual knowledge is an important ongoing task because it should determine what is presented and examined.

Gross Anatomy Teaching Should Linked Clearly with That of Tissue, Cell, and Molecular Anatomy

The function of any gross anatomical structure can only be understood if that structure is understood from the molecular level up. Often, and perhaps inevitably, different staff are involved in the teaching of gross, tissue, cellular, and molecular aspects, but this can lead to mental “ghettoization” and makes the task of integration more important. Some of this will be achieved by careful course committee timetabling. However, it is my view that an important competence of any anatomy teacher is to have a sufficient understanding of these non-gross aspects of anatomy that he/she can explain, in simple terms, how the function of the gross structure is determined.

> Gross anatomy teachers should acquaint themselves with a sufficient understanding of the tissue, cell, and molecular structure of the gross structures to be able to explain how that gross structure functions and malfunctions.

Gross Anatomy Should Be Presented in Three Interlinked Ways

Science students may use knowledge gained from anatomy courses in a variety of ways. Medical students, unless they become either surgeons or pathologists, will experience body structure mostly either via surface anatomy or one of the growing numbers of imaging techniques used in clinical practice. Nevertheless, they will need a good understanding of internal structure, and there is general, though not unanimous, agreement that this is best acquired from seeing those structures either by dissecting themselves or as prosections. Knowledge gained from cadavers needs to be linked up with that gained from surface anatomy studied on themselves, their peers, or live models. In Oxford, groups of students in a single class go from the dissection room to a living anatomy room where they are encouraged to disrobe sufficiently to demonstrate the relevant surface anatomy on each other. My doing the same “pour encourager les autres” is of course regularly lampooned in the student revues! But, seriously, students actually need to be encouraged by staff to explore their own bodies; too often schooling has suggested that learning is just about sitting down with books! Cadaveric anatomy also needs to be integrated with imaging anatomy which builds from simple radiological images to CT and MR sections. Increasingly, where appropriate, ultrasound images should also be introduced; I suspect that the rapid development, increasing portability, and advances in image presentation in ultrasound will make this something most doctors will be carrying in 10 years, just as they now carry a stethoscope. It is by combining these three approaches—cadaver, surface, and imaging—that staff can best help students develop a proper understanding of body structure. For students, it is the process of having mentally to translate information from one approach to another that is the key to learning and understanding. It takes a little more time and effort, but it leads to true

> Gross anatomy teaching should combine and integrate the study of cadaveric material, living surface exploration, and the various imaging methods now available.

understanding rather than memorization of the appearance of one- or other two-dimensional images.

Efficient Learning Involves Understanding Rather Than Memorization

> An essential for real understanding and deep learning is that teachers encourage students to study in a way that involves mental translation of information from one format to another.

The process of mental translation that comes from presenting together cadaveric, living, and imaging anatomy can usefully be extended. Students often copy down the words or the pictures from their texts, but this can become automatic and an eye–hand loop can develop which scarcely impinges on the conscious brain! I always encourage students to try to turn a piece of anatomy text they are reading into a diagram and to explain a diagram in words—this really aids deep learning rather than superficial memorization. Much anatomy teaching is by demonstration in the dissection room or in tutorials. For many aspects of gross anatomy, starting with a diagram of the skeleton of a part and then progressively adding whatever aspect is being studied is a helpful technique. During the process, it enables the teacher to ask the student, for example, "Does it go medial or lateral to that bony prominence?" before adding the structure. This all helps students build up a three-dimensional mental image. Students should be encouraged to do the same in their private study and avoid simply copying either text or diagrams. This is a particular problem now that the ability to scan and insert a picture or diagram is so easy. Too often, once the technical feat is achieved the real message of the illustration receives scant attention.

Teachers Must Encourage Directed, Active Exploration

Much of anatomy teaching is practical in nature, and there is much evidence that such active exploration is a real aid to deep learning. However, the exploration needs to be guided. All anatomy teachers probably have a memory of their own student time in a dissection room, when two of the six students were actively involved; two were standing, watching, and waiting for their turn with the scapel; and the other two were chatting about last night's party! Whether students are asked to dissect or to study prosections, clear and specific guidance notes for that class are required. Given the environment in the DR, such guidance is best presented as laminated sheets which can be washed after use; these sheets should not only give instructions but also ask questions that students should be able to answer to a demonstrator. We have found that a similar system works well for the living anatomy component of the class. For the imaging anatomy component, we have found the best method is to produce a set of an appropriate number of clinical images (radiographs, CT, MR, ultrasound) on which are arrowed structures that the students should be able to identify or indicate the action or function. Students in the group are then asked *sequentially* for the answers, which can appear on the screen at a click when the answer is correct. In this way, each student is thinking about all the answers, and the material can be put onto the web-learning system at some point (before or after the class as appropriate).

The more passive format of lectures is of course valuable for the efficient transmission of information, but the same principle of active involvement can be applied in moderation. Teachers can insert

> Anatomy teaching should be designed in such a way that active learning is encouraged and guided both in practical classes and in lectures.

into lectures questions or problems that students are then encouraged either to discuss or to "click" an answer with the technological aids now available.

"What Is Needed, When It's Needed" Means That Anatomy Education Must Extend Far Beyond the Medical Course

Medical courses in England are now the same length as in 1900, but in the intervening time there has been a vast increase in scientific and clinical information. It is therefore not surprising that anatomy—which was a large part of the course in 1900—has found itself increasingly squeezed. This is not entirely detrimental. Indeed, I recall being expected in 1961 to know the 15 branches of the maxillary artery which I can still reel off. The benefit is that courses have been compelled to think what is immediately needful. Anatomy teachers should therefore carefully consider what part of the information in the discipline needs to be presented before clinical qualification and what can reasonably be left for post-qualification. Of course, high-flying students should, at the same time, be encouraged to explore further with the support of teaching staff. As in other institutions, the use of our Anatomy Suite for post-qualification anatomy has increased enormously, and I anticipate that this trend will continue. We provide regular sessions for trainee surgeons in the 5 years after qualifying, and the suite and its materials are used extensively for specialist courses (e.g., in regional anesthesia, ENT, laparoscopy) and to provide facilities for surgeons contemplating new approaches.

> Anatomy education is a lifelong endeavor. Anatomy teaching should therefore carefully consider what material needs to be presented at the various levels of undergraduate courses and what might reasonably be better presented post-qualification.

Whenever It Is Presented, Anatomy Teaching Must Be a "Performance"

Whether delivering a lecture, demonstrating in a practical class, designing some model, or even preparing a website topic or a dissection, one key competence for an anatomy teacher is to be a "performer." Students are now used to the slick productions on the television and the Internet, and teachers can learn valuable lessons on how to engage with an audience. Simply delivering information is not enough! But equally the "performance" has to have substance. Anatomy teachers should consider how to make the information interesting and therefore memorable. It may be a clinical anecdote which illustrates why some small point of anatomy is important. It could be an evolutionary point that explains some anatomical arrangement (e.g., branchial arches). There are many ways to achieve the desired end. Each teacher must work out how they will make the particular topic they are to impart memorable.

> Every anatomy teacher must consider not simply "what information do I need to impart," but "how can I make the imparting of that information an event that will be memorable for the students involved." In that way, the interaction will be effective, efficient, and enjoyable for all concerned.

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Using Teaching Assistants in Anatomy

6

Darrell J.R. Evans

The recent resurgence in the need for and perceived relevance of anatomy in many medical and allied programs has left anatomy departments with a dilemma as there is a relative lack of suitable teachers available to inspire and develop appropriate student knowledge in anatomy [1–5]. Such an issue has been exacerbated by a reduction in the number of clinicians being recruited to anatomy, changes in clinical trainee availability, and the demands of basic scientific research [5, 6]. In response, many anatomy departments have therefore looked closely at the methods they use to teach anatomy to ensure they are efficient as well as effective. Combined with this has been a need to identify those best placed to provide the learning guidance to students. For many, this has resulted in the rise of the teaching assistant.

Teaching assistants have been used for centuries within the field of anatomy, although the assistant has taken on a number of guises. For most, though, the assistant has been exemplified by the junior qualified doctor or resident who intends to follow a career in surgery or radiology and who takes on a part-time or fixed-term role as an anatomy demonstrator [7–10]. It has been suggested that the success of this type of teaching assistant in anatomical education is due to the incorporation of attributes of peer teaching as well as providing opportunities for mentoring students [9, 11]. The revitalized utilization of demonstrators is widely seen as one of the primary and favored methods of providing teaching assistants; however, other departments of anatomy have investigated using alternative sources of teaching assistant. This chapter will outline a number of the ways teaching assistant programs can be integrated within anatomy courses and how such programs can contribute positively not only to student learning but also in the development of knowledge and skills in many of the assistants.

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Examples of the Teaching Assistant

The Traditional Anatomy Demonstrator

The anatomy demonstrator has traditionally been a recently medically qualified individual, with some clinical experience and who is in residency training to be a surgeon, anesthesiologist, or radiologist [8, 10, 12]. Alternatively, demonstrators can be those that are undertaking postgraduate training in biomedically related fields such as anatomy [13]. The demonstrator's participation in anatomy teaching can range from an informal approach using a "drop-in when available" style to a formalized program whereby demonstrators are appointed for a specified period to contribute to an anatomy course and may take on official titles [14]. Positions can have a salaried or unsalaried

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basis and can be an integral part of the teaching assistant's own formal medical or postgraduate training (through residency rotations, elective periods, or defined teaching modules) [13, 15]. Such versatility in the available approaches to including demonstrators as teaching assistants may provide the academic team with enhanced scope when designing anatomy teaching sessions.

The clinically trained anatomy demonstrator is ideally placed to highlight to students the importance of integrating clinically relevant anatomy into their learning, and this is recognized by students they teach [15]. Using such an approach allows students to realize the importance and relevance of anatomy to their later learning and practice. In addition, demonstrators are in an appropriate position to act as role models for students and should be able to exhibit a range of desirable attributes such as leadership, professionalism, and support and can provide opportunities for challenging the ethical awareness of students [14]. If programs are designed so that demonstrators have regular contact with particular students, an enhanced mentor role can develop with demonstrators dealing with pastoral as well as academic issues [8, 16]. Results suggest that students find demonstrators approachable, effective, and reliable and therefore a positive addition to their learning [14, 15, 17].

During tenure as a demonstrator, individuals can be exposed to a range of developmental opportunities in addition to those of deeper understanding of anatomy and teaching experience. Some programs also offer demonstrators to engage with anatomical or educational research projects [10], while others have demonstrators learn the skills of dissection through preparation of prosected specimens for teaching or during practical sessions [8, 14].

The Senior Anatomy Student: Near-Peer Assistants

Doctors have been recognized as experts in the discipline they teach but not for how they teach it; therefore, there has been a call for the provision of appropriate skills development training for students [18]. Unfortunately, until recently students received little or no formal training opportunities to develop their own teaching skills [19]. This is disappointing as evidence suggests that the inclusion of opportunities for students to have experience as teachers during undergraduate years is beneficial for the student, the student tutees, and the program [17, 20, 21]. Reports suggest that students who have acted as teachers may have increased retention and understanding of the subject material they have taught [22].

The concept of the near-peer teacher is an educational model which utilizes students who are more advanced in their studies as teachers in learning activities aimed at students in earlier phases of their learning. Near-peer teaching is an accepted approach that provides opportunities for students to develop and practice teaching skills and has been implemented in anatomy courses in a number of ways [9, 11, 23, 24].

In most cases, near-peer teaching assistants are best trained using the attributes of facilitators of learning rather than didactic teachers [19]. Because near-peer teaching assistants are not separated from the learner in the same way as a member of faculty will usually be, they are more easily able to explain complex topics and concepts but with a new-found deeper knowledge themselves [13]. The recent experience of the material and the more effective communication by the near-peer teaching assistant appear to be at the heart of the success of this approach [25]. In addition, if learners see that a near-peer assistant has been able to master the discipline when only a few years ahead, they are likely to feel they are able to achieve the same success [24].

With appropriate training and supervision, it has been reported that near-peer teaching assistants have increased their communication and teaching abilities. This along with increased knowledge and understanding in the discipline has an impact on their own future career development and progression and can act as a motivator for students to become involved [6, 9, 11].

Desirable Features of Teaching Assistant Programs

Development of any teaching assistant program requires the inclusion of features designed to ensure the most effective outcome for student learning and the continual professional development of the assistant.

Appropriate Selection and Training

Recruitment of appropriate individuals is a key factor for many of those responsible for developing programs that use teaching assistants. Some have used a selection procedure based on the practical demonstration of teaching skills or knowledge of anatomy, whereas some base recruitment decisions on motivation statements, personal interviews, enthusiasm for and interest in anatomy, and previous performance in anatomy [9, 11, 24, 26]. Once selection has been made, teaching assistants should be provided with appropriate training opportunities. Training programs for future anatomy teachers are not new [27] and have been developed in a number of ways to provide the desired skills for effective teaching in anatomy. The approach to training should be confined by the level of the assistant, the period of tenure, and the resources available to provide training. Some training can be offered in short bursts [28], while other training can take place over a prolonged period. Training can be a formalized activity which includes timetabled sessions, practice opportunities, and self-directed tasks or less formal with assistants learning from experienced academic staff through observation or by asking questions [8–11, 13, 23]. In most cases, the development of an "in-house" localized training program is most appropriate; however, more recently, national and international programs have also been developed, although these appear more suited to longer-term anatomical appointments rather than more "transient" assistants [5].

An additional component of training which should be considered is the inclusion of opportunities for defined reflection. Reflection is an essential part of developing teaching practice and enables a teacher to assess areas of their teaching that have gone well and those that may require further training and development. Reflection should become an everyday part of an individual's teaching practice and will help the assistant to grow in confidence and become established as an effective teacher and hopefully a thinking performer [29].

Opportunities for Curriculum Design

Where teaching assistants have a more substantive period of tenure, it is possible for them to be included in the design of teaching activities and where appropriate be given guided opportunities to develop and plan particular elements of the course or session. Creativity and innovation are important elements in establishing oneself as an effective teacher and providing a good learning experience for students. Assistants can be given chances to create supplementary teaching materials and in-class activities or devise student-selected elective components, but in each case this should be accompanied by integrated methodologies for evaluating the effectiveness of the resulting output [11, 30, 31]. Such opportunities provide assistants with greater insight into the pedagogy underpinning various approaches to teaching, can improve the interest and abilities of assistants, and can lead to conference presentations and publications [32].

Peer Observation

The inclusion of defined peer observation activity within a teaching assistant program can help assistants enhance the quality of their teaching by providing them with the opportunity to reflect on what they do, bringing the same sense of enquiry and curiosity that drives much of the best research into the teaching situation [9, 11]. An effective peer observation activity should be aimed at helping the assistant to develop and enhance their teaching by exchanging ideas, with an observer identifying areas of good practice and highlighting any development needs. Observation should not only be directed at the effectiveness of the presentation of material but also effectiveness within the teaching team and contributions made to the course [11]. For such an approach to have positive effects on the learning journey of the students being taught, observations should be made early and at other periodic stages during the tenure of the assistant so that a purely summative approach can be avoided.

Assessment

Teaching assistant programs that utilize clinical trainees or senior students provide opportunities for assistants to develop their own learning of anatomy. Programs can include tutorials from academic staff that are designed for the level of the assistant and can be directed toward their own professional examinations and portfolios [10]. Where possible, it is important to help assistants to assess the level of their learning and their improvement during the course of their tenure. This can be done using formal or informal viva voce opportunities or other explicit forms of assessment, although the provision of subsequent feedback to the assistant is key. Making sure assistants have an appropriate level of knowledge and understanding is essential for an effective student learning experience and avoids the worry of the assistant just being "one page ahead" of the student.

Support and Feedback

The provision of a supportive environment for teaching assistants is a key attribute to consider when devising an assistantship program. One way is to appoint experienced mentors for teaching assistants who are able to advise, guide, and provide appropriate feedback [8, 33]. Alternatively, faculty can act as the main providers with input from others within the team and even the student tutees. Feedback should be encouraging where appropriate and can also be provided through debriefing sessions, faculty evaluation systems, and student evaluation questionnaires [9, 11]. Without appropriate support and feedback to develop effective teaching and mentoring skills, the learning experience of the students may be compromised, and the future ability of the assistant to supervise and train others within their own clinical teams may be undermined [34]. The success of assistant-facilitated programs relies on the motivation and enthusiasm of the teaching assistant, and therefore it is important that support is directed in a way that enhances these attributes where possible [10, 17].

Reward

Teaching assistants can make significant contributions to anatomy teaching programs and in return receive the rewards of enhanced teaching skills, deeper understanding of anatomy, and other developmental opportunities such as confidence building [9, 14, 20, 28]. Depending on the nature of the program however, additional reward mechanisms may need to be considered as necessary elements of a teaching assistant program. These may include monetary rewards such as salaries, stipends, and bursaries or simply having the prestige of an academic appointment [8, 14, 15]. Certificates for the completion of training programs and events or official documents detailing any assessment of teaching including observation sessions should be encouraged so that assistants can make additions to their portfolios. Previous terms of appointment as teaching assistants have been viewed as a favorable attribute when applications are made for clinical posts such as those in surgery [35].

Desirable Features of a Teaching Assistant Program

- Appropriate selection and training
- Opportunities for curriculum design
- Peer observation
- Assessment
- Support and feedback
- Reward

Advantages of Using a Near-Peer Approach

The inclusion of teaching assistants who are students or trainees that are at more advanced stages of their training (i.e., near-peer teachers) provides certain advantages for the tutor–tutee relationship:

1. **Increased numbers of available tutors.** The inclusion of near-peer teaching assistants within anatomy courses can provide an additional pool of tutors and facilitators for teaching sessions and provide a means for reducing teaching pressures [17]. Such a group of available assistants is particularly useful when there are large numbers of students to teach and when the faculty-to-student ratio is usually low [24]. The availability of these assistants may require particular management in order to accommodate the assistant's own timetabling arrangements and workload, but it is clear that students feel they benefit from increased numbers of assistants [9].
2. **Conducive environment for questions and queries.** The basis of near-peer teaching has largely been built on the premise that it provides an environment that encourages enhanced interaction between tutors and tutees. This is because near-peer teaching assistants are not identified as members of faculty and therefore interaction is less intimidating and there is more freedom to ask questions. This "mediator" role may allow the students to focus on issues that they may be less willing to share with members of faculty in case they are perceived as ignorant. Evidence suggests that student learners believe near-peer teaching assistants to be effective, particularly in small group settings, although their overall knowledge base and experience both in teaching and providing clinical relevance may be perceived as less when compared to more senior teachers [9, 19, 24]. Therefore, the setting of expectations for student learners and assistants is important.
3. **Opportunities for mentoring and role modeling.** Professionalism is an integral feature of medical training, including in anatomy [33]. Using students as near-peer teaching assistants can provide an opportunity to enhance the mentoring that students receive and allow them to easily identify desirable attributes of those in later stages of their course. Both students and near-peer teaching assistants appear to believe that role modeling is an appropriate feature of a near-peer program [19].
4. **Increased knowledge and understanding in anatomy of teaching assistants.** The nineteenth-century philosopher, Joseph Joubert, said that "to teach is to learn twice." Near-peer teaching therefore provides teaching assistants with an excellent opportunity to develop their knowledge of anatomy to a level that enables them to communicate understanding to students. In addition, revisiting anatomical material allows teaching assistants to have a deeper knowledge of the subject area, which can be directed to their own future needs. This is particularly important for those entering specialties such as surgery or radiology and is supported by feedback from former teaching assistants [6].
5. **Skills development of teaching assistants.** It is expected that students in many professional courses are provided with opportunities for developing their teaching skills. The General Medical Council in the UK, for example, states that medical graduates must be able to function effectively as a mentor and teacher and therefore be given appropriate environments in which to develop and demonstrate such attributes [36]. The implementation of a program that allows at least some students to have face-to-face contact as teachers and facilitators of anatomical learning is therefore one such way. Primary skills covered include those of gauging the level of the learners, demonstrating appropriate information, practicing effective communication, and providing encouragement and motivation for learning [6, 8, 12]. In addition, such opportunities also allow the assistant to become familiar with other aspects of the teaching agenda such as providing useful and appropriate feedback and developing ways of eliciting student understanding [30].
6. **Generally less expensive.** The near-peer teaching assistants' main motivation for wanting to be part of such a program is usually to develop their teaching and communication

Advantages of Using Near-Peer Teaching Assistants

- Increased numbers of available tutors
- Conducive environment for questions and queries
- Opportunities for mentoring and role modeling
- Increased anatomical knowledge and understanding in teaching assistants
- Skills development of teaching assistants
- Generally less expensive

skills and their own understanding of anatomy [9]. Consideration may be given as to whether payments can be offered to these teaching assistants for the teaching they provide; however, this will be at a level that enables a core teaching team to be developed at relatively little cost. The adoption of near-peer teachers into an anatomy program should, primarily, be for pedagogical reasons and not as a cost-saving measure, although using near-peer teachers can also be an advantageous supplementary outcome for those departments with little financial or staffing resource [13]. The hidden costs of using near-peer assistants should not be forgotten though such as time for training, supervision, observation, etc.

Designing a Teaching Assistant Program

The design and implementation of an effective teaching assistant program involve a number of considerations:

1. **Identifying outcomes.** Like any course development, the inclusion of teaching assistants within anatomy programs should be based on outcomes needing to be achieved. As outlined in this chapter, there may be a number of particular drivers for including assistants such as lack of teachers in the anatomy program, the desire to develop the skills of trainees, or the need to provide role models for students. When recruiting assistants, it is important that the faculty's expectations are fully evident and the outcomes that the assistant might achieve are clearly presented.
2. **Ensuring the program is workable.** While ad hoc approaches for incorporating teaching assistants into anatomy teaching are used and can be beneficial, approaches that involve well-designed programs appear to have more extensive and measured outcomes and the reliability of increased assistant numbers. The design of the program should incorporate as many of the desirable features that have been outlined as is practical but should be as manageable as possible to enhance the student learning experience. Therefore, a careful balance is required between enacting a quality program that improves the anatomy course and one that becomes a burden to the faculty. Using different levels of assistants within the teaching activities can help provide a self-management system freeing up faculty time to spend on student interaction rather than assistant supervision.

What Will You Do?

- You have constructed a teaching assistant program which involves near-peer assistants teaching within the dissecting room. For one of the assistants, you observe effective teaching skills; however, you notice that he or she has given several inaccurate anatomical definitions and functions during demonstrations. What mechanism will you use to feed this back to the assistant, and how will you inform the students of the mistakes without undermining their confidence in the assistant?
- You develop a near-peer teaching program, and you are inundated with applications to become a near-peer teaching assistant. What process will you develop to select the most appropriate assistants?

Cross-Linking

See also Chapter 7.

3. **When and where to use assistants.** Depending on the format of the course, the coordinator must decide on what type of sessions in which to use the assistants. This may be activities such as practical sessions, tutorials, seminars or assessments, and sessions which include large or small groups. It is important to consider the experience and skills of the chosen assistants to ensure they are able to deliver in the desired environment and do not feel out of their depth, which could be damaging to the student learning experience and development of the assistant. It is usual for assistants to be given increased responsibility and further opportunities for teaching different formats as their experience develops, although additional training might be necessary.
4. **What to include in the training.** The content of the training program can include aspects that are largely generic to good teaching practice as well as those specific to the discipline of anatomy including particular approaches. Training that uses a pedagogical underpinning provides a framework for assistants to understand the principles which lead to effective teaching and learning. Therefore, when developing the training for teaching assistants, course coordinators should consider theoretically based as well as practical activities if possible. Sets of skills and attributes that might be considered are importance of a sound knowledge base, ability to be supportive and encouraging, when and how to highlight clinical or functional relevance, demonstrating professional behavior, developing a facilitating role, and knowing one's limitations. One other skill that should have a particular focus is that of a teacher's ability to gauge the knowledge level of his or her students and be able to adapt his or her teaching accordingly during a session. An apprenticeship model for teaching assistant training, which includes the provision of basic teaching instructions but is primarily based on the teaching assistant actively developing their skills through research of appropriate literature and extensive practice, is favored by some departments [9, 11, 32]. The key to the success of this type of model is active and ongoing mentoring by senior staff aimed at nurturing assistants to become effective independent educators [32]. Such an approach also requires a helpful evaluation system whereby trainees receive appropriate feedback on their performance, which can include debriefing sessions, peer assessment, and student evaluation [9, 11].
5. **Analyzing, reflecting, and improving.** As with the implementation of any new addition to a teaching program, it is essential that the inclusion of teaching assistants into teaching activities be appropriately analyzed to ensure that the approach is effective for both learners and teachers. Such analysis may be confined to informal observation or feedback or may include seeking formalized qualitative and quantitative feedback from student learners, defined peer observation activities by staff, and other forms of assessment. As well as the academic staff reflecting on the success of the initiative and students providing their opinions, the teaching assistants must be given the opportunity to provide input into the reflection process to ensure their views are actively considered. Taken together, such rich analyses will provide the foundation for developing a program further and maximizing outcomes.

Conclusions

Inclusion of teaching assistants in the delivery of anatomy teaching activities has proved to be a popular and effective approach for many years. When devising a program, it is important that the specific drivers for including teaching assistants be clearly identified so that a chosen approach is appropriate and delivers the most effective outcomes for that course. The design of a teaching assistant program should consider a range of features such as a selection and training approach, a system for observing and assessing progress, methods of providing feedback and support, and identification of appropriate reward mechanisms used. The success of such programs depends on aspects such as the assistant teaching to the right level, providing appropriate clinical and relevant insight, giving useful feedback, and demonstrating appropriate professionalism. When assessing the impact of using assistants in anatomy teaching activities, the program leads need to gauge the opinions of the teaching assistants as well as student learners. Results suggest that the utilization of teaching assistants can contribute positively not only to student learning but also in the development of knowledge and skills in the assistants.

Using teaching assistants in anatomy courses and activities provides a positive opportunity not only to support student learning but also for developing the skills and knowledge of the next generation of teachers and mentors.

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7 Engaging Residents and Clinical Faculty in Anatomy Education

Jennifer M. McBride and Richard L. Drake

Traditionally, the role of residents as teachers in medical school curricula has been limited to the core clinical areas including internal medicine, family medicine obstetrics–gynecology, pediatrics, surgery, and psychiatry. The crucial role residents play in educating medical students is emphasized by the Accreditation Council for Graduate Medical Education (ACGME) Common Program Requirements for residency education which among other activities requires residents to engage in clinical teaching [1]. This requirement has precipitated the emergence of several residents-as-teachers curricula in multiple disciplines, with positive results [2]. Inherent in their responsibility as clinical educators, residents also serve as role models, guiding medical student career choices, albeit not as strongly as their staff counterparts [3]. In addition to their clinical teaching role and perceived role model status, residents can also play a part in the basic science years of the medical school curriculum.

> Residents can also play a part in the basic science years of the medical school curriculum.

In the first 2 years of their education, medical students are immersed in a series of basic science courses to help build a foundation of knowledge which they can later draw upon in the clinical years. Often presented separately, with little to no integration between subjects, many of these courses create anxiety among the students as they scramble to memorize endless pages of details and essentially a new language of terms and definitions. In the last few years, the Liaison Committee on Medical Education (LCME) included in their accreditation guidelines that "A medical education program must include instructional opportunities for active learning and independent study to foster the skills necessary for lifelong learning." [4] This meant that long hours of didactic lecture were no longer acceptable and that other methods of instruction and learning were needed. While this "change in environment" elicited a visceral reaction from anxious faculty, it also opened the door to creative and innovative thinking. Since the announcement of this guideline, many schools and course directors have implemented a modified curriculum and written reports of their experiences and results. One area in which several groups have written about is their experiences in the areas of the anatomical sciences [5–8].

Often perceived by students as a formidable course, gross anatomy is an area of the basic science curriculum which harbors a rich opportunity for adding clinically relevant correlations, the introduction of which promotes students'

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acquisition of knowledge. In addition to the more obvious ways in which to introduce these types of correlations such as the use of imaging, case studies, disease process, or structures damaged by penetrating wounds, a higher-yield option and more memorable one for the students is with the use of residents in the gross anatomy laboratory. Several factors define residents as suitable teachers in this environment including their proximity of age to the average medical student and their prior experience in clinical medicine. The inclusion of residents in this learning environment can also benefit the residents as it offers an opportunity to review anatomical structures and provides them with an opportunity to teach and improve their teaching skills.

Advantages of Using Residents as Teachers

- Their proximity of age to the average medical student
- Prior experience in clinical medicine
- Gives residents a chance to review anatomical structures
- Provides an opportunity for residents to improve teaching skills

Regardless of course hours, residents from various disciplines can be utilized for instruction of anatomy in several different ways and with students at various levels of education. For example, in a first-year medical student course, residents can participate in the completion of cadaveric dissections and later present the dissection during the laboratory session. In this scenario, it is best to draw from a pool of residents working in the same system. For instance, contact orthopedic residents during the appendicular skeleton or musculoskeletal section of the course and ear, nose, and throat residents during discussion of the head and neck section. Beyond a basic introduction to anatomy of the region, they can also describe the clinical importance of the anatomy. This same collection of residents can be called upon in second-year or more advanced anatomy courses. In addition to the review of material students were exposed to in the first year, the residents can increase the amount of clinical material they relay in their presentation. In an advanced year anatomy course, such as the third year or beyond, residents can again review the anatomical structures as well as clinical correlations and add in details on current procedures utilized to correct common pathologies.

Key to any of these options is a time to meet with the residents for discussion of the session goals and develop learner appropriate clinical correlations that emphasize the learning objectives. For example, more detailed discussion of surgical techniques and the like may be a topic best suited for advanced anatomy electives or surgical anatomy courses. On the other hand, viewing a laparoscopic cholecystectomy can be a powerful visual way to solidify a novice student's understanding of the relationships between biliary system structures and surrounding vasculature. Perhaps the most important group of residents to meet with before inclusion in an anatomy course are those scheduled to participate in first-year courses in which the students have little and most often no anatomical knowledge. It is vital to spend additional time with these residents to clarify the educational goals of the session, specify what level of detail the students should be getting from the prosection

To Do

- Schedule meeting with residents to discuss session goals.
- Identify learning objectives appropriate to student knowledge base.
- Discuss clinical correlations which will complement learning objectives.

Tips on Engaging Residents in Your Academic Program

- Post a synopsis of teaching opportunities on affiliate GME web sites.
- Contact residency directors and discuss benefits of resident participation.
- Identify residency programs which include a research year.
- Establish some form of resident reward system such as monetary compensation, opportunity to work toward an academic title, or prospect of receiving a teaching award.

station, review the structures dissected by the residents, and/or review PowerPoint slides if the residents are preparing an oral presentation. All of these checks will help ensure that the students have a meaningful educational experience and avoid dissemination of misinformation or interpretation errors. When preparing for these meetings, it is important to remember that the residents are also students in the early stages of specialized training, and for many, anatomy is not a subject they have thoroughly reviewed since their first year of medical school.

Rewarding the Resident Teacher

A major consideration to keep in mind when planning the inclusion of residents in an academic program, particularly if they're going to be asked to participate in multiple sessions, is an appropriate reward system. Residents have many obligations to their programs with very little time for other activities so monetary compensation, the opportunity to work toward an academic title of clinical instructor, and the prospect of receiving a teaching award are a few examples of ways to acknowledge and reward their participation. The reward system which requires a little more effort but certainly carries more prestige is the appointment of clinical instructor. For this reward system, as outlined by McBride and Drake, the first step is to establish appropriate guidelines for this type of appointment in cooperation with your Committee on Appointments, Promotions, and/or Tenure [9]. Several things are important to consider such as limiting the program to trainees within a particular hospital system and establishing that the residents have a significant role which would directly impact student knowledge. From an evaluative standpoint, the residents must demonstrate proficiency in their academic or clinical field, exhibit effective teaching, and participate in a minimum number of pre-established hours.

Recruiting Residents

As mentioned previously, residents have very little time so another thing to consider is how to contact them or make them aware of teaching opportunities available. One of the simplest ways is through a short synopsis of how residents are included in your course posted on the Graduate Medical Education (GME) site of your affiliated hospitals. Another means of reaching them is by contacting the residency directors. Residency directors can be a powerful advocate if they support your cause; unfortunately, the reverse is also true. Lastly, if you are aware of residency programs at your affiliated hospitals which still include a research year, these residents are the easiest to work into your schedule as their time is somewhat less constrained. Again, contacting the GME office is a great resource for obtaining program-specific details like this.

Clinical Faculty

Another opportunity to include instructors with a clinical background is with the participation of clinical faculty. With more experience in their specialty, this group of instructors can offer real-world examples in the form of patient cases, surgical perspectives on anatomy, clinical methods to address pathologies, history of previous and current thinking regarding treatment, and existing areas of research.

From a learning perspective, it is most beneficial to schedule a clinical person after the students have had a basic introduction to the region of interest, accomplished with introductory lectures and/or seminars or with assigned reading. This foundation allows the clinician to emphasize salient points and provide perspective on the application of this knowledge. In addition, the students will be better prepared and feel more confident to participate in discussion and ask questions of the speaker. There are several ways to structure sessions which include clinical faculty members such as with discussion of a clinical case or through demonstration of common anatomically driven procedures in the lab. In the example of discussing a clinical case, it is best to include a common scenario with accompanying questions, all of which the students can review before the speaker comes. Again, the questions will help start the discussion and give the students some direction of what the case is about. For the procedures, they should be anatomically driven, which will allow them to review the relationships of the structures they've studied.

Conclusions

In summary, there are multiple areas in the instruction of gross anatomy where both resident and faculty clinicians can contribute to medical student learning. Throughout their educational career, medical students continue to build on their knowledge base of anatomy and its role in function, diagnosis, and treatment. Inclusion of these more senior health-care professionals plays a crucial role in their acquisition of knowledge with the use of level-appropriate activities, facilitated discussion, and application of knowledge.

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Part II

Teaching in Large Group Settings

8 Giving a Lecture

Lap Ki Chan

A lecture has been defined as "a process by which information is transferred from the notes of the lecturer to the notes of the student without going through the minds of either" (by Sir Joseph Barcroft, cited by Book [2]). This humorous definition reflects the fact that some lectures are like monologues, possible even in the absence of students. The students do not actively take part in learning, and there is little time for them to think and reflect. There is little feedback to either the students or the teacher. But lectures do not need to be monologues. It is possible to deliver lectures that promote effective student learning.

> "So, evidence is mounting that readjusting the focus of education from information transfer to helping students assimilate material is paying off. My only regret is that I love to lecture."
>
> Mazur [1]

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What to Do Before a Lecture

Formulate the Intended Learning Outcomes

Adopt the Outcome-Based Approach

"It's not what we do, but what students do that's the important thing" [3, p. 19]. Many teachers will focus on what they need to do when they plan a lecture ("what we do"). Instead, they should focus on what the students need to learn and acquire ("what students do"). In the outcome-based approach, the aims of teaching and learning activities (in this case, a lecture) are explicitly defined as what students are expected to be able to do after the activities (i.e., the outcomes), and the teacher plans activities and assessments accordingly to help students achieve these outcomes. The aim of the assessments is to find out whether students are able to perform the actions described in the outcomes, at the desired level and context. This alignment of activities and assessments with the intended learning outcomes is called *constructive alignment*.

Write Intended Learning Outcomes

For a lecture, three to six outcomes are appropriate. Each of these outcomes should be expressed as a phrase beginning with a verb that describes an action that is observable and assessable. Bloom's taxonomy [4] provides a useful list of such verbs

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for cognitive learning, which are classified into the following categories:

1. Knowledge, which is no more than memorizing facts (such as *describe*, *define*, *state*).
2. Comprehension (such as *explain*, *interpret*, *demonstrate*).
3. Application (such as *apply*, *solve*, *generalize*).
4. Analysis (such as *analyze*, *compare*, *infer*).
5. Synthesis (such as *combine*, *compose*, *hypothesize*).
6. Evaluation (such as *compare*, *defend*, *criticize*). Lectures in general are more useful for achieving the lower levels of Bloom's taxonomy (i.e., knowledge, comprehension, and application). If a higher level of learning is desired, other forms of teaching and learning activity are usually more appropriate. The outcomes should be declared to the students at the beginning of the lecture, so that students have a clear idea of what they are expected to be able to do afterward.

Cross-Linking

See Chapter 4.

Determine the Content of a Lecture

Help Students to Achieve the Outcomes

The content of a lecture should help students to achieve its intended learning outcomes. All other goals are secondary. If previous assessment results show that students are not achieving the intended learning outcomes, the teacher should modify the teaching and learning activities until they do.

Put the Lecture in Its Context

The teacher needs to know how his/her lecture fits into the course or the whole program: what the students learned before that lecture, how it relates to students' later study, and how the lecture helps students to achieve the outcomes of the whole course or program. The students can thus build on what they have already learned, in the context of their future study. It also helps the teachers taking part in that course or program to collaborate to achieve the overall outcomes.

Avoid Overpacking

Good teachers arouse students' interest, organize complex information, and provide the framework on which students can construct future knowledge. Teachers are not simply providers of information. Moreover, overpacking a lecture with information may actually decrease learning. Russell et al. [5] found that students in lectures with low information density actually learned more than those in lectures that conveyed more information. They suggested that only half of the time in a lecture should be used for introducing new information and the other half should be devoted to explanations, reinforcement, and applications.

Rehearse

Rehearsals enable the teacher to time the prepared lecture, which should be shorter than and not equal to the allocated time, to allow for time for questions and other interaction.

If presentation slides are used, rehearsals help the teacher to become familiar with them, so that there will be a smooth flow from one slide to another. If the teacher is not completely familiar with each slide, he or she may not know how to make the transition from one slide to another. Such a lack of preparation reflects negatively on the teacher, who is now being led by the slides, instead of leading the slides and the lecture. Teachers who are familiar with the slides move from one slide to the next with a continuity of ideas. They can even jump from one slide to another in response to the audience's needs or questions (by pressing the slide number and then "enter"). But the aim of rehearsal is not to enable the teacher to recite the entire lecture from the memory. Instead, rehearsing allows the teacher to become confident, spontaneous, and responsive and closer to the learners. It also helps to reduce any stage fright.

Rehearsal should include testing the equipment for the lecture and preparations for possible unexpected events in a lecture, which can include those arising from problems with the projector (e.g., burnt-out light bulb, low graphic resolution), the computer (e.g., not displaying certain graphics and movies, no network connection), the lighting (e.g., too bright for showing fine photos, too dark for keeping students alert), the audio system (e.g., faulty microphone, noises from outside), and the students (e.g., student behavioral problems). Checking the projector, computer, lighting, and audio system before the lecture can prevent many of these problems. The teacher should prepare for "unexpected" situations that cannot be prevented (e.g., student behavioral problems) and think of appropriate ways to react to these situations to minimize disruptions to the lecture and avoid wasting precious time. This helps the teacher to remain composed and in control. It also keeps the teacher focused on teaching and the students on learning.

What to Do During a Lecture

How to Present Yourself

Show Enthusiasm

An enthusiastic teacher can arouse the students' interest and motivate them to learn more about the subject. Enthusiasm will also encourage a social response from the students—it would be rude not to pay attention when someone is talking to them enthusiastically. Your enthusiasm is reflected in your voice, eye contact, gestures, movements, and the way you interact with the students.

Speak Enthusiastically and Clearly

A lecturer can speak more effectively by:

1. Conveying enthusiasm. Variations in the tone and speed, among other things, convey enthusiasm.
2. Emphasizing points. You can emphasize important points by saying them more loudly, at a higher pitch; by lengthening certain syllables; or by pausing before and after the important words.
3. Speaking clearly. A good teacher should avoid halting speech, false starts, redundancy, and fillers (e.g., *um*, *er*, *ah*, *uh*, *eh*, *right*, *like*, *you know*). The best way to self-diagnose filler is to listen to a recording of one's own lecture.
4. Pausing appropriately. Pauses are important, not only for emphasis but also to leave room for students to think, to digest, and to raise questions. Pausing is also important after you ask a question. Most teachers do not pause long enough before they give the answers themselves. Such self-answering behavior indicates to the students that they do not need to answer your questions since they know you will give them the answers.
5. Being humorous. Appropriate use of humor can relax both the teacher and the student and shorten the perceived psychological distance between them.
6. Using a wireless microphone. When the audience is large, you need a microphone. However, speaking into the microphone fixed to the podium immobilizes and limits your performance on stage. A wireless microphone is much preferred.

How to Present Yourself

- Show enthusiasm.
- Speak enthusiastically and clearly.
- Make eye contact.
- Gesture.
- Walk around.
- Dress appropriately.

Cross-cultural Considerations

The practices discussed in this and other chapters must be applied with great cultural sensitivity, especially in interactions between teachers and students coming from different cultures. For example, eye contact is not appropriate between men and women in some cultures. Different cultures also have different interpretations of what constitute enthusiastic behaviors, appropriate humor, gestures, movements, and attire.

Make Eye Contact

Appropriate eye contact instills enthusiasm and confidence and invokes social responses. The teacher should not stare at the screen, the computer, the podium, or the air above the students. However, the teacher should not always look at the same student, since that may make that student feel uncomfortable.

Gesture

Hand gestures can be used to emphasize important points. The left and right hands can be used in sequence to visually display "on the one hand" and "on the other hand." Head nodding conveys approval and can help students feel more confident in interacting with the lecturer. Opening your arms after a question invites answers. Leaning against the side of the podium can relax your students (and yourself). The size of the audience should be considered in using gestures. For smaller lecture venues, gesture with hands and forearms. For larger audiences, make slightly larger gestures than you would in ordinary conversation so that everyone can see them.

There are, however, some gestures that you should avoid, e.g., pointing at the students (people in general do not like being pointed at), holding onto the side of the podium, putting your hands in your pockets (both give the impression that you feel insecure), or any gestures and mannerisms that might distract students' attention, such as jiggling coins or keys in your pocket.

Walk Around

A podium can be compared to a turret during battle: it defends the speaker from the audience. Standing behind a podium transforms the relationship between the lecturer and the students into one of opposition. The lecturer should walk around on stage or among the students, so that students in different parts of the room get an equal share of the teacher's voice, eye contact, and enthusiasm. Walking around the stage or room will decrease the physical and psychological distance between the teacher and students. Students are more likely to listen to the teacher, respond to questions, and feel that the teacher is more approachable.

Dress Appropriately

Professional attire can lend credibility but can also establish a distance between the teacher and the students. If you are giving a series of lectures, you can wear more formal clothing for the first few lectures to establish your credibility and then switch to more relaxed attire when you want to decrease the perceived power distance between you and the students. But in any case, a teacher's appearance should not distract the students' attention from their learning.

Use Tools

There are several tools you can use to help to make a lecture run more effectively:

1. A pointer allows the teacher to indicate the point of interest on the slide. The pointer can be a laser pointer, the cursor on the computer (if one is used for the lecture), or even just a finger. However, whatever type of pointer you use, it should be clearly visible on the screen, or else students will be too busy looking for the pointer to pay attention to what you are saying. Therefore, the laser pointer needs to be bright (but remember not to shine it at the audience!), and the computer cursor needs to be large and visible at all times.
2. A presenter (or remote presentation clicker) remotely controls the progression of computer slides. Some have built-in laser pointers or even timers. It is a very useful tool if the teacher wants to walk around during the lecture.
3. A visual presenter (or document camera) consists of a video camera connected to the projector or a computer. The teacher puts an object of interest, such as a bone, under the camera and projects it on the screen to illustrate points in the lecture. One difficulty of using this method is that the teacher must pay attention to the orientation of the specimen on the projector screen since what the students see on screen is quite different from what the teacher sees when looking directly at the specimen.
4. An on-screen drawing device allows the teacher to digitally draw on the screen of the computer at the podium or even on the projected image. If PowerPoint is used on a PC,

pressing "control-p" changes the cursor arrow to a pen for drawing on the screen. Pressing "control-a" changes it back to a cursor arrow. On a Mac, press "command" instead of the "control" key.

5. Audience response systems (ARS) or clickers allow all students in a lecture to indicate their responses to, say, a question. Students have access to a device that is either handheld and wireless or mounted on their seats. The students' anonymous responses will then be analyzed almost instantaneously. Such formative feedback allows the students to compare their performance to their peers and the faculty to identify at-risk students [6]. The anonymous nature of the responses motivates the reluctant students to interact during a lecture [7]. The responses of the students also allow the teacher to get an overview of the audience's understanding as the lecture progresses, thus enabling him or her to adjust the lecturing strategies, e.g., by spending more time on any parts of the lecture that students have difficulties with.

What to Do in Different Parts of a Lecture

A lecture can generally be divided into three parts: introduction, body, and conclusion [8, 9], each with different aims.

The Introduction of a Lecture

The first few minutes of the lecture are very important since you establish your relationship with the students and prepare them for learning. A self-introduction will assure the students of the teacher's knowledge of the lecture content if it is the first meeting between the teacher and the students. An informal conversation with the students will relax both the teachers and students and is a good way to establish a closer relationship. In the introduction, the teacher should state the lecture topic. A short review of how the current lecture relates to previous ones can trigger relevant prior knowledge, thus facilitating knowledge building. The intended learning outcomes should be stated. People learn better if they know what they are expected to achieve [2]. For some complex lectures, a framework at the beginning can help students to organize the materials.

The Body of a Lecture

The body of the lecture needs to be well organized and presented. Some strategies for successful presentation of a lecture are:

1. **Divide it into key points.** Brown and Tomlinson [10] describe three methods of organizing the materials in a lecture in the medical and health sciences. In the *classical method*, a lecture is divided into sections and each section into subsections, each with its own key points. In anatomy lectures delivered using this method, a region is divided into subregions or a structure into its parts, each with its own elaboration and summary. The *problem-centered method* starts with a problem that forms the focus of the lecture, with the solutions forming the parts of the lecture. This method can be intellectually stimulating and motivating, can stimulate students to reflect on their prior knowledge, and can be used for illustrating the clinical aspects of anatomy. The *sequential method* consists of a series of linked statements, eventually leading to the conclusions. This method is commonly used in lectures on management of clinical problems. These three methods of organizing a lecture are not mutually exclusive. One can have a classical lecture, with one of the sections being organized by the problem-centered method or the sequential method. Dividing a lecture into parts may make it more manageable, but the linkage between the parts must be made very clear to the students.
2. **Elaborate the key points.** A well-delivered lecture should not be completely packed with key points. Each key point needs elaboration, which can be explanations, examples, stories, qualifications, photos, applications, etc. Such elaborations help the students to learn by repeating and reinforcing the new information, by presenting the same information in different forms, and by linking with students' prior knowledge. Furthermore, if the elaboration

involves applications in students' future study, students are more likely to be motivated to learn, and they are more likely to remember the information when they come across the same context in the future.
3. **Link the key points.** The linking of the key points needs to be made explicitly to the students, by using such words as "thus," "therefore," "consequently," etc. For an audience of nonnative English speakers in a lecture delivered in English, these linkages need to be clearly signposted by using such phrases as "the above is true because…" rather than more subtle markers like "because," "then," "since," etc. [2]. The linked chain of key points can help the students to understand the big picture.
4. **Manage the pace.** The pace of a lecture is proportional to the amount of material to be covered and inversely proportional to the time available. The more materials to be covered and the less time that is left, the faster the teacher will deliver the lecture. As the pace increases, the teacher tends to sacrifice elaboration in order to deliver all the key points. The best way to avoid getting into this situation of being forced to go fast at the expense of student learning is to avoid overpacking the lecture.

Parts of a Lecture

Introduction (not sequential steps)
- Establish a relationship with students.
- Introduce yourself.
- Announce the topic.
- Relate the lecture to previous ones.
- State expected outcomes.
- State the framework of the lecture.

Body (not sequential steps)
- Divide into key points.
- Elaborate the key points.
- Link the key points.
- Manage the pace.

Conclusion (not sequential steps)
- Summarize.
- Review intended outcomes.
- Facilitate self-directed learning.

The Conclusion of a Lecture

A lecture should not end abruptly. The attention of the students is usually the highest in the last few minutes of the lecture. The teacher should summarize the key points and explain how the lecture should have helped the students to achieve the outcomes. The students may be expected to use the lecture materials as a foundation for further self-directed learning. The conclusion of a lecture is the appropriate time to state this idea explicitly. The teacher can provide problems or resources to help the students.

Interaction Between the Teacher and Students

Interactions with Students

- Questions
- Think–pair–share
- Write–pair–share
- Demonstration
- Role-playing
- One-minute paper

Interactions are possible and should be encouraged in lectures. But students are more likely to interact with teachers who are perceived as having less physical and psychological distance from them (called *teacher immediacy*), i.e., those who speak enthusiastically, walk around in the lecture hall, make eye contact, adopt open gestures, etc. Interactions can renew listeners' attention spans and can let students actively participate in the learning process. Interactions also provide feedback to the teacher on how well the students are learning, so that the lecturing strategies can be adjusted in time. More importantly, interactions can help the students to achieve some of the intended learning outcomes (ILOs). For example, if one of the ILOs is for the students to be able to explain the function of certain muscles, the lecture should include some activities in which at least some of the students explain the functions of at least some of these muscles. This will demonstrate to the students what they are expected to learn and be able to do. Some types of interaction are described below:

1. **Questions.** The simplest interaction between the teacher and students is questioning. Questions can be used by the teacher to check student understanding, to trigger active thinking, and to stimulate students to reflect on prior or newly acquired knowledge or be used as the lead-in for a new section or even a whole lecture. But after asking a question, the teacher should pause for at least 10 s, to allow students to think and prepare the answer. If there is no response, the teacher should restate the question differently or more specifically. The teacher can move closer to the students, lean forward, and open his/her arms to invite answers. When an answer comes, the teacher should be supportive and nonjudgmental (verbally and in your facial expression and gestures), even if the answer is wrong, in which case the teacher can guide the students to the correct answers by asking the appropriate questions. The anonymity of responders in audience response systems can motivate more students to respond to questions.

   Questions raised by the students should be encouraged. When a student asks a question, repeat the question through the microphone to the whole class, so that everyone can think about it. If you do not know the answer to the question, you can say that you need more time to think or even put it back to the students.
2. **Think–pair–share** and **write–pair–share.** The teacher first asks a question which the students need to think about. Then the students form groups of two to exchange their responses. After 2 or 3 min, the teacher asks for the responses from some or all of the groups. Write–pair–share is similar except that the individual students write down their thoughts before discussing them with their neighbors.
3. **Demonstration.** Demonstration can take many forms. In anatomy teaching, the teacher can demonstrate surface anatomy on his/her own body or on another volunteer student or use tools to illustrate the anatomical relationships being discussed (see Chapter 29). In the teaching of some diseases, a demonstration can be an interview or physical examination of a patient.
4. **Role-playing.** The teacher and the students can both take part. Role-playing can be used for teaching communication skills, ethical issues, or clinical manifestations of illnesses.
5. **One-minute paper.** In the last few minutes of a lecture, the teacher asks the students to write down on a piece of paper their answers to such questions as follows: (a) What are the most important points that you learned today? (b) What are the most confusing points? (c) Are there points that are not clear to you? There are many variations. This is a method for the teacher to find out how well the students have been following the lecture and which parts of the lecture they have difficulties with, so that some of these difficulties can be addressed in future lectures, if necessary.

How to Prepare Presentation Slides

Presentation programs (such as PowerPoint and Keynote) are commonly used for lecturing. But it is important to stress that these programs are just aids to the teacher, whose messages should be the focus of the lecture. Therefore, the preparation of these presentation slides must be carefully done so as not to distract the audience from the teacher's messages [11, 12]. In fact, some anatomy teachers do not use presentation slides at all. Tufte argued that programs like PowerPoint should be abandoned because their linear and hierarchical structure and preoccupation with format and decoration make them inherently unsuitable for rich and complex content [13]. But PowerPoint or other similar programs are just tools. If the user uses these tools correctly, they can be helpful [12]. The most important thing is to keep the slides simple. However, making slides simple does not mean making them devoid of content. It means that all the elements of the slides must help the students to learn and there are no unnecessary or poorly constructed elements to distract the students. It is important to maintain the focus on student learning and not be tempted to add extras such as unusual typefaces and animated elements, which are more distracting than helpful to learners.

Background

The main function of the background is to keep the attention of the students on the slide content. Therefore, a solid color background is the best. A picture should not be used as a background. When a picture must be used, it should be dimmed or blurred. One should use a consistent background for a set of slides, since changing the background could be distracting. Using a light-colored background in a dark lecture hall will attract students' attention.

Text

Short Bullet Points

The messages of the lecture should be delivered by the teacher, not by the presentation slides. Therefore, the text in a presentation slide should serve only as textual anchors of what the teacher is delivering and should be very short (no complete sentences), in bullet points arranged to reflect conceptual structures. But the "six-by-six" rule, which states that a slide should contain at most six lines of text, each with at most six words, should not be taken too literally in presenting complex content to students. On the other hand, one should not put everything one wants to say on the slides and use them as script (a presentation style jokingly referred to as "PowerPoint karaoke"). Not only do slides presented this way become densely packed, but in reading material off the slides, one's voice becomes monotonous and lacking in enthusiasm. However, teachers may want to include more text in the slides if the presentation is in a language that is not the usual language of the teachers or the students.

Simple and Consistent Text Format

The text in presentation slides should not be distracting. Therefore, a teacher should use only one or at most two fonts. Sans serif fonts are preferred, since serif fonts may not display well, especially when using projectors with lower image resolutions. The point size should be of adequate size (at least 32 points, but it needs to be even larger if the lecture hall is large), and the text should contrast with the background and should be in only one or two colors, or else students will be distracted from the lecture content by focusing too much on trying to read the text or to decode the meaning of the colors. Incorrectly spelled words can also be distracting and indicate that the teacher is careless. Text that is written all in upper case should also be avoided since it is more difficult to read and gives the impression of the speaker shouting at the audience.

Platform Compatibility

If the slides are created on a Mac but will be presented on a PC (or vice versa), it is best to use a font which is available on both platforms, such as Arial, Times New Roman, or Courier. But even these fonts may be rendered slightly differently. Therefore, the placeholder (the box into which you enter text) should not be too tight, or else the alignment of the text may be affected. If other fonts, especially nonstandard ones, are used in the slides, one must make sure that the computer used for the presentation also has those fonts installed. Otherwise, the nonstandard font will be replaced by another font, and text may be misaligned. Misaligned text will distract students from the lecture, since they will need to mentally realign the text.

Multimedia

The use of multimedia, especially graphics, is important in anatomy lectures. The *multimedia principle* of learning says that people learn better when the instructional messages are delivered in both words and graphics, rather than in words alone.

Use Good and Relevant Graphics

Use high-quality graphics that can help students to achieve the intended learning outcomes. The graphics should be high resolution, have good colors and contrast, be properly aligned and cropped, and appropriately labeled to show the structure of interest (with the other non-relevant labels removed or covered). Their sources should also be acknowledged in a non-distracting manner. Decorative graphics are distracting and should be kept to the minimum.

Elaborate and Progressively Reveal Complex Graphics

The interpretation of complex anatomy graphics takes time. The teacher should help the students to comprehend anatomy graphics by first stating the directions of the three-dimensional axes and what structures have been sectioned, displaced, or removed to expose the structures in the pictures. When there are many labels, the teacher should reveal only those that are pertinent at the moment. The teacher can then reveal the others as the lecture moves on. This method of progressively revealing a complex anatomy graphic helps students to stay focused.

Avoid Animation

Excessive use of animation should be avoided, since it takes up precious lecture time, distracts the students without helping them to learn, and can be irritating.

Use Video

Video can be more powerful than static graphics in reinforcing student learning, e.g., in showing the anatomy of clinical procedures or the anatomical basis of some diseases. Many relevant videos are on the Internet and can simply be embedded into the presentation file as links without downloading (but make sure that the presentation computer has Internet access). Nevertheless, teachers should be aware of the massive amount of information presented in videos that may distract students from key learning points. A video that is suitable for more advanced students may overwhelm novices and not facilitate learning.

Avoid Chart Junk and Junk Charts

Chart junk is elements of a chart that do not contribute to its message and therefore serve only to distract. Junk charts are charts that are poorly designed to convey their intended message. For example, they may be unnecessarily complicated, difficult to read, impossible to understand, or just odd. They should be avoided.

Slides

Integrate Text and Multimedia

It is common for teachers to put text on one side of a slide and graphics on the other. But in the seconds spent on the slide, students will need to mentally integrate the text and graphic by reading the text and then finding the relevant parts in the graphic, all while they are listening to the teacher. Integrating text and graphics means doing this mental integration for the students by putting the parts of the text next to the corresponding parts of the graphic. It helps student learning by saving the students' cognitive resources, so that they can focus on the lecture content. This recommendation is called the *contiguity principle* [14].

Explain Graphics Orally

The *modality principle* tells us that students learn better when the graphics are explained in spoken words than with written text accompanying the graphics [14]. The working memory has a limited capacity and has one storage area for visual information and another for phonetic information. When graphics are explained orally, both the visual and phonetic areas are being utilized, thus gaining maximum access to the working memory. The *redundancy principle* says that when a graphic is explained orally and is accompanied by textual explanation, student learning may be impaired [14]. The reason is that the graphic and the textual explanation are both jammed into the visual component of the working memory, which may thus be overloaded.

Leave Space

Overpacking the slides does not help student learning. If the teacher wants to provide additional materials, he/she can put them in a separate handout or in the "Notes" area of the slide in PowerPoint.

Preparation of Simple Slides

Background

- Use solid color background.
- Avoid using pictures.
- Use one background throughout a presentation.

Text

- Use short bullet points.
- Use one or at most two sans serif fonts.
- Use only one to two colors; avoid bizarre colors.
- Use a large font (at least 32 point size).
- Use fonts that are available on both PC and Mac platforms.
- Run spell check.
- Avoid putting everything you want to say onto the slides.
- Avoid all caps.

Multimedia

- Use clear, simple, and relevant graphics.
- Elaborate and progressively reveal complex graphics.
- Avoid animation.
- Use video appropriately.
- Avoid chart junk and junk charts.

Slides

- Integrate text and multimedia.
- Explain graphics orally.
- Leave space.
- Use a consistent layout.
- Use B and W.
- Avoid animated slide transitions.

Use a Consistent Layout

The layout refers to the position of the text, graphics, titles, etc., on the slide. Using a consistent layout will help students to adapt to your presentation quickly. Every time the layout is changed, the students need to adapt, which distracts them from learning.

Use B and W Keyboard Functions

To focus students' attention totally on what the teacher has to say, temporarily black out the projector or press the "b" or the "w" key in presentations using PowerPoint and Keynote. Pressing "b" will turn the whole screen black while pressing "w" will turn it white. When the slide suddenly disappears, the students' attention will immediately be directed to the teacher.

Avoid Fancy Slide Transitions

Presentation programs offer many different ways to go from one slide to another. Such fancy transitions serve only to waste precious lecture time and distract the audience.

Conclusions

Lectures, when appropriately delivered, can promote effective student learning. During preparation of a lecture, an outcome-based approach helps the teacher to plan the content and activities to help students achieve the intended learning outcomes. The teacher also needs to consider the relationship of the lecture to the rest of the course or program so that the lecture builds on what students have learned and prepares them for further study. In the introduction of a lecture, the teacher needs to establish a closer relationship with the students and prepare them for learning. In the body of a lecture, the teacher needs to organize the content into key points and link them to give students the big picture. But the teacher must not pack too many key points into a lecture, sacrificing elaborations. There should also be an effective conclusion in which the teacher can summarize the key points and outcomes and stimulate further self-directed learning. Apart from the careful organization of the lecture content, the teacher's enthusiasm will also significantly affect student learning and attitude toward the subject, and it is reflected in the way that the teacher speaks, moves, makes eye contact, and interacts with the students. The teacher also needs to prepare the presentation slides carefully, if he/she chooses to use them, so that they do not distract the students from the content and the interactions with the teacher.

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Preparing and Recording Lectures for Online Delivery

9

Thierry R.H. Bacro

Historical Background

Despite technological advances in the last few decades, traditional lecture delivery remains one of the effective teaching approaches used to deliver a significant amount of information in anatomy courses in the USA and throughout the world. Although criticized in the last few years by educational specialists because it is not perceived as the "ideal" method to help students acquire and retain large amounts of information required to successfully pass required licensing exams. This mode of lecturing, however, is a necessary evil in curricula that are facing a shortage of trained anatomy teachers, significantly increasing their class size, coupled with diminishing hours dedicated to anatomy in an ever-changing academic environment weakened by decreased state and federal funding. However, while accepting that lecturing is still a reality of teaching anatomy in a modern fast-paced curriculum, the way one uses lecture in modern education has changed in order to remain as an effective teaching and learning modality and to appeal to what is now described as the millennium student.

Historically, the classic anatomy lecture was taught by a lecturer speaking in the front of students seating in a lecture hall, listening attentively (or not), asking maybe a few questions, and trying to take notes while the lecturer was drawing anatomical structures on a blackboard with colored chalks. To complete these visual resources, lecturers would sometimes provide rudimentary notes created using a stencil duplicator also called a mimeograph machine. Interestingly, to successfully learn the material, the students had to team up to capture all the drawings presented during the lecture and had to meet after the lecture to share their notes. This was an early form of what would now be labeled team approach to learning, collaborative learning, and peer learning. Although lecturing is now often considered passive teaching, these students had to remain very engaged and very attentive to the lecturer to benefit from this experience. Occasionally, the lecturer would project some slides or even an 8 mm movie to illustrate the lesson. At some point, plastic overheads showing drawings of anatomical structures were used by the lecturer to avoid having to draw during every lecture, allowing a faster delivery of the lecture content. The appearance of instant development of slide films in the 1970s fostered the adoption of slides for lecturing. These slides were created using a variety of software at the time, but PowerPoint (PPT) progressively started to dominate the educational market, and with the birth of the Course Management Systems (CMS), PPT became the standard to deliver large amount of anatomy materials through a live lecture and/or

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for online delivery. At that stage, very few faculty knew how and/or had the time to record their voice over the visual aids presented in PPT when using a CMS. Even with the use of complementary notes provided to support this format, these anatomy lectures were definitely delivered in a very dry and passive format, with very little interaction between teachers and learners. In parallel to the changes described above in the last decade or so, anatomy educators started experimenting with other forms of teaching online using audio–video recordings and started to realize that the use of online technology did not imply passive learning. As technology evolved and as educators became more creative with the existing educational tools, one started to see the reemergence of interactive learning/teaching, integrated in delivery models of synchronous teaching and/or for online delivery in asynchronous teaching models. These models were tailored to learning styles, providing for small and large groups of students, allowing for questions and discussion of materials as well as to ensure the acquisition of the knowledge to pass standardized licensing exams. The most recent development in terms of didactic lectures is the popularization of automatic lecturing recording systems (LRS).

How Does It Work?

The purpose of a lecture recording system is to capture the visual information displayed on the screen as well as the sound associated with it during the lecture. The software synchronizes the visual information with the sound and saves these data into a file format that can be displayed later in the chosen online model. The visual information captured can range from very simple to very sophisticated: simple text and images created with basic software, PowerPoint presentations, simple or very complex animations, or even audio–video files. The sound can be the voice of the speaker recorded through a microphone set on the computer station or any sounds displayed in a file played during the lecture, including from an audio–video file. So, a lecture recording can range from a simple short presentation of some text or images with a voice discussing these resources to a very complex mix of highly sophisticated learning objects. An additional important feature is that the visual information recorded will capture the mouse used by the speaker to point out elements of the presentation. The quality of the recordings, both in terms of the visual and the sound, will depend on the quality of the screen and sound capture hardware installed, the processor speed of the computer station used, as well as the type of LSR employed.

Lecture Recording Systems

Quite a few LRS software can be purchased commercially, but some are also available through open-initiative communities (see Table 9.1).

Now, the systems listed in Table 9.1 ranged from a very simple application for a single station to very large and complex systems to be distributed throughout large academic centers. In some cases, the recording can be done on a single station equipped with the proper hardware (see next section) on which the software has been installed. The lecture can be recorded on the station itself, and at the end of the session, the packaged file can be moved using a USB drive (or any other mode of transfer) to be distributed to the students directly or through a CMS. In that case, an Internet connection is not required when recording the lecture. With some more advanced software, the lecture can be recorded on the fly after an initial log-in on the software. Other software allows the faculty to stream the lecture to students viewing it online at other locations while also recording it to save and distribute later through a chosen mode of distribution. In that case, the viewing of the streamed lecture is delayed a few seconds (5–10 s usually) compared to the real lecture. Regardless of streaming or not, at the end of the lecture, the faculty might be prompted to upload it automatically (Internet connection required) or to open the file to view it, edit it (or delete it) before, and then upload it in a system where students can access it. Some of this software will allow you to do some editing of the file created, while others include very advanced features that will allow the faculty

Table 9.1 Lecture recording systems (in alphabetical order)

Accordent Technologies	http://www.polycom.com
Arrive ViewPoint	http://www.arrivesys.com/arrive/arrive-viewpoint.php
Echo360	http://echo360.com
Camtasia	http://www.techsmith.com/camtasia.html
Galicaster[a]	http://wiki.teltek.es/display/Galicaster/Galicaster+project+Home
Media transformation	http://www.cisco.com
Opencast Matterhorn[a]	http://opencast.org
Panopto	http://www.panopto.com
Presentations	http://www.presentations2go.eu
Presentations 2Go	http://www.presentations2go.eu
ProfCast	http://www.profcast.com
Tegrity	http://www.tegrity.com

[a]Available through open-initiative communities

or the educational specialist to perform some sophisticated editing, splicing, removing, or adding contents (visual and auditory) before final rendering and distribution of the file. This last approach is not recommended for the novice faculty as it is extremely time consuming and requires a high level of technical expertise of the chosen software. Many of these software programs have advanced settings which, when set properly, can automate and simplify the tasks required from the faculty to produce quality recording. Several of these programs can produce several different file formats (i.e., MP3 podcast for MP3 player or Linux; enhanced podcast and enhanced video podcast for iPod, iTunes, or Linux; video streaming to iOS and Android apps), and the faculty will need to spend some time familiarizing themselves with the advantages of each file type before deciding on the settings used: limitation in terms of the distribution through a given CMS, final size, necessity to have or not a specific application on the student side to read the file, and most importantly quality.

Getting Started

Besides securing the proper LRS software, the teacher will need to secure the proper hardware: a microphone, a camera, an up-to-date computer, and a fast Internet connection. The specifics of this hardware may vary greatly from station to station, but to ensure good audio–video recording, the teacher should choose good- to high-quality capture sound and video cards that are compatible with his/her own computer station as well as the specifications of the LRS chosen. The vendor for the LRS chosen should be able to provide the faculty with the details of the required minimum specs to ensure proper recording output. Even when these specs are met, creating quality recordings might be tricky sometimes, and the cooperation of the local technical support at the home institution might be necessary to optimize the hardware for success. Although it is sometimes absolutely necessary for some demonstrations, the camera can be optional as many teachers will use a still picture of themselves embedded in the resources and not use a live feed of the teaching itself. This greatly reduces the overall size of the final file (see later). Once the software and hardware have been chosen and the computer recording station is properly set, the faculty will be able to start recording the lectures. To be effective when using a recorded lecture, the teacher will need to review and critically assess a number of teaching parameters before starting the recording process.

Creating a Good Recording

Although it may seem obvious, a teacher must first create a good lecture to generate a good recording. The principles of good teaching described in earlier chapters in this book must be respected when creating the lecture, and the lecturer will need to ensure that the lecture:

- Covers the objectives listed in the course syllabus.
- Follows a well-structured lecture plan that flows logically, with an introduction; with a main body with breakpoints in the form of questions, illustrations, or examples; and ending with a summary and a take-away message.
- Uses the proper visual objects (background type, size of the font, color patterns) to induce learning in the population taught, i.e., younger undergraduate degree students (millennium students) versus graduate degree residents or even more advanced and older clinicians. Because the recorded screen is smaller than the image usually projected in a classroom, the faculty need to have good contrast in the images used for the lecture, avoid having cluttered and too detailed visual aids, and must use visual information in a somewhat simpler format than a traditional lecture, meaning try to present one or at the most two key concepts by visual aid.

Another component to consider for new faculty recording a lecture is the voice component. Some of us may have a tendency to speak faster when we enthusiastically teach a subject we love. Creating a good recording however requires the teacher to, in fact, slow down the pace, enunciate clearly, and fully appreciate the fact that the audio component of recording is as equally important as the visual information. Anecdotal evidence indicates that many students will speed up the recording and use it in fast learning mode when the technology allows it. The true extent of that practice, and whether it is beneficial, has not been studied, but recording the lecture with quality sound is usually appreciated by the students. In addition to the voice issue, an additional level of difficulty in recording a lecture is created by the fact that the faculty member not only needs to think about what he/she is going to say during the lecture and monitor the pace and the quality of his/her speech but must also point at the visual aids using the cursor on the computer throughout the lecture, rendering the live recording a very difficult practice, especially for the less seasoned faculty. In many cases, when starting new with this process, rehearsing the lecture several times, in its full length, on the equipment used for the recording in question, and examining the recording in its entirety for problems, errors, and quality issues are very effective ways to improve the quality of the final recording.

> Creating a good recording however requires the teacher to slow down the pace, enunciate clearly, and fully appreciate the fact that the audio component of recording is as important as the visual information.

Use of a Lecture in a Curriculum

Besides the obvious preparation of the lecture itself already described, the speaker needs to understand the issues associated with the distribution of online recording of even a well-designed lecture. The faculty will need to consider the environment in which the recording will be distributed which in fact can be one of two environments:

1. The lecture recording is distributed in a curriculum in which the students are given the choice to attend the live lecture and/or access the recording.
2. The lecture recording is made available only through an online environment without the possibility of attending the live lecture.

In the first environment, the students can decide if they will attend the live lecture or access the recording only or use both. Much has been written in the literature about how they choose, but after a certain of amount of time, some students, anywhere from about 10 to 30 % of the class, will continue to attend the live lecture, while others will stop attending the lectures and will only use the recorded lecture to study the information. Of course, some students will switch from the first or second approach and vice versa depending on the time of the day, the lecturer, or the topic. This situation creates a special set of problems for the faculty who choose (or are coerced) to record their lecture. It is very difficult to create quality recordings (slow speech, proper pointing with the mouse to visual elements of the lecture, etc.) during a live lecture. The students who decided to attend the lecture on that occasion expect the faculty to attend to their needs in the live classroom. They will resent the faculty who stay behind the podium in order to move the mouse (that one cannot see well on the main projected screen anyway) to point at elements of the presentation for the recording. So, this setting often makes it nearly impossible to create a high-quality recording in the given time allotted for the live lecture (often 45–50 min at the most). In order to alleviate this problem, faculty who have the time and the propensity to care about providing quality live teaching as well as creating quality lecture recordings have adopted a hybrid approach. They will teach the live lecture focusing on the students attending the live lecture, using a laser pointer to point directly at the screen where the visual aids are being projected, and answer live questions on the spot. At a later time (or, in some cases, in advance of the lecture), they will, just like a faculty member who teaches only in the second environment described above (recording made available only through an online environment), create a high-quality recording to be distributed. Although working very well, this approach is time consuming. It can, however, present significant advantages for both the students and the faculty.

Advantages of Recording Lectures

The recording of a lecture presents a number of advantages for the student unrelated to whether the recording session is live or not. The student can:

- Play it back as many times as needed to acquire the information.
- Skip or speed up parts of the lecture that are easy or already understood.
- Pause the lecture for convenience or, by necessity, to make notes, search for additional information using a textbook or online search engines, write an e-mail asking a question to the faculty, and doing so without missing information.
- Study it alone or in a small or large group.
- Catch up on the lecture material after valid absences due to personal or family illness and death in the family or absence due to weather conditions.

The recording of a lecture in non-live settings presents additional advantages for the faculty:

- The lecture recording, if needed, can be longer than the time allotted in a standard live lecture.
- The lecture, although possibly longer in total length, can be recorded by pausing every 10–15 min or at logical points in the lecture, allowing the faculty to pace themselves, achieving higher quality, and rendering the task of recording easier.
- The sound quality, an important component, of the recording is usually higher, with less interferences.

> LRS has been an invaluable tool for students who experience valid absences and is now part of our institutional response plan in case of significant emergency that could disrupt the teaching schedule.

Disadvantages of Recording Lectures

The use of recorded lectures in a curriculum may also present significant challenges. In most cases, these issues can be addressed as follows:

- The use of recorded lectures may impact attendance to lectures. To address this issue, faculty could propose more interactive and participatory classes to engage learners of all learning preferences and/or also use an audience response system (ARS or clickers) which has been shown to be effective in engaging students during lectures [1–3]. In that case, a single question per lecture presented to the audience through the ARS allows the faculty to determine the attendance of the class and then take action, if needed or required, to address the attendance issue. So, the attendance issue alone should not be used as a deterrent to the implementation of an LRS.

- The recorded lecture does not allow opportunity for questions. In this case, faculty may want to set additional time for questions and answer sessions or use e-mail, chat, forum, or blogs to answer the students' questions synchronously or asynchronously.

> Fear of decreased attendance should not be a deterrent in terms of using LRS in a curriculum. If attendance is an issue, mechanisms such as integrating clickers in the lectures can be used to monitor the presence of students in lecture hall.

Creative Use of Recordings

Some faculty use LRS for other purposes than lecturing. For example, LRS has now been used to:

- Prepare recordings for students to view to introduce them to the dissection laboratory sessions.
- Record mini educational modules on a given topic, lymphatic system of the head and neck, for example.
- Summarize information taught across several lectures.
- Answer FAQs.
- Use in what is now called the "flipped lecture" where students are provided with information to prepare for a session where a given topic is discussed.

In all above cases, the faculty can take advantage of the recording capabilities of the software chosen, by being more creative than in a live lecture, by creating resources in a format that appeal to the millennium student, by integrating information in manner not possible in classical teaching, and even by distributing the created recording though a medium that will entice the student, such as YouTube or Facebook.

Proper Use of Recordings

The published research in the usefulness of lecture recording clearly indicates that the use of LRS is usually well received by students [4–11]. However, recent published evidence indicates that not all students in a course will spontaneously use LRS. Bacro and colleagues reported in 2010 that 30 % of the medical students in the first year class at the Medical University of South Carolina did not use the LRS at all and that an additional 41 % used it very little (less than 10 times for the semester) even though the survey of the students' perception showed that 74 % of the students agreed/strongly agreed that the recordings were useful with 6 % disagreeing/strongly disagreeing and 11 % undecided [12]. Also, the pedagogical value of LRS has not been clearly documented and is somewhat unclear. In one instance, a research study showed that a group of psychology students watching a single lecture recording scored significantly higher on examination compared to a group watching the matching live lecture [13]. In another case, a report showed students who chose to use an LRS called Lectopia instead of attending live lectures scored lower on continuous summative assessment, examinations, and final marks in a medical pharmacology course in Australia [14]. McNulty and his group showed that students found the recordings of basic science lectures useful in a medical curriculum but also found that the students who accessed the lecture recordings more frequently scored significantly lower [15]. Other researchers, however, have found that the use of LRS does not impact grades, negatively or positively. Bridge conducted a 5-year retrospective review to assess the impact of lecture recordings on scores on the United States Medical Licensing

Examination (USMLE) for Step 1 for 1,736 students and concluded that, after correcting for the national trend over the same period, the effect of LRS on the measured outcomes was neutral [16]. Similarly, Bacro and colleagues did not find a significant correlation between final grades in three medical basic science courses (cell biology/histology, physiology, and neurosciences) and usage of LRS when examining the number of time students accessed the LRS as well as time spent using the recordings [12]. More recently, the same group showed that students who self-rate themselves as having an auditory preference component when studying and using the LRS on average for less than 10 min per access had an average final grade of 16.43 % higher than the students ranking themselves as non-auditory and using the LRS for the same amount of time per access [17]. In the same study, the data also indicated that the students accessing the recordings more than once per lecture were at risk of scoring lower in the course (Fig. 9.1).

Conclusion

In our experience, the LRS has been an invaluable tool for students who experience valid absences due to personal or family illness or a death in the family or absence due to weather conditions. It is also now part of our institutional emergency response plan in the case of a pandemic flu, major weather disaster such as a hurricane, or any other significant emergency that could disrupt the teaching schedule. However, the consensus among faculty who have significant experience in this area is that students should be educated about the proper use of LRS to benefit from it, i.e., use it one time per lecture on average with the most common time of use being about 10 min per lecture recording. The decision to use it and how to use it should also remain with them and not be decided centrally by administrators, as some successful students clearly refuse to use LRS when given the choice.

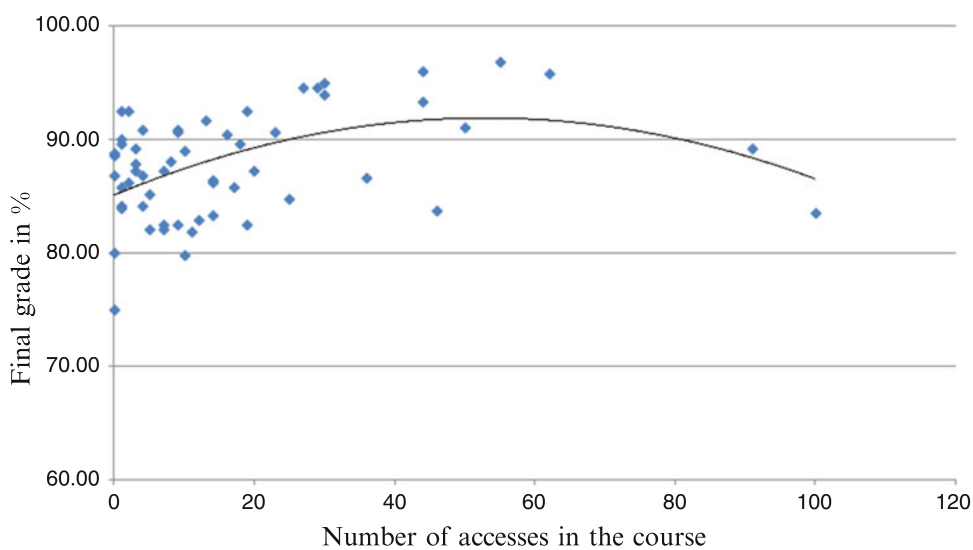

Fig. 9.1 Plot of the number of accesses per student versus the final grades in a dental gross and neuroanatomy course with 55 lectures. A significant but poor correlation was detected between final grades and the number of times the student accessed the lecture recordings ($r = 0.33$ with $P = 0.01$). The *black line* represents a best curve fit of the data using a quadratic polynomial

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Evaluating Your Own Performance in a Lecture

10

John Dent

Introduction

> "Although everybody thinks that they can lecture adequately it is probably true that meaningful, constructive feedback will be valuable to everyone."
>
> Dent [1]
>
> "A good lecture, like a good meal, should contain a light starter to whet the appetite, a main course containing a variety of tastes and textures that should be properly chewed and digested, and a light dessert to complement what has gone before."
>
> McLaughlin and Mandin [2]

Probably the most difficult thing for a lecturer to obtain is a truthful, objective critique of their lecture. Whoever it comes from, there is always the risk of it being deferential or biased, subjective or prejudiced. This is why personal reflection is often put forward as the main way to evaluate our performance. While this may well be true, it can nevertheless be improved on if we add to that reflection a glance at the opinion of students and colleagues. So we have three methods of evaluating our performance as lecturers that we can take into account:

- Student feedback
- Peer review
- Personal reflection

Of course, although the aim may be to evaluate the *lecturer* and his or her performance, it is not really possible to do this without also evaluating the *lecture* and its content and construction.

Student Feedback

The use of student opinion to rate teaching, introduced in the 1960s/1970s, has become the most common method used to provide feedback to lecturers and may also be used to inform faculty decisions for staff retention, tenure, and promotion. Although not universally popular with faculty members, it is nevertheless more widely used than peer feedback as a method of evaluating teaching. Studies have shown that it:

- can provide reliable and valid evidence of teaching effectiveness across groups of raters, time periods, and courses.
- is only slightly affected by class size and severity of grading.
- correlates with comparable ratings from colleagues.
- is positively related to more objective measures of teaching [3].

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Table 10.1 To evaluate the lecturer

	Strongly agree	Slightly agree	Slightly disagree	Strongly disagree
Was enthusiastic				
Was clearly audible				
Seemed confident				
Gave clear explanations				
Encouraged participation				

Adapted from Brown and Manogue [5]

Table 10.2 To evaluate the lecture

	Strongly agree	Slightly agree	Slightly disagree	Strongly disagree
Clear				
Interesting				
Easy to take notes from				
Thought provoking				
Relevant to the course				

Adapted from Brown and Manogue [5]

Student feedback may be verbal or written. Cantillon [4] lists four methods of acquiring student feedback:

- Ask a sample of students if you can read their lecture notes.
- Ask for verbal feedback from individual students.
- Ask students to complete a 1-min paper.
- Ask students to complete an evaluation questionnaire.

Verbal feedback may be acquired casually from private conversations or discussion with groups of students, or it may be more formally sought from focus group events. While personal conversations run the risk of omitting negative comments, group sessions are at risk of being dominated by the opinion of more vocal individuals.

Written feedback from students, if anonymous, may encourage more truthful comments and so highlight both good and poor aspects of a lecture. However, this approach is unlikely to give any thoughts about how the lecture could be improved unless this is specifically prompted, for instance, by an open-ended question. Students can be asked to complete an evaluation form to rate the general characteristics of a lecturer (see Table 10.1) [5]. Student opinion can also be sought on the lecture itself, and again a table by Brown and Manogue [5] may be used to focus comments on the lecture (see Table 10.2). Examples of student feedback questionnaires can be found online. One from University College London [6] asks students to answer 12 specific questions on a three- or four-point scale and then to give a overall rating for the lecture.

However, student opinion must be treated with caution as it is more likely to be swayed by the performance value of the lecturer than by the content [7] and may be influenced by a variety of other factors [8, 9]. We must not fall into the mistake of thinking that we must respond to every student comment.

Other ways of collecting student feedback may include the use of a personal response system (PRS) in the lecture theater to ask students to vote on various aspects of the lecture as it progresses. Alternatively, a discussion board can be set up in the medical school's virtual learning environment (VLE) for feedback, comments, and discussion of ongoing problems or to provide answers to frequently asked questions.

Peer Review

So is there a way of obtaining a more objective critique? A valuable adjunct to student feedback is peer review [3]. This may include rating scales, checklists, and open comments. Peer review can be required for part of the facility's quality assurance (QA) process in evaluating its program, as a component of your own continuous professional development (CPD) or to contribute to an argument for academic advancement in your institution.

Peer checklists may include scorings for:

- Presentation
- Relationship with the class
- Material
- Illustration
- Overall impression

Implementation

A system whereby two lecturers give mutual feedback to each other after lecturing is a relatively non-threatening example. The risks of this approach are a potential loss of honesty or objectivity, but it can lead to open, profitable discussion and be a stimulus for personal reflection later. A team approach to reviewing a lecture, on the other hand, has a risk of appearing threatening and judgmental. It is good practice, before the event, to have a discussion between the observer and the observed to define the content of the assessment and the objectives which are to be judged. Staff development sessions are probably necessary to prepare faculty to participate in these activities successfully; to warn of pitfalls, especially when giving feedback; and to maximize the positive benefits that can be achieved. Not everyone may be able to participate in the exercise however. Time constraints, a heavy workload, as well as fear of scrutiny and criticism may all deter participation [10].

Giving Feedback

When considering giving feedback, it is good to remember Pendleton's advice [11]:

1. Clarify any points of information/fact.
2. Ask the lecturer what she/he did well—ensure that she/he identify the strengths of the performance at this stage and do not stray into weaknesses.
3. Discuss what went well, adding your own observations (if there is a group observing the performance, ask the group what went well; again, keep them to the strengths).
4. Ask the lecturer to say what went less well (weaknesses) and what she/he would do differently next time.
5. Discuss what went less well, adding your own observations and recommendations (if there is a group observing the performance, ask the group to add their observations and recommendations).

The strengths of Pendleton's rules (http://www.gp-training.net/training/educational_theory/feedback/pendleton.htm) includes the following:

- Offers the lecturer the opportunity to evaluate his/her own practice and allows even critical points to be matters of agreement
- Allows initial lecturer observations to be built upon by the observer(s)
- Ensures strengths are given parity with weaknesses
- Deals with specifics

To help us provide good peer review, Siddique and colleagues [12] suggest 12 tips:

1. Choose the observer carefully. It is important that there is good rapport between the observer and the observed who should have comparable rank within the faculty and a shared empathy.
2. Set aside time for peer observation, which should include pre-observation discussion, the observation itself, and post-observation reflection.
3. Clarify expectations of the format of the event and the roles and expectations of the participants.
4. Familiarize yourself with the course, the type of lecture, its objectives, and the resources available.
5. Select the instrument wisely, e.g., a checklist that matches the session format.
6. Include students and let them know that an observer is going to be present, especially if their numbers are small
7. Be objective: Take the opportunity to observe the students' attitude to the lecture and their reaction to the lecturer.
8. Resist the urge to compare with your own teaching style: No one style provides a gold standard.
9. Do not intervene: Concentrate on making your observations.

10. Follow the general principle of feedback. Encourage initial self-reflection which creates a positive learning climate and can lead to discussion.
11. Maintain confidentiality. Avoid making any judgmental conclusions.
12. Make it a learning experience. Give supportive feedback and constructive advice. Learn how to do this well!

Personal Reflection

Reflection is the cornerstone of continuing professional development. At the end of your lecture, ask yourself: What went well and what did not go so well? Especially did you keep to time, did you lose your audience at any stage, and did you cover everything you intended to? A video recording of your lecture may provide a shocking insight into any annoying mannerisms you may have been unaware of and provides a good way of making objective decisions about which aspects of the lecture can be improved. However, finding time to do this after the event may be difficult for many. It would be good practice to review your lecture against the students' learning objectives for the course and to ask yourself whether you could improve the content or delivery of any part and possibly reconsider any activities your students could do in it.

A schematic approach may help us to organize our thoughts for this reflective exercise by giving us some questions to ask ourselves. According to McLaughlin and Mandin [2], the problem with a lecture ("lecturalgia"—a painful lecture) may be due to three primary causes: poor judgment, poor organization, and poor delivery (see Fig. 10.1).

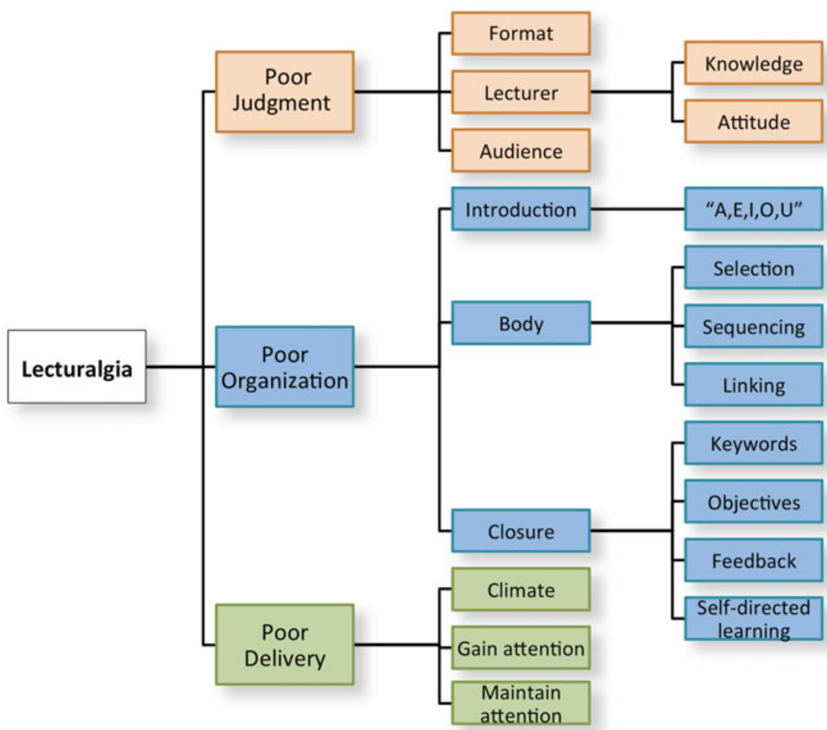

Fig. 10.1 A schematic way to identify the possible problems causing a poor lecture. Key: "A,E,I,O,U" : "Attracts attention, Establishes rapport, Identifies knowledge base, provides advance Organizer, and indicates Usefulness" (adapted from McLaughlin and Mandin [2])

Causes of Lecturalgia in the Teachers' Opinion

Misjudged learner/context	45 %
Flawed implementation of teaching strategy	30 %
Lack of preparation	25 %
Difficulty with audiovisuals	25 %
Too much content	20 %
Use of wrong strategy	15 %
Lack of purpose	10 %
Inflexibility	10 %

From Pinsky and Irby [13]

1. Was the problem with the lecture due to poor judgment

   The format: Was a lecture the best method to choose to present this information, or would a small group discussion or student activity have been better?

   The lecturer: Were you the right person for the job, or may someone else have been better? Did you have the right knowledge and the right attitude to motivate the audience?

   The audience: Did you make the subject relevant to the audience? Did you facilitate learning by activating prior knowledge or by using encoding specificity providing information in a sequence which mimics the way it will be used in practice? Did you use examples and elaboration to facilitate the recall of knowledge?

When Deciding on the Content of a Lecture:

- provide objectives and key points.
- choose contents congruent with the objectives.
- limit the content rather than seeking to "cover the ground."
- elaborate on the key points using illustrations and examples.
- plan to facilitate learning after the lecture is finished.

From McLaughlin and Mandin [2]

2. Was the problem with the lecture due to poor organization?

   The introduction: Did you attract attention, establish rapport, identify knowledge base, provide objectives/advance organizers, and indicate the use of the content?

   The body of the lecture: Did you select the right content, did you sequence the key points in a logical progression, and did you link these together in an engaging way?

   The conclusion: Did you review the key points and objectives, provide take-home tasks or revision handouts, and ask for any feedback?
3. Was the problem with the lecture due to poor delivery?

   The climate: Was there a problem with the physical or emotional climate for the students? Was there a problem gaining or maintaining student attention?

   Finally, you might like to compare your reflections on your performance in the lecture with feedback from students and colleagues. Analyze all the evidence available and ask yourself if the weak points you identified were the same ones your students or colleagues observed. Reviewing a comprehensive checklist completed by students or peers might be good to review at this stage (see Table 10.3). This example asks questions about the introduction, the body, and the closure of the lecture as well as generic questions about the presentation.

Two Bigger Questions Remain

Has Student Learning Been Improved by This Lecture?

A useful list of tips to improve student learning from lectures is given by Brown and Manogue [5]:

1. Outline the structure of the lecture. Describe signposts used and how students can recognize key points and be sensitive to verbal cues such as "However…," "Nevertheless…," and "So…."

Table 10.3 Lecture evaluation checklist

Introduction/set	Score yes/no	Comments
Attracts attention Establishes rapport Identifies knowledge base Provides advance organizer Indicated usefulness		
Body	**Score yes/no**	**Comments**
Structured the content Controlled the amount of content Emphasized major points Summarized after each sections Sequencing clear and logical Relevant/interesting examples provided Kept "with" the audience Interacted with/engaged the audience Appropriate amount of material covered encouraged and responded to questions		
Conclusion/close	**Score yes/no**	**Comments**
Summarized main points Related back to advance organizer Indicated further reading etc. Conclusions clearly stated Did not introduce new material		
General presentation	**Score yes/no**	**Comments**
Appropriate mannerisms/body language Maintained eye contact Spoke audibly and fluently Ensure clarity and modulation of speech Varied the speed of presentation Used silence Used appropriate AV aids Asked questions Used humor Kept to time Showed enthusiasm		

2. Provide listening, observing, and note-taking exercises and get the students to compare their notes after these events.
3. Discuss what constitutes "good" lecture notes and how to use them.
4. Provide a list of lecture topics at the beginning of the course and indicate the links between them.
5. Encourage them to review and compare their notes by setting mini-tasks at the beginning and end of some lectures.

A specific way of evaluating a lecture in terms of whether student learning has been helped is described in the "1-min paper" by Sinclair and colleagues [14] which asks students to review their notes and then to answer three questions:

- What was the most useful, meaningful thing you learned during the lecture?
- What questions remain uppermost in your mind as we end this session?
- What was the "muddiest" point in this lecture?

Lecturers can respond to these comments at the beginning of the next lecture and correct any misunderstandings of the content.

An unannounced open notebook quiz can be used at the end of a lecture to test factual recall of key points of content as well as to challenge critical thinking on the topics covered. The PRS can be used at the end of a lecture to ask students to answer a few multiple choice questions (MCQs) on the topic. It can also be used to ask them which parts of the lecture, or which of the styles used (passive/active learning), they found most helpful [15].

Does Evaluation of a Lecture Lead to Improvement of Lecturing?

Can student feedback actually lead to an improvement in a lecture? Murray [3] suggested that under certain conditions, this can be the case. Evidence from faculty surveys, field experiments, and longitudinal comparisons suggests that student evaluation of teaching has contributed to improvement of teaching and the contribution of student evaluation is enhanced when combined with contributions from the institution's experts in staff development. Evaluation of a lecture, especially if carried out during the session, may guide a lecturer about when to introduce a more active learning component.

So there is some evidence that student evaluation can lead to improvement in teaching and that this information is probably best used when combined with other sources of data, but perhaps most significantly, as McKeachie [16] commented, improvement in lecturing is more likely to occur when the lecturers themselves wanted to improve their teaching.

Conclusions

Information from a variety of sources is available to help us evaluate our performance in a lecture. Reviewing data from the various sources available may take a little time but generates a culture of personal questioning, reflection, adaptation, and improvement [17]. So do you think you can improve your next lecture? You might like to consider attending a staff development session in your institution on presentation skills or on "How to give a good lecture" [18]. You may look at some of the literature quoted in this chapter, observe a senior colleague lecturing, and, of course, discuss with your colleagues what they consider makes a lecture good.

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11 Choosing Between Lecture and Briefing Sessions

Nirusha Lachman and Wojciech Pawlina

Introduction

Teaching practices that once impressed undergraduate and graduate medical students can no longer sustain a generation of technologically skilled students for whom access to information is no longer confined to the classroom. The World Wide Web, online course material, electronic databases, and e-books present a unique challenge to traditionally approached curriculum delivery. For the anatomy professor, the time for lamenting is over. The focus is no longer on how knowledge should be *transferred* but rather on how knowledge should be *managed*.

One may argue that in the era of massive open online courses, students are able to independently direct their own learning, eliminating the need for formal class time. While this is true in the general sense of the underlying principle of online and Web-based learning, the need for student-to-teacher and student-to-student interaction has never been more important for intellectual and social development of future healthcare professionals. The challenge therefore is embedded in the question of how to incorporate desired global outcomes and maximize the skill of teaching for a group of individuals who have free access to multiple sources of information but lack direction on how to interpret and develop clinical reasoning.

> "The challenge should not be to determine supremacy of one methodology over another but to maximize the learning benefit available from the different methods."
>
> Turney [1]

In this chapter, we explore core elements of what should be included in a teaching and learning session that targets both the expected outcomes and the skill of clinical reasoning.

Objective of Teaching Anatomy

What Are We Aiming to Teach in Anatomy?

Anatomy still remains one of the most valued basic science subjects in medical education among practicing physicians and residents [1, 2]. There are few if any anatomy programs that still provide a content heavy course [3]. The decrease in course hours, reduction in laboratory time, and the positive move away from passive, didactic, detailed courses toward more clinically and functionally relevant anatomy [1, 4] have transformed traditional delivery of anatomical knowledge into a more contemporary student-facilitated experience.

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In a contemporary curriculum, a clinically integrated anatomy course for current healthcare students should be designed to provide opportunities to develop clinical reasoning skills based on (1) understanding of core anatomical concepts (through various modalities, e.g., radiology, ultrasonography, embryology) and (2) reflection and critical thinking. In addition, non-discipline-related competencies that foster social awareness, successful team interaction, communication skills, leadership, and professionalism [5] should be incorporated through assignments and student-centered activities that contribute toward the overall course grade.

Target Audience

Who Are We Teaching Anatomy To? What Appeals to the Millennial Student in the Anatomy Classroom?

With clearly outlined objectives, the millennial student has little trouble providing deliverables for assigned tasks. They have little trouble accessing resources and will present you with completed projects having exhausted the information available on the World Wide Web. As independent learners, however, students often lack the ability to critically evaluate or validate their knowledge. Furthermore, their ability to determine what key concepts are important to facilitate their understanding of anatomy and apply its basic science principles for proficient patient care remains inadequate. These academic themes provide the fundamental guiding principle that will determine how we enable our students to meet the competencies expected of them [6].

Raines and Arnsparger (2010) provide a comprehensive feedback-based report as to what promotes success for millennials in the workplace (http://www.generationsatwork.com/articles_millennials_at_work.php). When applied to the educational setting, a few key thoughts may be considered:

- **Interaction with peers and near-peer teachers is as important inside the classroom as it is outside.** Students value opportunities to problem solve with their classmates. They value being part of a team working toward a common goal while at the same time committing to their own achievement. The team-based setting caters best to students' need for social interaction within the learning environment. They are able to work effectively in teams and independently. The team arrangement characteristic of anatomy laboratory dissection tables may also be applied to the classroom setting. Organizing the classroom so that students are able to physically sit together in small groups encourages discussion and enables facilitators to lead question-based teaching sessions. In addition, physical proximity allows students within the group to gain better appreciation for team member's strengths and areas for improvement when providing peer feedback. Participation of teaching assistants [7] adds to the learning process as students are able to connect with their near-peer teachers at a level different than the way they would with faculty.
- **Active learning appeals to learning preferences.** To bring the best out of students, it is important to build into a curriculum learning activities that appeal to their learning preferences. Students who have been exposed to technology at an early age have an expectation that the curriculum they learn from will implement technologies. They are technologically savvy and able to multitask with exceptional skill—keep them actively engaged. For anatomy curricula that include a radiology component, scanning whole cadavers and implementing CT-based activities in the laboratory keep students engaged as it combines the use of technology with opportunity to practice spatial reasoning skills. In addition, the use of ultrasound and other scanning modalities may benefit students' appreciation for understanding anatomy as it relates to clinical practice [8].
- **Value good feedback and are goal and achievement oriented.** As young adult learners, millennial students are driven by achievement of tangible goals. They set high standards

for themselves and are determined to succeed. Providing them with regular quizzes and test scores and feedback encourages their learning drive. Provide them with meaningful feedback [9] and keep them motivated within an academically challenging environment. Feedback may be elicited during the course from peers through formal evaluations (leadership and peer evaluations) and from near-peer teachers and faculty through informal reflective sessions (see Chapter 17).

- **Need direction and reasonable structure.** While flexibility is important to them, millennials have a distinct reliance on guidance and defined objectives. Providing clear objectives and achievable outcomes creates a sense of reassurance in their ability to succeed in meeting learning expectations. This becomes increasingly important for courses that provide 120 h of teaching over a short time period (e.g., 6-week courses). With high volume of information, teachers have a greater responsibility to define specific objectives that are relevant to clinical interpretation. While students may be able to memorize with a reasonable level of understanding, actual depth of understanding depends largely on how they are guided through the material in order to internalize core concepts. In addition, information accessed through iPad and iPhone applications, the Internet, and anatomy websites may contain inaccuracies and points of focus different from courses in which they may be enrolled. Encouraging students to use a prescribed textbook and other faculty-endorsed resources helps provide students with the most reliable information.

> "Given that these students are much more likely to have been exposed to new technologies than previous generations of students it could be posited that these students will expect academic staff to be comfortable with and utilize a wide range of technologies in their teaching."
>
> Jonas-Dwyer and Pospisil [10]

Enabling Students to Achieve Outcomes

The past decade has seen extensive debate with the threat of de-emphasizing (and the fear of eliminating) the traditional approach to teaching anatomy [11]. In response, anatomy teachers turned to innovative ways in maintaining traditional approaches to teaching medical students about the human body [8, 12–14]. Regan and Mattick [13] further explored the complexity of anatomy as a subject and what is involved in achieving competency in understanding structure and its clinical application. Based on participant feedback, they defined anatomical competence as a multilevel expertise that combines factual knowledge; application of the knowledge; hands-on skills, insight, and understanding; personal awareness; and aesthetic appreciation. The study also affirms rote memorization as an unsuitable way of learning about a complex subject, the understanding of which depends on inquiry and creative thinking.

Traditional Lectures vs. Short Lectures

Traditional lecturing (at least 1 h duration) remains one of the most commonly used methods of delivering information. It is a teacher-centered approach that involves continuous periods of exposition with the primary focus on information relay. While content of the lecture may vary, the style of delivery has little flexibility and is often disengaging and ineffective in promoting clinical reasoning. Therefore, a lecture would be most effective in the event that resources are limited, and the goal is to provide students with information from reliable sources. On the positive side, time designated for presentations may be used more effectively to explain concepts that are not easily grasped through diagrams, animation, or case studies. Either way, the approach remains one dimensional and teacher centered.

With reduced emphasis on information transfer, anatomy teachers may choose to present shorter, more objective-driven presentations that help students determine important concepts while studying the material from assigned readings. The "short lecture" is designed to highlight the major anatomical points with greater focus on core objectives than factual information. When compared with traditional lecture approach, the short lecture reduces student listening time and provides more direction for both conceptual understanding and hands on learning. However, it too is not effective for engaging student participation or promoting student thought.

How Do We Promote Clinical Reasoning and Critical Thinking?

Eric Mazur's enlightening viewpoint in *Science* (2009) [15] emphasizes the notion that "*education is so much more than just information transfer.*" His philosophy of "*teaching by questioning*" instead of "*teaching by telling*" forms the basis for the design of a teaching and learning model that de-emphasizes content, promotes critical thinking, and reinforces core concepts that can be applied in clinical reasoning. The term "briefing session" will be used to describe an interactive teaching and learning session designed to reinforce anatomical knowledge through a process of clinical reasoning and the promotion of thought.

> "In hindsight, the reason for my students' poor performance is simple. The traditional approach to teaching reduces education to a transfer of information."
>
> Mazur [2]

The Briefing Session

Elements of a Briefing Session

The framework for delivery is based on a team setting. The expectation is that students would have read and become familiar with basic anatomy of the region under study, aligned with the principles of team-based learning [11, 16, 17]. Access to resources in the form of prescribed texts, suggested reading, and online sources may be used at the discretion of the student, thereby cultivating a sense of independence in information gathering. This may appeal to and benefit students with different learning styles, thereby promoting knowledge retention more effectively than a time-limited traditional lecture presentation is able to achieve. It aims to prepare students for deep level learning through questioning and critical evaluation as opposed to superficial memorization of material. In addition, it provides students with a form of immediate feedback such as formative feedback sessions using the audience response system (see Chapter 17) enabling them to evaluate their knowledge interpretation and retention. By reducing the time spent on information transfer, briefing sessions can allocate time for orientating students for the laboratory exercises allowing students with untrained dissection skill progress with more ease through laboratory assignments:

- **Team-based setting.** The briefing session is most effective when used in a team-based setting but is also useful for larger classroom settings. By promoting a partnership in teaching and learning, students are responsible for acquiring information under guidance of teachers and near-peer teachers, through endorsed online material and prescribed texts. As mentioned earlier, arranging the classroom so that students are able to sit in groups further facilitates team interaction both academically and in terms of promoting non-discipline-related skills.
- **Use a combination of resources.** The briefing session is designed to promote a culture of personal responsibility for acquisition of knowledge. Choose texts that are peer reviewed from well-established authors. The choice of text will depend on the target audience. Consider the academic level and academic expectation for the group. Anatomy courses for medical students will require a text that is clinically oriented with simple diagrams and high-yield highlighted concepts, whereas

an anatomy course for surgical residents may benefit from a more detail-oriented text focused on anatomical landmarks and relations as well as surgical approaches.

- **Search the Internet for reliable online course material.** The most reliable online course material is generally accessed from established university sites or a source affiliated with a learning center or educational institution. Despite being skilled at searching the Internet, teacher-endorsed material is of greater value to students.
- **Provide a database of electronic material.** Lecture notes, slides, short video clips, animations, and clinical images if available may be uploaded onto websites or accessed through course management systems such as Blackboard.
- **Encourage practice of peer sharing of resources and learning material.** Peer study notes, online material, assignments, projects, dissection findings, student-generated video clips, reliable anatomical images, and radiologic images are valuable shared resources.

> "Instead of teaching by telling, I am teaching by questioning."
>
> Mazur [2]

Delivering a Briefing Session

1. **Objective-driven orientation.** The briefing session begins with a review of core concepts that are re-emphasized through an objective-driven orientation. Students are reminded of their reading assignments, and objectives are clearly projected (verbally and visually).
2. **Clinically oriented team question.** The session immediately continues with a clinically oriented multiple choice question developed around a key concept. Students engage in a 2–3-min group discussion to reach a consensus, and answers are recorded using the audience response system [18]. Answer statistics are then revealed, and through a process of clinical reasoning, each answer option is then discussed through student–teacher dialogue to assess answer possibilities. Through a process of reasoning, the correct answer is derived. In doing so, students maintain a partnership in determining the correct answer and are given the opportunity to question and understand the concept more clearly. It is also important to look at every option and not just present the correct answer. This way, students are encouraged to think and assess their own knowledge and understanding of the concept.
3. **Reinforce concept with two to three good teaching slides.** A few good teaching slides may be used to reinforce understanding of the concept. Choose clear images with simple points. Avoid scans of text images with multiple labels in annotations. Concept maps or flow diagrams may also be useful.
4. **Relate core concepts to objectives for teaching within the context of the laboratory session.** At the end of the *briefing session*, students receive a pre-lab orientation highlighting important relations based on a list of anatomical structures relevant to assigned dissection.
5. **Formative feedback session and debriefing after laboratory session.** End the day's teaching by a short 15-min debriefing and quick test questions (e.g., audience response system) for individual student feedback [18, 19].

Core Elements of a Briefing Session

Design the presentation around the following guiding principles:

- Concepts should have an underlying clinical principle.
- Formulate multiple choice questions around the concept.
- Identify key anatomical structures easily located through dissection.
- Focus on anatomical relations.
- Avoid the tendency to present everything.

Choosing Content and Material for Briefing Session Slides

Figure 11.1 is an example of what may be included in a briefing session. The clinical concept (slide 1) may be determined from a prescribed clinically oriented text and should relate to commonly encountered clinical scenarios. The question (slide 2) should be written around the concept with answer possibilities that all relate to the concept. Two to three clear, simple diagrams (slides 3 and 4) accompanied by actual images (slide 5) should be used to explain the concept. Steer away from heavy textual information, but refer students to resources for further details. Provide tips for dissection and highlight the most important dissection outcome (slide 6). A 1-h time frame should be sufficient to discuss at least five important concepts.

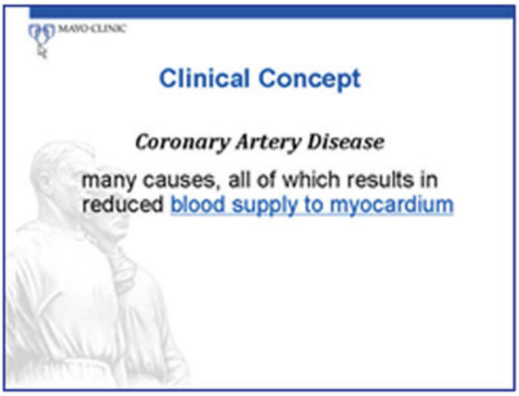
Saroyan and Snell [20] characterize three principle-driven lecture types: *content driven (teacher centered)*, *context driven (objective centered)*, and *pedagogy driven (student-centered active learning)*. While content-driven lectures received the lowest rating among participants (students and teachers), both context- and pedagogy-driven lectures were seen as useful methods of helping students get the most out of learning in the classroom. Pedagogy-driven lectures however seemed to be most valued as it targeted learning of clinically relevant material and provided opportunity to apply understanding by offering active learning opportunities during lectures.

Reviving Anatomy Teaching

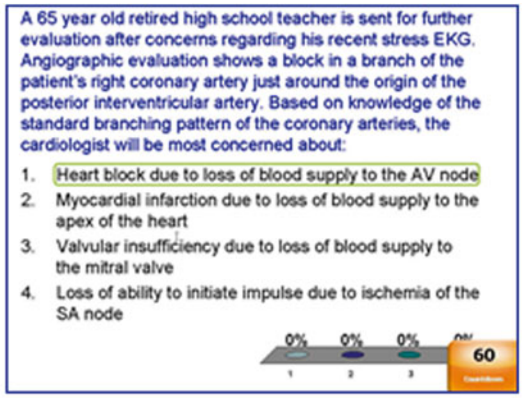
Philosophical Thoughts…

- Old style anatomy teaching has not survived a contemporary curriculum.
- Medium of teaching anatomy must evolve to meet the requirements of the twenty-first century.
- Welcome teaching innovations that appeal to millennial students [12].
- Minimize telling and promote discussion.

In this chapter, we have presented a method for conveying core concepts that are driven by inquiry, critical thinking, reflective learning, and student centeredness. While the design of the briefing session is embedded within a team-based learning framework, its principles may be as effectively applied to larger classroom settings. The implication of adopting a purely pedagogy-driven lecture is that not only is there greater student involvement but also greater demand on teacher creativity and planning and a change in the nature of the teaching mission—teaching by "questioning instead of teaching by telling" [15]. Millennial students will continue to inspire transformation [21, 22] of educational tradition. For the anatomy professor, this challenge will continue to inform how anatomy courses and, more importantly, the delivery of anatomical knowledge will adjust to cater for the changing learning environment.



Slide 1



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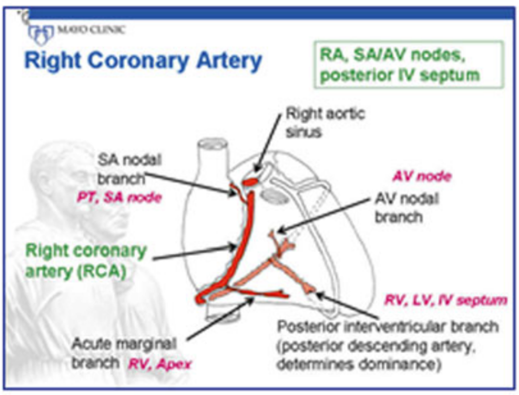

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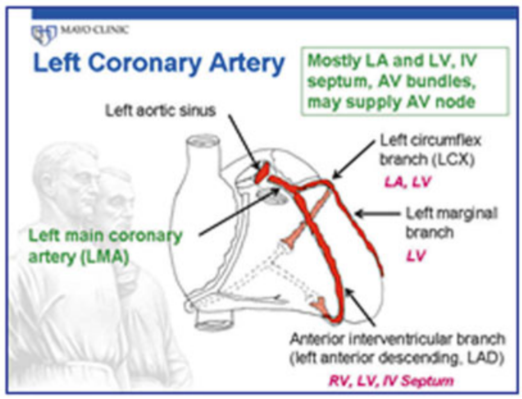

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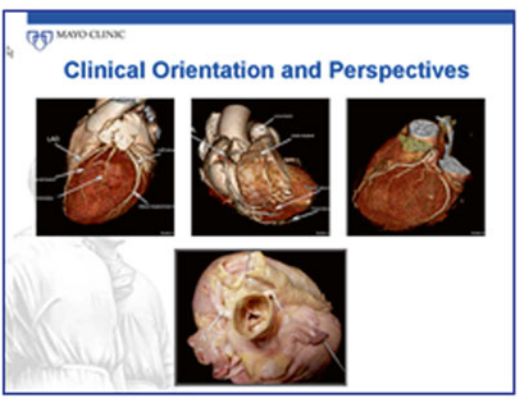
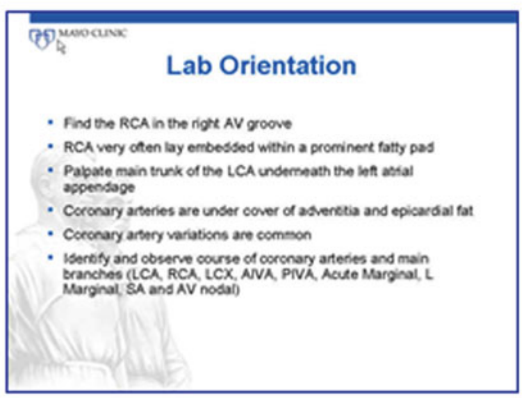


Slide 5



Slide 6

Fig. 11.1 Briefing session on coronary arteries: slide content

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Part III

Teaching in Small Group Settings

Facilitating Small Group Discussion

12

Boon Huat Bay and Samuel Sam Wah Tay

A proficient knowledge in human anatomy is not only essential to prepare medical students for their future training in the clinical disciplines but is also necessary for good clinical practice [1–3]. However, there has been a decrease in the total course hours dedicated to the teaching of human anatomy in most medical schools in the world today. In a survey of medical schools in the USA [4], gross anatomy contact hours in 2009 have decreased by approximately 11 % compared to statistics in 2002 and 55 % compared to that in 1955. Hence, there is a demand to develop the best instructional methods for teaching gross anatomy in many medical schools.

Patel and Moxham [5] observed that cadaveric dissection by students was the most preferred method of teaching by anatomists, followed by prosection classes, living (surface anatomy) and radiological anatomy, computer-aided learning, didactic lectures alone, and the use of anatomical models [1, 5]. Although the didactic lecture may not always produce learning [6] or promote long-term retention [7], this approach is still commonly used by many teachers.

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Small-group teaching has been extensively applied in the teaching of human anatomy [8, 9]. This teaching methodology was reported to be an effective method for laboratory teaching of human gross anatomy, especially when combined with the appropriate use of other modalities such as plastinated specimens and radiology-based imaging [10]. In the same study, 82.4 % of the students found that anatomy learning objectives were better understood in the laboratory than those derived from didactic lectures.

Small-group teaching is not only restricted to the study of human structures but has also been utilized to enhance students' understanding and application of physiological concepts [11] and for the teaching of biochemistry [12]. However, among the preclinical subjects, human anatomy classes tend to have considerable faculty–student interaction, as teachers have the opportunity to work with students directly in small laboratory groups and also during tutorial classes [13].

Examples of Teaching Pedagogies Using Small Group Discussions

1. **Dissection/Prosection Laboratory Classes.** The dissection/prosection classes are highly valuable as they provide hands-on experience, enable the appreciation of three-dimensional relationships and anatomical variations in the

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human body, and help to develop fine motor control skills as well as promote teamwork and professionalism [1, 14–17].

2. **Tutorials.** Tutorials are usually given after the students have attended didactic lectures on a region of the human body and completed their practical classes [18]. Here, individual tutors review and discuss the tutorial objectives (which have been made available earlier) with small groups of students.
3. **Team-Based Learning.** Dr. Larry Michaelsen [19] originally developed team-based learning (TBL) for business courses. TBL, an instructional strategy that involves discussions in small groups, has been credited for nurturing an active learning environment by promoting student engagement and peer teaching [20]. It emphasizes the importance of teamwork, mastery of content, and solving clinically relevant problems. Hence, TBL has emerged as an attractive strategy to adopt for imparting human gross anatomical knowledge, because it requires students to be conversant in gross human structures, from which they construct anatomical concepts and principles that could help to solve relevant clinical problems [9, 20, 21].
4. **Problem-Based Learning.** The integration of basic science knowledge with medical data pertaining to patients plays an important role in clinical assessment and patient diagnosis [22]. Problem-based learning (PBL) helps to consolidate integrative thinking among medical students [23]. First implemented by the McMaster University Medical School in 1969, the PBL approach focuses on collaborative learning in small groups of students based on a prescribed clinical scenario [24]. The students drive the learning process and are responsible for the acquisition of knowledge (which includes recalling prior knowledge), thereby not only promoting active learning but also preparing them for self-directed lifelong learning, which in light of the burgeoning medical information that is made available, is absolutely essential in the medical profession [25, 26].

Advantages of Small Group Discussions

1. **Encourages Participation of Students.** In a small group setting, students are more willing to share their knowledge and speak up as they would be in a less intimidating setting. Some students are reserved and shy and would therefore be more reluctant to speak out in a large class situation.
2. **Improves Communication Skills.** Students will learn to organize their thoughts before presenting to their peers, thereby developing their interpersonal and communication skills [10]. Effective communication between a doctor and his/her patients is regarded as an integral part of medical practice [27].
3. **Reaches Out to Students with Different Learning Styles.** Students come from diverse backgrounds and cultures and hence may have dissimilar learning styles. The words "learning style" have been defined as "a particular set of behaviors and attitudes related to learning context" [28]. The tutorial caters to both active students and reflective learners and also enable the teacher to tailor specific strategies for each student [29].
4. **Inculcates Responsibility.** Small group discussions help to develop a professional attitude of responsibility and accountability toward each other. The students are expected to come prepared for the tutorials and must actively contribute to the learning process. They are aware that if they frequently come unprepared for tutorials, they would leave an unfavorable impression of themselves not only to the tutor but to their peers as well.

Advantages of Small Group Discussion

- Encourages student participation
- Improves communication skills
- Reaches out to students with different learning styles
- Inculcates responsibility

Features of a Tutorial Class

As TBL, CBL, and PBL will be covered in later chapters, this chapter will emphasize more on tutorial classes. The tutorial reinforces what has been taught during the lectures and what students have observed during their laboratory classes. Tutorial classes are particularly useful for discussing the clinical relevance of the anatomical knowledge learned and also to achieve analysis type of outcomes, with special reference to clinical scenarios.

Typically, at the start of a tutorial, some teachers may set quizzes for the students so as to assess their understanding of the topic and others may give an overview of what is to be achieved during the class. The bulk of time in a tutorial class should be spent in discussing the tutorial objectives.

1. **Tutorial Objectives.** The compiled tutorial objectives for a region (for instance, the upper limb) would have been made available to the students at the start of their study for that region.
2. **Types of Objectives.** The objectives can be divided into general objectives which enable the students to have an overview of the conceptual framework and anatomical structures under consideration in the region of interest. The specific objectives review the details of structures in the region under study. For instance, for a topic such as "Nerves of the Upper Limb," an example of a "general objective" would be to "understand the formation of the brachial plexus and distribution of its major branches," and an example of a "specific objective" would be to "trace the course of the ulnar nerve and enumerate the functional loss if there is an injury to this nerve at the medial epicondyle and at the wrist."
3. **Student Preparation.** Some tutors may assign specific tutorial objectives to individual students while others may not. The pitfall of the former approach is that students may not prepare for the other objectives of the topic under study other than those specifically allocated to them.
4. **Mode of Presentation.** Tutors may also request the students to prepare PowerPoint presentations or may themselves use PowerPoint or more sophisticated flash presentations (Fig. 12.1) during their tutorials.
5. **Active Participation of Students.** One of the important ingredients of a well-conducted tutorial is active student participation. Students should be encouraged to present facts and information on the topic under study, answer questions, and seek clarification if they have any doubts. The tutor should only act as a facilitator during the tutorial session and should not conduct a mini-lecture, thereby providing answers to all the stated objectives.

At the closure of the tutorial class, some tutors give quizzes to find out how much knowledge the students have imbibed and whether they have acquired a better understanding of difficult concepts, while others may highlight take-home messages to the students.

Features of a Tutorial Class

- Tutorial objectives are distributed before the class.
- Students are required to make adequate preparation for the classes.
- Students are expected to participate actively in the discussion.

Tips for Facilitating Group Dynamics in a Tutorial Class

As pointed out by Lee et al. [30], tutorial skills can generally be divided into group dynamics and discussion content. Group dynamics has been defined as the flow of discussion and interpersonal interaction [31]. Lee and colleagues [30] have reiterated four principles, namely, (a) iteration of the principles for the class, (b) delegating the responsibility of learning to students, (c) creating a good discussion forum, and (d) developing a conducive learning environment. These principles have been incorporated into the steps below for facilitating group dynamics.

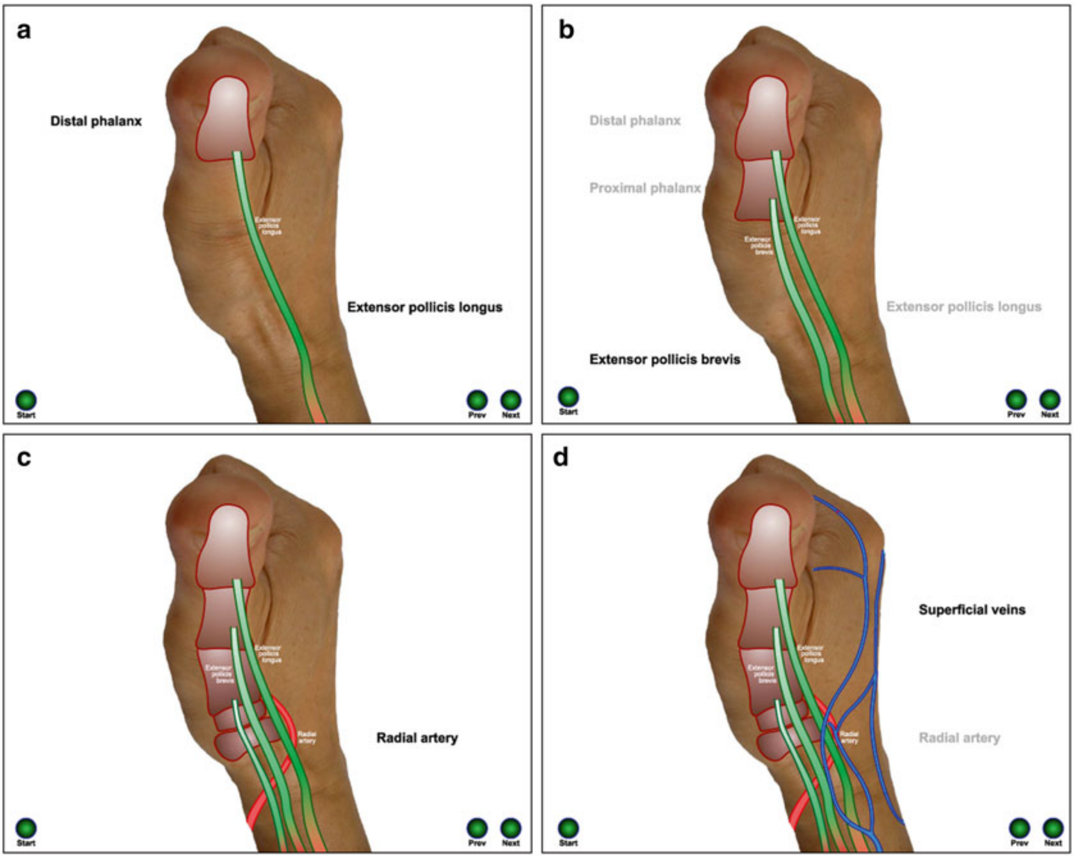

Fig. 12.1 A flash presentation on the boundaries and contents of the anatomical snuff box (Reproduced with permission from Professor Francis Voon, Department of Anatomy, National University of Singapore)

1. **Setting Up the Environment.** Depending on the size and shape of the tutorial room, the tutor may want to arrange the chairs either in a circle or in two or three rows so that student–student and student–teacher interactions can flow better.
2. **Establishing Ground Rules.** The tutor may want to set ground rules during the first tutorial class such as punctuality, respect, and showing courtesy to the tutor and tutorial mates by not interrupting unnecessarily or talking among themselves during class.
3. **Iterating the Principles of the Tutorial Class.** Students must understand that a tutorial class is not a mini-lecture delivered by the tutor. They should realize that they would benefit most if they have read up and come prepared for classes and be willing to participate actively. They should also be receptive of the mistakes made by themselves or other students, which ideally should be corrected by the tutor in each tutorial.
4. **Delegating the Responsibility of Learning to Students.** Tutorial sessions should be student centered and the students should be the driving force. They should be motivated to share their knowledge with their peers and be given the opportunity to clarify any difficult concepts and principles with the tutor. As student-centered learning is rooted in Western culture, one must be cognizant that cultural factors may have implications on student behaviors such as perception of group relations, competition, and achievement [32]. The dimensions of culture has been categorized by Joy and Kolb into "in-group collectivism, institutional collectivism, power distance, uncertainty avoidance, future orientation,

performance orientation, humane orientation, assertiveness, and gender egalitarianism" [33].

Things *Not* to *Do*

- Conduct a mini-lecture
- Speak all the time
- Be too authoritative

5. **Creating a Good Discussion Forum.** Time management is very important, and each student should be given a chance to answer questions. Students should be encouraged to speak up and given the opportunity to clarify any difficult concepts and principles during the course of their study. At the end of discussing each objective, the tutor should encourage students to reflect on what they have learned. Tutors can also gauge how each student is performing and identify the weak students for remedial action early.
6. **Engaging Students.** Some students may be shy and may not talk unless the tutor specifically directs questions to them. For students who are assertive and always want to be in the limelight, the tutor should speak to them discretely and explain to them that they have to give others a chance to participate in the class. There may also be students who show lack of interest during the class, and the teacher should speak to them after the class or at an appropriate time to find out what is bothering them and counsel them if necessary. What happens if none of the students are able to give an answer and all have become quiet? Rather than giving the answer straightaway, the tutor can ask related questions that would lead them to the correct answer.
7. **Developing a Conducive Learning Environment.** It is important for the group to be in an environment where the atmosphere is relaxed and comfortable. A tutor may want to introduce some humor or tell a story (viz., a patient with an interesting case history) at an appropriate time and ensure that there is a balanced interaction among the group members.

Tips on Facilitating Group Dynamics

- Know your students by their names.
- Be student centered.
- Try to involve every student in the discussion.
- Ensure balanced interaction among students.
- Allow students to clarify difficult concepts.
- Identify the weaker students.
- Make sure the atmosphere is relaxed.

What Will You Do?

- You have just traced the course of the ulnar nerve with the students and discussed its distribution.
- Going to the next objective, you asked the student what functional loss can result from a lesion to the nerve at the medial condyle and he replied "wrist drop." The student next to him looked perplexed. What would you do?

Conclusions

There is no doubt that small group discussions are an effective instructional method in learning the anatomy of the human body. An important facet of small-group teaching is the tutor's ability to facilitate the discussions [34]. Small-group teaching would imply that there would be a high teacher–student ratio so as to facilitate optimal teacher–student interactions. Faced with a manpower crunch, some medical schools have tried to alleviate the shortage of teachers by using experienced students (at more advanced stages of their training) as tutors [35] with what is termed as "near-peer" teaching [36]. For medical students and residents, small-group teaching would enable them to learn more effectively the "information and skills that are necessary for competent clinical practice of medicine" [37]. It is clear that small group discussion as a teaching modality in human anatomy is here to stay. A well-organized small group discussion session is dependent not only on the content for discussion but also on the group dynamics. In this respect, the tutor plays a vital role in facilitating a fruitful small group discussion.

> Small group discussions, if facilitated by a good tutor, enhance students' understanding of the subject, improve interpersonal and communication skills, reach out to students with different learning styles, and help to develop a sense of accountability to others.

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13 Applying Learning Styles to Engage a Diversity of Learners and Behavioral Problems in Anatomy Education

Mark Terrell

Introduction

Diversity in anatomical education continues to expand and consequently challenges the educational environment. On the instructional side, diversity is increasing due to class size increases, curricular changes, technological advances, and changes to medical school admission criteria. On the learner side, no two students are alike, differing in backgrounds, cognitive abilities, interests, external responsibilities, levels of motivation, and approaches to learning [1]. To meet these challenges, much pedagogical research has been conducted on the concept of "learning styles."

A learning style is a set of biologically based and sociologically developed cognitive, affective, and psychosocial characteristics influencing how learners perceive, interact with, and respond to a learning environment or task [2, 3]. Because these characteristics vary between learners, the same teaching method that is effective for some is ineffective for others. This is reflected in student teaching evaluations where some students loved the course, while others disliked the same course.

The study of learning styles can be organized into two models. Cognitive models emphasize differences between how learners process, encode, and retrieve information in the brain. Psychosocial models are based on personality preferences and the nature of interactions between the educator and learner. Understanding that students vary in their approaches to learning helps educators meet the educational interests and needs of diverse populations [4]. Therefore, applying both models to the teaching of anatomy has strong implications for improving student learning outcomes.

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Cognitive Models of Learning Styles

Multiple Intelligence Theory

Howard Gardner's theory of multiple intelligences [5] explains that each learner is capable of eight independent forms of information processing (Table 13.1). According to this theory, all learners process the eight intelligences, but each individual has his or her own unique set of developed intellectual strengths and weaknesses that lead to unique profiles of overall intelligence for the individual [6]. Consequently, individual differences in learning are due to variations in the specific profiles of intelligence and determine how easy or difficult it is to learn information when it is presented in a particular way. Variations in the profile of intelligences among learners challenge the educational system when a singular modality of instruction is used and assumes all learners learn the same way. Higher education has a preponderance of singular instructional designs that favor linguistic and mathematical

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Table 13.1 Multiple intelligence learning styles and implications for anatomical education

Intelligence	Core learning components	Instructional application	Assessment application
1. Visual-spatial	Learn by processing mental imagery from pictures and videos	Use 3D multimedia, visuals, CT scans, prosections, and dissections	Use radiographs on exams: identification on specimens
2. Bodily kinesthetic	Process bodily sensations	Dissecting, handling prosections, modeling clay, osteopathic manipulations, palpating surface anatomy	Evaluate and score dissection or modeling quality, palpations, manipulations
3. Logical mathematical	Process patterns, categories, relationships, reason deductively, and think logically	Hierarchical notes in outline format to reveal general categories, classes, subclasses; compare limb anatomy, explain reasoning between structure and function	Reasoning required in board-style questions
4. Natural	Understand knowledge patterns and relationships in nature and medicine	Integrate anatomical concepts to clinical importance; use case scenarios in lecture	Board-style questions with clinical vignettes
5. Linguistic	Process auditory information and think/visualize in words	Design PPT slides to include textual wording, not just pictures; record lectures into podcasts; integrate YouTube videos, assigned readings	Oral component to lab exam—"describe the muscles and muscle layers of the hand"; writing autopsy report
6. Musical	Process rhythm and sounds	Integrate cardiac and thoracic sounds	Incorporate heart and lung sounds on exams
7. Interpersonal	Process through interaction with others, gifted social skills, observant of feelings and thoughts in others	Collaborative group learning: think–pair–share activities in lecture; lab groups; have students teach peers in lab	Collaborative assessment—allow portion of exam to be taken as a group
8. Intrapersonal	Process through interaction with self, awareness of self	Independent study, provide practice problems or case scenarios, good metacognitive skills	Use practice tests to provide self-assessment and regulation of one's learning

intelligences [7]. Traditional anatomy instruction generally favors visual-spatial intelligence with lectures additionally favoring linguistic and auditory intelligences and labs favoring kinesthetic intelligence.

Multiple intelligence theory can improve anatomy education. Although specific teaching and assessment strategies are created (Table 13.1), three generalizations are made. First, strict adherence to one teaching method supports one type of intelligence but limits the vast majority of learners who do not have that particular profile of intelligence. Educators should view all intelligences as equally important and needed in a successful healthcare provider. Second, anatomy education should engage most, if not all, of the intelligences to facilitate a deep and transferable understanding of anatomy in clinical contexts. Using multiple teaching and learner assessment strategies (Table 13.1) activates a wide assortment of intelligences needed to transfer and apply what they learn in the classroom to new clinical situations. Application-based teaching excites students about learning and allows the educator to reinforce the same material in a variety of ways. Third, multiple ways of assessment should be developed to measure student learning across the intelligences that provide opportunities for students to demonstrate their competencies in different ways (Table 13.1), making assessment more fair for all types of learners.

Implementing multiple intelligence theory in anatomy should be conducted at the course or program level. Incorporating eight intelligences into each and every teaching lesson quickly becomes impractical. Instead, courses should be designed that incorporate where possible the eight intelligences by instructing and assessing in a variety of ways and guiding students to reinforce strong intelligences and hone less-developed intelligences [8].

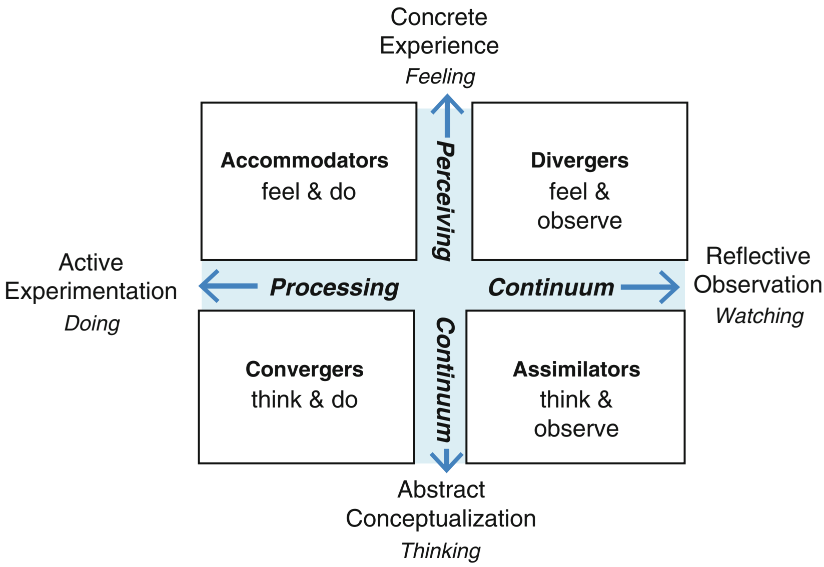

Fig. 13.1 Kolb's four learning styles derived from how learners perceive and process information

Kolb's Experiential Learning Styles

David Kolb's theory of experiential learning provides four distinct learning styles based on differences in perceiving and processing learning experiences that transform, refine, and add to a learner's preexisting knowledge base. Initial research was based on the observation of distress encountered by many students whose learning styles seemed mismatched to their disciplinary majors [9]. The four learning styles are schematically represented as quadrants that are separated by vertical and horizontal axes (Fig. 13.1). Each axis is a continuum or dimension representing how learning experiences are perceived and processed. The perceiving dimension (Table 13.2) is the vertical axis with two polar opposites indicating that learners respond to new information using concrete experience or abstract conceptualization. The processing dimension (Table 13.2) is the horizontal axis with two polar opposites indicating that learners approach a new task either through active experimentation or reflective observation. The perceiving and processing dimensions combine to form quadrants representing four different learning styles (Fig. 13.1):

- Diverging learners perceive new information through concrete experience and process through reflective observation. They observe things from different perspectives, gather information, and are sensitive and imaginative. These learners prefer to work in groups, listen with an open mind, and value personal feedback.

Table 13.2 How learners and educators approach and respond to learning tasks

Learning dimension	Modality of learning	Learning behavior	Anatomically related instructional activities
Perceiving How we respond to a task	Concrete experience	Sensing, touching; need tangible connection to content	Dissection work, use atlas, case problems, clinical examples
	Abstract conceptualization	Analyzing information and connecting to theoretical foundation	Write autopsy report, listen to lecture, organized hierarchical notes
Processing How we approach a task	Active experimentation	Doing; actively using information	Hands-on activities such as simulations, case studies, multimedia manipulations
	Reflective observation	Careful observing and thinking about information	Discussion groups, thought questions, patient scenarios

- Assimilating learners perceive new information through abstract conceptualization and process using reflective observation. They have a preference for a concise, logical approach focused on ideas and concepts. These learners require a good clear explanation rather than practical opportunity. They excel at understanding wide-ranging information and organizing in a clear logical format.
- Converging learners perceive new information through abstract conceptualization and process using active experimentation. They have a preference for solving problems to practical issues. They prefer technical tasks, experiment with new ideas, simulate, and work with practical applications.
- Accommodating learners perceive new information through concrete experience and process using active experimentation. They have a preference for "hands-on" activities and rely on intuition or "gut instinct" rather than logic. They use other people's analysis and are attracted to new challenges and experiences.

Implementing Kolb's learning styles in anatomy should strike a balance between the extremes in each learning dimension [10]. Designing a course using strategies from Table 13.2 should provide supplemental activities to yield a more complete educational experience. Educators should provide clinical context for content taught to engage divergers; use diagrams, visuals, cadavers, and models to engage assimilators; use case-based exam questions and practice problems to engage convergers; and provide time for student participation in open-ended questions in lecture to engage accommodators.

Psychosocial Personality-Preference Models of Learning Styles

VARK

VARK is an acronym of four learning styles: visual, aural, reading/writing, and kinesthetic. These learning styles are based on sensory modalities developed from observations of interactions between educators and students [11]. Visual learners prefer graphical and symbolic representations of information. Aural learners prefer auditory information and concentrate on listening to a live lecturer, rather than taking extensive notes. To study, these learners prefer to listen to lecture recordings, talk out their answers to questions, and discuss concepts among their peers. Read/write learners prefer printed written words and text. Kinesthetic learners prefer to process information through experience and practice.

The VARK questionnaire (http://www.vark-learn.com) is a free, easy-to-use, online instrument that gives users a quick profile of their VARK preferences. It consists of 16 questions with four options in which the user is able to select more than one option for each question. VARK scores are to be used as a point of inquiry, low-stakes diagnostic tool intended to stimulate discussion between educators and students [11]. Students gain a sense of self-awareness for how they learn best and in multiple ways using options not previously considered. It can also be a catalyst for faculty development in creating a variety of teaching strategies for different groups of learners [11].

Implementing VARK learning styles in anatomy should be centered on using a multimodal approach [12]. Anatomists should present information using symbolic modalities including arranging content into hierarchical flow charts and concept maps and enhancing verbal explanations using visuals, imagery, and drawings to engage the visual learners. Podcasts of lectures, small group discussions in lecture (e.g., think–pair–share activity), and collaborative assessment allow students to explore concepts and ideas, thus engaging the aural learner. Using summary lists, arranging lecture notes into outlines, and providing supplementary learning materials as handouts, learning objectives, and old exams engage the read/write learners. Finally, dissecting anatomical cadavers or organ specimens, handling prosections, and manipulating anatomical models engage the kinesthetic learners.

Table 13.3 Grasha's six learning styles matched with corresponding teaching styles to best meet the needs of the learning style

Learning styles	Characteristics	Matched teaching styles	Characteristics	Educational implications
Avoidant	Evades uncomfortable situations, problems, or people for self-preservation	*Formal authority*	Possesses status among students	Provides feedback, sets expectations and rules, creates learning objectives
Dependent	Knows limits and learns only that which is required, needs much help and direction	*Expert*	Possesses knowledge students need, transmits information	Answers students' questions, passive learning, didactic lectures, teacher centered
Participant	Interacts with ideas and with others, eager	*Socializing agent*	Exhibits role modeling behavior—teaching by personal example	Models professionalism, how to think and behave
Competitive	Self-improves, challenges status quo, competes, seeks attention	*Facilitator*	Guides, directs, explores, shares in student learning, promotes learner responsibility	Uses questioning, suggests alternatives, monitors progress, case based
Independent	Internal locus of control, self-confident with internal locus of control, handles problems effectively	*Mentor*	Avuncular, concerned with developing autonomy of their learners	Stimulates metacognitive activities of self-regulation (e.g., give practice questions)
Collaborative	Takes responsibility toward tasks and others, shares, assists learning of others	*Person*	Places subject matter at center stage, works alongside students to discover concepts and construct knowledge	Group work, discussion, active learning strategies, collaborative assessment

Grasha's Learning Styles

Anthony Grasha [13] observed interactions between educators and students to develop six learning styles with corresponding teaching styles (Table 13.3). These learning styles are situation specific that can be matched to a set of teaching styles that best reflect the needs of the interactions between faculty and students within the educational environment. The process requires the educator to diagnose the type of learning style and adjust their teaching style to it. Table 13.3 indicates the matched associations between diagnosed learning styles and teaching styles to best meet the needs of that learner. This approach works best for one-on-one and small group teaching.

Implementing Grasha's learning styles has several implications for teaching anatomy. Specific strategies can be developed including using small group discussions or collaborative assessments in lecture to engage the collaborative learner and using open-ended questions on assignments and feedback to engage the independent learner. Anatomy educators should facilitate the intellectual development of learners into more cognitively mature learning styles. For example, reducing the amount of support provided as the course unfolds fosters growth in the learner from a dependent learning style to a more independent style. Anatomy educators should identify the types of learners present in small groups and match their teaching style to best fit the learners' needs (Table 13.2). For example, an avoidant learner is best taught using strength from a formal authority teaching style, while a dependent learner needs the direction and confidence of an expert role teaching style. An independent learner will likely withdraw from a formal authority style teacher, and a competitive learner would likely conflict with expert and formal authority teaching styles. If the educator does not adjust their teaching style to the type of "diagnosed" learning style, conflict, frustration, misunderstanding, and other problems will develop [13].

Table 13.4 Managing various "problematic" learning behaviors occurring during small group teaching

Behavior	What happens	What to do
Rambler	Talks about everything except subject; uses farfetched analogies; gets lost	Use time constraint to cut the person off; interrupt with "that's interesting" and get back to topic
Obstinate	Won't budge; prejudiced; hasn't seen your point	Ask the person to discuss it afterward Ask the person to "agree to disagree"
Wrong subject	Not rambling; just off base	Take responsibility for possibly leading off topic and create a linkage back to the main topic
Griper	Has pet peeve; professional griper; has legitimate complaint	Indicate that policy can't be changed here, discuss it afterward, indicate pressure of time
Inarticulate	Lacks ability to put thoughts in proper words; getting ideas but can't convey them; needs help	Summarize, rephrase, clarify; ask them to write it out
Definitely wrong	Comes up with comment that is obviously incorrect or erroneous	Acknowledge their thought, but move on. Toss it to the group and let group members straighten it out
Overly talkative	May be an "eager beaver" or show-off; may be exceptionally well informed and anxious to show it; naturally garrulous	Slow them down with a more challenging question; interrupt with "That's an interesting point, what do others think?"
Highly argumentative	Combative personality; angry; may be normally "good" but currently upset about something	Model calmness; respond dispassionately; ask to discuss the issue privately afterward and move on
Helpful	Really trying to help; actually makes it difficult by keeping others out	Question others; give them extra task to slow them down (e.g., note-taking)
Silent	Doesn't say anything; may be lost; may be shy; may be bored	Start with closed-end questions, go around group asking all members to contribute; break up into dyads

"Problematic or Difficult" Learning Behaviors

Some learners exhibit behaviors that impede desired progress toward the development of competency and require effective educational skill when encountered. These learners often exhibit difficulty or deficiency in one or more of the medical competencies, including problems with knowledge, judgment, clinical reasoning skills, professionalism, communication, and interpersonal skills. The best approach to dealing with the problem or difficult learner is to relate the behavior to the principle of patient centeredness [14]. Patient centeredness is a way of thinking, acting, and making choices and decisions at all times in accord with what is in best interest and care for the patient. Healthcare professionals who function using the principle of patient centeredness exhibit behaviors consistent with (1) what is good for the patient (versus what is not good for the patient), (2) the primacy of patient needs (versus the primacy of self-needs), and (3) the integrity of the profession (versus the disintegration of the profession) [14]. Consequently, to reduce medical error, the discussion on the problematic learning behavior must focus on its impact or potential on patient care. For example, if lecture attendance is an issue, relate the lack of attendance to creating a knowledge gap and its potential impact on the learner's ability to care for patient. Many educators avoid conflicts and discussions of or have a blind eye for unprofessional behaviors because "they don't want to be the bad guy" or the student "won't do it again" or they "just don't like conflict." In fact, the issue of not identifying and dealing with an observed unprofessional behavior is in itself unprofessional because it puts needs of the educator over that of the patient or the profession. Clarity and constructive feedback coupled with descriptions of service to patients (patient centeredness) is crucial [14].

In addition to the principle of patient centeredness, Table 13.4 describes specific strategies on how to engage other problematic behaviors that may occur in small groups.

Discussion of Six Learning Style Principles for Anatomy Educators

1. Learning styles and teaching styles should be reflected upon and identified. Knowing one's learning style can be beneficial if learners take the next step and consider how and when they learn, as part of a reflective, metacognitive process, with action to follow.
2. Learning styles are preferences and are not the only way a learner can learn. Learners should initially have the opportunity to learn through their preferred style and then be advanced toward other, less developed styles. Strengthening students' less preferred learning styles helps them become more versatile learners and amendable to the requisites of real world of the health professions [15].
3. Learning styles should drive the selection of teaching styles. It is more effective for the educator to match their teaching style with their learners than learners to adjust their learning style to the teaching style.
4. Learning styles are equal; one is not superior to the other. Educators should develop specific educational activities that support each learning style. Using only one strategy selectively excludes many learners. Educators that teach in a multi-style fashion reach the greatest diversity of students and challenge all students to grow [16].
5. Learning styles should drive multimodal assessment. This allows students to demonstrate competency in alignment with their preferred style of learning.
6. Problematic learning behaviors impede development toward competency. Applying the principle of patient centeredness to the problematic learning behavior is powerful approach to discuss the behavior's impact on patient care.

Six Learning-Style Principles

1. Teacher's teaching style and learner's learning style should be reflected upon and identified.
2. Learners should initially have the opportunity to learn through their preferred style but should later be challenged to develop above and beyond their default style.
3. It is easier and more effective for the teacher to match their teaching style to the learners' learning style than the other way round.
4. Educators should develop specific education activities that support each learning style.
5. Multiple forms of assessment of anatomy learning should be developed.
6. Problematic learning behaviors must be dealt with promptly, using the principle of patient centeredness.

Conclusion

The contribution of anatomy educators to patient care is in caring for their learners. The application of learning styles to a diversity of learners helps develop competent healthcare professionals. Experience with learning styles gives these healthcare providers the tools to learn about and teach to a diversity of patients they encounter in the clinic. Effective teaching in anatomy requires flexibility, energy, and commitment among a diversity of learners, technology, and curricula. Theoretical eclecticism suggests that best practice be based on using the strengths of multiple learning theories and instructional strategies [17, 18]. If educators use a variety of teaching methods and styles, learners are exposed to both familiar and unfamiliar ways of learning that provide both comfort and tension during the process, ultimately giving learners multiple ways to excel [19]. Having this toolbox of strategies can be helpful in dealing with behaviorally problematic learners, reducing student attrition, and improving skill development. Therefore, anatomy education should be designed with a wide range of modalities to meet the needs of students whose learning styles are neglected by traditional pedagogy [20]. Anatomists will reach more students more effectively with improved student satisfaction if information is presented and assessed in more than one modality.

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14 Teaching and Learning Anatomy in a PBL Curriculum

Esther M. Bergman

This chapter describes good practice and pitfalls when teaching anatomy in a problem-based learning (PBL) curriculum. This should be distinguished from including PBL in anatomy education, which means applying the learning principles underlying PBL—constructive, collaborative, contextual, and self-directed learning [1]—in one or more anatomy courses, even when PBL is not included elsewhere in the program. However, some paragraphs may be useful for teachers who want to teach anatomy in a PBL format, and there are other valuable publications for them to draw from [2, 3]. Additionally, this chapter draws attention to some outdated notions and misconceptions concerning anatomy education in PBL.

Definitions

- **Constructive learning principle.** Learners should be involved actively and should be stimulated towards activation of prior knowledge, elaboration, and deep learning, because this leads to deeper and richer understanding and better use of knowledge.
- **Collaborative learning principle.** Learners should be stimulated to interact with each other because these interactions may positively influence learning.
- **Contextual learning principle.** Learners are preferably exposed to a professionally relevant context and confronted with cases or problems from multiple perspectives, because this stimulates transfer of knowledge.
- **Self-directed learning principle.** Learners should be stimulated to be aware of their prior knowledge and should be stimulated to regulate or direct their learning process both from a motivational and a cognitive perspective.

Anatomy Education in a PBL Curriculum

To clarify the teaching of anatomy in a PBL curriculum, it is helpful to compare it (somewhat simplistically) with teaching anatomy in a "traditional" curriculum. Within a traditional curriculum, there is a "preclinical phase" in which basic sciences are presented in an isolated, department-based course. There is little or no integration across disciplines, little deliberate

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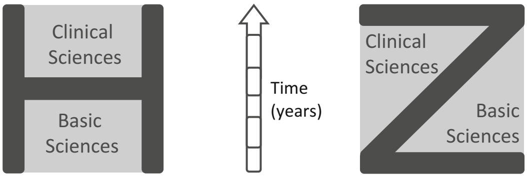

Fig. 14.1 The traditional curriculum can be represented by an H shape, with all clinical sciences later in the curriculum. The innovative curricula can be represented by a Z shape, where students are introduced to clinical sciences at the beginning of the curriculum

instruction in the application of basic science to clinical problems or the use of basic sciences in clinical skills, and limited student–patient interaction [4–6]. Courses consist mainly of lectures and teacher-centered instruction in laboratories.

In PBL and other "innovative" curricula, basic sciences are taught simultaneously and in an interrelated manner. This is called *horizontal integration*. Furthermore, clinical sciences are frequently introduced in the early years of the curriculum and integrated with the basic sciences. And basic sciences are revisited in later years in the context of clinical sciences. This is vertical integration [4]. Consequently, traditional curricula can be represented by an *H shape* and innovative curricula by a *Z shape* (see Fig. 14.1).

Curriculum integration can be achieved by providing interdisciplinary courses aligned by organ system or multidisciplinary courses aligned by theme (e.g., by disease) [7]. A PBL curriculum aligned by organ system should not be confused with a systems-based curriculum. Within a PBL curriculum, learning is centered around problems (see section "General Aspects of PBL") and education is based on the four aforementioned learning principles. A systems-based curriculum may still be lecture based and teacher centered.

Influence of PBL on Anatomical Knowledge

Individual studies and meta-analyses examining the effectiveness of PBL have shown students to have more favorable attitudes towards and opinions about their education but no clear benefits or drawbacks of PBL curricula on students' basic science or clinical knowledge [8–15]. Therefore, it has been hypothesized that students' perceived and actual basic science (anatomical) knowledge is less determined by the general educational approach of the curriculum than by educational strategies such as time on task, repetition, and teaching in context [13, 16]. This shows the importance of a vertically integrated and spiral curriculum design.

Vertical integration within inter- or multidisciplinary courses is attained by integrating the teaching of basic sciences with clinical sciences. While there is widespread support among clinicians for more vertically integrated anatomy teaching in undergraduate curricula [17], vertical integration is often unidirectional. In other words, clinical topics are integrated into the early years (traditionally the time for teaching basic sciences like anatomy), but basic sciences are far less commonly taught in the later years [18–21]. A vertically integrated curriculum provides an opportunity to teach basic sciences in the context of the clinical sciences.

"A spiral curriculum is one in which there is an iterative revisiting of topics, subjects or themes throughout the course. A spiral curriculum is not simply the repetition of a topic taught. It requires also the deepening of it, with each successive encounter building on the previous one" [22, p. 141]. Knowledge is presented in a logical sequence from simple to complex in a spiral curriculum. Studies have shown this to be motivating because it activates and reinforces prior knowledge and stimulates a more advanced level of application and integration of knowledge, which increases expertise and feelings of competence [22, 23]. A spiral curriculum provides the opportunity for repetition and scaffolding of basic science knowledge.

To ensure anatomical knowledge is repeated and taught in context, anatomy teachers need to take on educational coordination tasks and play an active role in curriculum development committees. Furthermore, they need to be proactive in establishing collaborations with clinicians to teach basic sciences in the later years of the curriculum.

To Do

- Ascertain whether you know the options within your medical school through which you could integrate anatomy vertically or spirally.
- Furthermore, think of one clinician you know who is teaching in the later years of the curriculum and how you could collaborate with him or her to teach anatomy during that later clinical phase of the curriculum.

Teaching Anatomy in a PBL Curriculum

General Aspects of PBL

In order to strengthen connections between and within students' knowledge networks, PBL curricula are student centered and focus on active learning [1, 24]. Furthermore, clinical exposure is scheduled very early in the curriculum: even first-year students may, for example, attend noninvasive procedures like angioplasty.

Basic to PBL is that student learning is organized around problems (patient cases, patient problem scenarios, professional problems). Tutorial groups of, on average, ten students and their tutor or facilitator meet about twice a week to discuss problems. These problems consist of a description of some phenomena, which students try to explain in terms of underlying biomedical or psychosocial processes, using their prior knowledge, opinions, and preexisting ideas. During this discussion, students discover what they already know and what they do not know. They then develop learning objectives to which they seek answers during the self-study phase by making use of faculty resources (lectures, laboratory sessions, skills training, etc.) and/or studying relevant literature. The initial discussion helps them with both the direction and extent of study they need to undertake [1, 25]. During the first part of the next tutorial group meeting, students discuss their answers to the learning objectives and thus acquire a deep understanding of the problem. They are then presented with a new problem and the cycle starts again.

Most anatomists have (at least) two roles in a PBL curriculum: PBL tutor and anatomy teacher. The challenges and opportunities of these two roles are described in the following paragraphs.

Learning Anatomy in Tutorial Groups

The notion that tutors should do nothing more than guarding the group process is outdated. What often happens is that students have information (the information on their learning goals or "the ingredients" in a cooking analogy) but are unable to make a complete story of it (use the information to explain the phenomena in the patient case, or use the ingredients to "bake the cake"). A tutor really needs to have some knowledge of the subject to help students create links between concepts (tutor as "recipe"). Furthermore, when problems are constructed to serve as a starting point for learning, the phenomena described are chosen with certain learning objectives in mind. With a well-written problem and a good discussion, students tend to formulate the intended learning objectives by themselves. Sometimes, however, students overlook or overemphasize a piece of information, which results in the learning objectives becoming too superficial or deep. The writers of a problem under discussion should create a "tutor manual," which would help address both types of issues. This tutor manual often includes the intended learning objectives so that tutors can steer the discussion and formulation of the learning objectives in the correct direction. Furthermore, it contains some concise information about the discussion topics. It is possible, nevertheless, that an anatomist has to do some studying—for example, on immunology if this is involved in the tutorial they are attending. The reverse may also be true: an immunologist attends a tutorial group in which he/she has to guide students discussing anatomical learning goals. It is therefore preferred that anatomists play an active role in writing the tutor manual to help non-anatomist tutors.

Within tutorial groups, learning can be hindered by the quality of the written problem, failure by tutors to act as facilitators, or dysfunction in the groups themselves. There is an abundance of literature on these issues; see for example Dolmans et al. [1]. Another very practical article for tutors is "Goals and strategies of a problem-based learning facilitator" by Hmelo-Silver and Barrows [26]. This section therefore focuses on issues that can be encountered when addressing anatomical knowledge in tutorial groups.

Practical Tips for Tutorial Groups

In your role as a tutor in tutorial groups, pay attention to:

- Using problems that fit with students' prior knowledge but are realistic, open ended, and *not* too simple or well structured
- Orientating your guidance towards the students' learning process
- Giving more guidance in the beginning and less towards the end
- Knowing when and how to intervene
- Monitoring students who show lack of elaboration, lack of cohesion, and lack of motivation

With regard to addressing anatomical knowledge in tutorial groups, pay attention to:

- Creation of *not* too general anatomical learning objectives
- Discussion of anatomical learning objectives to repeat and apply knowledge

Formulation of Anatomical Learning Objectives

Students have a tendency to skip the initial exploration of probable causes and underlying mechanisms of patient problems and not to bother formulating appropriate learning objectives related to basic sciences. Instead, they confine themselves to looking up a diagnosis and its associated symptoms and treatments [27].

When formulating anatomical learning objectives, students often jot down "anatomy of the heart" when the problem involves a heart attack or "anatomy of the ankle" when the problem involves a sprained ankle. The challenge is to get them to be more specific by, for example, asking questions about what they already know about the heart or ankle, what structures they need to study or they think they will encounter while studying, why these structures are there, what their function is, and how they relate to the phenomena described in the problem.

A word of caution: students often need to learn more of the anatomy of the region under discussion than is strictly necessary to "solve" the problem. For example, the anatomy department may choose to include information about the large arteries in lectures and dissection room sessions that accompany the "heart attack tutorial group." As often occurs, this may be the only opportunity to widen students' knowledge of the cardiovascular system within a packed curriculum. Some students do not understand why they need to learn about the large arteries when the tutorial group has discussed the anatomy of the heart, so it is up to anatomy teachers to show the relevance of this knowledge. That can be done by, for example, putting the large arteries in the context of the physical examination of a patient with a heart attack (measuring blood pressure: brachial artery; feeling pulse: radial artery) or treatment of a heart attack (angioplasty: entering the vascular system through the femoral artery).

Discussion of Anatomical Learning Objectives

"[The] potential disadvantage [of PBL] is that students may become more interested in the clinical aspects of a problem and neglect the underlying basic science knowledge" [19, p. 608]. When an anatomical learning objective is up for discussion in a tutorial group, students often adopt a "been there, done that" attitude. Everybody has attended the lectures and dissection room sessions so they tend to move to the next learning objective if nobody has a specific question. A tutorial group discussion, however, is an excellent chance to repeat information ("repeat to remember"; opportunities to repeat information are scarce in today's packed curricula) and practice the application and transfer of the knowledge. Possible ways to do this are to have students draw on the whiteboard, interpret X-rays or MRI scans, and bring skeletal material/plastinated specimens or low-tech models (described in a separate chapter in this book) into tutorial groups.

Role of the Anatomy Teacher

As an anatomy teacher within a PBL curriculum, you are still responsible for "teaching anatomy." On-demand education (which is often associated with PBL) is not really possible in larger medical schools (100+ students). Anatomy teachers should know when certain problems are to be discussed in tutorial groups so they can estimate when students will need to study a certain topic and lectures and dissection room sessions need to be planned. In a true PBL curriculum, sessions are almost never compulsory, adhering to the self-directed learning principle. If students feel they can get the information they need to pass their assessment in a different way, they are free to do so. Therefore, it is *not usual* to register attendance. An exception is when, for example, students have signed up to attend sessions or when failure to attend has consequences.

It is a misconception that "teaching" is not part of PBL. Especially in dissection room sessions, anatomy is still "taught" in the sense that anatomists help students in every possible way (often similar to more traditional curricula) to attain ("learn") a complete and accurate understanding of the structure of the human body.

Role of Anatomy Lectures in a PBL Curriculum

It is a misconception that lectures are not included in PBL. They are certainly part of the curriculum; however, they have different goals from lectures in more traditional curricula. A lecture in a traditional curriculum often summarizes what the lecturer believes to be the core course content [28],

Practical Tips for Anatomy Lectures in a PBL Curriculum

When creating a lecture in a PBL curriculum, do *not* summarize the course content, but focus on:

- Introducing students to a new topic and organizing their study effort. Lecture content can be a short overview of the anatomy of the to-be-studied region and/or their aim to familiarize students with the Terminologia Anatomica of the region before a dissection room session.
- Explaining particularly difficult concepts or problems or addressing frequently occurring misconceptions. Lecture content could recapitulate complex anatomical structures after a dissection room session.
- Placing the study material in context. Lecture content can illustrate the clinical relevance of the anatomy under study either before or after the dissection room session.

which can result in a series of lectures, each of which lasts up to 3 h. Lectures within a PBL curriculum serve three very different goals:

1. To introduce students to a new topic [28] and organize their study effort [29]
2. To explain particularly difficult concepts or problems or to address frequently occurring misconceptions [29]
3. To place the study material in context [28] and put the content into a broader perspective (place in the curriculum and how it prepares the students for professional practice) [29]

A lecture that aims to reach goal 1 (and 3) is usually scheduled after the initial tutorial group discussion but before other faculty resources or self-study. A lecture that aims to reach goal 2 (and 3) is usually scheduled after other faculty resources and self-study and either before or after the second tutorial group meeting. As the lectures are aimed at "understanding the whole," rather than memorizing content by rote learning [28], they last a maximum of 1.5 h.

Dissection Room: Studying Prosected Specimens and Cadaveric Dissection

In Winkelmann's [30] extensive review, although confounded by the included studies differing in more than one variable, cadaveric dissection appeared to offer a slight added benefit compared to studying prosected specimens. A review study comparing cadaveric dissection to other teaching tools also slightly favored dissection. More important, however, a combination of teaching tools appeared to give the best results [31]. Furthermore, recent research has shown that a dissection course is not a uniformly positive learning experience [32]. Different students may have different approaches to dealing with a dissection course (or other teaching methods for that matter) and therefore undergo divergent learning experiences. This may result in a difference in the amount and form of knowledge between individual students. Further research needs to be conducted on *what* and *how* students learn from dissection and other teaching tools before drawing conclusions in favor of either method. For more information, see Chapter 24.

The choice to use prosected specimens in PBL curricula is often a practical one. When the problem under discussion in the tutorial groups is a heart attack, there is not enough time to dissect a cadaver from the skin down to the heart. Therefore, several cadavers are prosected and made available for students to study from, often guided by specific clinically relevant assignments to guide them (contextual learning principle). Furthermore, it is common to schedule multiple dissection room sessions. Students are not assigned to a specific one but can select a convenient session, so they can choose to attend either early or later during the self-study phase (self-directed learning principle).

To offer students the experience of cadaveric dissection, many medical schools with PBL curricula schedule extracurricular or elective courses. In these courses, different approaches may be taken. For example, an anatomy department can schedule a musculoskeletal course in the morning (with four students working on a limb each) and a head/thorax/abdomen course in the afternoon (with up to five students working on a specific region). In that case, students often dissect from skin to skeleton, after which the remains of the cadaver are of no further use and are cremated. Another option is for an anatomy department to have students create prosected specimens for use in future teaching. This is of course a better use of the cadaveric materials, especially when their supply is scarce. Even though students learn a lot, it still does not give them a full dissection experience. A problem with extracurricular or elective courses is that there is often a restriction on the number of students who can attend them, so it still does not allow all students to have the experience of dissection.

Teaching Dilemma

How can extracurricular (elective) dissection courses be made available for a large student population (many medical schools accommodate over 300 students per year)?

Surface Anatomy, Body Painting, and E-Learning

Other laboratory-based teaching methods such as surface anatomy, body painting, and e-learning may also be part of a PBL curriculum. Surface anatomy and/or body painting sessions are scheduled after dissection room sessions and, if possible, before the second tutorial group meeting, whereas e-learning sessions can be scheduled at any time depending on their aim. As body painting and e-learning are discussed in other chapters in this book, the focus here will be on surface anatomy sessions.

Studying surface anatomy stimulates elaboration on the static anatomy of the cadaver by enabling students to see phenotypical structures (particularly those of the musculoskeletal system) move and function in a living human being. Whereas surface anatomy sessions in more traditional curricula could involve demonstration of structures by a teacher on a model, surface anatomy sessions in a PBL curriculum include constructive, collaborative, contextual, and self-directed learning [33], by, for example, making use of peer examination (collaborative learning), referring to information studied in the dissection room (constructive learning), or elaborating on anatomical structures by relating them to physical examination, medical imaging, or symptoms and signs in common diseases (contextual learning).

Teaching Materials for Anatomy Education in PBL

Most of the differences between a traditional and a PBL curriculum is in the availability of materials during the self-study phase. The self-directed learning principle implies that students should be able to decide from which resource they want to study. Therefore, students in a PBL curriculum do not have one core textbook to study from (although most of them do buy one to study at home). Instead, they are encouraged to use many different resources, which is facilitated by the different anatomical textbooks and atlases in the medical school's library. In the case of anatomy, books are often supplemented with digital atlases, e-learning material, and a "study landscape" with models, plastinations, medical imaging, etc., which students can use on request. This practice is also reflected in the teaching materials created by anatomical staff. For example, images from many different resources are used to illustrate the subjects of lectures.

Learning Anatomy in a PBL Curriculum

Two main issues arise when students learn anatomy in a PBL curriculum: not taking a deep approach to learning and losing a coherent mental representation of the anatomy of the whole body.

Reproduction of Names and Structures Versus Understanding Signs and Symptoms

In a study by Mattick and Knight [23], students said that anatomy is unique in that it represents a huge set of facts, codified in a specialized language, which calls for different learning strategies than other basic sciences. Because of this, learning anatomy relies on both surface and deep learning approaches. Memorizing information is generally referred to as a surface approach to learning. A deep approach, in contrast, is characterized by efforts to understand the structure of material to be learned and manipulating the information to make sense of it in relation to what a student already knows about the subject matter [34]. Because anatomy has a complex vocabulary, it has been hypothesized that a deep approach to anatomy learning needs to build on a preliminary stage of rote learning, which is difficult to distinguish from a surface approach [35].

PBL curricula should facilitate many aspects of learning. With respect to the basic sciences, PBL should, among other things, stimulate intrinsic interest in the subject matter. Research suggests that if students recognize the relevance of basic sciences, their learning is enhanced.

In traditional curricula, students may have the impression that they are studying basic sciences because they must, without being aware of their clinical relevance. On the other hand, PBL stimulates students to learn basic sciences in order to understand clinical problems, thus fostering a deep approach to learning [13, 18, 19].

However, what is often seen is that students perceive and describe memorization of details as an endpoint of learning anatomy rather than a stage in the process leading to understanding signs and symptoms [23, 34, 36]. The patient problem presented in the tutorial group does not seem to be enough of a stimulus to adopt a deep learning approach during an anatomy session later in the week. One solution is to apply the constructive, collaborative, contextual, and self-directed learning principles of PBL in anatomy education. Do not send students into the dissection room with a list of structures they need to know, but create challenging assignments in which they need to apply anatomical knowledge to explain signs and symptoms, interpret medical imaging, etc.

Loss of Coherent Mental Representation of the Anatomy of the Whole Body

Monkhouse and Farrell [37] pointed to the danger that systems-based curricula prevent students from gaining a coherent view of the anatomy of the whole body, as anatomy is likely to be taught piecemeal with no regard to the whole organism. Inevitably, students are left with only a fragmented knowledge of anatomy. Experience suggests that this is true of all integrated curricula, including PBL. Some students struggle with the random order in which body regions are studied, while others refer to having to learn nerves and blood vessels in the lower leg without having any idea where they originated from or not recognizing a stomach herniated through the diaphragm on a CT scan because the thorax and abdomen were treated as two totally unrelated regions [38].

It is up to anatomy teachers to come up with creative solutions to the problems described above.

To Do

- Think of another way of stimulating students to adopt a deep approach to learning anatomy.
- Ascertain whether your medical school facilitates students to gain a coherent view of the anatomy of the whole body and how you as an anatomy teacher could facilitate students to accomplish an improved mental picture.

For example, to get a better overview of the peripheral nervous system, always go back to the same pictures in your lectures. Start at the spinal cord and the nerve plexus of the region to be studied. If applicable, show nerves that have already been studied and then zoom in on the nerves under discussion, their origins from the plexus, and their spatial relationships to previously studied nerves.

Conclusions

It is basic to PBL that student learning is organized around problems. The biggest difference between anatomy education in PBL and any other curriculum is that anatomy is taught in tutorial groups. The correct formulation and discussion of anatomical learning objectives may rest on the shoulders of non-anatomists. It is therefore preferred that anatomists play an active role in writing the tutor manual to help non-anatomist tutors. Furthermore, anatomy education in PBL curriculum is shaped by the learning principles underlying PBL: constructive, collaborative, contextual, and self-directed learning. As repetition and teaching in context seem to influence students' anatomical knowledge strongly, PBL seems to have an advantage when a curriculum is truly spiral and vertically integrated.

Lectures in a PBL curriculum serve a different purpose, but dissection room sessions do not really differ from those in other curricula with a student-centered, active learning approach. PBL curricula struggle with the same issues as do other curricula when it comes to stimulating students to take a deep approach to learning. More unique to PBL curricula is having to make several learning resources available to students and having to facilitate students to create a coherent mental picture of the anatomy of the whole human body.

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Learning and Teaching Anatomy Through Case-Based Learning (CBL)

15

Jill E. Thistlethwaite

Defining Cased-Based Learning

Case-based learning (CBL) is a well-established method of learning and teaching across many disciplines such as law, medicine, and education. Law and medicine are indeed case-based professions, and logically trainees and qualified professionals will learn from and about cases throughout their careers. However, as CBL is delivered in many formats and at different stages of programs, it lacks a universally agreed definition. Indeed many educators and the literature also refer to the approach as case study teaching and case method learning. The underlying commonality however is the "case," which in medical and health professional education refers to a patient or client case.

CBL is not a new approach and pre-dates other forms of educational interventions by many decades. In 1912 James Lorrain Smith, the first full-time pathology professor at the University of Edinburgh in Scotland, introduced the "case method of teaching pathology" [1]. Medical students attending postmortems had to look up the deceased patient's history, clinical symptoms, and physical signs from the medical record and relate these to the anatomical and pathological findings of the autopsy. Smith's underlying aim was for students to link their scientific knowledge with clinical practice. A best evidence medical education (BEME) systematic review of CBL showed that this linkage between theory and practice continues to be a goal and a hallmark of effective CBL [2].

The BEME Definition of CBL

- CBL is a learning and teaching approach that aims to prepare students for clinical practice, through the use of authentic clinical cases.
- These cases link theory to practice, through the application of knowledge to the cases, and encourage the use of inquiry-based learning methods.

The Evidence for CBL

The BEME review [2] of 104 papers describing CBL across a diverse range of health professional education settings and programs concluded that typically CBL takes place in small face-to-face groups (2–15 students) but may also take place online and, less commonly, is undertaken by individuals or by large groups of more than

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30 participants. Cases obviously often feature in lectures attended by many more learners than this, but for CBL to be inquiry based, learners need to be involved actively in looking up information, discussing with their peers, and monitoring their learning outcomes. CBL fits between the structured and guided levels of inquiry-based learning as defined by Banchi and Bell [3].

Both learners and teachers have very positive views about CBL, but overall, while it helps promote learning, the evidence is patchy and inconclusive that it is more effective than other learning and teaching methods. Its efficacy appears to be due to the cases enhancing the relevance of the basic and biomedical sciences and integrating these with clinical management [4] in addition to learners' understanding of concepts. In relation to anatomy teaching, student evaluation has indicated that CBL does help make anatomy more relevant [5–7]. CBL is therefore a complementary process to lectures, dissection, and online learning. The learning process helps foster a deep approach to learning [8]; students gain greater understanding through the application of the knowledge they are learning to the cases presented rather than merely reproducing facts learned at a more superficial level. Student performance in the Step 1 USMLE (United States Medical Licensing Examination) has been enhanced through the use of CBL for cell biology, histology, and pathology when compared to the results of students taught anatomy in a more traditional way [9].

Developing a Case-Based Approach

As with any educational activity, it is important to define the learning outcomes that educators wish the students to achieve. Established anatomy programs will have a set of learning outcomes that students and faculty are aware of: which of these should be the focus of the CBL? Of course in most instances, the CBL will be complementing other methods of learning and teaching, as described in this book, and will be in addition to, not instead of, other teaching modalities. In some institutions, however, the medical program is delivered primarily as a case-based approach, in a similar way to those universities that have developed problem-based learning (PBL) curricula. Note that PBL is "learning that results from the process of working toward the understanding of a resolution of a problem. The problem is encountered **first** in the learning process" [10]. Students define their own learning outcomes in relation to the problem. In contrast, in the guided inquiry method of CBL, learning outcomes are defined for the students and the approach is more structured than PBL.

If CBL is not to be the principal curricular approach, then cases may be used to complement or substitute in some instances for other educational methods such as lectures, laboratory work, and dissection. If you are not considering changing the delivery of your entire anatomy

According to the National Center for Case Study Teaching in Science, Cases Should:

- be aligned with defined learning outcomes for the course.
- be authentic (based on real patient stories).
- involve common conditions.
- tell a story.
- have educational value.
- be interesting and enhance students' participation.
- create empathy with the patients.
- include quotations in the patient voice to add drama and realism.
- have general applicability.
- serve as memory aids.
- reduce cognitive overload.
- be easy and inexpensive to produce.

Adapted from Herreid [12]

curriculum, then you will need to decide how best the cases may be incorporated into existing teaching. Cases may follow didactic instruction to help students apply knowledge to practice; students may work on their own or in groups after lectures. In the flipped classroom model, learners independently watch short videos or other material online, which could include cases, and then come together with a facilitator to review what they have learned, to work in more depth through cases, and to engage collaboratively with the aid of a facilitator [11]. In clinical settings, the cases are the patients with whom the students interact, but CBL may be used in tutorial settings to integrate anatomy with clinical presentations and help remind students of their prior learning.

The learning outcomes for a case will dictate the focus of the case itself. Cases are best created from the stories of (de-identified) real-life patients, for whom authentic investigation results such as blood work, X-rays, and scans are available. Patient consent is required depending on how much the case is altered to mask identity.

Cases may be developed for a paper-based delivery, but more usually these days, cases are in an electronic format involving virtual patients (though these are usually based on individual real patients or a combination of different patients). Virtual patients are interactive computer simulations of real-life situations for the purpose of health professional education [13], whereas real patients are "flesh and blood people" with whom students interact in clinical or community settings. Real patients may also be invited into the classroom and lecture theater to tell their stories or to demonstrate physical signs. Simulated patients are also "real" people, but they work to a script for the purpose of specific learning or assessment purposes and are able to adapt their roles to enhance learning. Many are also able to give feedback to learners. For clinical examinations such as the OSCE (objective structured clinical examination), standardized patients do not deviate from prepared histories.

To Do—Developing CBL

- Do you already use cases in your teaching? Do they match the criteria in the previous box? What should you change about your existing cases?
- How might you incorporate a CBL approach into your teaching?
- Consider the necessary steps to introduce CBL: where, when, how, and who?
- Consider how CBL could complement your existing teaching; maybe you could substitute some of your existing delivery with cases, in particular to achieve outcomes related to application of knowledge and clinical reasoning.

Writing Cases

Basic scientists are advised to work with clinicians to write cases in order to ensure their authenticity and to obtain material that can be used to enhance the delivery of the case such as MRI scans and even videos of surgery. Writing cases is not easy and can be time-consuming. It is more fun developing and discussing newly written cases in groups within your department. If you and your colleagues work alone, you may find that some cases are too similar. You may be able to use one case across several learning sessions as the patient's story unfolds. Reading a case to your colleagues allows for feedback. You can discuss where longer cases can be split so they can be given to students in digestible parts rather than overloading them with too much information at one time. Your colleagues can check whether the case is congruent with the stated learning outcomes. The clinicians can vouch for the reality of the patient experience. You may also want to consider how you will assess that the students have met the learning outcomes and how this assessment fits with the overall assessment of anatomy in your program.

To Do—After Writing Your Case

- Check that the case will meet the defined learning outcomes.
- Consider if the case is at the right level for your learners.
- Ensure the case is realistic and interesting.
- Determine if the material presented will stimulate the necessary questions and/or answers from the students.
- Decide what other resources are required—for example, X-rays, models, and websites.

Teaching with Cases

As mentioned above, CBL is usually a small group activity. Approached in this way, CBL also promotes collaborative learning. Groups may be self-directed but often have a facilitator. The facilitator should encourage learners to think critically about the material presented. The case scenario is given to the students and includes the learning outcomes and any questions that the students are required to answer. Cases can be given to students prior to the sessions so they can come prepared through background reading or handed out on the day, which is more challenging. Students should work in their groups with minimal input from the facilitator, brainstorming answers, looking up further required information, and reaching a consensus about the answers to the questions. The session draws to an end by students presenting to the facilitator and receiving feedback on their work. In some models, all the small groups meet together, present to each other, and then give feedback on both the content and the presentation itself.

The teacher/facilitator acts as a guide, asking students to explain or clarify their thinking, encouraging discussion and debate. When necessary, the facilitator asks for evidence of any statements: what is the evidence for that? Finally, the learning outcomes for the session are revisited to check that they have been covered and what further reading or work is required.

Senior students may not need questions in addition to the learning outcomes but should be thinking of their own questions and developing hypotheses to explain the unfolding of the case. If there are questions, these should be formulated to build on knowledge students have already assimilated but that also require some additional research, pushing the students in new directions and encouraging them to apply their knowledge in new situations. For example, to follow up a session on the anatomy of the arm, a case may involve a patient requiring to have venipuncture with the students considering where the blood should be taken from and why and how. The session could be combined with students practicing the clinical skill of venepuncture on an appropriate model.

The same cases may be revisited several times in a year or program, but the questions are different and more challenging to reflect the stage of the students' prior learning. Complexity can be increased as the case develops. When learners are near the beginning of their anatomy journey, the questions should be focused on normal anatomy and function, with pathology and disease becoming a feature as students mature and the "patient" ages and/or develops further problems.

Faculty Development

Traditional teaching of anatomy has been didactic with students gaining practical experience through dissection. CBL is a much more facilitated approach, and therefore, its development, introduction, and delivery will require many educators to teach in a different way. Some may be anxious; some without a clinical background may find it difficult to write and engage with clinical cases. Therefore, it is important to carry out a needs assessment of staff in terms of their experience and skills in order to provide appropriate professional development activities.

It is vital when initiating a curricular change that all staff have a chance to discuss the implementation, the educational rationale, and their concerns. Faculty expressing personal negative or ambivalent opinions about CBL when facilitating undermine student confidence. Skills required for CBL, depending on how cases are used, include but are not limited to: engaging all students, giving just the right amount of guidance but allowing students to collaborate and set their own pace, giving formative feedback, and time management.

Suggested Steps for Students in Working with Cases

1. Read the learning outcomes for the case. Are there new learning outcomes? Are some related to previous work that you can now build on?
2. Read the case and clarify any terms or concepts with which you are not familiar.
3. Consider the members of the group—does there appear to be a difference in the level of understanding of the group members and why might this be so?
4. Read the questions, which are to help you meet the learning outcomes.
5. What systems of the body are involved in this case?
6. What anatomical concepts and other related topics need to be explored and/or explained?
7. Work through the questions, dividing up tasks between group members. Where might you find information to help?
8. Regroup to summarize your answers and prepare your case analysis.
9. Have you met the learning outcomes?
10. What other work do you need to do now?

To Do—Facilitation

- Consider what skills you and your colleagues require for facilitation.
- How will you develop these skills if you need to do so?
- What size groups will you work with?
- How will you ensure that all students are involved with each case?

The Learning Environment and Context

When preparing for CBL, you need to consider the learning environment and the context of CBL within the curriculum. Is the learning space conducive to small group work? How many students are in the class and how should they be divided into groups? Have they worked in groups before? How you deliver the cases will be dependent on your course structure. Does the CBL session follow a lecture? How does it fit with other teaching such as surface anatomy or dissection? One case may be completed in one session or may carry over to a second session with students continuing to work on it in the intervening days.

Students also need to be orientated to CBL especially if they are not used to guided learning methods compared to being "spoon-fed" information. If working in groups for the first time, they need to start by discussing ground rules such as respect, use of mobile phones, letting others speak, everyone actively contributing, etc.

CBL and Learning Outcomes in Anatomy

As anatomy courses involve students learning the vocabulary of the human body and recognizing and describing the structures of the body initially from the perspective of "normality," teachers need to be cautious when writing cases that they do not focus solely on pathology and thus disease. This can be a challenge particularly as students may be undertaking a spiral curriculum, which focuses on the normal in year 1 before tackling the abnormal in year 2. However, as CBL helps students understand the rationale for learning anatomy in relation to their potential profession, introducing pathology at this stage is acceptable as long as the underlying learning outcomes for normality are still met.

As the majority of health professional courses are now integrated through system-based learning, CBL may in fact involve the integration of physiology, biochemistry, and anatomy through interdisciplinary cooperation. This allows more interesting cases to be developed, which have learning outcomes across the sciences. Faculty need to understand the whole curriculum and what is learned where in order to develop cases that do build on prior knowledge and integrated learning.

Examples of Cases

Case One: Max and His Muscles

Max Lucas is a 23-year-old engineering student who has decided to "get fit" this year. His current fitness regime consists of walking to and from university five times a week, which takes about 45 min a day. He is slightly overweight and has started to reduce the size of his meals and the amount of beer he drinks. Max has no health problems. He joins the university gym and asks a personal trainer for some advice. He wants to enhance his muscle definition, bulk up his upper body, and gain a six-pack.

Learning Outcomes

- Name the muscles of the arms, shoulders, upper back, chest, and abdomen.
- Identify the origins and insertions of these muscles on the articulated skeleton.
- Name the associated tendons.
- Describe the movements of muscles using the correct anatomical terms.
- Outline the surface anatomy of the muscles.
- Outline the processes by which muscle size and power is increased.

Questions

- Which muscles does Max need to work on to build his upper body strength?
- What do these muscles do?
- What exercises would you recommend to Max?
- What advice would you give Max about his exercise regime to avoid muscle injuries?
- What is the evidence base for your prescribed exercise regime and advice?

To Do—Max and His Muscles

- In relation to your own teaching, what other learning outcomes and questions might you add?
- What resources may the students require to complete this case?
- How would you assess student learning?

Comments

This is a fairly simple case, which should resonate with the student population. This case could complement a lecture on the musculoskeletal system of the upper body and torso, or it could be solely a small group learning activity with the addition of prosections and anatomical models. The learning outcomes are the same but are reinforced through the case, which puts the knowledge into a clinical context. Resources are also the students themselves in terms of surface anatomy and perhaps even a set of hand weights to demonstrate muscle contraction and relaxation with different forces.

Extension of This Case

Six months later, Max is fitter and stronger. He begins to play soccer in the local park on weekends though he is not particularly skillful at the game; he enjoys the team element of the sport. One Saturday afternoon, he twists heavily on his right knee, which gives way with an audible crack. He limps off in some pain and watches the rest of the match from a bench. By the time the whistle blows, his knee is swollen.

Learning Outcomes

- Describe the anatomy of the knee joint.
- Describe the mechanics of movement of the knee.
- Explain any symptoms, signs, or loss of function in the knee due to ligament damage.
- Explain any symptoms, signs, or loss of function in the knee due to cartilage damage.

Questions

- Why was there an audible crack?
- Why is Max's knee swollen?
- What investigations may you require to help diagnose the anatomical disruption to Max's knee?

Comments

The case has moved onto a clinical presentation, but students should be able to find out the answers and meet the learning outcomes. This is a common problem. It would be interesting to provide MRI scans of a normal knee joint and one with collateral ligament damage or even show footage of an arthroscopy.

Case Two: Lisa's Abdominal Pain

Lisa Balotelli is a 25-year-old teacher who presents to the emergency department one Saturday evening complaining of lower abdominal pain for 6 h. She has vomited once and looks distressed. The resident elicits a full history and examines Lisa, who is tender in the right lower abdomen and centrally above her pubic bone. Based on the history and external examination, the doctor also carries out a digital rectal examination (DRE) and bimanual pelvic examination (PE).

Learning Outcomes

- Describe the normal anatomy of the lower abdomen and female pelvis.
- Outline the structures that the resident is palpating externally and suggest possible causes of Lisa's pain based on the identified structures.
- Describe the anatomy examined with the DRE and PE.
- Describe the differences in the anatomy examined with a DRE in a male patient.

Questions

- What are the possible causes for Lisa's pain given your knowledge of the anatomy of the lower abdomen and pelvis?
- What investigations may be helpful in this case in relation to examining any abnormalities of the anatomy?
- If Lisa gives a classical history of appendicitis, with central abdominal pain localizing to the right iliac fossa, explain the change in the location of the pain.

Comments

The learning outcomes relating to knowledge can be attained through lectures and other didactic methods, but again the CBL, either as facilitated group work or independent study, helps link the anatomy to clinical presentations and enhances the relevance of the material.

> **To Do—Writing Cases**
>
> - Choose a learning outcome for your student cohorts and develop a case to stimulate their learning around this outcome.
> - Write relevant questions for them to answer through research and discussion.
> - Decide on the format—are you able to develop your case online?

E-Learning and CBL

Online CBL is becoming more common within medical education as e-learning becomes more prevalent. Electronic cases range from simply uploading paper cases onto an educational platform to fully developed avatars living in virtual worlds. Very sophisticated cases are expensive to develop and maintain. Virtual patient cases do not need to be high fidelity though students (and tutors) used to costly video games and sophisticated avatars may be disappointed to begin with. For example, CT images from an embalmed cadaver have been readily constructed into a VP [14]. It is important to remember CBL is about learning and not technical prowess. There are open access VPs and cases online, which may be used to complement an institution's own resources. Enthusiastic students can be directed to these sites for further learning.

Conclusion

CBL is a learning and teaching method well suited to anatomy as it helps bridge the gap between knowledge and practice. There are a variety of approaches that may be used to deliver CBL. CBL is effective for groups but requires faculty development of authentic cases. However, there are now many open access cases that students may use to complement the resources provided within their own departments.

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16 Team-Based Learning: An Effective Pedagogical Strategy to Teach Anatomy

Cheryl Melovitz-Vasan, Grace Pinhal-Enfield, David O. DeFouw, and Nagaswami S. Vasan

Teaching anatomy in medical education is changing due to integrated curriculum models, technological progression, larger class size, decreased curriculum time and teaching staff, and technically savvy "millennial learners" [1]. Furthermore, accreditation bodies demand students to be engaged in their learning (https://www.lcme.org/publications/functions2013june.pdf), essentially decreasing the large group lecture format in favor of small interactive group models. TBL strategy meets these demands by effectively guiding selfdirected experiential learning. Our TBL pedagogy to teach anatomy has progressed through trial and error as well as self-reflection and refinement processes over the last 10 years [2–6].

In the following pages, the readers will learn about implementing and sustaining TBL strategy. Additionally, the goal is to create a connection between concept and classroom implementation. Before choosing and instituting a formal TBL strategy, ask the following questions: (1) Is sufficient time available in the course for students to work both in class and out of class to evolve into a cohesive team? (2) Will it help development of skills such as efficiency, critical thinking, higher-level reasoning, and teamwork? (3) Is the teaching faculty prepared to deviate from the traditional lecture-based strategy? (4) Is there support from administrative "higher-ups" to champion the strategy? The sequential steps we followed to successfully implement the TBL strategy in teaching anatomy include the following.

Starting Small and What We Learned

We first piloted TBL in the spring of 2004 with our graduate student anatomy program and then with the summer anatomy program for incoming freshmen medical students. We learned from the pilot study that:

- TBL was an excellent substitute for lectures if appropriate session objectives, reading assignments, and "content-specific learning topics" were created (Appendix).
- Individual readiness assurance tests (IRATs) were essential for TBL session accountability.
- Group readiness assurance tests (GRATs), where considerable teaching and learning occur among peers, provided an opportunity for faculty to clarify any ambiguities and misconceptions.

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- TBL fostered deeper learning among the students, and they were excited about coming to class.
- It will work for large class sizes (180) and for students with diverse educational backgrounds.
- TBL is appropriate for a concept- and content-rich course like anatomy that includes a large dissection component. We could cover all of the material in the same time frame.
- A pilot study allowed us to learn the essentials and potential mishaps before expansion.

Important Tip for Novices

For first-time users, piloting one module is safe for getting feedback and making changes before expanding.

Study Guide

For each TBL session, it is critical to create appropriate learning objectives, reading assignments, and "content-specific learning topics" (see Appendix for pre-class preparation in phase 1) (Fig. 16.1). Since human anatomy is a vast subject, we made sure the reading assignments and learning topics were unambiguous and focused on overall session goals and objectives. Providing focused learning topics assured students that there would be help from the group during team discussions (phase 2; Fig. 16.1) to resolve any conceptual difficulty.

The study guide included text pagination to study, points of clinical relevance, concepts to be developed, questions for application of knowledge, and pertinent dissection instruction. This offers students a clear idea of what knowledge they are expected to master to be successful in the course. This is a substantial undertaking that needs time investment and is not to be taken lightly, since the success of TBL very much depends on it. It is highly advantageous when two colleagues work together in this process. Well-organized learning activities are vital to help students build baseline facts into a framework of conceptual interpretation and understanding [2–7].

How the TBL Fits in Discipline-Based First-Year Curriculum

Except for the TBL anatomy course, the remaining discipline-based first-year courses and the integrated second-year courses retained much of the pedagogical approach associated with passive, lecture-based learning. Anatomy is the only course where lectures are not given (except clinical correlation) and the "content-specific learning topics" are utilized. Hence, TBL is a unique and welcoming experience that the students embraced passionately.

Classic TBL

The classic TBL includes out-of-class preparation (phase 1), in-class IRAT followed by GRAT, and an appeal process (phase 2). In the appeal process (phase 2), a team can successfully challenge a question and each team member receives credit; however, the credit is not given to teams that do not appeal. In addition, an application exercise containing a clinical vignette with a few multiple-choice questions is discussed within the teams, and the answers are declared simultaneously by all teams (phase 3).

Need for Modification

The classic TBL lasts up to 3 h; our curriculum time required limiting TBL to 2 h. Furthermore, all our MCQ exams (IRAT and GRAT) are clinical vignette-based, and hence, we felt phase 3 of the classic method was unnecessary. In our experience, the phase 2 appeal process, to give grades only to the members of the team that successfully appealed a question, was not a popular approach. Hence, we changed it so that any successful appeal resulted in credit given to all students. Due to changes in the preclinical curriculum and additional teaching time allotted to anatomy, we modified the TBL to include four phases as described below.

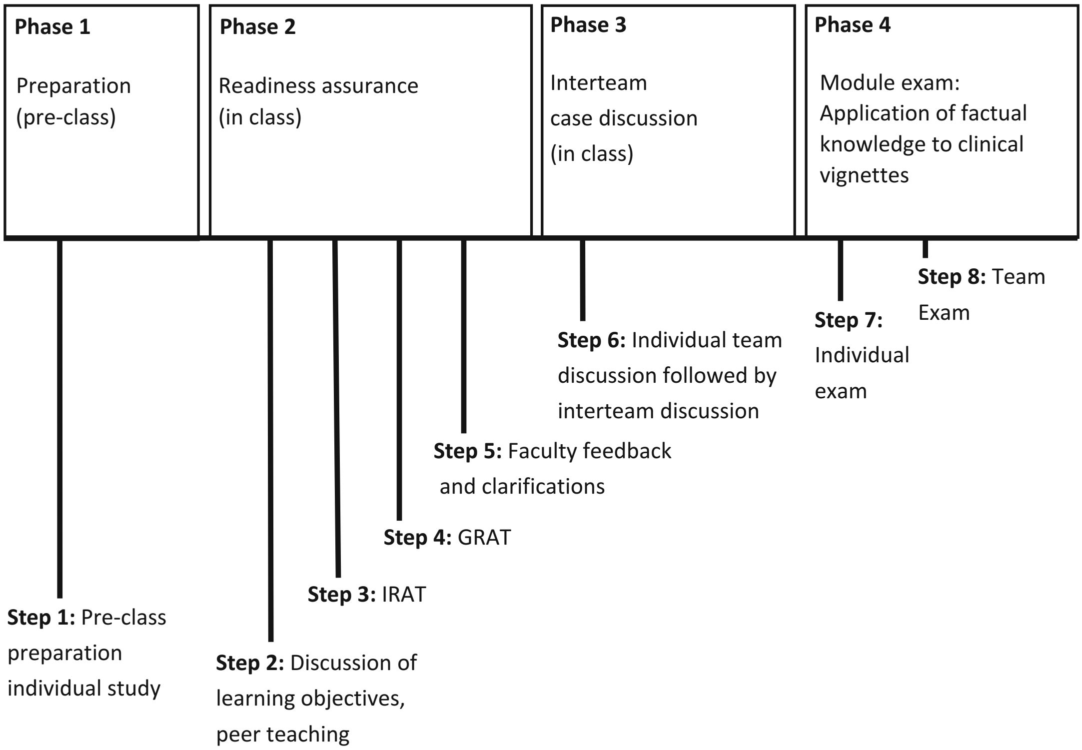

Fig. 16.1 Four phases of team-based learning (TBL) and the sequence of steps involved are shown. As described in the text, the steps are different from the classical three-phase TBL. *IRAT* individual readiness assurance test. *GRAT* group readiness assurance test

Modified TBL

Modification of the classical TBL strategy is common and based on the needs and faculty acceptance. It is often done to fit a course structure and curricular time or to introduce and pilot new pedagogy in an existing curriculum. During the early years, we only used phases 1 and 2 of the "classic TBL" model. With experience, success, additional teaching time, and acceptance in the last few years, we have developed a "four-phase" model of TBL that students and faculty embraced and are excited about (Fig. 16.1) [8].

Phase 1

Reading assignment and content-specific discussion topics from required texts are created for self-directed preparation.

Phase 2

Team discussion (90 min) of the assigned learning topics and questions for application of knowledge includes peer teaching to consolidate required course concepts. During the team discussions, faculty moved among the teams to clarify any troublesome concept and provide additional resources to build knowledge. We have determined that two faculty members can successfully address the needs of 15 six-member teams during the discussion sessions. Following the discussion, the members of each team complete the individual readiness assurance test (IRAT) that is a case-based clinical vignette MCQ quiz (10 min) to monitor each student's understanding of the required material and provide feedback for self-assessment. Immediately following the IRAT, teams collectively retook the individual quiz, now designated as the group readiness assurance test

(GRAT) whereby the members discuss each question before selecting one common answer (10–15 min). Immediate Feedback Assessment Technique forms (IF-AT1 Epstein Educational Enterprises, Cincinnati, OH) were used for the group quizzes. This form helped students identify incorrect answers immediately and discuss questions more in depth, thus facilitating deeper understanding of the materials. IF-AT answer sheets contain rectangles (marked A, B, C, D, or E) for each MCQ. After the team agrees on an answer choice, a thin opaque covering on the chosen rectangle is scratched off. If the answer is correct, a star appears within the rectangle and full credit is received. If the answer is incorrect, further discussion within the team creates additional choices until the correct answer is identified. No credit is received for the additional choices.

Phase 3

Interteam case discussion (90–120 min)—Recently, we introduced "cases for team discussion" *at the end of each module* to sum up the TBL content (course consists of four modules). Teams discuss several cases and prepare responses to targeted items presented in each case. After individual team discussions are completed (60 min), their responses are presented during a faculty-monitored interteam discussion. These sessions enabled the faculty to use probing questions to expand student knowledge and clarify knowledge deficiency. This is a "new" phase to the "classic model" that provides better understanding of the content and helps students get ready for the "high-stake" phase 4.

Phase 4

There are four "high-stake" MCQ module exams that cover each of the four course modules. Questions are clinical vignette-based and are taken individually (IRAT) and as a team (GRAT). Note that all quizzes and module exams are taken both individually and by group except the NBME exam.

Modification to the Classical TBL

- It is commonly done based on the course structure, experience, and faculty acceptance.
- It is often done to fit curricular time and to introduce and pilot TBL pedagogy into existing curriculum.
- It is critical to have buy-in from students and faculty to embrace the new approach.
- A well-structured study guide is the backbone to TBL implementation.

Constructing a TBL Session

There are three interrelated entities to be considered in developing session content and ensuing quality of the session: (1) amount of material covered per session, (2) amount of student time needed to prepare for the session, and (3) lengths of each session.

Ideally, 4 h of preparation time is required for each session (phase 1); thus, the amount of content covered and required reading assignment must be appropriate. If not, students will split the workload and each student will not acquire the required knowledge for team discussion. Each TBL session (phase 2) should not exceed 2 h; otherwise, students will lose focus. If the session is too short and teams are unable to complete their discussions, they will assume the material is not important or the faculty is not enthusiastic about TBL. A visible expression of faculty's passion for the pedagogy is vital. This balance is achieved through clearly written learning topics that match the reading assignments and expectations of the "readiness assurance tests."

Trained Support Staff

A dedicated staff is crucial to the TBL program and the course director should *not* assume clerical responsibilities. Before the course begins, the staff is responsible for getting all course materials copied for student distribution. This includes typing team lists, creating team folders with members' names on the cover, and making copies of the IRAT and GRAT for timely placement in the team folders. Importantly, all testing tools are color coded to make the sequence of activities clear, and since the quizzes and exams are protected, each question booklet, Scantron answer sheet, and IF-AT form is numbered to insure accountability and security. Following the IRAT, the staff collects the Scantrons and immediately scores them for faculty to identify unprepared poor performers. Staff also scores the GRAT and continuously maintains the IRAT and GRAT grade book. These activities, which are detail oriented and time consuming, are typically done more than once a week.

Preparation for TBL Sessions by a Trained Staff

- Prepare all course materials for student distribution.
- Color code all testing tools.
- Collect the Scantrons and immediately score them.
- Score the GRAT.
- Maintain the IRAT and GRAT grade book.

Faculty Development

It is important for at least one member of the faculty team to have hands-on experience from a TBL workshop. Thus, the trained person can provide training for the other faculty to gain experience in all aspects of the TBL pedagogy. It is critical to have faculty who are interested in the TBL, since an uninterested faculty can derail the process.

Student Workshop on TBL

For most students, TBL will be a new pedagogical classroom experience, and concerns such as competition for better grades, sharing knowledge with others, or apprehension about exposing knowledge inadequacies are anticipated. Furthermore, the process of employing the phases of TBL requires full understanding through a working session. Hence, we conduct a mini-workshop on the first day of the course to walk the students through the required steps of TBL and their mechanics. This also allows new staff and faculty training. In addition, during course orientation, we share with the students how TBL has improved overall class performance and invite second-year students to share their experiences with TBL. These proactive processes have profound effects on student's preparedness and acceptance of small group interactive learning.

Establishing Ground Rules

Inherently, medical students are highly competitive with strong personal desires for high achievement. Thus, we establish rules and guidance for the team process that emphasize the importance of being punctual and prepared for meaningful contribution to each TBL session. Emphasis is also placed on being flexible, open, and respectful during the sessions. Lastly, we declare that high-performing teams consist of members who are mutually accountable for each other's performance and embody a collective action that arises from task interdependency [9].

Gathering Student Information to Form Teams

Our entering class (180 students) is admitted to various programs such as a 7-year baccalaureate-MD, MD-PhD, or MD-MPH program. The class also includes students with post-baccalaureate educations and decelerated and returning students, and the largest proportion has recently graduated with 4-year undergraduate degrees. In forming teams, we attempt to evenly distribute science and non-science majors and students with post-graduate education. In addition, students from the same college are placed in separate teams. Based upon the diversity and demographic background of the class, we assign individuals to teams with the intentions of evenly distributing individual resources for well-balanced teams. This provides similar opportunities for each group to develop into a "learning team" with cohesiveness and high performance. The course director is responsible for creating the teams, and the students are knowledgeable about the transparent process. We request the Office of Admission to provide the above information about each student and do not require MCAT or GPA (since it is not released to the faculty!) data to complete the purpose.

Size of a Team

We create six-member teams. A smaller team has fewer individual resources to meaningfully create, critically analyze, and synthesize subject knowledge. A larger team size results in "pockets" of sub-teams that diminish the opportunity to develop "team cohesiveness." Students remain in the same team for the entire course, and over time, the members develop trust among themselves and interdependence. To minimize impediment to team cohesiveness, special attention should be paid to coalitions that might develop through previously established associations (boyfriend/girlfriend, siblings, colleagues in the past, same ethnicity, etc.).

Grading

The students take four MCQ module examinations (see course structure above), which are based solely on clinical vignettes. The examinations are taken individually (Scantron® scored) and by teams (IF-AT® form scored). Teams are also allowed to challenge any answers, and if a challenge is accepted, the result is applied to the entire class (unlike the classical TBL where only the challenging teams receive credit). The comprehensive final examination consists of the anatomy and embryology National Board of Medical Examiners (NBME) Subject Examination and is taken individually only. Course grading is formulated as per guidelines from the Office of Education. The course grading rubric is as follows: 40 % from the individual unit exams, 15 % from the individual NBME final, 30 % from the individual practical exams, and 15 % from the team (group) unit exams. Thus, 85 % of the course grade for each student reflects individual achievement and 15 % denotes a combination of team score.

Peer Evaluation: To Do or Not?

Peer evaluation can be employed to promote students' accountability to their teams and develop individual competency in this active learning professional process. However, closely monitoring student participation in team discussions and IRAT and GRAT performances has enabled us to evaluate individual accountability without

Step by Step: How We Do TBL

- Gather support/create sense of urgency for changing pedagogy, e.g., the need for active learning opportunities as recommended by LCME (https://www.lcme.org/publications/functions2013june.pdf).
- Instill interest and passion for TBL among course faculty.
- Establish importance of punctuality, preparedness, flexibility, and collegiality during all team sessions.
- Start small and use only phases 1 and 2 to begin.
- Publicize outcomes to enhance student alliance.
- Employ step-by-step mini-workshops to insure proper mechanics.
- Match preparation time with complexities of the learning topics.
- Correlate learning topics with IRAT, GRAT, and module exams.
- Continuously monitor team discussions, IRAT, and GRAT to address misunderstandings and individual weaknesses.

peer evaluation. Furthermore, we have discovered peer evaluation is a contentious process that makes students uncomfortable and leads them to game the system. Hence, after 3 years, we dropped peer evaluation and are still satisfied with the process.

Conclusions

Team-based learning allowed us to cover course content and improve student performance despite reduction in course time. Furthermore, TBL provides opportunities for active learning and independent study to foster the skills necessary for lifelong learning. These skills include self-assessment on learning needs; the identification, analysis, and synthesis of related information; and the evaluation of the reliability of information sources. Embedded in the assessment is frequent feedback on performances. Finally, successful implementation of the TBL strategy depends on the sincerity of the faculty and staff and support of the administration to foster positive student's perception of the process.

Appendix

Completion of this TBL will require the use of designated figures and text in *Clinically Oriented Anatomy (COA), Moore et al., 6th edition* [10] and *Medical Embryology (ME), Sadler, 11th edition* [11].

Phase 1: Reading Assignment, Pagination from Textbooks

Heart: Anatomy to Comprehend

After completing **Pericardium**, you should be able to:

- Describe the fibrous pericardium.
- Distinguish parietal and visceral layers of the serous pericardium.
- Define the transverse pericardial sinus.

Content-Specific Learning Topics: Fibrous Pericardium and Serous Pericardium

Use *Figure 1.43, p. 129 (COA)*, to observe that the tough external fibrous pericardium covers the cellular serous pericardium. Recognize that mesothelium (simple squamous epithelium) forming the parietal layer of serous pericardium lines the inner surface of the fibrous pericardium. Observe at the origin of the great vessels that it reflects onto the heart as the visceral layer of serous pericardium.

Use *Figure 1.48 (B), p. 131 (COA)*, to recall that fusion of the pleuropericardial membranes divides the thoracic cavity into the pericardial cavity and bilateral pleural cavities, and use *Figure 1.48 (C)* to observe after the division that the membranes form the fibrous pericardium.

Use *Figures 1.32, p. 110 (COA)*, to recognize that the pericardium (aka pericardial sac) fuses to the central tendon of the diaphragm, and use *Figure 1.33, p. 111 (COA)*, to envision continuity of the parietal and visceral layers of serous pericardium at the roots of the great vessels.

Use *Figure 1.46, p. 131 (COA)*, to recognize that the transverse pericardial sinus (arrow) is a pathway posterior to the intrapericardial parts of the aorta and pulmonary trunk and anterior to the intrapericardial parts of the superior vena cava (SVC) and pulmonary veins.

Embryology to Comprehend

After completing **Heart Tube**, you should be able to:

- Summarize the formation of the interatrial septum.
- Summarize the formation of the interventricular septum.

Content-Specific Learning Topics: Formation of the Atrial and Ventricular Septa

Use *Figure 13.15, p. 172 (ME)*, to determine that formation of interatrial and interventricular septa completes the differentiation of the primitive atria and ventricles. Recognize that formation of the septa involves mesenchymal cell-derived endocardial cushions (ridges) and narrow tissue strips that completely or incompletely separate the chambers.

Phase 2: In-Class Discussion, IRAT and GRAT.

Questions for Application of Knowledge

1. From *Cardiac Tamponade and Pericardiocentesis, pp. 133–134 (COA)*: Why can cardiac tamponade be fatal and how is pericardiocentesis normally performed?
2. From *Surgical Significance of Transverse Pericardial Sinus, p. 133 (COA)*: How do cardiac surgeons utilize the transverse pericardial sinus?

Examples of questions (based on reading assignments, topics for discussion, and application of knowledge) in the module exam:

Case: A 21-year-old college student on spring break fell from the balcony of his hotel and sustained blunt chest trauma. He was rushed to the ER, and very weak heart sounds, reduced cardiac output with declining blood and pulse pressures, bilateral jugular distension, and respiratory distress were detected.

1. The patient's symptoms most likely resulted from:
   A. Hemothorax
   B. Cardiac tamponade*
   C. Cor pulmonale
   D. Deep vein thrombosis
   E. Pancoast's syndrome

Case: A 61-year-old female complains to her physician about tiring easily and shortness of breath on exertion. Auscultation of the chest detected a diastolic murmur and a collapsing pulse was detected.

2. The patient is most likely suffering from:
   A. Aortic valve insufficiency*
   B. Mitral valve stenosis
   C. Diseased left ventricular papillary muscle
   D. Pulmonary valve insufficiency
   E. Heart bundle block

Case: An underdeveloped 3-year-old child was brought to this country to correct a congenital heart defect. The child had dyspnea and often suffered from pneumonia. Surgery corrected the congenital defect; however, several days later, the child was diagnosed with a heart block.

3. The surgery was most likely performed to correct:
   A. An atrial septal defect
   B. A ventricular septal defect*
   C. A patent ductus arteriosus
   D. A double aortic arch
   E. Coarctation of the aorta

Phase 3: Interteam Case Discussion (Example of a Case)

Case: A 67-year-old man, who has been a smoker since the age of 15, is seen at the family clinic.

History of present illness: Numbness and tingling on the medial side of his right forearm and hand and swelling in the right supraclavicular region. He also started to notice that his voice was becoming hoarse.

Physical exam: Edematous face and neck, puffiness around the right eye, and right jugular venous distension. Exhibits ptosis of the right eye and pupillary constriction.

Imaging: Chest X-ray shows large tumor of the right apical lobe.

Discuss and explain the reason(s) for the following:

1. Numbness and tingling on the medial side of his right forearm and hand
2. Voice becoming hoarse
3. Swelling in the right supraclavicular region
4. Edematous face and neck, puffiness around the right eye, and right jugular venous distension

Phase 4: Module (Thoracic Structures) Exams with MCQ (Examples)

Case: A first-year medical student Sara Niches was observing a "C" section at the university hospital. The attending physician asked Sara to describe the blood pressure changes that occur in a neonate.

1. Sara correctly responded:

	Right Atrium	Right Ventricle	Pulmonary Trunk	Left Atrium	Left Ventricle	Aorta
A.	Increases	Increases	Increases	Increases	Increases	Increases
B.	Increases	Increases	Increases	Decreases	Decreases	Decreases
C.	Increases	Increases	Decreases	Increases	Increases	Decreases
D.	Decreases	Decreases	Decreases	Decreases	Decreases	Decreases
E.*	Decreases	Decreases	Decreases	Increases	Increases	Increases

Case: A 65-year-old male, living alone, was found dead in his apartment. Postmortem examination of the heart showed necrotic changes limited to the anterior two-thirds of the interventricular septum.

2. If chronic coronary artery disease had resulted in arterial occlusion, the artery most likely occluded was the:
   A. Left coronary artery
   B. Left circumflex artery
   C. Right coronary artery
   D. Marginal artery
   E. Left anterior descending artery*

Case: A 52-year-old female with dyspnea came to the ER. During examination, crackling sounds (rales) were heard when the stethoscope was positioned on the right midclavicular line at the level of the fourth intercostal space, and acute bronchitis was suspected.

3. The location of the acute inflammation and resulting rales was most likely the:
   A. Lateral bronchopulmonary segment*
   B. Anterior bronchopulmonary segment
   C. Apical bronchopulmonary segment
   D. Anterior basal bronchopulmonary segment
   E. Lateral basal bronchopulmonary segment

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17 Giving Feedback to Students

Nirusha Lachman

Introduction

In a truly integrated, student-centered teaching and learning environment, successful achievement of competencies is strongly dependent on a dynamic exchange of performance-related communication. While the student-centered approach to teaching places greater emphasis on self-directed learning, it places an even greater emphasis on *teacher-dependent feedback*. Students cannot be expected to know what they *do* or *don't* know if they have nothing to measure it against.

For anatomy teachers, understanding that whatever the design, whatever the grading structure of the course, providing students with meaningful communication regarding performance is imperative if one is to expect them to progress through their learning experience and achieve the desired competencies [1]. In a competency-based educational environment, assessing student performance is crucial to the achievement of core objectives and successful implementation of the curriculum.

Within the framework of a teaching and learning partnership, the use of meaningful *feedback*, as it relates to student performance, is no longer an optional exercise but rather an essential element in helping students achieve successful learning outcomes.

Two central terms relate to feedback: (1) summative and (2) formative. Discussion surrounding the interpretation and application of these terms can be somewhat confusing [2]. The simplest way to understand the difference is to recognize that the goal of summative feedback is to provide an evaluation of student learning at the end of an instructional section using a benchmark (e.g., midcourse assessment of knowledge of anatomy of the back, upper limb, and thorax; final assessment of anatomy covered over entire course), whereas the goal of formative feedback is to supervise and guide student learning on an ongoing basis *during* the course (e.g., daily quizzes, practice practical tests, feedback on professional development) to improve student learning. While the information gathered from summative feedback is important, it is limited in its ability to enhance student competency. *Summative* feedback is an effective way of evaluating effectiveness of course delivery and achievement of course objectives through measuring overall student performance. *Formative* feedback on the other hand is part of the instructional process, informing students and teachers about student comprehension so that pedagogical adjustments can be made to enhance overall student performance [3].

This chapter will focus on how to effectively apply formative feedback strategies within a contemporary anatomy curriculum. We will discuss how directive and facilitative feedback can enable students to achieve competencies embedded within the core objectives of the anatomy

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course. The terms "students" and "learners" will be used interchangeably when relating directly and generally to the learning participants. While many of the principles embedded throughout the discussion are based on classroom design for team-based learning, the key skills to providing effective feedback may be applied to any classroom setting.

Formative Feedback

Formative feedback is a representation of assessment and observation that provides students with meaningful commentary *relating to performance* for the *purpose of improving performance*. When correctly applied as an educational strategy, feedback can be a powerful tool, not only in enhancing student performance but also in augmenting student motivation. For it to be effective, formative feedback should be non-judgmental, student specific, timely, supportive, and multidimensional [4, 5].

Literature pertaining to formative feedback is abundant in the field of education and business [6–10]. However, its use in medical education and, in particular, in the teaching and learning of basic sciences is a more recently introduced topic [7, 11–14]. While anatomy courses are by nature designed to promote the understanding and retention of factual knowledge, they are no longer confined to providing students with such [15]. In fact, very few anatomy courses still maintain such a one-dimensional approach to the teaching and learning of the anatomy. Courses that have evolved to include more nontraditional discipline-independent skills and competencies have placed greater expectation on the critical evaluation of these skills. Black and William [16] discuss provision of feedback by distinguishing two main categories which may be applied in the anatomy course assessment structure: (i) *directive feedback* used to provide students with information on knowledge deficits that may place them at risk for achieving required grades and (ii) *facilitative feedback* used to provide students with verbal or written commentary on their performance relating to nontraditional discipline-independent skills with the intention of guiding them through their professional development. The "Educational Testing Services Research Report" on formative feedback [17] unfolds three important directives for effective and useful feedback: (1) the understanding that the student needs the feedback, (2) the detection of opportunities to provide timely feedback, and (3) the mind-set that the student has the ability and is open to using the feedback to strengthen learning.

Directive Feedback

With the shift away from content-heavy courses, the contemporary anatomy curriculum [15] focuses on facilitating student learning of anatomical material (knowledge-based competency) within the framework of two main objectives:

- **The ability to demonstrate knowledge of normal function** (i.e., relating structures of the human body to its function)
- **The ability to apply knowledge of basic sciences to patient care** (i.e., identify and apply anatomical knowledge to clinical problems, apply principles of anatomical sciences to clinical scenarios, translate basic science knowledge into clinical decision-making processes, and possess effective laboratory observation skills)

Use of Audience Response System

The use of the audience response system (ARS) has been well described with significant data to support its effective use among students [18, 19] and its ability to reinforce learning by promoting knowledge retention and clinical reasoning [20, 21]. In addition, studies [18] show that the use of classroom clickers promotes both active learning [22] and social interaction within the team-based classroom environment [23].

One of the biggest challenges students face in anatomy relates to information overload. Apart from being overwhelmed, students are often unsure of where they stand with regard to application of newly acquired information. As a result, such uncertainty tends to decrease student motivation which further impacts student performance [17]. Summative evaluation is a valuable tool often used in providing a measure of what a student has retained and understood by the end of a given period. While this information may be used to determine what has been successfully *learned*, it does very little for the *process of learning*. The responsibility for facilitating student learning is coupled with the responsibility for providing well-timed, regular feedback. Providing timely (through daily debriefing or weekly consolidation sessions) and quality feedback (reviewing answers through a process of critical evaluation) reinforces concept understanding and integration of the material. The use of ARS as a method of providing directive feedback enables students to individually comprehend the question, determine an answer, share their thoughts with teammates, and, through a process of shared feedback and critical evaluation, agree on the most likely answer. The dynamic approach to this exercise encourages clinical reasoning and helps students determine for themselves where they stand in terms of their performance. With regular scheduled use, ARS scores have shown to be good predictors of final grades and good identifiers of students who may be experiencing academic challenges [18]. However, the key to making this source of feedback meaningful for student improvement lies in the skill of determining the most likely answer. Studies show directive feedback to be far more effective when it promotes thinking and reasoning in deriving at a correct answer as opposed to students simply receiving a correct answer [24, 25].

Use of Electronic Feedback in Midcourse or Quarterly Assessments

In the absence of ARS technology, the use of midcourse or quarterly assessments through curriculum management systems such as Moodle® and Blackboard® can be used as an electronically accessible tool to provide directive feedback. Despite being less socially interactive and not immediate, pretest questioning is an indispensable assessment instrument in determining student assimilation of anatomical material and progress in applying their knowledge in clinical-based scenarios. The challenge, however, and one most teaching faculty would face with using this system, is that it is time-consuming to provide electronic feedback to each student—a challenge that is accentuated with the prospect of large class sizes.

One option for dealing with this challenge is to implement a near-peer teaching [26] approach through delegation of tasks to teaching assistants (TAs) [27]. Based on the peer feedback model described by Camp et al. [28], expanding the TA role as student tutors [27] is an effective way of integrating knowledge-based feedback on a more structured level. The type of feedback provided by the TAs need not be elaborate. Simple presentation of a score/grade/results from practice practical tests combined with a few short comments or a brief description highlighting areas for improvement with helpful resources determined by the TA would serve as an acceptable form of feedback. By receiving this feedback, students would feel equally noticed and value the teaching team's investment in the progress of their learning.

Use of Dissection Grading and Formative Practical Tests

One of the more underemphasized and often overlooked areas for providing student feedback revolves around activities in the anatomy laboratory. For courses that include a dissection component, providing feedback to teams is crucial in ensuring that students maximize the invaluable hands-on experience of dissection. It is not surprising, given the lack of expertise, that students in general are unable to make efficient use of laboratory time. More often than not, with the focus on "getting through" the laboratory objectives, cadavers end up being poorly dissected, structures remain unexposed, and teams trudge on leaving most if not all of their practical learning for the end of the course.

To encourage students to dissect in a thoughtful and efficient manner, a diminutive percentage of their final grade should be allocated to the quality of their dissection. Despite its low impact on overall performance, providing students with directive feedback on task quality provides them with the motivation needed to ensure that the resource offered to them is valued. Students should receive clear objectives and a list of key structures for identification [29], be informed in a timely manner of when the evaluation will occur, and supported throughout the laboratory session by faculty and TAs. Again, the responsibility for providing the feedback may be easily assigned to TAs [27]. Subjective directive feedback using a grading plan may be given via electronic communication (email correspondence to each team or curriculum management system) with a dissection grade and explanation of where the team's dissection falls short and what the team dissected well. In addition, helpful techniques and tips for uncovering structures as well as structures that have been clearly demonstrated should be provided to the class as a whole.

> "Feedback is the cornerstone of effective clinical teaching. Without feedback, good practice is not reinforced, poor performance is not corrected and the path to improvement not identified."
>
> Cantillon and Sargeant [14]

In addition, the use of practice practical tests with an opportunity for students to review the correct answers for tagged structures keeps students on task and track, eliminating the uncertainty associated with simply receiving a grade at the end of the test. During the review, faculty and TAs should be available for immediate feedback.

The fundamental nature of *directive feedback* lies in its capacity to (1) *verify* student knowledge of anatomy and (2) *elaborate* on the process of deriving the most likely answers through clinical reasoning. Studies agree that this type of feedback not only encourages student understanding of subject-specific concepts but also promotes student thinking, decreases student uncertainty, and enhances student motivation [30].

Grading Quality of Dissection

Provide feedback on how well the cadaver was dissected:

- Very well dissected (structures easily identified, attention to detail, all required portions of dissection completed in an excellent manner).
- Well dissected (most structures easily identified, all required portions of dissection completed).
- Adequately dissected (most if not all required portions of dissection completed).
- Poorly dissected (multiple structures destroyed or unidentifiable, visibly incomplete dissection).
- Very poorly dissected (no time or thought spent on isolating structures, incomplete).
- An example of feedback on how dissection can be improved: *Uncover the recurrent branch of the median nerve; the superficial branch of the radial nerve is often obscured by fascia as it passes beneath brachioradialis*….

Facilitative Feedback

Use of Facilitative Feedback to Promote Holistic Student Development

Facilitative feedback may be used to promote holistic student development. Within the integrated medical curriculum, anatomy courses provide an ideal platform for creating awareness of the importance of nontraditional discipline-independent skills in the current health-care

Characteristics of Directive Feedback

- Focuses specifically on knowledge-based competency (anatomical concepts)
- Objectively measures knowledge and understanding (application of anatomical concepts)
- Identifies knowledge paucity
- Reduces uncertainty for students regarding their own progress during the course
- Encourages self-evaluation and clinical reasoning
- Motivates students to improve performance
- Helps teachers identify class challenges in understanding material and reinforce anatomical concepts
- Verifies student knowledge and demonstrates use of critical thinking in deriving answers

system. These skills—social, inter-professional, creative, communication, leadership, and professionalism—are vital to successful integration within the team-based environment. While anatomists are no longer hesitant to incorporate these ideals as measurable outcomes within the curriculum [15, 31], they are expectedly apprehensive about providing feedback relating to nontraditional discipline-independent skills [14]. With facilitative feedback involving provision of verbal or written commentary to students with regard to these skills, the task poses a daunting challenge for teachers who have had no training in assessing students with the intent of guiding them through their own professional development [1].

For students, four main objectives require feedback during the course as well as upon completion: (1) *consistent demonstration of professional and ethical behavior*, (2) *effective communication*, (3) *display of effective teamsmanship*, and (4) *display of leadership*.

Communicating Facilitative Feedback

For experienced anatomy teachers, a new and very real challenge lies in learning how to work with the "millennial student." Awareness of generational characteristics is important if providing feedback is meant to be meaningful. Millennial students, reputed to be technologically savvy, confident, and optimistic with high expectations for themselves, are goal oriented and self-driven [32, 33]. Studies have shown that for students to remain engaged and motivated, teachers must be able to create cohesion between what is expected of them and what they are able to achieve for the level of training they are at [34].

Communicating facilitative feedback is no easy task. In fact, the majority of teachers avoid the use of verbal or written communication to effect student improvement simply because they feel uncomfortable doing it [13].

Without the proper tools, facilitative feedback can come across as being judgmental and subjective, oftentimes causing the recipient to become defensive or sensitive. If feedback is too detailed or complex [35], students may not pay attention to it or may diminish the message. If comments are too complimentary and focused on student embellishment, the opportunity for improvement is lost. The most meaningful and effective feedback must include a balance of (1) *direct observations* (positive behaviors and limitations for learning), (2) *points for reflection*, and (3) *guidelines for improvement*.

It is important to keep in mind that the students to whom you are providing feedback are at a very early stage in their career. They cannot be expected to have mastered nontraditional discipline-independent skills. For most, this may well be the first time they are expected to demonstrate such skills. Research has shown that for a learner to remain motivated and engaged, a lot depends upon *reaching a balance between a learner's goals and the expectations that these goals can be met*. If goals are set so high that they are unattainable, the learner will likely experience a sense of failure and become discouraged. If goals are set low so that students are certain that they will achieve them, the need for further effort is diminished [17].

Providing Verbal Feedback to Students

The teaching and learning environment of an anatomy course is a multidimensional platform, providing a variety of opportunities for student–teacher interaction. However, the issue of how to provide verbal feedback is as important as when to provide it. Set expectations at the right level—remember that these are students learning to develop skills by being introduced to them during an already demanding anatomy course.

The classroom setting is a good arena to provide students with global feedback (general feedback relayed to the class as a whole) relating to good practice and demonstration of professionalism or opportunities for improvement, e.g., faculty observation of overall student disposition and attitude in the anatomy laboratory, team cohesiveness, and peer interaction. Feedback may be addressed at the end of each week in the form of a 10-min debriefing session at the end of class.

Scheduled time for feedback allows for reinforcement of course expectations and invites students to openly reflect and/or share their thoughts that strengthen nontraditional discipline-independent skills.

In addition to providing group feedback, it is important to set time for students to meet with faculty for individual feedback. Leadership evaluations provide ideal opportunities for student feedback sessions. Leadership evaluations represent both assessments by peers and self (leader being assessed) for the same set of criteria: respect, integrity, responsibility, compassion, problem solving, commitment to excellence, and overall professionalism. According to Garrison and Ehringhaus [3], self- and peer assessment supports the awareness of a learning community within a classroom. It illustrates that students who are able to reflect (on their own and on their peers skills) while being engaged in higher-level thinking maintain responsibility for their learning. Comparing self- and peer evaluation scores elicits deeper reflection and strongly influences the outcome for self-improvement.

Students should be invited to meet with faculty to discuss their experience and reflect on their peer evaluation as team leader. Meetings should be scheduled in advance and need not take more than 15 min [36].

Conducting a Verbal Feedback Session

During the feedback session:

1. Always begin by stating the purpose of the meeting: “Thank you for meeting with me/us. The purpose of our meeting is to provide you with feedback regarding your role as team/dissection group leader.”
2. Present the student with a paper copy of a graph plot of peer evaluation vs. self-evaluation with a summary of the results and invite the student to reflect on it: “Here is a copy of your peer evaluation mapped against your self-evaluation. (i) Overall you have received good/very good/excellent scores that match your self-evaluation scores; congratulations on the good work. (ii) Judging from the graph, it appears that you have rated yourself much higher/lower than peers have. Would you like to reflect on this?”
3. Review peer comments, if any, and summarize so that only the most valuable feedback is presented to the student. Avoid handing over handwritten peer comments to the student. Keep in mind that the majority of students are not skilled at providing feedback and unedited comments from peers have the potential to create discomfort for the student working within the team.
4. Begin with comments that strengthen the student’s self-esteem and then point out skills that the student could benefit from improving upon: “Student X is a valued team member, he is always prepared for class and always makes sure we understand the material without pushing us all to be right,” “Good listener,

open to others' points of view." Be aware and knowledgeable about characteristics of the skills being assessed and translate student comments so that they relate to the positive markers for the skill.

5. Approach weaker attributes with caution: "Student X has difficulty identifying most important or high-yield content, tends to be less focused." "Student X is insensitive and lacks respect when speaking to some members of the team. Student X is always unprepared and late for class." More often than not, peers do not provide examples of incidents that describe an action or behavior. Steer direct statements into more guiding comments so that student attention can be channeled toward working on behaviors that will benefit them: "It may benefit you to be more focused so that you can support your team members in identifying more high-yield knowledge." "It is important to remember that when working in a team, the way we present ourselves through what we say or how we say it may be sometimes be misperceived by others to come across as lacking respect." In the absence of information pertaining to a specific incident, ask the student to reflect on an occasion/s where his/her behavior could have led to formation of the perception. By doing this, the teacher indicates to the student that he/she is equally responsible for the learning experience. It creates a less discouraging environment, enabling the student to accept the constructive feedback and make the effort to improve on the skills concerned.
6. For more challenging reviews, include a TA or another faculty member in the feedback session. While not always logistically possible, it is still important as the nature of verbal feedback is such that what is discussed during the session may be susceptible to misconceptions from the student. When it comes to providing verbal feedback, teachers must ensure that comments are always thoughtful, directed toward positive learning opportunities, and justifiable.

Elements of Effective Feedback

Key Points

- The skill of giving feedback is central to good teaching.
- The process of giving feedback is linked to promotion of learning.
- Creating a partnership with students helps feedback to be received more positively.

Good feedback is:

- formative and occurs regularly.
- well timed and encourages and promotes the learning process.
- supportive and delivered with sensitivity and objectivity.
- directed toward behavior and not focused on the student.
- able to identify strengths, areas of deficiency, and areas for improvement.
- focused on behaviors that can be changed.

Providing Immediate Feedback

With the day-to-day course of activities, and the close interaction students and faculty share within the laboratory setting, faculty may need to provide immediate feedback to ensure student learning and progress, e.g., to prevent the poor dissection of a team or individual students from damaging important anatomical structures. It this situation, in order to minimize student stress, it is important to invite the student or team to reflect on the error or potential error before providing feedback. Under these circumstances, feedback should be non-evaluative, tactful, and purposeful so that the student or team may be directed back on task.

Providing Student Elicited Feedback

Frequently, students seeking advice may initiate feedback sessions with faculty.

Providing feedback relating to conflict within teams, far-field behavior, or student-initiated concerns can be more challenging. Under these circumstances, verbal feedback (*delayed feedback*—feedback given after a certain amount of time has passed) should be given in a more neutral setting such as in an office space or common study area with an additional teaching faculty or TA in order to create a culture of safety. Feedback should start with a diplomatic articulation of the conflict/observation followed by an invitation for the student(s) to express their thoughts followed by guidelines for improvement or resolution. Avoiding judgmental language and opinions is an effective way of creating a feeling of acceptance and enabling students to improve [37]. Stay with the observed behavior and focus on the incident, not on the student. Know what institutional resources (e.g., Office of Dean for Student Affairs) are available to the student (such as tutoring, social development, student support, wellness programs, etc.) while understanding your own limitations (limit your involvement and deal with emotional situations in an objective manner). Create a culture of safety for the student and remind the student that whatever is discussed is confidential and that you are there to encourage and work with the student to overcome challenges.

Providing Written Feedback to Students

As is the case with many medical school courses, anatomy faculty is required to submit a written evaluation for each student at the end of the course. Included in these evaluations are observations on students' knowledge-based as well as nontraditional discipline-independent competencies described earlier in this chapter. Submission of the written feedback should be the responsibility of the anatomy course director, complied through a consensus of opinions of the teaching faculty and TAs. Designating time to meet is essential to ensure that comments are well documented. This should be done at scheduled debriefing sessions during the course [27] and at a formal meeting that includes all members of the teaching team, at the end of the course once collective data for the entire course are available.

Compiling Written Feedback: Thoughts for Reflection

It is important to remember that written feedback [35] has a strong impact on student psyche. Not only is it a permanent unit of constructive commentary, it also serves as official documentation of student strength and weaknesses within the integrated medical curriculum. Students should be made aware at the start of the course that they will receive formal written evaluations in addition to a course grade upon completion of the course. Faculty and TAs should be aware of their responsibility in identifying areas for providing students with feedback. Weekly debriefing sessions with TAs and faculty [27] afford good opportunity for highlighting student-related issues and performance. In this way, feedback can be cumulative rather than a cluster of comments being generated at the end of the course. It also allows faculty to assess change in student behavior and comment positively on lessons learned, considering that the student has just completed the anatomy course and that post-course feedback is meant to promote student learning as they continue on to courses that will assess the same competencies.

When compiling written feedback, always begin with the most positive comments and end with a positive or encouraging statement, including more constructive commentary in between. The choice of words matters; the tone with which they are written matters—clarity is crucial. There are many factors that influence the effect that feedback may have on students. Self-esteem, integrity, maturity, and willingness to self-improve, to name a few, are aspects of learner characteristics that impact the effectiveness of faculty-generated feedback [1]. Providing students with an open invitation to discuss written feedback with faculty helps in clarifying student interpretation of the feedback and dissipates any misperception that could be a potential hindrance to student self-improvement [6].

Promotion of cultural competency and diversity remains a fundamental value in providing patient care. Understanding that the typical anatomy class of the twenty-first century contains a unique cultural blend of students [38] necessitates at least some degree of cultural competency [39] among anatomy teachers. With this in mind, anatomy teachers should recognize that when assessing student attitudes and behavior, what a teacher may perceive as being unacceptable may not occur to the student (who may have grown up under different cultural influences) as being unacceptable. Aligning attitudes and behaviors with what is necessary for functioning within the health profession should remain the only guiding principle for skill transformation.

The following helpful techniques may be considered when compiling written feedback:

1. Do not present feedback that discourages the learner or threatens the learner's self-esteem: "Student X is overconfident, disrespectful, and difficult to work with in the anatomy laboratory. Student X is culturally insensitive when working within a team."
2. Focus feedback on the skill, not the learner: "Student X may benefit from strengthening leadership skills by being more inclusive and aware of team members' strengths and weaknesses. Being sensitive to others' styles of learning and needs and open to sharing responsibilities is an important aspect in developing good teamworking skills."
3. Present elaborated feedback in manageable units. Use paragraphs to get specific observations across with guidance on how to strengthen learning [35]: "Student X would benefit from learning to reflect on her actions and work on her ability to self-improve. We suggest that the student contact the Dean for Student Affairs to enlist resources that will help improve this skill."
4. Be specific and clear with feedback messages, avoiding the use of emotive language and personal judgment: "There was room for improvement in student X's performance during dissection and attitude toward cadavers. As with any task, producing the best result possible is in keeping with putting the needs of the patient first" instead of "It was disappointing to see student X's reaction toward his assignments, his lack of enthusiasm toward dissection and poor treatment of cadavers, as well as the quality of his presentations, all of which were extremely poor."
5. Keep feedback as simple as possible, giving unbiased objective feedback: "Student X would benefit from having more confidence in her work and herself, being more assertive with team members and interacting more closely with teaching assistants and faculty," or "Student X would benefit from being aware that her attitude and manner of communicating can come off as being short and abrupt. She would benefit from improving her communication skills and being more aware of her verbal interaction with teammates and faculty."
6. Keep positive comments simple and tone down on exaggerated statements [1]: "Student X was a great leader. He was an exceptional student with a wonderful attitude and great personality! Faculty and TA's loved having him in class" may be stated more effectively as "Student X showed strong leadership skills. His grasp of the material was impressive and his participation in the course was positive for both peers and faculty."
7. Avoid drawing comparisons regarding course performance: "After failing all practice practical examinations and receiving ARS grades below 50 %, student X was unconcerned about his knowledge level and even when asked, his answer was that he did well…! Student X had the lowest score on the final examination in the class (348 points) 10th percentile rank nationwide." For providing information relating to scores, simply state overall grade: "Student X received a grade of 348 points (10th percentile rank)."
8. Be sure to include feedback acknowledging improvements made during the course: "Student X was receptive to feedback from TAs and faculty and made the effort to improve on the way in which she communicated with peers and teachers."

Students are eager to receive feedback. They are eager to learn and to succeed in their future careers and determined to achieve goals set out for them [33]. But they are also eager for support and mentorship. What students gain through the social interaction that comes with active participation in an anatomy class is unparalleled. Anatomy teachers should not underestimate their ability to influence students early in the medical curriculum. Incorporating the practice of providing regular formative feedback while teaching anatomy speaks to the needs of the student. As with any skill, the art of giving effective feedback to students takes effort, time, and practice [9, 11–13, 31, 39–41]. It takes a belief that the learning of anatomy demands active partnership between the teacher and the student—a partnership built on trust, honesty, and the genuine endeavor to promote and improve learning.

> "The important things to remember about feedback in clinical medical education are that (1) it is necessary, (2) it is valuable, and (3) after a bit of practice and planning, it is not as difficult as one might think."
>
> Ende [9]

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18 Using Body Painting and Other Art-Based Approaches to Teach Anatomy

Gabrielle M. Finn

Recent years have seen a change in the teaching methods utilized within human anatomy education. Fewer cadavers, coupled with time constraints and limited numbers of trained staff, have forced anatomists to formulate new approaches to teaching. Student-led dissection has been replaced by the use of prosection; student–teacher interaction has been replaced by self-directed learning. In response to such challenges, faculty are opting to use novel methods of teaching, often drawn from outside of the medical context, including virtual dissection, wearable anatomical garments, and life drawing classes, all of which have added new dimensions to the classroom. One of the most popular approaches is body painting.

Body painting is considered by some to be the most ancient form of art. Origins of body painting stem from tribal cultures and are ceremonial. Body painting is now most frequently seen on the face, usually at sporting events or children's parties. However, body painting is now being used in the medical setting as a way of projecting the inside onto the outside.

Body painting is an innovative method of anatomy teaching. Op Den Akker et al. [1] first used body painting, described as painting internal structures on the surface of the body with high verisimilitude, during teaching in 1999.

Body painting within medical education is described as painting internal structures on the surface of the body with a high degree of detail [1]. This contrasts with simple line drawings as used in conventional practice, which can be dated back to at least a century [2]. Body painting proves particularly useful as a method for introducing surface anatomy in medical teaching and complements the teaching of clinical skills and peer examination, including techniques such as palpation and auscultation [1, 3, 4]. The value of body painting as a teaching tool is frequently attributed to its kinesthetic nature [3–5]. Furthermore, it is thought that the active and kinesthetic nature of body painting, coupled with the strong and highly memorable visual images of underlying anatomy, contribute to its success as a learning tool [1, 3, 4, 6]. Body painting has also been reported to be a valuable tool for diminishing the apprehension often exhibited by students when conducting peer physical examinations [3]. Since it has been suggested that a fear of death may be oppressive for students studying in the dissecting room and may be correlated to poor academic performance, the use of alternative teaching methods, such as body painting, may therefore be beneficial to students who struggle with cadaveric work [4, 7, 8].

Within this chapter, the practicalities and advantages of using body paint and other art-based approaches to teaching and learning

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anatomy are described. Examples are provided, along with recommendations for anyone considering developing their own body painting session. This process of painting internal structures onto the body promotes knowledge retention, creates an exciting teaching environment, and improves student engagement in their anatomical studies.

Examples of Anatomical Body Painting

Muscles of Facial Expression and Associated Neurovasculature

Painting the muscles of facial expression is a fun activity for students. It is of particular relevance for medical, dental, physiotherapy, and speech therapy students. Rote learning extensive lists of muscles from a textbook is dull and fails to demonstrate to students the associated actions of the structures. By painting the muscles onto the face, looking in a mirror or at a painted peer, and pulling various expressions such as winking, puffing out the cheeks, or raising the eyebrows, students are able to immediately see the muscles in action. The parotid gland, facial nerve, and other neurovasculature of the face also can be painted onto the face, either simultaneously or in isolation (see Fig. 18.1).

Topics Which Lend Themselves to Body Painting

- Abdominal viscera
- Facial muscles and neurovasculature
- Areas of referred pain
- Musculature
- Dermatomes
- Bones
- Borders of the heart and the position of valves
- Position of the lungs and thoracic osteology

Dermatomes

Mapping dermatomes onto skin is a great way to learn this invisible map of the body. Not only do students learn the dermatomes, but they also revise their bony landmarks, as they must palpate the relevant bones in order to correctly map the dermatomes. Dermatomes can be painted from head to toe simultaneously (see Fig. 18.1), or students can paint the dermatomes region by region as they encounter them through the curriculum. Dermatome painting lends itself to the use of bright bold blocks of color, which is highly memorable for students. Similarly, innervation from peripheral nerves also can be mapped.

Abdominal Regions, Quadrants, and Areas of Referred Pain

A quick and easy activity for students is to paint regions of the abdomen alone, or better still, the associated abdominal viscera can then be painted in situ. This activity has much impact when students observe the relative size and positions of organs. Viscera can be painted using an appropriate anatomical color palette or using vibrant colors to promote subsequent recall. Again, as with dermatomes, this reinforces knowledge of surface anatomy and bony landmarks. Instead of painting viscera, or by painting onto another peer, students can paint blocks of color to represent the referred pain from corresponding organs.

Skeletal Anatomy

Osteological knowledge is imperative for students. Painting the skeleton is a memorable task. Regions can be painted in isolation, such as the bones of the hand or an entire limb can be painted. Musculature and neurovasculature can be added if required. Bones of the hand are something that individuals can paint onto themselves, rather than having to work in pairs. An easily accessed area, such as the hand, lends itself to a painting activity with school groups, recruitment fairs, or for other such public engagement events.

Fig. 18.1 Body painting (**a**) dermatomes, (**b**) facial anatomies

> "Body painting has helped me to interact with individuals in a manner that is outside the normal socially acceptable level of conduct. This has helped me develop a more professional attitude towards patients and I see this as very useful."
>
> A medical student at Durham University, UK

Advantages of Using Body Painting

Although body painting has origins in ancient tribal customs, it has a number of educational advantages within contemporary curriculum [4, 5].

Creation of Learning Landmarks

Students have reported body painting as a highly motivating exercise [4]. Its main advantage appears to be the creation of what could be called "learning landmarks": vivid experiences which are memorable in themselves and which then provide access to the educational content associated within that context [4]. In particular, students acquire a good understanding of dimensions and positions of anatomical structures using this method while studying [1]. Literature is in accordance with the idea that body painting is a highly memorable experience, which gives students an appreciation of the links between the visual, tactile, and auditory aspects of human anatomy.

Emphasis on Living Anatomy

Historically, anatomy has been taught by dissection. Cadavers are useful for studying the anatomy of large organs [9] and give an overview of spatial orientation [10, 11]. Anatomy is most commonly encountered by medical practitioners in the form of living anatomy and medical imaging [6]; therefore, students should also be encouraged to engage in teaching activities with an emphasis upon living anatomy and body painting is one such activity. "Clinicians often blame anatomists for teaching students too many details and not enough clinically relevant structures" [12]. Body painting allows the clinical relevance of the gross anatomy to be emphasized to students. Surface anatomy is a way of bringing cadaveric anatomy to life [13] and body painting falls into this category.

Cost-Effectiveness

Body paints and paint brushes are readily available for purchase and are relatively inexpensive [5]. Old containers can be used for storage of water; the paint brushes do not need to be specialist. Large numbers of students can engage in the activity simultaneously and require little direction once instruction sheets have been produced, making the activity cost-effective in terms of both staff time and physical resources.

Positive Learning Environment

It is rare for even the most reserved students not to positively engage with body painting sessions. This fun activity becomes a break from the tedium of the dissecting room. Student enjoyment results in a positive learning environment and peer–peer teaching often results. As body painting is not a didactic modality for delivering teaching, its use creates positive and more relaxed relationships within the classroom between faculty and students [4, 5].

Retention of Knowledge

By actively engaging in the painting process, rather than passively learning in a didactic teaching session, students' learning becomes deep rather than surface [4, 5]. The use of bright colors aids students' memory of the structures that they paint. The painting process is multisensory and utilizes all learning approaches simultaneously; students visualize, students paint (kinesthetic), students read instructions aloud (auditory), and students feel the paint on their own skin when acting as the canvas (sensory). Thus, retention of knowledge is promoted. Furthermore, students often photograph their painting for revision and sentiment—both positives in terms of subsequent recall.

Emphasis on Future Clinical Practice

During a body painting session, students must palpate bony landmarks in order to demarcate the associated anatomical structures. This has direct learning benefits for future clinical practice. Moreover, regions such as boundaries of the lungs and positions of heart valves can be painted on and lend themselves to subsequent clinical examination with the stethoscope. When dealing with peers in a state of relative undress and completing palpation and examination—students must communicate appropriately, empathize with their peer canvas, and approach their peer in a professional manner; thus, skills required in the clinical environment are developed. These body painting sessions allow integration between anatomy and clinical skills and enable the future patient to be the focal point [4, 5].

An Alternative to Cadavers

One of the major advantages of using body paint is that it can be used as an alternative approach to cadaveric study on occasions where living and surface anatomy are being studied or for students who struggle with cadavers [4]. The dissecting room environment can be one that students who have emotional difficulties with cadavers find troublesome. Learning out of the dissecting room context can be both supportive and educationally beneficial for students who struggle emotionally. Similarly, surface anatomy is difficult to demonstrate on cadavers, and for this reason body painting is useful—it emphasizes living anatomy throughout. When time is short for dissection, or cadavers are in limited supply, faculty may wish to consider implementing body painting into their curricula. Body painting cannot entirely replace cadaveric study, but it is a powerful tool and adjunct for emphasizing the living nature of anatomy [4, 5].

Use Outside of the Classroom

In addition to anatomy teaching, body painting can be used for a number of other uses and institutional activities. Quick and easy activities are often required for departmental open days and tours. Painting the hand lends itself to such an occasion as no undressing is required and participants can paint their own limbs. Bones of the hand, the dermatomes of the hand or neurovasculature can be painted within a few minutes. Prior anatomical knowledge is not necessary; participants can work from images or simple instruction sheets. Similarly, body painted models can be used for other public engagement events, such as museum exhibitions.

Designing Body Painting Teaching Sessions

Planning body painting teaching sessions can be daunting. By following these simple steps [4, 5], body painting sessions can be easily designed and implemented.

Identify Your Chosen Teaching Session and Learning Outcomes

All sessions need specific learning outcomes. Give careful consideration to which structures you wish the students to learn. What is the take-home message of your session, and can that be achieved using body painting as opposed to dissection or a lecture? Develop one session as a starting point, then following evaluation, move on to develop further sessions. Body painting sessions can form part of timetabled anatomy and clinical skills teaching. Body painting fits particularly well into a multi-station practical whereby each station addresses one aspect of the body region being taught. For example, a teaching session on the anterior thigh may have the following stations: musculature, nerve supply, blood supply, and osteology. When body painting is introduced into a practical, it may form one of the stations or become a double station if a clinical skill is being taught simultaneously. The stations for the anterior thigh session may then become a musculature, neurovasculature, osteology, and a body painting station which teaches the distribution of dermatomes.

Design Your Instruction Sheet

Students need specific instructions to follow to enable them to achieve the desired learning outcomes. Instructions need to be formatted as a step-by-step guide which is easy to follow. Photographic images of a pre-painted model or diagrams are helpful. Copies of the instruction sheets, presented as a checklist which students can mark off, are a good aid for regions which are

To Do

- Think about a teaching session with either gross anatomy or surface anatomy learning outcomes. How could you incorporate body painting into that class?
- Consider the environment, the resources, and which body region and structures will be painted.
- Can you devise easy-to-follow instructions? Will you include images in your instruction sheets?

more complex and have combined clinical examination. Following their first use, ask students for feedback as to whether the instructions were easy to follow. From a practical perspective, laminating instruction sheets is useful due to surrounding water and paint.

Choosing Your Teaching Environment

Body painting is easily adapted to a number of teaching and learning environments. Consideration needs to be given to safety; are you using a laboratory where students can come into contact with irritants or other hazardous substances? Consider student dignity; is the interior of the room easily viewed from outside? Are the surfaces wipeable after painting? As the paints are water based, classrooms other than laboratories can be utilized for painting. Students need a surface for their equipment and instructions, as well as enough space to move around their chosen student canvas.

Sourcing Your Equipment

Body paints are often sold as children's face paints. The most important considerations are that the paints you buy are water based and hypoallergenic. The colors you select depend on whether you wish to paint in an anatomically correct palette, such as beige, red, and brown, or whether you wish to use bolder colors such as orange, blue, and purple. Paints are available from arts and crafts suppliers, toy shops, and the Internet. Paint brushes do not need to be specialist. Brushes can be natural fibers or synthetic—depending on your budget. It is advisable to purchase a selection of sizes of brush as some areas, such as dermatomes require large block painting, whereas others, such as nerves, require finer lines to be painted. Any plastic pots will suffice for washing brushes and wetting paints during the session. Disposable wipes are ideal for removing paint from skin or work surfaces after teaching, although often students wish to keep their paint on!

Equipment Needed to Use Body Paints

- Supply a range of colored paints, paint brushes, and/or sponge applicators.
- Body paints should be water based and hypoallergenic.
- Water or wipes need to be available for paint removal/mixing.
- Have mirrors available so that the student canvas can observe the painting.
- Screens or cubicles may be needed for dignity.

Assigning Student Roles and Groups

Where possible, allow students to self-select their partner or group members. This eases any discomfort associated with undressing and physical examination. Some students may have a preference for the role they undertake, whether that is the painter or the canvas. Students can be encouraged to alternate roles as there are advantages to each [8]. To ensure that the canvas engages, they can read the instructions to the painter and observe the painting process in a mirror.

Tips for Using Body Painting Within Anatomy Teaching

Use Within Both Large and Small Group Settings

Body painting use is not limited to small group settings. Sessions can easily be adapted for large numbers of students. The number of paints available and space requirements are the only limiting factors. Resource-wise, students can easily share paints and brushes. Students can work in pairs, or larger groups, depending on the amount of anatomical structures to be painted and the time frame in which they must work.

Consider Students' Sensitivities and Cultural Perspectives

The majority of students will have no hesitations in participating in a body painting session. However, as with peer examination, students may have concerns with being in a state of undress. Faculty members are advised to be sensitive to these issues, particularly to students who are body image conscious. Providing screens or cubicles helps students feel more comfortable. Some students may choose to paint on top of clothing, which works well. Allowing students to self-select the groups they work in also encourages their participation.

Cross-Linking

See also Chapters 3, 13, and 17.

Allow Photography

Permitting students to take photographs of their paintings promotes reflection and revision. Of course, caution must be used, and students should be encouraged to seek consent before photographing others. Advise students that photography is permitted in advance of the session.

Introduce and Demonstrate

Students may be reluctant to start painting without an introduction to the topic or a quick demonstration of surface anatomy palpation. A brief overview gives students greater confidence. This can include the instructor painting a model or volunteer if time allows. Instructors should circulate as much as possible in order to reassure students. In doing so, they should be mindful of student dignity and comfort, especially if regions such as the thorax or abdomen are being painted.

Give Students Feedback

During painting sessions, faculty can observe the painting and palpation being conducted by students. Timely and appropriate feedback should be given but with sensitivity and encouragement. Use this as an opportunity to engage the students in a dialogue about the learning objectives and, if appropriate, the relevance to their future clinical practice.

Reflect on the Success of the Session

Being a reflective practitioner is an important part of the teaching process. Following painting sessions, teachers should take the time to consider the successful elements of the session and the aspects that could be improved for future iterations. Was the time devoted to the activity appropriate? Did the session fulfill the learning outcomes? Did the students engage with the painting process? Was student comfort and dignity maintained? Did students receive adequate instruction and feedback? Was the equipment provided sufficient?

Other Important Considerations When Using Body Paints in Anatomy Teaching Sessions

- Provide easy-to-follow instructions.
- Allow students to self-select the peers they wish to work with.
- Involve the student canvas in the process by encouraging them to read the instructions aloud and by providing mirrors for them to observe through.
- Encourage students to use bold colors—this promotes retention of knowledge.
- Ensure sufficient time is provided.
- Encourage students to take photographs of their painting—this promotes subsequent recall.

Other Art-Based Approaches to Teaching Anatomy

Body painting is just one of many art-based activities which can be readily adapted for use in anatomical teaching.

Life Drawing

Engaging students in life drawing is particularly useful for teaching surface anatomy. Drawing provides a medium by which students can consider differing body morphologies and surface anatomy. Drawing trains students to observe the asymmetry in a body—a skill particularly useful for those going on to clinical practice. When taking the time to draw something, the artist must study the object in great detail, whether that is drawing anatomical prosections or plastic models. Due to this study, life drawing is therefore also a beneficial process for learning, in particular when considering spatial relationships between anatomical structures.

Plasticine (Clay) Modeling

Children's reusable modeling clay (plasticine) lends itself to anatomical teaching. As with body paints, the clay is cheap, readily available for purchase, reusable, and can be adapted for use in large group sessions. Examples of its use include modeling the muscles of facial expression on to a plastic skull (see Fig. 18.2) and modeling vertebrae or embryological structures. The advantages are similar to body paint in terms of appeal to a variety of learning styles, diffusion of emotional responses to cadavers, and memorability.

Anatomical Cake Baking

Studying anatomy does not need to be a task confined to the classroom; students can enjoy learning anatomy at home too. Baking and decorating foodstuffs such as cakes, bread, or cookies to resemble anatomies is a fun way to study (see Fig. 18.3) without reading textbooks. By depicting the anatomy, students must orientate themselves with the anatomy and relevant spatial

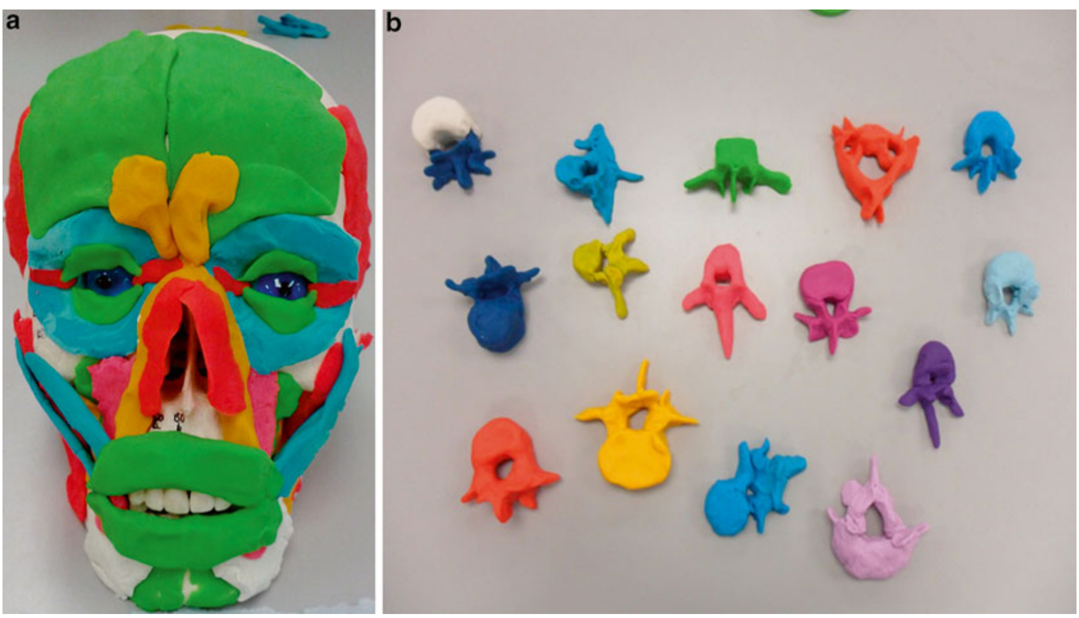

Fig. 18.2 Modeling clay (**a**) muscles of facial expression, (**b**) vertebrae

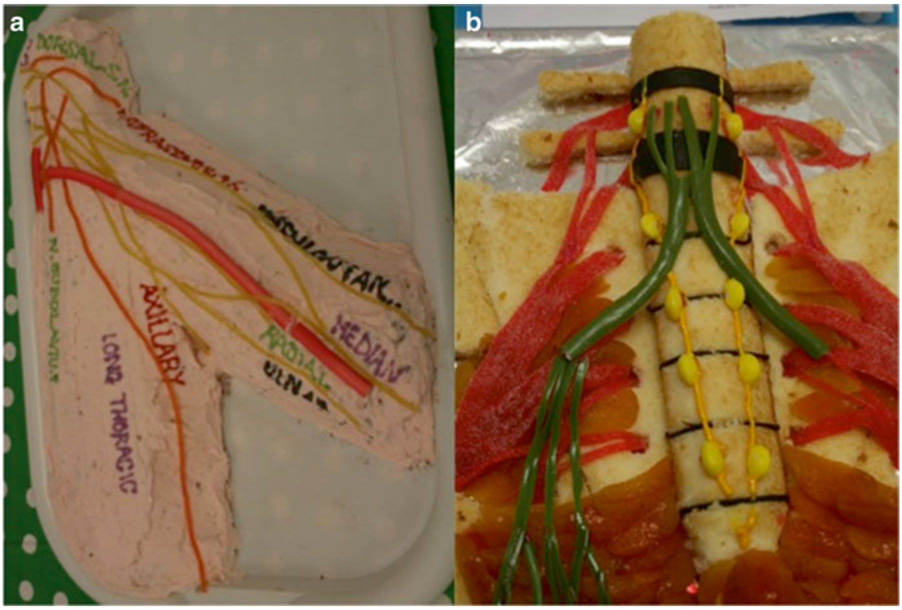

Fig. 18.3 Anatomical cake baking (**a**) brachial plexus, (**b**) hypogastric plexus

relationships. As this task takes time, the students are reinforcing the anatomy over a prolonged period, but often without realizing they are doing so. Holding an event where students can bring in their baked items makes a great end-of-semester revision session.

Conclusions

Art-based approaches to teaching and learning add new dimensions to the educational environment and to the student experience [4, 5, 8]. Body painting remains one of the most popular art-based modalities employed within anatomy education. Body painting is a useful tool for learning gross and surface anatomy. It actively engages students in the learning process and enables long-term retention of knowledge. The use of bold color promotes memorability and adds an element of fun. Utilizing body painting encourages students to confront issues associated with clinical examination such as vulnerability, communication, professionalism, and body image in a positive and safe learning environment [4, 5, 8]. Life drawing, clay modeling, and other art-based approaches are also educationally beneficial due to their engagement, memorability, and context outside of the dissecting room.

> "Body painting is fun, very enjoyable and often a challenge. You do not need to be a good artist, just to be able to follow instructions. Also body painting allows you to realize the situation of organs in the body, often for myself I find it surprising their exact locations and actual size."
>
> A medical student at
> Durham University, UK

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19 Evaluating Your Own Performance in Leading a Small Group Discussion

Jon Cornwall

Small group discussions are a valuable tool for aiding education in a tertiary environment. Used successfully, small group discussions can promote and enhance student learning through the implementation and development of discussion skills such as listening, questioning, explaining, and responding, skills which form the platform for facilitating discussion and thinking [1, 2]. These skills also provide the basis for the development of teamwork and collaborative learning, allowing the exploration of attitudes and the sharing of experiences [2]. Small group discussions do have advantages in some areas and have been shown to be better than large groups at promoting thought, developing attitudes, and implementing values. However, they are thought not to be as efficient as large group teaching for the purpose of imparting information, though this is still debated [2, 3]. They can be challenging, informative, instructive, a lot of fun [1] and can be a successful method of teaching and learning anatomy [1, 4, 5, 6].

The teacher has a vital role in the process of the small group discussion as a facilitator, mediator, and educator. In order for teachers to continually develop, refine, and improve their practice in leading small group discussions, they need to be capable of assessing their own abilities in this skill. This involves being able to measure and evaluate their own performance in leading small group discussions so that future interactions with small groups can be informed and developed on an ongoing basis. In this way, the quality and effectiveness of the small group discussions led by the teacher will continue to be improved.

The Aim of Self-Evaluations for Small Group Discussions

Self-evaluation, in most contexts, should have a purpose. Before you undertake any sort of self-evaluation, you should have a clear idea as to why you are performing it. The purpose may be as simple as an answer to one specific question about your performance in a class you have just taught, or as complex as providing information on multiple aspects of the small group discussion. It may be for generating information that is relevant to job promotion or an assessment of teacher performance. In effect, many individuals would like to answer the question: how do you know you have done a good job? This chapter examines how teachers could approach this question in relation to teaching anatomy classes that involve small group discussion.

With any type of evaluation, teachers should have a very clear idea of the framework of the class they are about to teach and the way they are going to undertake this in the classroom scenario. This may include what they are hoping to achieve (objectives), how they will do this (methods), and

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how they may measure outcomes satisfactorily (assessment of learning outcomes). It could involve assessing whether specific teaching objectives were met, including working effectively or productively, setting or achieving goals, efficient time management and planning, or maintaining group behaviors and balancing contributions from individuals [7]. All these aspects can contribute to good small group teaching and are therefore potential targets for evaluation, and may be specifically assessed during the process of self-evaluation.

Tools for Self-Evaluation: Critical Reflection and Feedback

There are many different ways of evaluating performance, including peer review; this chapter focuses on two self-evaluation tools that teachers can use to improve their own performance. Broadly speaking, self-evaluation has both individual and social components [8]. The individual component (the "I" or "me") involves critical reflection by the teacher of their own performance, while the social aspect ("they" or "them") utilizes feedback from people that attended the small group discussion or class. Both of these components are important tools for teachers as they provide different types of information, and both can be used to improve teaching performance and potentially improve learning outcomes.

Critical Reflection

Critical reflection involves being able to identify, consider, and reconstruct the implicit assumptions that underpin an individual's actions to develop a better understanding about the concepts driving their behavior, thereby enhancing their teaching practice [8, 9]. In essence, it involves the performance of reflecting critically on one's own performance. The terms "reflection" and "critical reflection" are used somewhat interchangeably in education [10, 11], with the key difference between the two being critical reflection supposedly demands an increased depth of prior knowledge, consideration, and focus upon factors such as the underlying assumptions about teaching, or how factors such as student diversity affect teaching style [12]. Critical reflection therefore involves a greater understanding of the factors influencing learning outcomes, and it has been suggested that the two processes are different and their definitions require further clarification [13]; despite such differences both reflection and critical reflection involve the same basic processes that are outlined in this chapter [10, 11].

It is important for teachers to be able to critically reflect on their own performance in leading small group discussions, as critical reflection has been shown to have positive effects on teachers' own learning and task orientation [8]. A simple definition of critical reflection is perhaps that it involves "thinking about thinking" [14]. Perhaps more than this, critical reflection also involves knowing how to reflect and analyze thought, draw conclusions from that analysis, and put what is learned into practice [9, 14]. It can therefore be framed in terms of *specific tasks* that can enable teachers to evaluate their own teaching. Of course the term *reflection* has different meanings when used in different contexts; here it is being used to define the high-level analysis that is required for transformative learning or rather learning that provides an identifiable transformation in thinking or actions as a result of this process [15].

The process of critical reflection involves an ongoing process of self-assessment and can be summarized as a three-stage model that involves the following components: planning, doing, and reviewing [16]. It involves the teacher using this framework on an ongoing basis, using their observations and own knowledge to provide information that guides their teaching. It is a metacognitive process that involves the individual "thinking about thinking" to arrive at a conclusion that informs future practice. Metacognition itself is a self-regulatory process that selects, monitors, and evaluates a cognitive process, with the cognitive process in this instance being reflection [16]. This is an important concept as it indicates that critical reflection is a skill that can be informed, controlled, and enhanced. In this way, critical reflection can be thought of as a framework that allows individuals to critique their own performance and experiences to lead to a new understanding, and that this skill can be improved with practice and over time. Such a construct is handy for teachers to enable and facilitate critical reflection, and it is a method that teachers can continually use to evaluate their performance during any stage of a small group discussion, whether this is before, during, or after the teaching has taken place.

In practice, educators should have a very clear idea about what they are teaching, what their expectations are, and how they are going to achieve this. In relation to leading small group discussions, and using the model described above, teachers should consider the basic features of critical reflection at each stage of the teaching session—the three steps of planning, doing, and reviewing. This basic model of the process utilized to perform critical reflection can be used at any point of small group discussion: before, during, and after any class.

Before Small Group Discussions

Undertaking any teaching session involves prior preparation that is initiated sometimes months before the class actually takes place. Evaluation of a teaching session that has not yet happened is perhaps contradictory; however, it may begin with critical reflection of previous classes (the "doing" part of the reflection process) in preparation for optimizing performance in the upcoming small group discussion. This may involve such reflections as:

- Were there any problems that I need to address before this next class?
- What outcomes were reached last time I held this class?
- Were the objectives successfully met last time this class was held?
- Were the teaching or learning objectives met in the last class?

Such critical reflections can help teachers consider their upcoming class and focus their attention on areas that specifically require attention or improvement.

During Small Group Discussions

The act of critical reflection during a small group discussion involves planning, doing, and reviewing actions in "real time", as the events occur. Essentially the teacher can be thinking about what they are about to do—including thinking about reasons why and for what purpose—then performing the task or action, and then reviewing the response in relation to their expected or anticipated outcome. The teacher may also be critically reflecting on their automatic responses to a given scenario to inform their future actions. Examples of this could include:

- Changing the topic of discussion to direct students to a particular outcome
- Asking a student to perform a specific task or provide input at a particular time
- Suggesting a different seating arrangement in order to facilitate interaction
- Providing an anecdote at a particular time that is relevant to your class objectives

Each of these examples is different in nature; however, they are similar in that the action was driven by the desire to reach a particular outcome. Critical reflection can be used in each instance to decide what to do (and the basis for this decision), to actually reflect on the doing of the task, and to review whether the interaction was successful and provided the intended outcome.

After Small Group Discussions

After a class has taken place, critical reflection enables teachers to be able to assess the preceding class based on their own experience. They can reflect on almost any aspect of the teaching or classroom experience:

- Did students find the objectives to be clear?
- Were the objectives achieved?
- Was the time management appropriate?
- Was the discussion enjoyable?
- Was the class productive?

After the completion of each class, it is helpful to critically reflect on the structure and implementation of the small group discussion. What were the reasons for planning the small group discussion? How was each of these performed?

What was the outcome for each of these elements? This circular pattern of questioning and reviewing of performance will help ensure teachers are continually assessing their own actions.

To Do

- Think of a class you have taught that was personally challenging to you.
- Identify three or four individual instances where critical reflection during the class may have altered the outcome that was originally achieved.
- Think about how you may use critical reflection to improve your performance in the future should similar circumstances arise.

The common theme of action by the teacher before, during, and after small group discussions is the process of planning, doing, and reviewing that forms the basis of critical reflection. However, in each instance there are subtle differences. Prior to classes, teachers are looking to ascertain whether past experiences have been acted upon appropriately and can use this information to "fine-tune" their approach to an upcoming classroom scenario. During classes, this process is more rapid and fluid, depending on how the class is progressing. After the class has been completed, the process allows the immediate review of information by the teacher based on their perspective of the completed class. Critical reflection in each instance enables the teacher to be able to identify how their small group discussion skills may be best modified to improve their performance in future classes.

Features of Critical Reflection

- Involves employing a framework that can assist teaching processes.
- Framework requires systematic planning, doing, and reviewing of tasks.
- Can be used in any stage of teaching to analyze own performance.
- Performance of this task improves with practice.
- Different aspects of performance can be reflected on and responded to in "real time."

Feedback

Feedback can be very useful in terms of improving the teaching of anatomy [1, 17]. The term "feedback" can be used in many different contexts; in this instance it is information about how we are doing in our efforts to reach a goal [18]. It is not advice or an evaluation of performance ; it should tell the individual something helpful and goal referenced so that performance can be improved [19]. Feedback is best implemented soon after teaching has taken place for an accurate impression to be given by participants, and can be done in public or in private depending on the information or responses you are wishing to elicit from participants. You may wish to obtain feedback from many people or just specific individuals; however, you should have an aim in mind with respect to the type of information that you are wishing to gather. Try not to over- or underreact to feedback, and think carefully about feedback before you decide what to do with it [7]. Also remember to thank individuals who provide it, as it can be difficult to receive open and honest feedback from students or individuals who do not feel valued [7].

There are different types of feedback; however, all should provide information that is useful to the individual seeking it [19, 20]. It should be goal referenced, actionable, user-friendly, timely, ongoing, and consistent [18]. Goal referenced refers to the feedback being able to be used to improve the task in reference to the student learning outcome or the teacher's objectives, for instance, by informing you directly about how good the discussion was about reaching the intended outcome or objective. Actionable feedback is specific and usable and not judgmental. Instances of such feedback could include "I was inattentive until we started discussing a particular topic" as opposed to "I was bored for half the class", which tells you little about how you may teach the class in the future. Feedback that is user-friendly should be easily understood and not overwhelming, such as highly technical comments on performance. It should be in the context of points that are easily understood and that will lead to an immediate improvement in the performance of the teacher. Timely feedback should also occur sooner, rather than later. Teachers don't want to wait for days to hear how their classes were perceived; it is much more useful to get feedback straightaway so that improvements can be actioned.

Define Your Question

It is helpful to have a specific purpose in mind when trying to decide what sort of feedback you require. This will also determine how you are going to ask for the feedback you require. Making the question useful for the teachers' own practice is essential, so that future practice can be informed and modified accordingly. It also helps to structure your question in relation to the type of information that is required, for instance, relative to objectives, skills, or performance. It may also consider the type of learning platform that was being utilized in the classroom (challenge-based, team-based, or problem-based learning). Points to consider:

- Why do I want feedback?
- What specific question(s) am I going to ask?
- How am I going to ask that question to get the information I require?

What Will You Do?

- You have just completed a small group discussion with students via an online e-platform that allowed you to see and talk with students in real time.
- Several students appeared to be less interested than others during the course of the discussion.
- How are you going to acquire feedback to determine how your online discussions could be improved?
- What sort of questions are you going to ask?
- Once you have the feedback from the students, what are you going to do with it?

Cross-Linking

See also Chapter 12.

Time Your Request for Feedback

It can be important for some feedback to be gathered as teaching is taking place and for other feedback to be gathered after classes have taken place. For instance, feedback on whether anatomical images are better teaching aids than plastinated specimens for learning about specific anatomical relationships does not need to be performed after the class; however, feedback on the format of the class and the questions employed is best suited to after the class has finished. Points to consider:

- When is the best time for me to ask for feedback?
- Would I get more appropriate feedback if I asked for it at another time?

Modes of Giving Feedback

One should also consider the mode of giving feedback that the feedback providers are comfortable with. In some circumstances, it may be more appropriate for feedback to be written and sometimes verbal, or on some occasions individuals could be better served by students being identifiable; sometimes it may be necessary for them to be anonymous. This also takes into account the setting the class was performed in, whether it was lab based that involved discussions where gloves and wet prosections were being used, perhaps an e-learning tutorial via live web link, or a group held a few minutes prior to students having to finish for the day. Each of these scenarios may dictate how successful the teacher may be in acquiring appropriate and useful feedback. Examples of different modes include feedback provided by e-mail, via wiki, or use of a questionnaire. Points to consider:

- What is the best mode for me to ask for feedback?
- Would another mode of acquiring feedback be more appropriate for this group of students?

Analyze the Feedback Objectively

Feedback should be judged as positive contributions to improving a teacher's performance; however, this can be difficult. It is easy to take negative comments as personal criticism of how "bad" a teacher or class may be. Even when the feedback is negative rather than positive, it is hopefully a constructive comment that is designed to bring about improvement in the performance of the teacher. Such comments should always be viewed objectively rather than subjectively, and in a positive way that allows performance to be altered and improved accordingly. Feedback should be weighed in context and in reference to other feedback to provide a "picture" of how the class was perceived by those involved. Points to consider:

- Why were particular comments made?
- What reason did the individual have for making this comment?
- Are these comments valid given other feedback that was gathered?

Implement Changes That Consider the Feedback

Once feedback has been appropriately gathered and analyzed, changes should be designed and integrated in a way that considers the feedback. This should be measured against the goals, outcomes, or objectives of the particular course and should take the needs and requirements of students into consideration. Feedback may be general enough to be used by teachers in all their classes or may be related to a specific mode of teaching or location. It is helpful for teachers to think about where the feedback may most appropriately be utilized. Points to consider:

- How can I best use this feedback to improve my teaching performance?
- In what setting(s) is the feedback best utilized or implemented?

Features of Feedback

- Define the question you want feedback to answer.
- Time your request for feedback.
- Consider the most appropriate mode for gathering feedback.
- Analyze feedback objectively.
- Implement changes that consider the feedback.

Conclusions

In any aspect of teaching, evaluating one's own performance is important in helping one to understand how to improve the delivery of course material and to better help students achieve learning outcomes in the classroom or laboratory. Critical reflection and feedback are two very important tools for the evaluation of one's own performance in small group teaching, with each providing a unique subset of information that can be used to improve the different aspects of a teacher's performance. Educators should be aware of the process of critical reflection that involves planning, doing, and reviewing on an ongoing basis and understanding that this tool can be used to improve performance in all aspects of teaching or educating. Similarly, feedback can be used to facilitate performance and can be employed in many different ways. However, it must be targeted to specific questions that the educator wishes to answer and used in a way that is appropriate for each teaching environment.

Self-evaluation helps improve a teacher's own performance. Critical reflection and feedback can both be used to provide information that helps refine teaching practice. Both critical reflection and feedback provide useful information but in different ways; understanding how and when to use each of these methods is important for teachers to be able to develop their small group discussion skills.

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Part IV

In the Gross Anatomy Laboratory

20 Running a Body Donation Program

Andrea Porzionato, Veronica Macchi, Carla Stecco, and Raffaele De Caro

The Importance of Body Donation Programs for Medical Education

In recent years, several authors have reported a decrease in the quality of undergraduate education in anatomy [1, 2], mainly ascribed to reduced gross anatomy courses [3, 4] and less time devoted to dissection. This is even more important for postgraduate surgical trainees, who are now often obliged to acquire knowledge of surgical anatomy directly in the operating theater [5], as cadaver training courses in general surgical programs are also being reduced [6]. It has been emphasized that expertise in dissection, tissue handling, and suturing are obviously difficult to acquire for the first time in the operating room [7]. The crucial role of dissection for improvement of surgeons' experience has also been widely stressed [8]. In our opinion, it should be clearly stated that direct experience with cadavers is mandatory for both undergraduates and postgraduates and that it cannot be completely or adequately replaced by other teaching instruments.

The above considerations stress the importance of developing and maintaining body donation programs for direct acquisition of anatomical knowledge of and surgical ability in working on cadavers. The main aspects for running a body donation program are examined below.

Legal References

The development and maintenance of a body donation programme must start from profound knowledge and critical consideration of its legal and bioethical references [9, 10]. In some countries, legal frameworks already in place allow the use of unclaimed bodies by anatomical institutes; in others, explicit consent by donors is mandatory. In Italy, the main normative reference directly permitting the use of cadavers for medical training and scientific research is Art. 32 of the *Regio Decreto* no. 1592 of August 31, 1933, concerning university teaching. It states: "… cadavers …, the transport of which shall not be performed at the expense of relatives up to the sixth degree or by confraternities or associations which may have made commitments for the funerary transport of their associates and [cadavers] from medico-legal investigations (apart from suicides) and not claimed by relatives in the family group, are reserved for teaching and scientific study" [10, 11]. More recent references stress the importance of donors' consent, matching general considerations of the "ethical superiority of using bequeathed bodies over unclaimed ones" [12]. Art. 14 of the Veneto Region law no.18 of March 4, 2010 ("Regulations on Funerary Matters"), states that individuals may decide "to donate their

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bodies for purposes of study, research and teaching" after their death. In 2013, the National Committee for Bioethics [13] produced a document which emphasized the importance of providing correct information to intending donors and the need for specific consent.

In France, the only legal reference to body donation is Art. R2213-13 of the *Code Général des Collectivités Territoriales*, which states that donors in life must have completed a handwritten, dated, and signed statement confirming their wishes [9, 10]. Informed consent is also required in the United Kingdom (Human Tissue Act of 2004) [14]. In other countries (e.g., Portugal, Serbia, Brazil), anatomical dissection is permitted of both donated and unclaimed bodies.

In the United States, the Revised Uniform Anatomical Gift Act (2006) [15] states that "an anatomical gift of a donor's body or part may be made during the life of the donor for the purpose of transplantation, therapy, research, or education … by: (1) the donor, if the donor is an adult or if the donor is a minor and is: (A) emancipated; or (B) authorized under state law to apply for a driver's license …; (2) an agent of the donor, unless the power of attorney for health care or other record prohibits the agent from making an anatomical gift; (3) a parent of the donor, if the donor is an unemancipated minor; or (4) the donor's guardian." The donor "may make an anatomical gift: (1) by authorizing a statement or symbol indicating that the donor has made an anatomical gift to be imprinted on the donor's driver's license or identification card; (2) in a will; (3) during a terminal illness or injury of the donor, by any form of communication addressed to at least two adults, at least one of whom is a disinterested witness; or (4) … by a donor card or other record signed by the donor or other person making the gift … included on a donor registry …."

Integrative Material for Dissection: Body Parts Resulting from Surgical Procedures

The availability of donated bodies varies considerably from one country to another. We propose that an alternative source for dissection may be represented by body parts resulting from surgical procedures. These parts, otherwise destined for destruction, would be particularly useful for postgraduates learning basic surgical techniques and for specialists in developing new procedures [16].

In some countries, the law regulating the disposal of body parts is the same as that of whole bodies. In the Netherlands, a 1991 law concerning the disposal of dead bodies regulates both bodies and body parts, by burial, cremation, or donation to medical science (teaching and/or research) [9, 10]. In the United Kingdom, the Human Tissue Act (2004) [14] states that consent by living patients is not needed for the use of surplus or "residual" tissue left over from diagnostic or surgical procedures, for the purposes of clinical audit, education or training relating to human health, performance assessment, public health monitoring, and quality assurance, nor is consent needed for the use of "residual" tissue in research, provided that the research project has received ethical approval and that the researchers cannot identify the tissue donor and are not likely to be able to do so in the future [16]. In Italy, Presidential Decree no. 254/2003 states that after appropriate diagnostic procedures, organs or body parts are considered to be hazardous biological waste and are destined for destruction. Alternatively, they may be buried or cremated, if the patient had expressed this wish. Nothing prevents these parts from being donated in a written declaration by patients for teaching and research purposes, before their ultimate destruction.

Our Section of Human Anatomy has an agreement with the University Hospital of Padova regarding the possibility of receiving body parts resulting from surgical procedures after informed consent by the patients in question [16].

Promotion of Body Donation and Its Ethical Value

A shortage of cadavers has been reported from anatomical institutes in many countries, due to the limited numbers of donations, and many authors have discussed and proposed methods to increase such donations. The reasons associated with decisions to donate or not to donate must first be analyzed and borne in mind. Many authors have evaluated these aspects through population surveys and have found that the main factors involved are quite similar all over the world [17–22]. Population surveys in several countries (Europe, United States, Australia, India, Libya) have shown that younger age, male gender, and higher educational status are positively associated with greater willingness to donate whole bodies or cadaveric organs [22–25].

Reasons Given by Donors for Body Donation

- Altruistic desire to be useful after death for medical progress (education and research)
- Expression of gratitude to medical science
- Negative attitude towards funerary practices
- Economic reasons (rarely reported)

Factors Associated with Decision Not to Donate

- Lack of awareness about body donation programs
- Fear about insufficient respect for the donated body
- Religious concerns
- Unacceptability of the idea of being dissected (above all, if physicians, by colleagues)

Education campaigns about body donation are extremely important in promoting awareness of body bequest programs. They may be promoted through posters, leaflets (in hospitals or general practitioners' offices), and mass media (newspapers, television, Internet websites, social networks) [19, 22, 26, 27]. It has been suggested that participation by religious leaders in such awareness campaigns may be particularly useful [22].

Donors must be assured about the fact that their bodies will be treated with respect and dignity, and the ethical value of body donation must be discussed and emphasized with students. A cadaver has been defined as an "ambiguous man" showing both material and personal qualities [28]. These personal qualities must be stressed in order to encourage respectful treatment by students. In Western countries, some anatomists have suggested presenting cadavers in anatomical education as "first patients" [29, 30]. In Eastern cultures, donated bodies are frequently presented as "teachers," this title also being considered a way of motivating donors [31, 32].

In order to enhance the ethical significance of body donation, respect ceremonies have been proposed at the beginning and/or end of dissection courses [26, 31–34]. During these ceremonies, students further develop a respectful relationship with their cadavers by meeting donors' families. Students may also be stimulated to write their reflections or ideas to be read during the ceremonies, and some of these have been published [33, 34]. Some institutes of anatomy have also built specific monuments for body donors [35]. At Nanjing University, a "memorial forest" has been created, with the planting of a tree for each donor [19].

Body donation could also be promoted by specific legislation (still lacking in many countries) and by developing special centers for body donation (an example is the body donation center in Paris) [36], with public support and possibly with coordination of the need for cadavers in anatomical institutes [19].

Information and Consent

Detailed information about all aspects of body donation must be given in talks by members of the anatomical staff to potential donors and their relatives. In our experience, the questions from donors and relatives mainly concern the purpose of body donation (research, teaching, or both), the methods of conservation, the issues of storing (how, for how long, embalmed or not), and the final destiny of the body after its use (cremation, collection by relatives). Sometimes donors cannot come to talks at the anatomical institute. In our experience, a telephone conversation is usually sufficient, but if the donor requests a home visit, the anatomical staff of the program should satisfy the request.

As regards consent in body donation, donors must express their wishes by means of a written disposition of body donation given to the personnel of the program, together with a photocopy of their document of identity. All dispositions are of course recorded and conserved by the administrative staff of the program. Consent from relatives is also usually requested when there is no specific norm which allows reference only to the expressed wishes of the donor. Thus, at the moment of death, relatives are also asked to sign a consent form, in which they accept the previously expressed wishes of the deceased person. In Italy, by analogy with Law no. 91/1999, the relatives making such declarations are the non-separated consort, common-law consort or, in their absence, children over the age of eighteen, parents, or legal representatives of the deceased person. In other countries (e.g., United States), the will of the donor cannot be revoked by relatives.

Exclusion Criteria for Body Donation

- HIV
- Hepatitis (B, C)
- Tuberculosis
- Methicillin-resistant *Staphylococcus aureus*
- History of dementia (Creutzfeldt-Jakob disease)
- Suicide
- Obesity (relative criterion)
- Previous autopsy (relative criterion)
- Major surgery (relative criterion)

As regards donation of body parts after surgery, upon the surgeon's report, if possible 2 or 3 days before surgery, a trainee, surgeon, or a member of our body donation program explains to the patient that with their written consent, they can donate that part of their body which will be surgically removed for therapeutic purposes and which would otherwise be destroyed. An information sheet is also supplied. If patients consent, the trainee or surgeon asks them to sign the informed consent form. After the surgical operation, the body part is taken directly to the Section of Human Anatomy, together with a copy of the patient's medical record [16].

Patients who wish to donate body parts also give their consent to the possibility of information being acquired about their serological data and any microbiological/serological analyses being carried out on donated body parts. In the case of infections, or if the donor refuses to authorize microbiological/serological analyses, body parts are not acquired. In Italy, serological results are communicated to patients in accordance with Law no. 135/1990 and Legislative Decree no. 196/2003. Patients are given any significant information about their current health status which might arise from dissection, and on their specific request, they are also informed about the later destruction of the body part in question.

Methods for Conservation and Storage

A properly organized body donation program involves particular methods of conservation of anatomical materials, and it needs special facilities for conservation and storage. Evaluation of the required facilities is obviously based on the number of donations the program receives and the number of bodies/body parts it manages. Structures which receive small numbers of donations and few bodies per year need complete, rational use of anatomical material. In order to permit more rational preservation and use of bodies, some parts (the head, limbs, or parts of limbs) may be stored separately in refrigerators. This allows a more practical approach to anatomical/surgical teaching sessions on particular anatomical regions.

Among the most frequently used embalming methods are the mixtures described by Tutsch [37] and Thiel [38, 39]. Embalming is usually performed by perfusion through the carotid, brachial, and femoral arteries [40]. Fresh frozen cadavers are frequently preferred for training and research in many surgical procedures. Thus, some centers for body donation also freeze some bodies.

Body parts, separated from cadavers or resulting from surgical procedures, are usually stored frozen in refrigerators and must be carefully identified and catalogued. They can be refrozen after use or fixed in embalming solutions as prosections.

Plastination is also a useful method for conserving organs or prosections for scientific and teaching purposes [41, 42]. Vascular corrosion casts, obtained by injection of vessels with acrylic and radiopaque resins, have also often been used in our program [43, 44]. Vascular casting, although mainly performed for research purposes, can also be used in teaching to demonstrate vascularization.

All samples taken from bodies and all body parts subjected to anatomo-microscopic analyses, plastination, corrosion casting, or simply conserved in formalin must be systematically recorded.

At the end of the period during which the body is retained for dissection, the remains are usually cremated, but they may be buried if this is requested by donors or their relatives. In some centers for body donation (e.g., Paris), cremation is required and must be accepted by donors in their declarations. The ashes are buried in a cemetery, in which a gravestone may acknowledge the ethical value of donation (as, for instance, in the Thiais Cemetery in Paris) [9].

Staff and Facilities for a Body Donation Program

The staff of body donation programs should include anatomists, technicians, and administrators. If possible, anatomists should include medical doctors with various specialties, in order to give an approach as wide as possible to dissection, teaching, and research. Our working group, for instance, has physicians specializing in orthopedics, plastic surgery, pathological anatomy, legal medicine, and radiology. A special team of administrative staff is essential for correct, efficient recording of all documentation, with particular reference to the written dispositions of donors and consent forms signed by relatives. The technical staff should have specific competence in the conservation of bodies and management of anatomical materials.

Separate rooms should be devoted to conservative methods, storage, and education/training sessions. Several mortuary refrigerator chambers are necessary for storing bodies. Fresh bodies must be stored at -20 °C, although embalmed bodies may be conserved at 4/5 °C, so that chambers working at different temperatures are needed. For body parts, ordinary refrigerators may also be used. Dissecting rooms for education and training sessions are also necessary. It is best to have several dissecting rooms of different sizes for different kinds of sessions. The Section of Human Anatomy of the University of Padova has two dissecting rooms, with 12 and 15 dissecting tables (Figs. 20.1 and 20.2). Both have air ventilation, closed-circuit television, and monitors for direct video transmission. It is particularly important to be able to have video recordings, used to integrate anatomical education. A structure in which a body donation program is active and education/training sessions on bodies are performed should also be endowed with operatory microscopes, arthroscopes, echographs, and laparoscopic and endoscopic instruments. A plastination laboratory can also allow the conservation of specimens of particular interest for anatomical education purposes.

Standardization and Certification of Body Donation Programs

The recent literature contains many reports of certification processes in tissue banks [45, 46], health care [47], and medical education [48–51]. In our experience, body donation programs may also greatly benefit from the development of a quality management system and achievement of certification. Our program underwent a process of certification which led to ISO 9001:2008 certification in 2011 [40].

Standardization is usually defined in various fields as actions aimed at putting order into

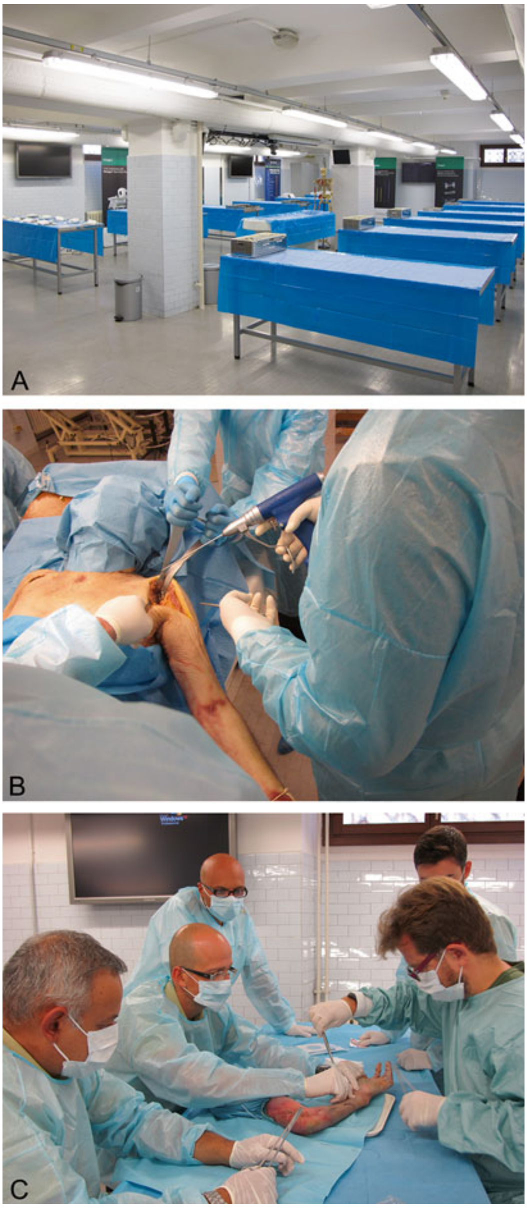

Fig. 20.1 The dissecting room "Andreas Vesalius." (**A**) A panoramic view of the room, which is endowed with a master table and other 11 dissecting tables. It shows televisions for video transmission of dissections performed on the master table. (**B**) A trial of shoulder arthroplasty performed on an embalmed body. (**C**) A course of sutures for military surgeons performed on upper limbs

repetitive applications. The ISO 9001:2008 criteria stress the importance of a "process approach," a process being defined as "an activity or set of activities using resources, and managed in order to enable the transformation of inputs into outputs." A process approach implies the "application of a system of processes within an organization, together with the identification and interactions of these processes, and their management to produce the desired outcome" [40].

In our experience, the certification process of the body donation program was particularly useful in improving the efficiency and quality of the various activities involved, with particular reference to the final users (i.e., students and graduates) and to the optimized use of a limited quantity of anatomical material. Of fundamental importance was the involvement of external experts in the quality management system in the services and higher education sectors, who were directly involved in all phases of the certification process. Throughout, frequent meetings with these experts enhanced the awareness of the personnel of the importance of quality assurance/improvement. Internal audits were conducted and an accredited third-party registrar (Certiquality Srl©, Quality Certification Body, Milan, Italy) then audited the quality management system and certified the program [40].

A quality management system requires specific documentation, subdivided into internal and external documents. Internal documents mainly include quality policy and quality objectives, a quality manual, and documented procedures and records to ensure the effective planning, operation, and control of all processes. External documents are normative references, scientific publications, EN ISO 9001:2008 Quality Management Systems Requirements, manuals of instruments, and documentation from the certification authority.

The quality policy must be "appropriate to the purpose of the organization" and must be "communicated and understood within the organization" [52]. In our program, the policy for quality assurance and quality improvement was developed with the main aim of promoting *dissection* as a necessary training instrument for students, residents, and surgical specialists. Particular attention was also paid to the *ethical value* of the donation of bodies or body parts, which is stressed at the start of all training sessions. The quality policy also stresses the importance of the following aspects: the obligation to guarantee *compe-*

Fig. 20.2 The dissecting room "Hieronymous Fabricius ab Aquapendente." (**A**) A panoramic view of the room, which is endowed with a master table and other 14 dissecting tables. It has three large screens for video transmission. (**B**) A course of dissection for neurosurgeons involving operatory microscopes. (**C**) A cadaver lab for orthopedics about external fixation in the inferior limb

tence and *privacy*, the need for an effective *monitoring system* of the processes to stimulate continual *improvement*, and the search for continual *updating* of the program's personnel.

A quality management system also requires written specification of all the processes of the organization, differentiated into main and supportive processes. In a body donation program, the main processes are collection of written dispositions; collection of certificates and data after death, transport, receipt, and identification of cadavers or body parts; and management of bodies/body parts and of anatomical education sessions. Supportive processes are those not directly involved in the management of anatomical material and education, such as management of equipment/instruments and documents/records, and of the purchase of necessary materials [40].

With the setting up of the quality management system, the minutes of all meetings must be put on record, with detailed traceability of all processes. This allows better control of all the operative phases of the body donation program and an easier approach to continual improvement.

Need for Continual Improvement

The application of ISO standards should be a dynamic process, promoting continual improvement of the quality management system and donation program. Improvements of all the aspects of the program are possible by monitoring each process with efficiency indicators closely related to objective data. In our quality management system, monitoring indicators are the numbers of donors and donated body parts per year, the numbers of training sessions involving the use of anatomical materials, and the satisfaction of learners and donors, as evaluated by questionnaires.

Each body donation program should develop and use specific questionnaires for donors and for learning satisfaction. In our institution, the questionnaires covering learning satisfaction ask for an evaluation of the following aspects: congruence of contents with course objectives, degree of trainee interest, quality of anatomical material, management of sessions, and location and equipment. The questionnaires covering donor satisfaction consider the following aspects: how donors obtained initial information and its quality; the organization, efficiency, and quality of preliminary contacts, by e-mail and telephone; the quality and completeness of information received during explanatory talks with the anatomical staff; and the positive attitude of the member of the anatomical staff with whom donors talked. Obviously, all questionnaires are anonymous.

Continual improvement is also guaranteed by critical analysis of all processes, by both internal and external audits and management reviews, and by controlled updating of the various professional figures involved. Training and updating for staff members must be defined in detail, and its effectiveness is analyzed in the "Review of outcomes and improvement planning," performed every year before the external audit.

Conclusions

Only a well-developed and clearly organized body donation program can ensure the constant availability of anatomical material and its correct and effective management in education/training sessions. In the experience of the Body Donation Program of the University of Padova, the development of a Quality Management System and the achievement of ISO 9001:2008 certification may help in improving efficiency and quality and in stimulating continual improvement.

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21 Designing Gross Anatomy Laboratory to Meet the Needs of Today's Learner

Quenton Wessels, Willie Vorster, and Christian Jacobson

The global advancement of technology in recent years has had a considerable impact on anatomy pedagogy, related facilities, and teaching spaces [1–3]. Classic curricula, those following a traditional sequential examination of preclinical basic science coursework followed by experiential learning in clinical settings, have attempted to move away from pure memorization and didactic teaching. This is, in no small part, in response to changing content, the needs of students, and the adoption by some institutions of the Western Reserve curriculum or derivations thereof. Institutions such as McMaster and Maastricht have, since the 1960s, restructured their medical curricula and associated anatomy courses toward problem-based learning (PBL) [4–6]. Learning in these circumstances is constructive [6]. It is practice based and learner driven and as such highlights the importance of the informal and hidden curriculums in medical education. This movement has however been met with some apprehension due to perceived lack of structure and progression, a lack of rigor in specific preclinical disciplines, and pointedly, the taxing resource requirements of these curricula. This becomes most apparent when the student numbers grow in the excess of 100 [6, 7]. Other curricular approaches have evolved from classic and/or PBL origins; these include team-based learning (TBL) [8–10], self-directed learning [11], computer-aided learning (CAL) [12–14], as well as hybrid models. Today, regardless of the formal curriculum, anatomy pedagogy relies strongly on multimedia equipment and prosected specimens. Furthermore, despite the numerous teaching approaches, there appears to be a revival in anatomy pedagogy in medical curricula. This revival is occurring in the face of a global reduction in anatomy course content and decreased time spent on cadaver dissection [13, 15–19]. Given these disparate trends, advances in anatomy pedagogy are necessary in modern medical education. The challenge lies in objectively measuring how much anatomy is enough and largely depends on the viewpoints of the traditionalists and the educationalists [13].

Curricula evolve to suit the health-care requirements of patients, and dissection laboratories have similarly adapted to the educational needs of students. Old anatomical theaters paved the way for today's state-of-the-art facilities [20].

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The design of anatomy pedagogy facilities for today's student requires an understanding of the current generation and anticipating the needs of the next generation. Today's student has been described as being comfortable with technology and is attracted to the use thereof [21]. From an educational perspective, they have a propensity to prefer a variety of facts that are skillfully and rapidly conveyed [22]. Technological progress and the availability of electronic devices allow for today's student to accomplish various tasks simultaneously; this generation has high expectations from technology and expects utility in all situations [21–24]. Furthermore, they are team focused and interdependent with an ability to unify and organize, but they require structure [23, 25]. It is safe to say, given today's trends, that we should anticipate continued adoption of e-learning and a move toward the further integration of mobile devices.

Today's Learner (also see Chapter 2):

- is a team player.
- requires structure and guidance.
- is comfortable with technology.
- relies on fast-paced facts.

It is therefore an imperative, from a design perspective, to focus on learning spaces that are flexible and that allow for aspects of TBL and e-learning. The application of TBL in anatomy relies on predetermined reading assignments (pre-class preparation) for the students followed by content-specific in-class discussions. The principle relies in teamwork and the provision of an opportunity to use the assigned reading material and resources to solve problems. TBL encounters are supervised and expect both preparation and attendance by students in order to attain specific competencies and capabilities in the subject matter [8–10]. A flexible learning environment in this instance will allow for easy reconfiguration to suit discussion groups to formal didactic lectures. A major concern for universities is the cost of teaching, the associated space that is required for these activities as well as the support services required. In many instances, these support services must allow secure and hygienic accommodation for human remains in accordance with prescribed regulations. If needed, adequate space for the processing of human remains and the preparation of museum specimens should be provided that is not too extravagant or wasteful. It is also vital to consider the university aims beyond that of teaching. These aims typically include research, continued professional development, and institutional cooperation [26].

Obviously, learning spaces are expensive long-term resources and careful consideration must thus be taken at the point of investment. Critically, faculty must adapt to and adopt these resources if they are to improve educational outcomes. Lecturers who don't actively use collaborative or cooperative teaching techniques typically do not adopt these practices even if teaching in a space that is conducive to active teaching. Similarly, active lecturers that promote dynamic learning are likely to maintain their particular style of education [27].

Evidence indicates that teaching space, and the implementation of multimedia within that space, has a dramatic effect on learning outcomes [28–31]. Something as simple as applying multimedia design principles to lecture slides significantly improves short- and long-term retention of material [31, 32]. Minimally, new facilities should make some attempt to include student engagement systems. Audience response systems (ARS) or in the vernacular, "clickers" or "zappers" are electronic voting systems typically deployed in larger lecture environments to increase student participation within traditional, didactic-style, lectures [33, 34]. All modern systems are wireless, but hardware requirements and thus fixed costs vary considerably from one manufacturer to the next. Two basic technologies predominate, however, radiofrequency (RF)-based systems that use proprietary hardware built directly into lecture facilities and mobile phone-based systems that append onto and are dependent on Internet connectivity and services. Regardless of platform, data indicates that lecturers often see increased attendance rates and quantifiable improvements in student performance coincident with ARS use [33]. These systems also enjoy a high student satisfaction rate [33–35]. This is not surprising as there is a growing body of evidence that active, "constructivist"-style lectures, as opposed to traditional theory-based "objectivism"-style lectures, are better received by students, and students are more satisfied with the learning experience [30, 31, 36].

Learning in a gross anatomy laboratory can be a function of the various learning activities within a specific community that relates to the subject matter. It is therefore situated as proposed by Jean Lave and Etienne Wenger in 1991 [37]. Generally, two distinct educational settings exist within medical education. The one is where the students learn such, as the dissection room, and the other where they apply their knowledge. The latter refers to a clinical setting or practice setting, and this is typically separate from the milieu in which students learn anatomy [38]. This division creates a gap between situated learning within a community of practice needs to be bridged. The environment and context has been suggested to have a positive effect on the recollection of information [38]. Research demonstrated the positive impact of wearing scrubs on contextual learning. Their findings show that those students that were assessed in the same context as they were trained remember significantly more information [38]. Contextual learning of anatomy sparks ideas such as the incorporation of theater lights, a gowning area, and a scrub room. The reproduction of contextual and environmental factors to match a clinical setting should therefore be considered.

Learning Spaces and Anatomy Pedagogy

Education and the learning space are closely intertwined [39]. The conceptual and practical interplay between place, space, and learning is pivotal for the construction and remodeling of learning spaces. The work of Bleakly, Bligh, and Browne refers to these interactions and mentions hospital architectural design and its influence on patient care [40]. The use of place in undergraduate education as well as the influence of vertical hierarchies and horizontal layouts influences interprofessional interplay. Interprofessional education relies on aspects such as flexibility, interaction, communication, and student focus [41]. Flexibility in these spaces is pivotal in allowing for the accommodation of current and future technological and pedagogical trends. Future-proofing space is difficult. It is nearly impossible to anticipate the direction of technological advancement; tablets, for instance, comprised a sliver of computer sales until recently. Further, if history is our guide, how anatomy faculty, staff, and students use space may change dramatically.

Medical education during the Renaissance was marked by the study of human anatomy through observation within anatomical theaters [42]. This was a new dimension in medical education as the study of anatomy was previously restricted to the study of ancient texts [43]. The first of these permanent anatomical theaters was completed in Padua, Italy [44], in 1594 and this funnel-shaped wooden construct served as a blueprint for many others [45, 46]. Student involvement or the "Paris method" was brought back to London in 1746 by William Hunter, and cadaveric dissections continued to gain popularity in the years that followed [47]. The adoption of PBL curricula by many institutions coincided with the development of lifelike simulators, models, and advanced computer simulations. In many institutions, these developments brought about dramatic changes in the use of anatomy spaces. Certain technologies are likely to play a critical role in future educational space design regardless of the curriculum. Wireless and wired, fixed networks are and will, in one form or another, be critical in future space [48].

Key Design Considerations

Defining Your Needs

Modern-day anatomy curricula have become more interactive and clinically orientated and in contrast to classical didactic lectures riddled with detail.

The design of a gross anatomy laboratory or appropriate educational spaces depends on the teaching methods employed and with each comes specific challenges. For instance, with curriculum that focuses on cadaver dissections, there are challenging infrastructural requirements. In general, four broad areas should be established within any anatomy facility: (a) public space, (b) teaching and learning space, (c) practical/simulation space, and (d) related support space. Each of these areas has their own specific requirements as listed below:

- Public space—social space, for leisure and study
- Teaching and learning space—multimedia-ready, multifunctional, reconfigurable
- Practical laboratories/exhibition space—dissection laboratories, simulator and anatomical model space, and anatomy and pathology museum
- Support spaces—offices, cold storage, general storage, locker rooms, embalming facilities, a maceration area, and water purification

These learning spaces correlate with the ideal anatomy learning content, which, as proposed by Sugand and colleagues in 2010, include the following entities: dissection/prosection, anatomical models (Fig. 21.1), interactive multimedia, procedural anatomy, surface and clinical anatomy, and medical imaging [20]. In general, specific design considerations have increased over time beyond the conventional needs of adequate lighting, plumbing and water purification, total laboratory floor space, adequate ventilation in the case of formalin-based embalming techniques, and waste management [18, 45, 49].

Adequate ventilation is also required when formalin-based wet specimens are used for demonstrations or assessment. Air quality, according to the American Society of Heating, Refrigeration, and Air-Conditioning Engineers [50], can be ensured through at least 12 air changes per hour along with a supply of fresh air, a negative pressure, and the expulsion of used air to the outside.

Fig. 21.1 Lancaster University Medical School's CALC (Clinical Anatomy Learning Centre) where a combination of anatomical models, digitized medical and histology images, and e-learning resources are used to teach human anatomy

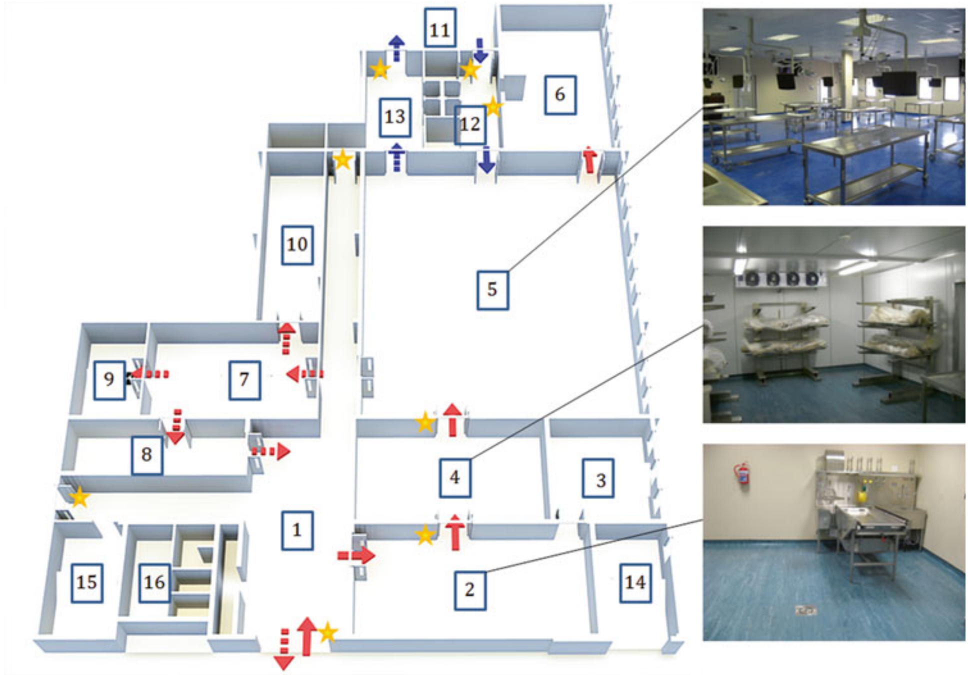

Fig. 21.2 A three-dimensional blueprint of the typical facilities associated with anatomy teaching as well as a selection of photographs. The delivery area (1), embalming facilities (2), mortuary refrigerators (3), and refrigerated storage (4) are separated from the main dissection hall (5) as well as postgraduate dissection hall (6). Students enter the dissection hall from the north (12). Following dissection, the students exit via a second set of doors (13), and soiled coats are dropped off in designated bins (12) toward the atrium of the facility (11). The atrium should be closely associated with resource centers and lecture theaters. Male and female toilets are also provided along with a locker room (not in view). The cadaveric material is processed (7) to either become wet specimens (9) or macerated (8) for osteology material (10). A water purification plant (14) ensures chemical possessing prior to the introduction of the water into the municipal system. Technical staff facilities are adjacent to the embalming and maceration rooms and an office is also provided (15) as well as toilets (16). *Yellow stars* indicate biometric access points and restricted access. The *blue arrows* depict the movement of the students and the *red arrows* the subsequent processing of cadaveric material. *Solid red arrows* represent the sequential movement of cadaveric material into the dissection hall. *Dotted red arrows* point to the movement of cadaveric material away from the dissection hall after completion of the curriculum. *Dotted blue arrows* represent the movement of the students after dissections. Adapted from Wessels et al. [51]

Furthermore, an average room temperature of 21 °C should be maintained. The same standards can be applied to other specialized areas such as embalming and maceration rooms [50].

Any formaldehyde-containing wastewater, including water drained from hand basins, should be processed prior to its recirculation into the municipal system (Fig. 21.2 (14)). A water purification plant can accomplish this in conjunction with easily cleanable surfaces and the use of laminated poly-flooring with drains. Sequential processing involves filtration through a polypropylene filter, hydrogen peroxide oxidation and pH correction, and lastly additional filtration through sand and granular activated carbon. From here, the processed water can be introduced into the municipal system as gray water. The specifications vary based on the frequency of embalming, number of workstations, and wet specimen usage [51].

Technological advances include the further integration of audiovisual equipment and associated computer or network support for these facilities. This in turn accommodates teaching modalities such as computer-assisted learning and the presentation of medical images, X-rays, and MRIs, in conjunction with dissection or use of prosected specimens [1, 14, 18]. An example of such an application is the work presented by Reeves and colleagues in 2004 that integrated wall-mounted Apple iMac computers at each of their 26 cadaver workstations [52]. Wall-mounting preserves floor space, and the anatomy faculty and staff tailored an anatomy software package that complements an integrated systems-based medical curriculum. The package includes a digital dissection guide, medical images (CT scans, X-rays, and MRIs), and cross sections related to the course material. Their work showed that computerization of the workstations, in conjunction with the developed software, promoted autonomy, student proficiency, and the effective use of dissection time. Furthermore, it also provided room for the assessment of specific competencies and the application of anatomical knowledge [52]. Alternatively, computer monitors can be mounted from the ceiling [51]. However, evidence by McNulty et al. in 2009 emphasizes the significance of understanding student preferences and their learning styles when making use of CAL. Their results show that students do not consistently make use of CAL that relates to the curriculum, and this might be credited to personal partiality [14].

Additional key design considerations have also been highlighted by Van Note Chism [53] and include flexibility that allows for easy reconfiguration and accommodates changing trends in pedagogy, comfortable seating and work surfaces, support for technology and adequate electricity supply, and the concept of the entire campus as a learning space. The latter implies certain “decenteredness” where learning activities occur within the corridors of a building as well as the living spaces of students. This also breaks away from the notion of having a designated front or a privileged space in a classroom. Van Note Chism also recommended the inclusion of sensory stimulation as a design consideration [53].

Anatomy Learning Content Drives the Design

- Programs offered: forensic medicine, training tomorrow’s anatomists, allied health sciences, workshops, and continued professional development
- Dissection/prosection: gross anatomy laboratory/morphology museum
- E-learning: interactive multimedia and wireless technology
- Procedural, surface, and clinical anatomy: the display of 3D digital images and direct link to surgical theaters
- Imaging: C-arm-compatible equipment and visual display of medical images such as X-rays and MRIs

Choosing the Right Lights

There are two principal characteristics of light that influence perception: the intensity or illuminance of light and its color temperature. The first, intensity, is described as the luminous flux per meter (lux), and the latter, temperature, is related to the principal wavelengths emitted by a light. In general, increased illuminance improves visual acuity [54], and higher illuminance coupled with cooler color temperatures, such as blue-enriched white lights, is stimulating and improves alertness and performance [55]. Lower illuminance with warmer, yellow, color temperatures appears to improve communication and social behavior [56]. As such, lighting in various areas of an anatomy facility should be task specific and in some instances modifiable to suit various specific uses. For instance, blue-enriched lighting is desirable in practical and simulation areas where a combination of dimmable, warmer lighting and blue-enriched lights might be more appropriate for public spaces where discussions or communication (lower, warmer) or studying (brighter, cooler) might occur. Visual stimulation within the learning environment has the added advantage to reduce monotony and inactivity. Learning spaces should thus incorporate a diversity of colors to combat and reduce boredom while refreshing

Sensory Considerations

- Light and color affect mood and behavior.
- Visual stimulation reduces monotony and inactivity.
- Extraneous noise affects cognition and memory.
- The use of irritants in many facilities requires adequate ventilation.

awareness. Color, in the same way as light and temperature, seems to significantly influence how students learn and their concentration required for a specific task. However, the importance and use of color within the learning environment remains contentious with conflicting results [57].

Reducing Extraneous Noise

Extraneous noise has an effect on cognition, affecting memory and reading comprehension; basically, acoustics influence learning outcomes [58]. It should be noted that most of this research was centered on the performance of primary and secondary school pupils. We might extrapolate and apply these concepts to tertiary institutions. In any new facility, pains must be taken to control sound to improve intelligibility in lecture facilities and reduce background noise in open plan areas to improve concentration on tasks [59].

Planning for Assessment

In any design, a critical question will be: Where will assessments take place? Is there a space that is conducive to assessment, and is it suitable to the format of assessment? The Association for Medical Education in Europe (AMEE) Guide No. 25 proposes a multidimensional model of assessment [60]. This guideline suggests selecting suitable assessment tools for the evaluation of a range of learning objectives. Multiple-choice and short-answer questions, oral examinations, and essays are typically used to evaluate knowledge recall as well as applied knowledge. Clinical performance assessment, however, requires more sophisticated methods such as objective structured clinical examination (OSCE), standardized patients (SP), and direct observation of clinical cases [60]. An assessment tool, such as objective structured practical examination (OSPE) (Fig. 21.3), can only be implemented within a suitably designed environment. Flexibility ensures easy transformation of the learning environment for assessment as depicted in Fig. 21.3. There should be ample room for movement in order to allow access to the test material. Figure 21.3 further illustrates that all of the furniture is mobile, creating further flexibility in the environment. Computerization of the stations permits the inclusion of digitized medical images and histology slides. This allows for the employment of various assessment methodologies in a space typically configured for practical sessions.

The Design Process

The design process depends on establishing and building a relationship between the architect, the user client, stakeholders and interest groups, and a professional team of engineers and consultants. The process needs to be interactive, a creative process that is essentially similar to product design. In it, there will be various phases: conceptualization, research, blueprinting, testing, and modification [61]. All will occur within a framework provided by the project budget and the interprofessional relationships developed by the design team. With vigilance, the end result should represent the needs of the user client.

Briefly, the department, or a designated individual from the department, should develop an accommodation list. This list must specify all the departmental requirements for the building—the number and size of the offices, area of public

The design process relies on a reflective process of conceptualization, research, blueprinting, testing, and modification. The end result should represent the needs of the user client.

Fig. 21.3 An example of an OSPE assessment process. The practical assessment environment plays an important role. Each station is either located at the head or the toe end of a cadaver and is carefully blueprinted with the learning objectives, and the flow of the students is planned beforehand. The configuration can be changed based on the number of students that will be assessed

space, specific laboratory requirements, hopefully including everything the department will need over the next 20 years. This list will provide a framework from which the architects and consulting engineers will generate coherent ideas and plans for the facility. This is a dynamic process and a work in progress; it is imperative that faculty and staff play a role in this planning process to ensure alignment with the desired outcomes. Technology will play a critical role in any design. Ensure that all the technology you may need is incorporated early in this process and do not rely on consultants to bring that technology to the table. Research is the key in this regard. During the early planning phase, visit other institutions and ask relevant questions such as: What did they do right? What did they do wrong? Discuss with the architects how dissimilar elements and ideas may be integrated into your design and question how previous designs can be improved.

Someone will need to buy a hardhat and safety shoes. It is pivotal to continue the established relationships after the design is approved. The department needs to play an active role during the construction process. Get faculty involved. Do not rely on individuals who will not be using the space to represent you in the process. Identifying a problem early in construction is significantly cheaper than discovering it after completion. Remember that you will be using a facility for the next 20–30 years, not the contractor, subcontractor, or members of the professional team. Therefore, make sure what you get is what you wanted. In the end, it is never going to be perfect; there will always be some regrets, but these can be minimized by being active in the process from start to finish.

From Design to Commissioning

- Involve all the stakeholders and faculty.
- Continue relationships with the professional team and project manager after the design has been approved.
- Early identification of construction errors and consequent corrections is significantly cheaper than discovering it after completion.
- Participate in every stage until final completion.
- Ensure that you get what you asked for.

Conclusions

Turney aptly pointed out in 2007 that there are three aspects of anatomy pedagogy that need to be resolved: when, how much, and how to teach anatomy [13]. These curricular attributes require an awareness of today's learning as well as the learner's environment. A holistic approach is required in order to enhance teaching, and the system in its entirety should be considered. This includes the methods of assessment. The assessment tools and the assessment environment should be aligned with the learning objectives and teaching methods in order to ensure achievement of outcomes [62, 63]. In creating this learning environment, the following aspects of anatomy teaching space design thus need to be considered: appropriate sensory stimulation, plumbing and electricity, surface area required per student, appropriate assessment space, e-learning capabilities, and a dynamic environment that can be suitably reconfigured. The design process relies on adequate research prior to construction and faculty involvement from the conception of the idea, blueprinting, testing, and modification, and finally the commissioning of the facilities.

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22 Preparing Students Emotionally for the Human Dissection Experience

Anja Böckers

Emotional Reactions of Medical Students to Dissection

For centuries, human dissection has been a well-established teaching method in the gross anatomy lab, and it calls for additional professional competencies such as team spirit, self-reflection, or "detached concern", which are also important in novice doctors' later medical practice [1, 2]. For many years, these teaching objectives were represented only in the "hidden curriculum." Today's anatomy teaching is guided by the principles of humanism and puts professionalism and reflection in the gross anatomy lab into practice.

Definition

The term "detached concern" was introduced by GE Dickinson (1997) and was used in a preclinical teaching context [2]. It describes the effort of medical professionals/students to "care" for the patient/body donor, but yet "not get too close."

Detached concern prevents overly strong emotional reactions which might interfere with the best possible medical treatment and the learning process.

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During recent decades, teaching time has been markedly shortened in nearly every medical school. As a result, students are subjected to increased stress with regard to learning and examinations. Additionally, students undergo emotional stress thinking about the dissection process. This stress might even resemble the symptoms of post-traumatic stress disorder (PTSD), causing somatic symptoms such as illness, disgust, or sleeplessness [3].

This emotional stress hinders students from developing an adequate learning process and medical competencies such as professional empathy for the students' first and future patients [4–6] and might contribute to mental burnout [7, 8]. Therefore, anatomy staff members should be committed to reducing this mental distress in the anatomy lab as much as possible.

Fortunately, "the strongest reactions by medical students to dissection were in anticipation of it" [9] (see Fig. 22.1). The nature of these reactions was summarized as follows: "For many, facing the cadaver for the first time elicits a wide range of emotions. These may include thoughts of their own mortality to the sheer admiration of knowing that someone cared to help others learn about the body, even in death" [10]. Shortly after the first contact with the cadaver, a habituation process starts in most students and students' fears reduce significantly.

These findings have been confirmed by many other research groups [11–16]. During the dissection course, they become more aware of mental stress as soon as they have to work on body

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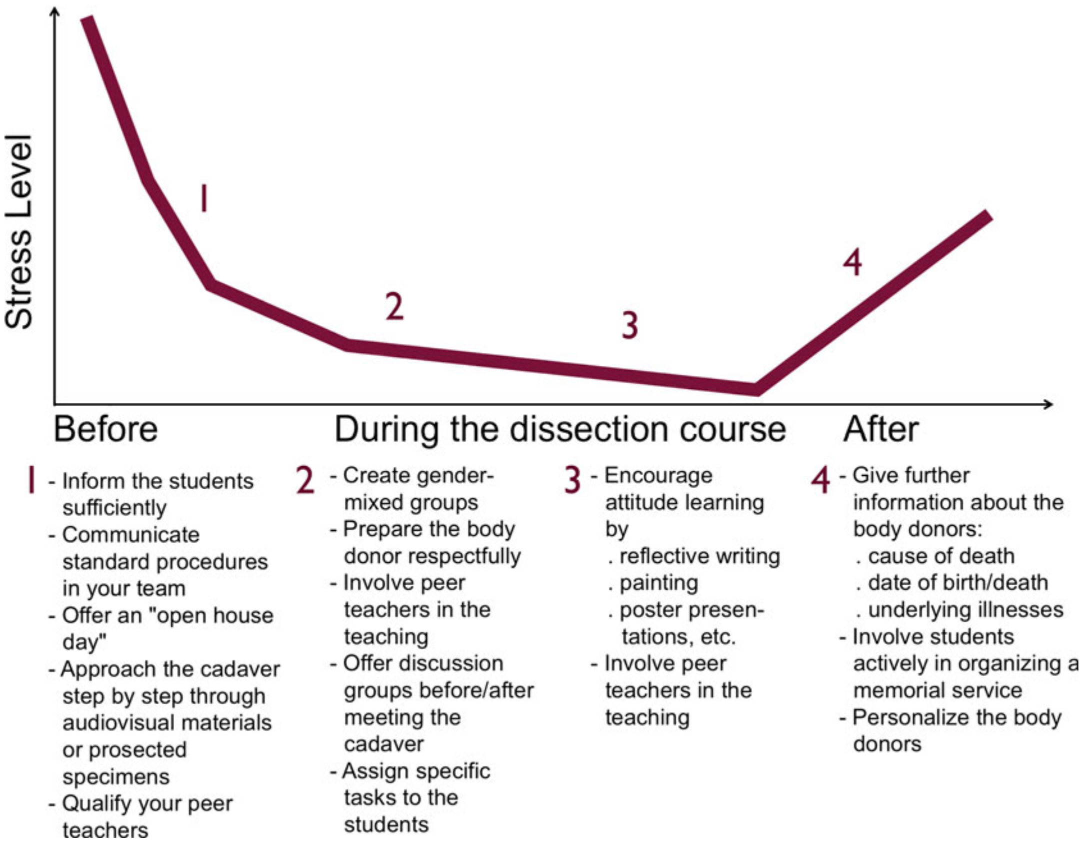

Fig. 22.1 Students' typical stress level before, during, and after the dissection course and an overview of suitable interventions to handle the students' emotional reactions

parts which are intimate or express the human personality such as the face or hands or at times when the cadaver still appears intact [17]. In due course of time, the fear of dissecting the cadaver gives way to professional curiosity, assessment, and occupational stress [18, 19]. However, between 4 and 6 % of the students experience difficulties adapting, which is expressed in the form of ongoing nightmares, poor appetite, sleeplessness, and learning difficulties. It is only at the end of the assessment period that students once again focus on the role of the body donor, and this requires further guidance by staff members.

Different strategies were described regarding how students might handle mental distress during the dissection course. Without proper guidance to visualize a cadaver as a learning object, faulty strategies might be learned. If students do not develop this professional ability of "caring for the body and yet not getting too close"—a concept Dickinson et al. [2] labeled "detached concern"—this could in the long run lead to burnout or non-empathetic treatment of patients [8, 16, 20, 21]. Other coping strategies are humor, interest, intellectualization, and the application of philosophic or religious attitudes [14]. In addition, the skill of "detached concern" could even be a predictor for assessment results and state examinations [22, 23]. Therefore, emotional distress and its coping strategies demand the faculty's attention.

Reasons Why Anatomists Should Care About Emotional Stress in the Dissection Laboratory

- Interferes negatively with the students' learning process
- Interferes negatively with the development of medical competencies
- Increases the risk of students' burnout
- Reduces students' willingness to donate their own body

Factors Causing Strong Emotional Reactions

Gender

Particularly with regard to the first contact with the body donor, women were shown to have greater psychological distress than their male colleagues. This may be explained by the fact that women have a high body esteem and think more frequently about their own mortality [24]. Subsequently, female students do not get used to the new situation in the dissection lab as quickly as male students and they generally request introductory courses to get used to the dissection lab [15, 16, 25].

Strong Emotional Reactions are Likely to be Shown by:

- female students.
- students with no previous medical training.
- students with recent death experiences in their social environment.

No Previous Medical Training

Most investigations have shown that students without previous medical training have a higher need for psychological support and take longer to form proper coping strategies than those students who had completed some sort of medical training before entering medical school.

Previous Experience With Death and Dying

In general, at the start of dissection, about half of the students have never seen a cadaver before. For these students, the first day of the course is particularly hard. Apart from not being acquainted with the sight of a cadaver, the emotional turmoil caused by a recent death in the family can be connected to strong emotional reactions [25].

While there is no obvious impact of age on the extent of mental distress, there seems to be a relationship between reporting anxiety and personality traits measured by the "Big Five" personality inventory [26]. Unfortunately, personality tests are not quite recommendable as filter instruments, if only because of practical reasons such as anonymity and the considerable expense of performing these tests.

Recommended Interventions of Psychological Support

If questioned, students wish in particular for adequate preparation before their first contact with the cadaver and dissection—preferably in small groups such as their dissection teams on the first day of the course. Fear of death and additional stress due to dissection are reduced significantly if the students feel well prepared to enter the course [27]. Therefore, mental distress in the dissection course demands anatomists' attention.

During preparation of the dissection experience, teachers have to support the initial habituation process and assist students in developing the professional skill of "detached concern" and encourage students to reflect on their work and emotions.

Curricular structures in various medical schools require different concepts about how, when, and to what extent students' preparation for the dissection experience is possible. The habituation process needs a preparatory period ahead of the course. Therefore, it is advantageous to start the dissection course in the students' second academic year and to integrate the habituation process into first-year classes. Lectures are ideal to demonstrate specimens or audiovisual material; seminars allow predissection peer-group discussions under the guidance of anatomy and/or medical humanities staff members. On the other hand, in a modular structured curriculum, which is based on functional body systems and/or uses primarily prosected specimens, the body donor as a human being recedes from being the main focus. In this setting, students might show less emotional reaction, but indispensable teaching objectives like professionalism and self-reflection are more difficult to inculcate. Thus, the interventions listed below have to be checked in each individual case for their suitability.

Recommended Interventions Before the Dissection Course Starts

1. Create an atmosphere of trust and transparency by passing on comprehensive information to the students about the dissection course itself, in particular those concerning emotionally charged questions, because dissection involves working on preserved dead bodies:
   - Body donation program: From our own experience, it is of particular importance for the students to be told that the cadavers were donated on a voluntary basis during their lifetime. Body donations are mostly motivated by the donors' personal positive experiences as patients during their lifetime and the wish to support young medical students in becoming good doctors. (See also Chapter 20).
   - Techniques of body preservation: Certainly, it would go far beyond the scope of comprehensive information to inform students beforehand about specific body preservation techniques. However, they should be informed about specific features in body appearance after death and preservation such as changes in consistency and color which they have to be aware of on the first day of the dissection course.
   - Counseling services: Inform about possible counseling services in your department, medical school, or university. Many students do not know that these services exist at all or how to contact them.
2. Remember to develop and communicate standard procedures for staff to deal with students' emotional reactions. Keep your staff members informed about counseling services too and guide them to an understanding of a uniform role model *you* want them to represent for your students.
3. Offer an "open house day," which allows students to familiarize themselves with the premises, gross anatomy dissection, and learning facilities without yet being in contact with a cadaver.
4. Another possibility for accelerating the students' habituation process is the integration of audiovisual material, which shows the dissection or prosection of human specimens. Audiovisual material might be presented on a single occasion, e.g., during anatomy lectures, or as web-based presentations for personal usage. It was shown that realistic video presentation and interaction with the human cadaver are able to reduce emotional reactions before the dissection course [28].

   Audiovisual material should preferably be integrated into the curricular educational concept. Within this scope, audiovisual material could be part of a preparatory lab manual for students to work through before actually starting the first course session, thus utilizing already limited lab time more effectively. Audiovisual material might illustrate the preparatory process and its necessary skills (video) and show additional medical images, problem-based case reports, or image-based quizzes.

5. The habituation process in relation to the new situation in the dissection course, specifically the confrontation with the cadaver, should start before the course with students gradually approaching the cadaver.

   A "step-by-step" approximation can occur through initial demonstrations of prosected specimens such as individual organs, progressing to whole body parts, and culminating in the presentation of an intact dead human body. In analogy, the teaching method should be adjusted appropriately with lectures at the beginning, then an interactive learning process, and finally active dissection. Depending on their previous knowledge, students should get the chance to follow their natural curiosity to approach the cadaver at their own pace, to touch and to smell it. Several comparable projects and their positive effects have been described in the past [29–31].

Recommended Interventions on the First Day of the Dissection Course

1. Female students more frequently experience feelings of fear and disgust than men in expectation of the dissection course. Hence, gender-mixed dissection groups could be advantageous for the purpose of mutual support, a fact that should be considered when organizing the gross anatomy course.
2. Create a standard operating procedure for the first day in the anatomy lab with regard to the students' first confrontation with the body donor, in coordination with your colleagues. Instruct staff members and peer teachers of each dissection group adequately beforehand. Hence, preparing students emotionally for the dissection experience should be an explicit learning objective in previous peer-teacher training.
3. The first contact with the body donor can be markedly eased if reverent and respectful preparation and handling of the cadaver is ensured. Students are less emotionally involved if the donor does not appear overly human. Accordingly, the donor's face and genital region should be covered, e.g., with towels. Similarly, emotional reactions are frequently enhanced at the sight of hairy skin regions, therefore requiring a thorough total body shaving of the donor.
4. The majority of students favor emotional preparation immediately on the first day of dissection in a small group setting with peer teachers as their trusted person with whom to share their fears and feelings. This kind of small group setting might occur before and/or after the first contact with the cadaver and—wherever applicable—this might be supported by audiovisual material. Referring to our personal experiences, quite often the students' anticipatory fears do not allow a reflective conversation beforehand, yet in some instances, a prolongation of this tense situation could even increase emotional reactions. Hence, we favor a rather quick guided confrontation with the body donor and sufficient time afterward for reflection and feedback about one's individual feelings looking back on the first contact with a cadaver.
5. Additionally, students might be emotionally relieved to be preoccupied with professional duties. Thus, it could be advisable to have the students perform a physical examination—just as if the donor was their first patient—and document the findings on an admission sheet. Looking at the cadaver in a professional manner diverts the focus from a holistic view toward isolated body parts, regions, or organs.

Recommended Interventions on the First Day of Dissection

- Arrange into gender-mixed dissection groups.
- Create a standard operating procedure for the first day.
- At all times, ensure a respectful handling of the cadaver.
- Arrange a small group setting with peer-teachers to reflect on one's fears and feelings before/after the first cadaver contact.
- Engage students with distinct tasks (e.g., admission sheet).

Recommended Interventions During the Dissection Course

Due to stress related to learning and assessments, 75 % of the students do not want to participate in extensive programs of psychological support during the time of dissection [30, 32]. Apart from that, once they have distanced themselves from the human being they are dissecting, it might not be advisable to rekindle their fears, as this might complicate coping strategies and the development of competencies such as "detached concern." Nevertheless, voluntary measures such as discussion groups or consultation with psychosocial services or clergy members are welcomed by the majority of students and might be desirable especially for those 4–6 % students who continue to experience emotional distress during their work in the anatomy lab. The majority of the students are able to handle their emotions within a short period of time through the mechanisms mentioned above. However, this process might be only short term and superficial, therefore requiring additional interventions. Medical humanities projects could be valuable in this process of encouraging students' "self-reflective learning" which in the long term promotes a physician's professional skill in "staying grounded" [33].

1. Students use talking to their peers as their main coping mechanism to overcome their fears about dissection. Implementing peer discussion early in the dissection course by, for example, questionnaires about their feelings concerning dissection is a valuable method of introducing students to an important coping mechanism [34].
2. Previous research suggests that students might be more willing to communicate their feelings associated with death or the dissection experience through *written correspondence* rather than by oral communication. Therefore, memorable experiences are often communicated by reflective writing [10]. However, other multimodal approaches can also be used by students to express their feelings. Hammer talks about "narrative medicine" as an instrument of self-reflection and "attitude learning" in the dissection course. Humanistic learning tools such as paintings, vocal performances, writing poetry, or presenting the content of a poster to others are common instruments to reduce mental stress and to cope with the new environment of the dissection room [23, 35, 36].
3. Peer teachers, specially trained and more experienced students acting as tutors, function as role models and trusted personnel in the dissection room. Therefore, students experience a lower inhibition threshold with regard to contacting their peer teacher with any kind of problem compared to contacting staff members. The effectiveness of these peer-teaching concepts has been proven several times in the past [37–39]. A ratio of one peer teacher assigned to one dissection group around one body donor appears ideal. However, the crucial factor is that qualified peer teachers need in-depth training before entering the dissection course.

Recommended Interventions After the Dissection Course

After course assessments have been completed, students experience a rapid decrease in learning and assessment pressure. Thus, the need to cope with emotions through distancing or depersonalization vanishes. The body donor ceases being an object and turns back into a human being with an individual biography.

Despite the fact that a follow-up meeting might not be explicitly requested by students and that anatomy staff members are not their first choice as partners with whom to discuss their emotions, this is the right time for anatomists to act as role models and to demand students' participation [16]. Students feel quite capable of reflecting their experiences and impressions gathered in the dissection course; hence, guidance by the anatomy staff is of particular importance at this time. Generally at this point in time, the desire to obtain further personal information about the body donor increases. They seek information such as the donor's cause of death, previous illnesses, and their life or family situation [9, 12].

Anatomists should take the students' desire for a closer personal relationship with the body donor into account in order to leave behind the emotions associated with the process of dissection:

1. Anatomists can meet the desire for information about the donor by disclosing information from the body donor's death certificate about age, date of death, cause of death, and underlying illnesses. An admission sheet documenting the findings before cadaver fixation might be added.
2. Most faculties in European or Anglo-American universities conduct a thanksgiving ceremony at the end of the dissection course. This event is a ceremonious occasion of reflection and farewell for all parties concerned. The students "dismiss" their body donor, a person they have not known personally yet who has influenced not only their acquisition of anatomical knowledge but also their personal and professional advancement [40, 41]. Most often, students, tutors, staff members, and relatives participate in this memorial service; students participate actively by expressing their deep gratitude through valuable music and oral contributions. Asian cultures refer to the cadavers as great teachers, and students establish a relationship of respect for a highly valued teacher. Often, Buddhist ceremonies accompany the dissection course even on the first day in the lab, and body donors are personalized by reading their names aloud [42].
3. Nowadays, this tradition is also applied in western medical schools to set up a personalized connection with the body donor and to possibly strengthen the students' empathic competence. The personal relationship between the body donor and the student might be consolidated—among other things—by an informal meeting of the dissection group and family members of the donor or by video-documented interviews of the donor [43, 44]. Up to now, such a concept has primarily been offered as a preparatory measure; however, this would also be applicable as a measure at the end of the dissection course to work through any retained emotions.

Conclusion

There are many possibilities concerning the arrangement of the dissection course to meet the students' different desires depending on their personal backgrounds to prepare them slowly for the confrontation with the body donor, to accompany the variety of feelings arising, and to help students perform the dissection course successfully from an anatomical and also emotional perspective. With the aid of the interventions mentioned here, the dissection course has an eminent potential to help students develop their professional attitudes and competencies.

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23 Promoting Reflection in the Laboratory

Lap Ki Chan

Problem-Oriented Dissection

Reflection is an important part of learning. It is one of the four stages in Kolb's learning cycle [1]. The learner needs to reflect on the materials before the new knowledge, skills, and attitude and values can be integrated into the learner's cognitive framework (see Chapter 1). In medical education, reflection has in fact been considered a core skill in professional competence, especially in the learning of professionalism [2]. This chapter will focus on how to make better use of the small-group learning environment in the dissection laboratory to stimulate reflection in the learning of anatomy.

In traditional cadaveric dissection, students follow the step-by-step instructions in dissection manuals. The specific instructions tell students what to do in order to reveal and then study the structures in different regions. However, the gross anatomy laboratory is an ideal small-group setting for faculty/student interactions and provides invaluable opportunities for active learning and reflection on anatomical knowledge [3–5]. Moreover, the dissection experience itself is an experience that students can reflect on. But students usually do not reflect spontaneously. They need to be deliberately stimulated to reflect in their learning environment [6].

What Can Stimulate Reflection

- A complex authentic problem [6, 7]
- Ill-structured real-life example [8]
- Tasks that are challenging, demand ordering of thoughts, involve evaluation, and require integration of new into previous learning [8]

Mamede and Schmidt [7] and Mann et al. [6] suggested that a complex authentic problem may stimulate reflection. Moon [8] also pointed out that ill-structured real-life examples can stimulate reflection, as well as tasks that are challenging, demand ordering of thoughts, involve evaluation, and require integration of the new into the previous learning.

In the gross anatomy laboratory, clinical problems artificially created on the cadavers that the students are going to dissect can be used to stimulate them to reflect on their anatomy knowledge. This helps students to integrate anatomy and clinical medicine and to apply their basic anatomical knowledge in an authentic, and yet safe, environment. The essential features of this approach to dissection, called

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the problem-oriented dissection (POD), are outlined below:

1. **Student knowledge.** The students should have the basic knowledge of the anatomy of the region concerned. The basic knowledge and concepts are what students reflect on to solve problems, form connections among, and make new meanings of.
2. **Small group.** During the dissection session, students work in groups of preferably fewer than ten members. Each group of students will collaborate on solving the clinical problem on a cadaver.
3. **Clinical case.** All groups of students are given the same clinical case. The case gives the history of a patient who eventually needs a surgical procedure to be done on him or her, e.g., cricothyroidotomy, tracheostomy, exploration of penetrating wounds, aspiration of joints, surgical approach to a tumor or fracture of a long bone, insertion of a catheter, etc. (see text boxes for examples of these cases). The cadavers on which the students are going to perform the procedure have been prepared to mimic the pathologies described in the clinical case, e.g., in the case of septic arthritis, color fluid has been injected into the wrist before the dissection session, so that if the students successfully enter the wrist joint, they will be able to aspirate colored fluid.
4. **Problem solving.** Students then need to *reflect* on their basic anatomical knowledge to devise the appropriate way of performing the procedure in the case, in order to achieve the aims of the procedure without causing unnecessary damage to adjacent structures. Students can discuss the case in their own groups to arrive at the most appropriate method. In that process, they will need to articulate their existing knowledge and share it with their group members. The students then perform the procedure devised by their group on the group's cadaver.
5. **Dissection.** After the students have performed the self-devised procedure, they need to dissect the region to find out results of their procedure, i.e., whether the procedure is successfully done and whether it has caused unnecessary damage. For example, after students have done a wrist aspiration using the method they devised, they dissect the wrist to find out whether they have actually entered the wrist joint and whether the needle has cut any tendons or nerves. Students then *reflect* on their self-devised method and the anatomy of the region in light of the dissection findings.

Problem-Oriented Dissection

- Student knowledge: Students have basic knowledge of the region.
- Small group: Students work in small groups of fewer than ten members.
- Clinical case: Each case involves a clinical procedure.
- Problem solving: Students in a group *reflect* on their anatomical knowledge, devise their own method of performing the clinical procedure in the case, and perform the procedure on the cadaver.
- Dissection: Students then dissect the region to examine the results of the procedure and *reflect* on their self-devised procedure and the anatomy in light of the dissection findings.
- Self-directed learning: Students then look into the literature on the recommended method(s) of performing the procedure and further *reflect* on their self-devised procedure by comparing it with the recommended method(s).
- Sharing: Students then gather together again to share their self-devised procedure, the results on the cadavers, and their reflections after comparing their devised procedure and the one(s) recommended in the literature.

6. **Self-directed learning.** After the dissection, the students will leave the dissection room and engage in self-directed learning, in order to acquire more knowledge in areas that they found themselves deficient in and the recommended way(s) of performing the procedure in the literature. The students then need to *reflect* on their self-devised procedure and its results, by comparing it with the recommended procedure(s) in the literature.
7. **Sharing.** Students gather again in the dissection room after their self-directed learning. Each group of students will present in front of all the other groups their devised procedure, the rationale behind it, and the results of the procedure (the findings of the dissection after the procedure). They also compare their devised procedure and the one(s) recommended in the literature and evaluate the effectiveness of their devised procedure. The students not only *reflect* on their own performance but also those of the other groups and learn from each other. Each group also needs to hand in a written report containing the above sections.

Case: Wrist Swelling

A 90-year-old woman who lives in an old-age home is admitted to your unit. She has a history of diabetes, hypertension, and stroke and is bedridden. The nurses at the old-age home report that she has been very lethargic and has a very poor appetite. She has also been running a fever. Her right wrist is very red, hot, and swollen. She becomes very irritable when you touch the wrist.

You suspect that she may have septic arthritis of her wrist and you want to perform an aspiration of the wrist. Based on your anatomy knowledge, devise an appropriate approach for the aspiration and then perform the aspiration using your suggested approach, followed by a dissection of the wrist to find out what structures the needle has gone through.

Case: Knee Instability

A 25-year-old woman was involved in a single-car traffic accident 1 week ago. She was a front-seat passenger in a car which hit a wall. The only injury she had was a contusion on the front of her left knee. She complained of significant pain on the back of her knee. CT imaging showed that she suffered from a PCL avulsion fracture.

You need to perform an operation to reduce the fracture fragment and fix it internally using a screw. Based on your knowledge of knee anatomy, suggest the appropriate surgical approach to reach the fragment, then perform your suggested approach on the cadaver, and put a mark on the "fracture" fragment.

The intended learning outcomes of these cases include those in the knowledge level of revised Bloom's taxonomy [9], such as being able to recognize and name the various anatomical structures in the concerned region. These are oftentimes also achieved in the traditional instructional dissection, in which students simply follow instructions to expose the structures. But the problem-oriented dissection (POD) also aims to help students to achieve higher-level outcomes, such as application, analysis, synthesis, and evaluation. Students need to go well beyond simple name tagging to apply their three-dimensional comprehension of anatomy in solving the problem of devising a clinical procedure, to compare their self-devised procedure with the recommended procedure(s), and to evaluate their self-devised procedure. The achievement of these intended learning outcomes can help the students to acquire new meanings of anatomical facts in the broader context of clinical medicine and a deep learning of anatomy, which in turn may change the way students learn anatomy in the future.

Teacher's Roles in Problem-Oriented Dissection

The teacher in the problem-oriented dissection should not teach, but help students to reflect to construct knowledge and meanings. The role is similar to that of a PBL facilitator [10].

A useful model for teacher behavior in the gross anatomy laboratory is the one-minute preceptor (OMP), which was originally designed for a busy ambulatory clinical setting, where preceptorial encounters need to be time efficient in order to minimize disruption to clinical service while at the same time be effective for the learners [11]. Salerno et al. [12] showed that teachers using the OMP are more able to lead students to reach their own conclusions, to evaluate their learners, and to create plans for post-encounter learning. It has been shown that the OMP allows clinicians to ensure educational effectiveness and at the same time maintain effective patient care in ambulatory care setting [13]. Teherani et al. [14] found that students rated the OMP as a more effective model of teaching when compared to the traditional model.

The OMP has been adapted for use in the gross anatomy laboratory, where a teacher oftentimes needs to supervise several groups of students at a time and therefore needs to manage time efficiently in each encounter with students in order to provide the best possible learning experience for the students [15].

> **One-Minute Preceptor (OMP)**
>
> - Get a commitment from the students.
> - Probe for supporting evidence.
> - Reinforce what was done right.
> - Correct errors and fill in omissions.
> - Teach a general rule.

The Five Microskills of the One-Minute Preceptor

The OMP approach consists of five microskills that are relatively easy for the teachers to learn and use:

1. **Getting a commitment.** The teacher needs to respond to the students' questions by first inviting the students to reflect on what they already know. The students need to try to answer their own questions first.
2. **Probing for supporting evidence.** The teacher then further invites the students to reflect on the reasons behind the students' answer. From the answer, the teacher can evaluate how much the students already know and how they have applied their prior knowledge to answer their own question.
3. **Reinforcing what was done right.** It is important that the teacher gives positive comments so as to create a safe environment for students to explore and to express what they think. It also serves to indicate to the students the right behaviors and competencies that are regarded as desirable. However, the positive feedback should not be general praise but specific comments on the correct parts of their answer or the behaviors or competencies that the teacher wants to encourage.
4. **Correcting errors and filling in omissions.** The teacher nevertheless also needs to point out the mistakes and omissions in the students' answers, if there are any, in objective, nonjudgmental language.
5. **Teaching a general rule.** The teacher should help the students to generalize and transfer what students learn in a specific case or problem to other situations. The teachers can stimulate the students to think about a similar procedure in another anatomical region (e.g., in joint aspiration, similar considerations in deciding where to insert the needle should apply to other joints). In the original one-minute preceptor technique proposed by Neher et al. [11], the step is in fact the third among the five microskills. But in gross anatomy learning, it is more appropriate for this step to appear at the end of the preceptorial encounter [15]. This is very much aligned with the idea that the OMP is a "pliable set of guidelines that can be shuffled and altered as the ever-changing teaching situation warrants" [16].

The Advantages of the One-Minute Preceptor

The OMP approach is useful in the gross anatomy laboratory because of the following features:

1. **Learner centered.** The OMP structured approach encourages the teacher to adopt the role of a "guide on the side" instead of a "sage on the stage." The teacher encourages the students to actively take part in the learning process by asking questions at various different stages aiming to trigger reflections. The teacher also diagnoses the knowledge level and the needs of the students and pitches the subsequent parts of the encounter accordingly [16, 17]. If the teacher finds that the students do not have a good comprehension of basic anatomical knowledge, the subsequent encounter should avoid questions founded on this knowledge, since such questions will just discourage the students.
2. **Rich in feedback.** The adoption of OMP ensures that high-quality feedback is provided to students. The latter three steps of the OMP involve giving feedback that is specific to individual students and questions: what the students have done right, what has been done incorrectly, what other aspects were not considered, and how the specific case can be generalized to other situations. Rich feedback helps reflection.
3. **Stimulate reflection.** The rich feedback from the teacher promotes reflection. By getting the students' commitment, the teacher fosters students' ownership of the problem, thus inviting them to reflect on their prior knowledge to think of an answer as best as they can. When the teacher asks for the reasons behind the students' answer, students need to think of the reasons to support their answer. The positive and specific feedback, correction of mistakes, and the filling in of omissions are all valuable feedback on which students can reflect. When the teacher tries to help the students to transfer the learning in one specific case to other situations, students are further stimulated to reflect on their immediate learning experience to connect it to past and future learning opportunities.
4. **Explicit structure.** The explicitness of the structure is useful especially for novice teachers in order to make sure that their interactions with students can be educationally effective. It provides a framework for reflecting their teaching encounters with students and for improving their future teaching. But its explicitness must not be taken to mean rigidity, since the OMP is meant to be a flexible guideline that can be and should be adjusted to the local situation [15, 16]. For experienced teachers, following too closely the five-step model of the OMP may even affect students' learning experience.
5. **Prepare students for clinical learning.** The use of the OMP approach in the early years of the medical curriculum may help students to get used to this type of teacher–student interaction, which they may encounter in their later clinical years.
6. **Enhanced teacher immediacy.** The OMP consists of multiple teacher and student interactions, which provide opportunities for the teacher to reduce the perceived distance between the teacher and the students, i.e., increased teacher immediacy [18]. The appropriate voice, gestures, eye contacts, etc., can indicate to the students that the teacher is interested and involved in their learning, which could have a positive impact on their learning.
7. **Flexible application.** The OMP can be used in both traditional instructional dissection and problem-oriented dissection. Chan and Wiseman [15] originally proposed it as a way to structure teacher–student interactions in the gross anatomy laboratory, irrespective of whether it is a traditional instructional dissection or the problem-oriented dissection. The OMP is simply a time-efficient and structured framework incorporating many elements conducive to successful learning; and these elements will work under diverse situations, be it traditional instructional dissection or the POD.

Advantages of the One-Minute Preceptor (OMP)

- It is learner centered.
- It is rich in feedback.
- It stimulates reflection.
- It has an explicit structure.
- It prepares students for clinical learning.
- It enhances teacher immediacy.
- It can be applied flexibly.

Factors Affecting Student Reflection in Dissection

Gustafson and Bennett [19] studied the factors affecting reflection among military cadets during their training. The framework they used can be generalized to other situations such as dissection in the anatomy laboratory:

1. **Learner's skills and experience in reflective thinking.** Although the habit and ability to reflect may be at least in part determined by the personality of a learner, Gustafson and Bennett [19] believed that appropriate instructional designs can promote reflections. Mann et al. [6] also concluded from the literature that reflection needs to be deliberately stimulated. Therefore, in the gross anatomy laboratory, students are not left to reflect by themselves but are stimulated to reflect through the clinical cases in POD.
2. **Learner's knowledge of the content area.** In order for the students to reflect, they need to have the basic knowledge to reflect on. Through their reflections, students acquire deeper understanding of this basic knowledge, such as how and why they are important in clinical medicine. The POD is thus fundamentally different from problem-based learning (PBL), in which the problem comes before the learning [20], although they do share some common features such as being student centered, small-group setting, teachers as facilitators (see section below), and using authentic problems as stimuli. Therefore, the name "problem-based dissection" is deliberately avoided to draw a similarity between POD and PBL.
3. **Learner's motivation to complete the reflection task.** Students' motivation has obvious impact on whether they will engage themselves in the various reflective tasks in POD. The use of a clinical case can create powerful motivations in students since they reveal discrepancy between the present state of the students (not knowing how to apply their basic anatomical knowledge to perform the procedure) and the preferred future state (being able to perform the procedure with anatomical reasoning and the ability to generalize to other situations). Motivation is the student's perceived need to reduce the discrepancy [21].
4. **Mental preparation (mental set) of the learner for the reflection task.** Mental preparation is the readiness of students to engage in reflection. In the study by Gustafson and Bennett [19], the military cadets were not ready for reflection because it took place after a day of hard physical labor. The interactions among the cadets at those times typically surrounded superficial issues like commenting on how hard the work was and food. However, in POD, the cadaver with clinical problems artificially created on it mentally prepares the students for a clinical situation.
5. **Degree of security felt by learner in reporting actual reflections versus perceived desired responses.** In Gustafson and Bennett's study [19], this variable referred to how confident the learners are in the professionalism and integrity of the teachers or reviewers who will be reading their reflections. If they are confident, they tend to give more and better reflections. In POD, the attitude of the teacher is important in determining whether the students will discuss and share their explorative thoughts when they are problem solving. That is the reason why in the one-minute preceptor technique, the teacher will give the positive feedback on the parts of the student answer that is right,

before correcting mistakes and filling in omissions. Even so, the latter step should still be done in objective, nonjudgmental language. The teacher is aiming to create a positive environment so that students feel safe to explore and to think aloud without the fear of being penalized (even just verbally) by the teacher. Pearson and Heywood [22] found that the use of portfolios for reflection is also enhanced by supportive trainers.

6. **Nature of the physical environment in which reflection is being expected.** This refers to the availability of desk space for writing reflections and the presence of distracting factors like ambient noise, poor ventilation, uncomfortable temperature, and furniture. In POD, the gross anatomy laboratory should be set up to reduce the distracting factors in order to allow reflections to occur.
7. **Nature of the interpersonal environment in which reflection is to occur.** Social interaction probably promotes reflection by motivating and engaging the learners [19]. Sharing reflection may further promote it because such sharing offers ideas and information from multiple perspectives [23]. In POD, students need to reflect in order to articulate their knowledge and ideas for sharing among members of the group and to co-construct a shared body of knowledge for solving the problem at hand.
8. **Nature of the stimulus questions, directions, or probes.** The nature of stimulus affects the quality of reflection. Moon [8] pointed out that tasks that encourage reflections are those that are ill-structured, messy or real-life, have no clear out answers, challenging, demand the ordering of thoughts, and require evaluation. The problem-oriented dissection exactly provides these kinds of challenges to the students to promote their reflection of anatomical knowledge. The clinical problem created on the cadavers is as close to a real-life problem as one can get without the possibility of causing harm to real patients. It is a challenging problem since there is always more than one solution (e.g., there are many different ways of entering the wrist joint in performing a wrist aspiration) and the students actually need to perform their devised procedure on a real human body. Moreover, the problem requires students to apply and organize their previously learned anatomical facts, to come up with possible solutions, which they need to evaluate before they decide on the best. All of these features of POD stimulate reflection. The students may be surprised to find out their deficiencies in certain aspects of anatomy. They must ask themselves whether they have the information or skills to deal with the problem and what information or skills they further need [24]. Such experience in POD, with the accompanying reflections, may change the way the students learn and apply anatomy in the future.
9. **Format required for the learner to report on results of reflection.** Written reflection is probably more powerful than oral reflection. Therefore, in POD, the students should prepare a written report after they have completed the three rounds of reflection: reflecting on their basic anatomical knowledge to devise a clinical procedure, reflecting on their self-devised procedure after they find out the results of the procedure by dissection, and reflecting on their self-devised procedure again after they look up the recommended procedure in the literature.
10. **Quality of the feedback provided the learner following reflection.** If no feedback is given to the students, they are much less likely to continue to engage in reflection. In POD, the dissection that the students do after they have performed their self-devised procedure is another form of feedback to the students. The dissection reveals what their self-devised procedure, performed by their own hands, has accomplished, i.e., whether the goals of the procedure are achieved (e.g., in wrist joint aspiration, whether the needle entered the joint space) and whether any damage has been done to adjacent structures (e.g., in wrist joint aspiration, whether the tendons, nerves, vessels, or even the joint cartilage are damaged). The dissection thus

provides immediate and specific feedback that is important for the students to reflect on. Evaluative feedback such as the teacher's praise can promote further reflection. If the positive feedback is specific, the students can pinpoint the specific parts of their ideas or behaviors that are desirable and will persevere with them in the future. The one-minute preceptor technique in interacting with students can provide feedback-rich learning experiences for students.

Factors Affecting Student Reflection in Dissection

- Learner's skills and experience in reflective thinking
- Learner's knowledge of the content area
- Learner's motivation to complete the reflection task
- Mental preparation (mental set) of the learner for the reflection task
- Degree of security felt by learner in reporting actual reflections versus perceived desired responses
- Nature of the physical environment in which reflection is being expected
- Nature of the interpersonal environment in which reflection is to occur
- Nature of the stimulus questions, directions, or probes
- Format required for the learner to report on results of reflection
- Quality of the feedback provided to the learner following reflection

Conclusions

The traditional approach to dissection, with students following a set of specific instructions to reveal the structures for studying, does not make maximal use of the small-group setting in the gross anatomy laboratory. In problem-oriented dissection (POD), a clinical case is introduced before the students start dissecting the cadavers, which have been prepared to mimic the clinical condition in the case. The students need to reflect on their basic anatomical knowledge in order to devise a clinical procedure which needs to be done on their patients (i.e., the cadavers). They then perform their self-devised procedure on the cadaver, followed by the dissection of the region to look at the results of their procedure. The dissection results prompt the students to reflect on their self-devised procedure and the anatomy. Students then go to the literature to search for the recommended way(s) of performing the clinical procedure, which will stimulate students to further reflect by comparing their self-devised procedure to the recommended one(s). Different groups of students then gather together again in the laboratory to share their self-devised procedures, the results of their procedures on the cadavers, and their reflections. The teacher in the POD should be a facilitator, whose role is to guide the students to reflect and to apply their anatomical knowledge. One method to structure the teacher–student interactions is the one-minute preceptor model, a learner-centered and time-efficient framework which provides rich feedback and promotes reflection. It consists of five microskills: get a commitment from the students; probe for supporting evidence; reinforce what was done right; correct errors and fill in omissions; and teach a general rule.

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24 Teaching Anatomy: Prosections and Dissections

Nalini Pather

Introduction

While traditionally dissection has been the gold standard for teaching anatomy, over the last few decades, institutions worldwide have transformed their anatomy teaching practice to include the use of prosections as a modality for learning anatomy. At the outset, it is important to acknowledge that an overwhelming number of anatomists concur that using cadaveric material is unsurpassed in ensuring that programs are of high quality and students have sound anatomy knowledge.

The merit of learning by prosection and by dissection has been debated in literature and has largely remained unresolved. There have been calls for further evidence [1] to support claims that dissection is superior [2–4], while at the same time, others have concluded that prosections are equally effective [5, 6] in teaching anatomy.

As an anatomist, it is important to appreciate the usefulness of each of these modalities in teaching anatomy and to use ways of implementing them that optimize student learning and experience while remaining efficient and feasible. As anatomy teaching morphs with advances in medical education, a growing number of medical schools have embraced integrated curricula with a combination of prosection and dissection teaching modes to serve specific program requirements [7].

This chapter will describe dissection- and prosection-based laboratory sessions, in particular

Definitions

- *Study by dissection*: (etymology: Latin; *dis* "apart" + *sectio* "a cutting, cutting off")

  Traditionally, students are assigned to teams and learn by actively undertaking a systematic process of uncovering the embalmed cadaver's structure layer by layer in each region. An anatomist is usually present to guide students in this process.
- *Study by prosection*: (etymology: Latin; *pro-* "before" + *sectio* "a cutting, cutting off")

  Students learn by observing anatomical structures on specimens that have already been dissected by an experienced anatomist. Prosections usually display specific anatomical regions and structures. Study by prosection is flexible enough to be accommodated in both teacher-led and student-centered learning approaches.

  A growing number of institutions use a combination of dissection and prosection learning activities to suit specific program needs.

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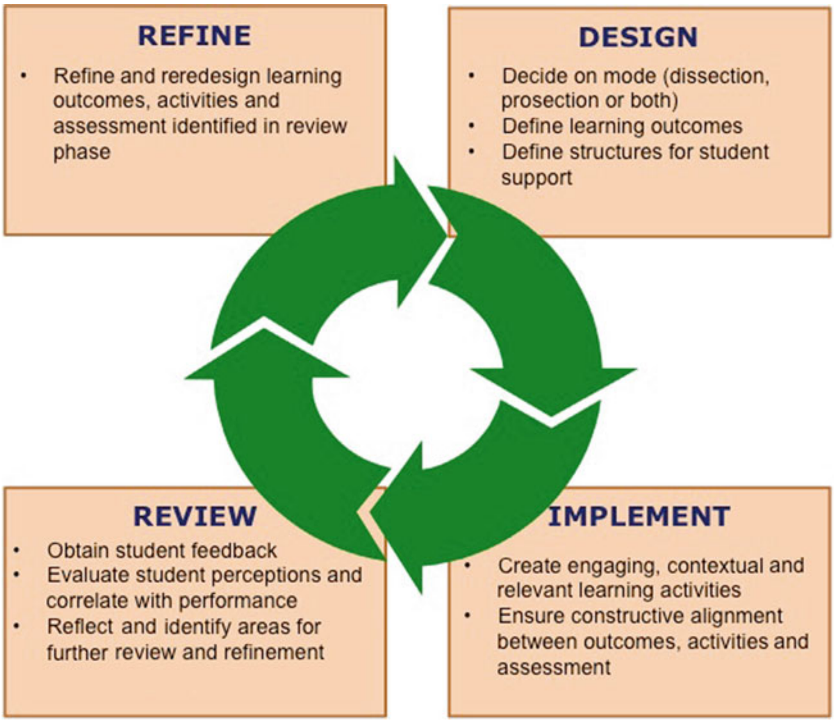

Fig. 24.1 Model of continuous improvement for designing and implementing teaching activities

key principles in design and implementation based on a continuous improvement cycle (Fig. 24.1).

Designing Anatomy Laboratory Activities

An initial decision in designing an anatomy course is to decide which learning outcomes are best served by dissection- or prosection-based learning activities (Fig. 24.1), bearing in mind that these modalities can also be used in combination within a course.

Learning Anatomy Using Dissection

When dissection is the mode of learning anatomy, there are a number of advantages, including:

- The hands-on nature of dissection ensures that students are actively engaged in learning [8], and this enhances and promotes deep learning, information retention, and confidence [1, 9, 10].
- As students dissect and examine relations in situ, they develop clinically relevant visuospatial

Learning Process in a Traditional Dissection-Based Course

- Typically, anatomy is studied in regions.
- Students are assigned into dissecting groups of usually four students per cadaver, two on either side (the number depends on cadaver resources).
- In order for the team to work optimally and to ensure active participation, roles can be assigned to members (e.g., dissector, assistant, reader/researcher) and rotated over the period of the course.
- Each group follows a dissection manual or guide to uncover, layer by layer, the regional structures and observe its spatial relationships.
- As the dissection proceeds, teams compare structures and relations in other dissections. In this way, students become aware of human variation and disease.
- Students use their dissection to review and revise their learning.

conceptualization and appreciate the multidimensional organization of the human body [11]. They encounter structures in their anatomical context, for example, the heart is found in the middle mediastinum within the pericardial sac.

- In comparing the anatomy of the cadavers in neighboring dissections, students encounter anatomical variation and pathology firsthand [11, 12].
- Mastering a discipline language is an important part of learning. During dissection sessions, students are introduced to, practice, and use the language of anatomy and of medicine.
- Dissection develops manual dexterity and procedural skills that are important in future practice.
- Students develop teamwork skills by working in dissection teams [12] and have opportunity to experience different roles within teams.
- For some students, the cadaver is their first close encounter with death and is pivotal to formulating their attitudes towards death and dying [13] and palliative care. Multicultural teams are valuable in exposing students to differences in cultural perceptions and attitudes to these issues.

Things to Consider

- While students place a high value on dissection-based courses [14, 15], there is a high cost-benefit ratio associated with maintaining a cadaveric facility [16]. Furthermore, modern dissection laboratories are equipped with expensive computers, monitors, and cameras at each dissecting station.
- Dissection-based courses can be labor intensive and requires a large amount of time to ensure that the dissections are done appropriately and structures are clearly visible and correctly identified. Sufficient supervision will be needed to ensure learning—including the participation of invited clinical staff and surgeons to ensure that these activities are immediately clinically relevant.
- In some countries, access to a sufficient number of cadavers for teaching by dissection is limited. It is imperative that the use of cadavers complies with the national legal and ethical requirements (e.g., in the UK, the Anatomy Act).
- While for most students, the dissection experience is positive, a minority would experience negative psychological impact [6, 11, 17, 18]. Appropriate and timely intervention and support for these students should be planned.

Advantages of Dissection

- Engages students actively.
- Enhances deep learning.
- Increases visuospatial conceptualization.
- Increases awareness of anatomical variation.
- Provides opportunities to master discipline language.
- Develops manual dexterity.
- Develops skills in teamwork.
- Develops attitudes to death and dying.

Learning Anatomy Using Prosection

A prosection-based course can be flexible and has been shown to have the following advantages:

- Prosection-based courses are very focused, contextual, and time-efficient [19]. Structures and their relations are observed more quickly as they are already dissected and clearly exposed [6–8].
- The flexibility of prosection-based courses allows elegant integration with other biomedical and clinical sciences. Students can, for example, study the normal anatomy of the respiratory system alongside relevant histological and pathological specimens.
- Prosection-based courses can also be founded on team-based learning where students complete laboratory activities in teams. Individual readiness and team tests can support this process [20, 21].
- Like in dissection, activities can be designed to focus on issues dealing with death and dying—without the emotional stress of dealing with dissection [19, 22].
- Prosection-based courses can be relatively cost-effective [22] for the anatomy department with regard to facility and laboratory requirements. Fewer cadavers are required as

Learning Process in Traditional Prosection-Based Courses

- Typically, anatomy is studied in systems.
- Learning activities are flexible in delivery and can be teacher-led in small groups or student-centered in teams.
- If teacher-led, usually the instructor demonstrates structures on the prosected specimens and facilitates a discussion/tutorial based on these.
- If student-centered, activities can be station-based. Stations can be used to easily integrate with other biomedical and clinical sciences.
- In a station-based session, prosections, models, and other learning tools are arranged in a series of stations around the laboratory, with specific learning outcomes and defined activities. Students work progressively through the stations in teams. Students may be guided by a worksheet/guide which includes questions for each station—the questions should include all domains of Bloom's taxonomy.

more than one student cohort can use the prosections. Depending on the national legal requirements, prosections can be retained and used for a few years [1, 6, 7].

- Plastination can increase the life cycle of good prosections, and these can be used repeatedly and in dry labs [23]. When considering using plastinates, it should be noted that there is good evidence that its use should be in combination with wet cadaveric material to provide a richer learning experience [24].

Things to Consider

- Students place a low effort-value ratio on prosection-based courses [14, 15]. This is usually because they are able to view and study anatomy in high-quality prosections without investing the time to uncover these by dissection.
- Prosections are presented out of their anatomical context. For example, the heart can be presented as an isolated prosection (i.e., out of the mediastinum and thoracic cage). In these situations, students may have difficulty understanding threshold concepts like in the case of the thorax, the mediastinum. Care should be taken to design learning activities that develop students' visuospatial understanding and conceptualization. Furthermore, cadavers without anatomical variations are frequently used for prosections.
- As structures are already dissected and exposed, prosection-based activities must ensure that areas such as surface anatomy are not overlooked [25].
- Student learning and experience is dependent on the quality of prosected specimens. For this reason, it is important to secure the skills of an experienced anatomy dissector.
- Preparing prosections is labor intensive, and at all times, care should be taken to comply with national legal requirements regarding how long specimens can be retained.

Advantages of Prosections

- Focused, contextual, and time-efficient.
- Flexible course allowing for easy integration.
- Can be used to develop teamwork skills.
- Develops attitudes to death and dying.
- Cost-effective.
- Fewer cadavers needed.
- Plastinated specimens increase the life span of good dissections.

Learning Outcomes and Activities

Irrespective of which of the above modes is chosen for specific anatomy sessions, careful planning will ensure a positive learning experience for the student. Important considerations in designing and implementing laboratory activities (Fig. 24.1) include:

- Defining learning outcomes that are clinically relevant, explicit, and supported by learning activities.

- Developing student-centered, practical, and engaging learning activities. To increase student engagement and enthusiasm, study by dissection and/or prosections should be augmented with models, tactile tools (like "playdough," string, pipe cleaners, and felt), and body painting.
- Ensuring constructive alignment between learning outcomes, activities, and assessment to promote and reinforce learning.
- Supporting learning outcomes and activities with good, relevant resources. Dissection-based activities will require a dissection guide—several good published dissection guides are readily available. Prosection-based activities will require a learning guide for each session outlining learning outcomes and activities—the course designer can develop this.
- Incorporating time for student reflection within dissection and prosection activities to foster professionalism. Feedback from peers and tutors can be valuable in embedding aspects of professionalism [26].
- Strategically designing activities to prevent cognitive overload. Cognitive load theory [27] provides a useful framework to design learning activities that optimize learning. This theory stresses the importance of considering the limited capacity and availability of working memory when designing learning activities, i.e., engaging students, limited working memory will enhance learning and understanding [28].

Implementing Anatomy Laboratory Activities

Once the mode of teaching (dissection- or prosection-based) and learning outcomes have been determined, activities should be implemented in ways that encourage student engagement and promote learning. Some ways to do this include the following:

Create a Multidimensional Anatomy Laboratory Experience

As the nature of today's student body changes, teachers need to cater to multiple learning styles and to include a multifaceted approach to learning in the anatomy laboratory. Irrespective of whether one uses a dissection- and/or prosection-based model, one should try to design clinically relevant and interesting anatomy sessions and to incorporate learning tools (e.g., videos, models, tactile equipment, body painting) into laboratory activities alongside dissection or prosection activities.

Videos, for example, can augment learning in the anatomy laboratory in two ways. They can:

- **Focus students on learning outcomes without cognitive overload.** Tailor-made videos for laboratory sessions can be used to introduce the session's learning outcomes and then comprehensively demonstrate the major anatomical structures and relations that the students need to focus on. Depending on the course design, students can view these videos before, during, or at the beginning of the laboratory session. In prosection-based activities, these videos provide an initial quick guide and students can then navigate their way through a series of prosections mastering the content. In dissection-based activities, students can refer to the videos as they proceed with the dissection. As an alternative, dissection videos can be alternated with dissection sessions, and this has been shown to significantly increase student performance in examinations [29]. Videos can also be made available to students to use for revision and for consolidating information in their own time and at their own pace.
- **Arouse students' interest and participation in learning activities.** Videos demonstrating surgical approaches, including from laparoscopy, viewed at the end of the laboratory sessions immediately engage students and make the session contextual and clinically relevant (e.g., a session on hand anatomy can end with a video on carpal tunnel release, or a session on abdominal organs with a cholecystectomy video). These videos can also be incorporated into laboratory activities, for example, by requiring students to identify anatomical structures and relations visible in the video, thus reinforcing learning.

Videos Can Be Used to:

- reduce cognitive overload and focus on learning outcomes.
- arouse student interest and participation.
- allow material to be reviewed before and after a laboratory session and in the students' own time and at their own pace.
- allow for orientation to learning activities before attending the anatomy laboratory and may reduce stress on students before entering gross lab for the first time.

Integrate with Living Anatomy

Anatomy laboratory activities should relate cadaveric anatomy to living anatomy and to clinical practice. Incorporate living anatomy by implementing activities that include a study of surface anatomy and projections, relevant medical imaging and surgical approaches, and analysis of movement.

Medical Imaging

The anatomy laboratory provides the ideal platform for side-by-side correlation of the three-dimensional human body with two-dimensional medical imaging [30]. Interpreting medical imaging also provides students with an opportunity to evaluate their anatomical understanding. Ultrasound allows the safe noninvasive visualization of structures in the living and during movement. Portable ultrasound machines can be used in the anatomy laboratory [31] to demonstrate relevant living anatomy, to reinforce learning, and to increase student retention of knowledge [32].

For example, in foregut anatomy laboratory sessions, the learning outcomes for this activity should include correlating cadaveric anatomy with the medical images. Along with cadaveric specimens, make available barium meal radiographs, angiography of the celiac trunk and its branches, and CT and MRI images of the upper abdomen. Additionally, after studying the normal anatomy and medical images, pathological images can be included in problem-solving and reflective exercises.

Surface Anatomy

Surface anatomy is an important part of an anatomy course and is an imperative in patient assessment. Both dissection- and prosection-based sessions should include surface anatomy. Implementing activities involving palpation on peers requires planning and consent from students, with consideration for different cultural attitudes.

In dissection sessions, surface anatomy of bony landmarks and the course of nerves and vessels can be outlined on the cadaver before skin incisions are made. Other surface anatomy requiring a living person (like palpation of arterial pulses and organs) also can be easily included by requiring "non-dissecting" team members to demonstrate corresponding surface anatomy as the dissection proceeds. Likewise, in prosection-based sessions, surface anatomy can be studied alongside relevant prosections, for example, when studying a prosection of the axilla, students can palpate the muscular boundaries of the axilla on peers.

Some ways to include surface anatomy in upper limb laboratory sessions:

- Using body paint, outline the course and relations of nerves or vessels on the upper limb of the cadaver before dissection, or if using prosections, on peers.
- Using body paint, outline the dermatomes and cutaneous innervation of the upper limb.
- Palpate arterial pulses (e.g., brachial and radial) and bony and soft tissue landmarks (e.g., the acromioclavicular joint, clavicle, spine of scapula, epicondyles of humerus, boundaries of the cubital fossa) on peers.

Analysis of Movement

Analysis of movement provides opportunity for students to correlate cadaveric study of muscle with its actions in the living person, allowing students to understand muscle function and testing, and to extrapolate this to effects of nerve lesions. Analysis of movement can be done in dissection- and prosection-based laboratory activities.

For example, ways to include analysis of movement in both dissection- or prosection-based sessions in lower limb laboratory sessions are as follows:

- Demonstrate muscle action and muscle testing against resistance. Palpate muscles as they contract.

- Analyze gait with respect to muscles' actions in each stage of movement—relate this to muscle attachments.
- Demonstrate the knee jerk reflex and explain how this works in relation to nerves of the limb.
- Ultrasound can also be used to demonstrate changes in anatomy during movement.

Integrate With Living Anatomy by Including:

- medical imaging.
- surface anatomy.
- analysis of movement.

Embed Graduate Attributes

Graduate attributes refer to the qualities or skills that the university or institution seeks to develop in its graduates so that they will be well prepared for successfully engaging in the professional practice of their discipline. In some countries, significant consolidated proposals and arguments have been made to ensure a minimum national core anatomy curriculum for medical programs. The anatomy laboratory presents a unique platform to embed graduate attributes into learning activities. Here are some ways to embed common institutional graduate capabilities in dissection- and/or prosection-based activities:

Develop a Knowledge and Skills Base for Professional Practice

Both prosection and dissection teaching modes are based on acquiring a sound three-dimensional knowledge base of anatomy. Dissection and prosection activities enhance conceptual knowledge especially when learning outcomes and activities engage students in finding, evaluating, and using information. Care should be taken when developing these dissection and prosection activities to ensure that these are clinically relevant. Including clinician and surgeon participation in learning activities can foster direct application of anatomical knowledge to surgical and clinical contexts. This has been shown to increase student engagement and learning in anatomy [33]. In dissection sessions, clinicians and surgeons can be invited to participate and supervise in the dissection activities. Similarly in prosection-based sessions, clinicians and surgeons can be invited to demonstrate relevant surgical approaches to structures in the region or system being studied.

Develop Effective Communication and Team Skills

Team-based learning has been shown to improve student performance in assessment [34]. Both dissection and prosection laboratory sessions lend themselves to team-based learning. This can be fully embedded to include individual readiness tests and team quizzes. Team activities can be designed to develop communication skills. At the end of a dissection-session, for example, dissection teams can be rostered to present a "tableside" summary of the session's dissection. Alternately, at the end of a prosection-session, teams can present related human variation or solutions to clinical cases.

Critical Thinking and Self-Directed Lifelong Learning

Critical thinking requires students to apply their knowledge and skills to problem solving. In the anatomy laboratory, this can be done using clinical cases, activities correlating anatomy with medical imaging, implications of human variation, etc. During a dissection- or prosection-based session on thoracic anatomy, for example, students can apply anatomical knowledge learned to a clinical case. The case should require application of knowledge and immediately make the session clinically relevant. It should also allow students to reflect and identify areas that they need to further investigate. An actual example can be:

The chest X-ray of a patient at a local clinic reveals fluid accumulation in the thoracic cavity. A thoracocentesis to obtain a sample of pleural fluid is required. There is no ultrasound equipment available at the clinic.

In what situations would fluid accumulate in the thoracic cavity? How would this appear on a radiograph?

Where in the thoracic wall should the needle for the thoracocentesis be inserted? Why?
What are the layers of tissue that the needle passes as it is inserted into the pleural space?
What structures are at risk of damage in this procedure?

Ethical Practice

The use of cadavers provides an opportunity to raise awareness of issues around death and dying. The increase in student diversity allows natural exploration of cultural differences in attitudes in areas such as medical uncertainty, ethical issues like body and organ donations, the declaration of brain dead, and compliance with legal and ethical requirements on cadaveric use.

For many students, the exposure to cadavers provides an opportunity to reflect and formulate ideas on death and dying. This should be encouraged and opportunities taken to foster respect and dignity for cadaver donors. It is for this reason that many anatomy departments institute a practice of homage to donors and their families, e.g., a dedication or memorial service with or without religious involvement.

Embed Graduate Attributes

- Develop a sound and relevant knowledge base.
- Develop communication and teamwork skills.
- Promote critical thinking.
- Develop an ethical framework.

Review and Refine Anatomy Laboratory Activities

Course design and implementation needs a process of continuous development (Fig. 24.1) to remain relevant and engaging. Learning activities should be subjected to a process of review, evaluation, and refinement. Dissection- and prosection-based activities can be reviewed and evaluated using multiple and a variety of ways to obtain student feedback like perception survey tools and correlation with student performance in assessment. Ideally and if opportunity presents, crossover studies can provide objective data on innovative techniques. All feedback should then be reviewed and used to refine the course learning activities for the next iteration of the course.

Conclusions

Cadaveric resources provide a rich environment for teaching anatomy using dissection- or prosection-based activities. These should be designed to be engaging, contextual, and relevant to professional development, both in cognitive ability and in professional skills. As with all educational development, its design and implementation should be a process of continuous development based on robust evaluation and reflection.

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25 Use of Unembalmed/Fresh Cadavers in Anatomy Teaching

Jennifer M. McBride and Richard L. Drake

Introduction

Human cadavers have always been an integral part of physician training and medical education [1–4]. Since anatomy courses typically last several weeks to months, they were embalmed or fixed in a process, which involves some combination of ethanol, formaldehyde, glycerin, and phenol, to halt decomposition and extend the usefulness of the cadaver. And while embalming procedures have been modified, the embalmed cadaver still greets most new medical students as they enter their anatomy class. However, an increased role for the cadaver in physician education began as medicine entered the last quarter of the twentieth century.

It was during this time that a new surgical discipline referred to as minimally invasive surgery had its roots. Procedures using these approaches, also referred to as laparoscopic or endoscopic approaches, required unique skills and a new training paradigm was needed. This led to the development of unembalmed/fresh cadaver/tissue laboratories and training centers [5–8] and an expanded role for the cadaver in physician training and education. However, is there a role for the unembalmed/fresh cadaver in the early education of medical students?

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Why Unembalmed/Fresh Cadavers?

Is it possible, practical, or of any value to use unembalmed/fresh cadavers in an anatomy course for medical students? Some would suggest that for the beginning medical student, gaining basic anatomical knowledge is what's most important. However, what if the learning experience was enhanced in such a way that students felt that knowledge gained was immediately applicable to real situations?

Clearly, this is not the case when learning occurs using an embalmed cadaver which has little in common with the living body. The color is unnatural, and the tissue, organs, and joints are stiff. Add the odor present in most cadaver laboratories and this is not a very pleasant learning environment. However, would there be a benefit if unembalmed/fresh cadavers were used in this initial exposure to anatomy? One report indicates that using unembalmed/fresh cadavers was found to provide students with more confidence as they proceeded with their training in the operating room [9]. The tissue color and texture of the unembalmed/fresh cadaver are as close as possible to those of the living body, and the young medical student would feel that the experience is like being in an operating room (see Table 25.1). But is this difference worth the added issues of rapid deterioration and possible health hazards?

The individuals involved in planning the unique and innovative educational program at the Cleveland Clinic Lerner College of Medicine of

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Table 25.1 Comparing embalmed and unembalmed/fresh cadavers

Embalmed cadavers	Unembalmed/fresh cadavers
Color is unnatural	Color is natural
Tissue is tough	Tissue is soft
Joints are stiff	Joints are flexible
Strong chemical odor	Natural odors
Possible health hazards from chemical exposure	Possible health hazards—cadavers are tested
Unlike clinical situation	Like clinical situation

Case Western Reserve University thought it was. The curriculum at this medical school is a problem-based, organ-systems-oriented approach stressing small-group interactive learning with no lectures and no traditional tests or grades. Each educational offering stresses the integration of basic sciences with clinical medicine which blends nicely with an anatomy program that uses clinical cases to introduce anatomical concepts and facts that are reinforced using unembalmed/fresh cadavers and relevant imaging [10]. Additional factors that made this the perfect setting for a unique laboratory experience was a small class size (32 students), a prosection or previously dissected approach in the laboratory in which residents would be doing the dissections and the teaching, the existence of an unembalmed/fresh cadaver/tissue laboratory that was developed for the practice of minimally invasive surgical procedures, and a strong body donation program.

Precautions

The use of unembalmed/fresh cadavers in a dissection laboratory comes with potential health hazards that must be considered and dealt with appropriately. At the Cleveland Clinic, this is handled at four separate and distinct levels. First, when the Body Donation Program is discussed with a potential donor; second, when the Cleveland Clinic is initially notified that a deceased individual's body is being donated; third, when the body arrives at the facility; and finally, when the body is being used in the laboratory.

1. When individuals are considering body donation and contact the Cleveland Clinic Body Donation Program, the first step is to answer any questions they might have and send them a brochure and donation forms. During this initial conversation, it is also indicated to them that we cannot accept a body with an infectious disease such as hepatitis, HIV/AIDS, Creutzfeldt–Jakob disease, methicillin-resistant *Staphylococcus aureus* (MRSA) or *Clostridium difficile (C. diff)*. Additionally, this policy is clearly stated in our brochure.
2. When calls are received that a deceased individual who was either signed up in the Body Donation Program prior to death or always wanted to donate their body to science when they die, but never got around to filling out the form, whoever receives the call asks "Did this individual have any infectious disease such as hepatitis, HIV/AIDS, Creutzfeldt–Jakob disease, methicillin-resistant *Staphylococcus aureus* (MRSA) or *Clostridium difficile (C. diff)*." If the answer is yes, the body will not be accepted. Additionally, if there is any indication the individual was using illegal drugs, the body will not be accepted because of the potential for the presence of an infectious disease.
3. When the donated body is received at the Cleveland Clinic, several things occur. First, the body is inspected to make sure that nothing is observed that would suggest the presence of an infectious disease or cause other issues of concern related to potential health hazards. Second, blood samples are taken and sent for serology testing: HIV using an HIV 1 and 2 antibody by EIA, hepatitis C antibody by IA, hepatitis B core antibody total, and hepatitis B surface antigen by EIA. If any tests come back positive, the body is immediately excluded from the Body Donation Program and cremated as soon as possible. Finally, if an individual dies of sepsis, their medical record will be checked and, if possible, the cause identified. The situation will then be discussed with the Infectious Disease group at the Cleveland Clinic and a decision made as to whether to keep the body or exclude it from use.

4. Finally, it is clearly explained to all participants in any function or activity in the unembalmed/fresh cadaver laboratory that they exercise biohazard safety/universal precautions. A detailed description of biohazardous materials, precautions, blood-borne pathogens, and exposure control plan can be found by reviewing the state Department of Health website. At our institution, they are expected to wear scrubs or a gown, gloves, a mask, and protective eyewear. There are no exceptions to these rules.

Storage

Once a cadaver has been cleared for use in the program, it is stored in a refrigeration unit. Stored in this manner, we have found that cadavers will remain usable for 4–6 weeks. However, once a region of the body is entered, it only remains usable for a few days to 2 weeks and must be covered with a moist towel or sutured closed. But upon entering a new region of the body, the anatomy in that region will appear as if the cadaver was just removed from refrigerated storage for the first time.

The cadaver can be frozen to hold for a later program, but we have found that once it is defrosted, it does not last as long and the quality of the tissue is not as good as cadavers that were only refrigerated and never frozen. We never use a cadaver after a cycle of multiple freeze/defrost patterns as we have found the usefulness of the cadaver after the second freeze/defrost cycle is very limited.

Finally, we try to only have a cadaver out of refrigeration for 2–3 h. Long exposures at room temperature have adverse effects on the length of time a cadaver can be used and tissue quality.

Use in Educational Programs

The majority of unembalmed/fresh cadavers in the Body Donation Program at the Cleveland Clinic are used in educational programs for medical students, residents and fellows, and students in a physician assistant program.

The educational activities for first- and second-year medical students and the physician assistant students are unique and follow a similar format. The anatomy laboratory sessions in these two courses use a prosection or previously dissected approach and no student dissection occurs. For example, the dissections for the medical student anatomy course are completed by residents from the various surgical disciplines the week before the class. When the class meets, the medical students are divided into groups of six or seven, and they rotate around various dissected cadavers. The anatomy on these cadavers is being demonstrated and discussed by the residents. A similar pattern is followed for the physician assistant anatomy class, but in this case, the dissections are completed by first-year medical students who then do the teaching during each class session. In both of these cases, the instructors, residents, and first-year medical students are able to review their anatomy and gain valuable teaching experience which is expected to be part of the residency program and promoted by the ACGME [11]. Additionally, since unembalmed/fresh cadavers are being used, the students and instructors are learning and teaching in an educational environment that more closely resembles clinical situations.

Use in Research/Clinical Activity

A smaller number of the unembalmed/fresh cadavers in the Body Donation Program at the Cleveland Clinic are used in research projects involving medical students, residents, fellows, and faculty members. These involve a variety of different groups but are especially popular with the ENT, plastics, and dermatology groups. Additionally, requests concerning the availability of an unembalmed/fresh cadaver are made on very short notice when a group may want to evaluate a new or different surgical approach for an upcoming patient.

Conclusion

In conclusion, the Cleveland Clinic has developed a very active program that uses unembalmed/fresh cadavers in a variety of educational and research opportunities. These include a unique anatomy course for first-year medical students where their learning occurs on a cadaver that resembles the living body.

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26 Facilities and Instruments for Learning in the Gross Anatomy Laboratory

Joy S. Reidenberg and Jeffrey T. Laitman

Introduction

This chapter will cover the basics of the physical instruments recommended for a gross anatomy laboratory in which a dissection-based class is conducted. The specifics of the acquisition and maintenance of the anatomical materials, and the design of a laboratory for today's learners, are covered in previous chapters of this section. Here, we focus more specifically on the physical attributes of the equipment in the room, rather than the room itself

Dissection Workstation Equipment

Work Surface

The work surface on which dissections will take place must be impervious to fluids. This is essential to ensure that the surface can be properly cleaned and disinfected. Check that your laboratory meets any local regulations requiring minimum standards for certification. For example, New York State Department of Health requires that anatomy laboratories for human dissection must be inspected and certified with a license for Tissue Bank Operation. One of the requirements to obtain such certification is that the laboratory must have dissection tables that are impervious to fluids.

Recommended surface materials include stainless steel and stone. A stainless steel cadaver dissection table is preferred for human and other moderately sized specimens due its surface being impervious to water-based fluids, its resistance to rust and corrosion, and its sturdy construction. Stainless steel tables offer the additional advantage of being lightweight, allowing the flexibility to change the room configuration as necessary.

Stone is a second choice material because it is difficult to obtain in standard sizes and is expensive to cut and custom fit. It is also harder to utilize in a flexible room configuration, because it is very heavy. Stone is best used when the workstations are built-in and will not be moved. The advantage of stone is that it can also double as a chemistry bench due to its nonreactivity with strong oxidizers.

Other hard nonporous surfaces, such as porcelain or enamel, are acceptable for delicate dissections of small specimens. Note that they can easily crack or chip during bone cutting procedures that utilize tools such as hammers, chisels, and saws.

Plastic is a lightweight alternative that can be easily moved in a modular laboratory arrangement. Plastic-laminated counter tops (e.g., vinyl) are undesirable because knife cuts may penetrate the surface and cause leakage below the surface

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layer. Solid plastic counters may be used as fluids cannot penetrate easily below the layer of the surface veneer. However, caution must be used when choosing a soft surface, as it may be difficult to clean or disinfect material caught inside deep gouges made by knife cuts.

Fluid Drainage

Specimen fluid drainage is a practical concern. The ideal dissection surface will allow drainage of fluids away from the specimen. Stainless steel cadaver tables can have recessed drip channels along the edges of the table to catch specimen fluids. Ideally the table should be able to tilt by raising one end and/or lowering the other end, thus allowing fluids to flow in one direction toward a drain or catch basin on the low end of the table. This drain can either allow drippings to be collected into a bucket positioned directly underneath the hole, or it can have a hose attached that is directed toward a floor drain or a more distantly positioned barrel for fluid collection.

Permanently positioned counter surfaces may be designed to drain fluids into an adjacent sink basin with a drain. In this case, the counter should either be constructed as a tilted surface that allows fluids to flow toward an attached sink basin or include drainage channels that are scored into the surface as gradually deepening grooves that direct fluids toward the basin.

Chairs

We are all becoming more aware of workplace ergonomics, including appropriate furniture promoting proper body alignment. Unfortunately, dissection laboratories do not always lend themselves to such types of furniture. More often than not, these rooms are equipped with stools, which are cheaper than chairs and easier to clean. Stools are acceptable for short classroom periods and have the advantage of being less expensive than chairs, having less moving parts to break, have less protrusions that impede mobility around the chair, and store easily under counters. Chairs may be appropriate for longer laboratory sessions utilizing dissection stations that resemble a desk or counter. These stations might benefit from chairs with a lumbar support to relieve tension on the back musculature. The chairs should also be adjustable in height, allowing students to raise or lower the seat position so that their feet can touch the floor and/or elbows can rest easily on the table. Elevated chairs should have a foot rest bar. It is not necessary to have rolling or swivel chairs, but these options may be desirable for ingress/egress in cramped spaces. If the floor is exceptionally smooth, rolling chairs with self-locking wheels may prevent wandering, as the wheels lock automatically when weight is put on the chair.

Chairs may not be feasible when the dissection techniques require mobility around the specimen. This is particularly true of working on large specimens. It is also best to not have chairs when working in a confined space or crowded conditions, as emergency egress can be impeded.

Tables

Dissection tables that can be raised or lowered are preferred when height-adjustable chairs cannot be used. Raising the dissection table height prevents tall students from straining back muscles due to extended periods of leaning in or bending forward over the specimen. Lowering dissection table height protects short students from calf muscle strains due to extended standing on tiptoes to view or reach the specimen. Student teams with large height disparities should compromise on a higher table height for the comfort of taller students, combined with the use of portable step stools for the comfort of shorter students.

Wheeled dissection tables can be an advantage for a flexible lab design. For example, tables can be rearranged to make space for an in-class demonstration, temporarily moved to allow floor cleaning or access to blocked areas, rolled into/out of storage, or used to transport specimens. Caution: wheeled tables are also a liability, as unpredictable movements can cause a serious knife injury. Therefore, wheeled tables should have adjustable locking mechanisms that prevent movement while dissecting.

Covers

Embalmed cadavers should have a cover placed over the specimen to prevent evaporative loss of water. These covers can be made of any fluid-impervious material. Some cadaver dissection tables come equipped with stainless steel covers. For example, one manufacturer makes a style that has a pair of covers that attach by hinges to the sides of the table and can be swung up over the specimen or down under the table surface during a dissection session. Although they are a more expensive up-front cost, the advantage of the steel covers is that they will always be available, they will not rip or tear as do plastic covers, and they allow the body fluids to continue to drain even while dissection is not in progress. Flexible materials can also be used, such as body bags made of vinyl or a similar material. These bags will ideally zip close, preferably with a zipper on one side rather than in the middle of the bag. This allows the covering sheet to be folded back to reveal the specimen, as opposed to parted like two curtains. Parting the bag with a central zipper will lead to frustration, as the bag will wrinkle around the opening, will have a tendency to reclose and therefore need constant retraction, and likely will prevent access to peripheral parts of the specimen tucked into the edges of the bag. Body bags are relatively inexpensive yet are very durable, easy to wash out in a large sink, and may be reused each year until they get damaged. The major drawback is that they do not allow fluids to drain out, thus complicating the dissection as the specimen will soon be soaking in leaked embalming and body fluids. Some body bag styles have a tendency to develop leaks over time, as the seams are usually stitched and will eventually leak through the thread holes when overly saturated. It is advisable to use a style with an inner vinyl liner that is sealed around the edges. An alternative and very cheap solution is a simple flat sheet made of a waterproof but flexible material. When the sheet is draped over the body, it will prevent evaporative fluid loss. However, the sheet can easily tear, particularly when book racks or other objects are moved around over the sheet. The sheet also has a tendency to become very greasy, as it likely will be draped over the fluid drip channels along the sides of the table, or scrunched to one end of the table over a greasy part of the specimen. The advantage of the sheets is that they can be tucked close to the body and the edges pushed underneath the specimen to get a better seal against evaporation. They are also easily replaced due to their low cost and do not require any storage after the course as they are disposable.

Bookstand

Students will prefer to have a place to put their dissector and atlases during the dissection. Ideally this should be a stainless steel surface, so it can be easily cleaned, but other washable, nonpermeable materials will be acceptable. Bookstands come in many styles. For example, one style looks like a music stand but is attached to the corners of the dissection table. The stand can be rotated to achieve the best viewing angle. The drawback is that students must walk around the stands to get access to the specimen, and it impedes their movements around large specimens. Another style resembles a bridge over the body, with two vertical support walls and two angled bookrack surfaces connected back-to-back at their highest point so that they resemble an A-frame house roof. This style exposes one side of a cadaver table for dissection, but has the drawback of blocking access to the remainder of the specimen under the bridge. The drawback of these racks is that they often end up decorating the floor during dissections that require turning the specimen or accessing the majority of the specimen, and even worse, present a tripping hazard as students try to move around the table in a confined space. The books usually end up being placed directly on the dissection surface or directly over a portion of the specimen, and thus, the whole idea of using book stands to protect the books from body fluids become moot.

As digital atlases and other virtual media become more widely accepted, the style of, or even the need for, bookstands may change radically. In anticipation of this, the bookstands should be removable so that they can be exchanged for updated stand designs that include a power outlet and can host laptops, tablets, digital books, or smaller electronic devices (see Part V).

Cleanup

Waste in the laboratory usually falls into four categories: contaminated disposables (e.g., gloves, aprons, masks, paper towels, papers), sharps (e.g., scalpel blades, broken tools, needles, broken glass), chemical waste (formalin, wetting solution), and specimen tissues (e.g., skin, fat). Each of these waste streams must be separated and disposed of properly according to institutional and governmental regulations. Contaminated garbage may need to be collected separately and mitigated or discarded in a special manner according to the rules of the institution (e.g., red biohazard bag, orange autoclave bag, etc.). In some institutions, it is permissible to mix disposable items with the regular garbage, so long as the contact was made only with an embalmed specimen. Fresh (e.g., unembalmed) specimens pose an infection risk particularly from bloodborne pathogens, and thus, contaminated disposables should be discarded separately as infectious or biohazardous waste.

Sharps must be placed in a special container designed to protect people from accidental contact with the sharp. These special sharps containers are usually red and have a tamper-proof lid to allow one-way flow of material into the container. The sharps containers must be made available in the dissection laboratory, placed according to the specifications of the institution (e.g., wall mounted or free standing on the floor), and should be replaced with new empty containers when they fill up. In addition, it is a good idea to have small, handheld blade-removing devices available at each dissection workstation. These small units can be easily kept with the dissection tools and therefore be readily available at the workstation as needed. The great advantage is that students are not walking around the laboratory looking for a sharp container while carrying an exposed sharp (e.g., dull or broken blade dangling on the end of a forceps). This behavior can lead to injuries if the student accidentally bumps into another student along the route. As the sharps are safely contained inside these blade-removing boxes, the whole box can be simply tossed into the regular garbage if there has been no exposure to unembalmed specimens. An additional advantage is that these blade-removing boxes simplify the task of removing a scalpel blade. The art of using a hemostat or forceps to remove a dull blade is not easily acquired. Unfortunately, it is common to have scalpel blades accidentally flung into the air during the removal process, thus presenting the obvious risk of injury to anyone within range of the flying blade.

Chemical waste management should follow institutional and governmental regulations. Depending upon the nature of the chemicals involved, liquid waste may be disposed of either down the drain into the local sewer or into a satellite collection container for pickup and remote disposal or recycling by a chemical waste management service. Wetting solutions used on dissection specimens that contain nonflammable household chemicals diluted in water (e.g., ingredients that kill microbial pathogens, "softening" agents) are usually not considered hazardous wastes. In most institutions, it is acceptable to dispose of these chemicals in liquid form down a sink drain, although local regulations may require that industrial strength solutions be diluted even further with running water as they are disposed. Small quantities of soft tissues removed from bodies during dissection may also be disposed of down a drain with a tissue grinder (garbage disposal). This may be permitted for noninfectious and nontoxic animal tissues, but is usually not acceptable for human tissues.

Specimen tissues should remain associated with the specimen if possible for the duration of the dissection course. For human specimens destined for cremation, it is desirable to return as much of the hard tissues as possible. Since only bones and teeth contribute to the cremated remains, students should be encouraged to keep all hard tissues removed during dissection with their specimen. This chapter does not cover the details of the various acceptable methods of managing the final disposition of the specimen (e.g., burial, cremation, chemical dissolution, etc.).

Dissection Workstation

- Work surface: fluid-impervious
- Fluid drainage: recessed drip channels, tiltable surface
- Chairs: stools, chairs
- Dissection tables: adjustable height
- Covers: fluid-impervious materials, stainless steel, body bags
- Bookstand
- Disposal of consumables and wastes

Dissection Instruments

The Instruments

A number of different tools are required to perform the dissection. Tools that will be washed and reused should be made of stainless steel to prevent rusting. Tools that are disposable can be made of plastic. The standard dissecting kit should include a cutting and a retracting tool at a minimum, but the actual composition of the tools necessary will depend upon the size and condition of the specimen. For example, a scalpel works well on a human cadaver, but a knife would be necessary if cutting through the thick hide of a hippopotamus.

Human dissection kits most commonly include a #4 scalpel handle and #22 disposable scalpel blades. Smaller handles and smaller blades of various sizes are useful for fine dissections in difficult-to-reach spaces.

A large scissors is useful for cutting through broad planes. Sharp scissors can be used to initiate a cut by making a puncture hole, while blunt scissors can be used to push apart adjacent tissues without cutting them. A small pointed scissors has a double usage: it can cut small structures, but it can also be used to spread and separate fine structures from their delicate covering of fascia.

The retracting tool of choice is a large "rat-toothed" forceps (a forceps with pointed "teeth" that grip tissues). A blunt forceps is useful, but not ideal, as it is difficult to grasp oily tissues without the traction of the "teeth." Smaller straight forceps are useful for performing more delicate procedures, such as lifting a delicate nerve or blood vessel. Small curved forceps are useful for reaching underneath delicate structures, particularly when pulling though a string to affix a label or identification tag.

Tension on a tissue makes it easier to cut. While forceps can be used to generate tension, the tool of choice for longer dissections is the hemostat. This tool can be clamped onto a tissue, using a ratchet interlock. As it does not need to be held closed with the dissector's finger muscles, it is more useful during longer retraction periods, when the finger muscles are likely to fatigue. Hemostats can also be used to fasten two tissues together. This is particularly helpful when a tissue needs to be retracted out of the dissection field to widen access or prevent visual obstruction.

A needle probe can be used to isolate very fine tissues, but can also be used to pin tissues together, thus effecting the same retraction described above with the hemostat. The needle-like point is more useful than a hemostat when the "wall" to which the structure needs to be pinned is very flat and rigid and gives no raised or flexible surface that can be grabbed by a hemostat.

The towel clamp is a rarer tool to find in a dissection kit. However, it is also useful as a retracting device. Unlike the hemostat, it does not crush the tissues between two surfaces. Rather, it punctures the tissues with two opposing points. However, unlike the needle probe, the opposing points can be ratcheted closed and will stay in that position until released.

A blunt probe can separate tissues without cutting them and therefore tends to spread tissues along natural cleavage planes. It also makes a very useful pointer that does little or no damage to tissues when touched to their surfaces.

Tool Kit Container

It is useful to have a plastic tool kit container at each dissection workstation to hold pooled dissection tools. It will not only keep all the tools collected (rather than dangerously dispersed among the specimen), but it also facilitates safe transport of the tools to and from the sink for washing.

Carpentry Tools

An assortment of larger tools generally associated with carpentry or even landscaping can be useful in the dissection laboratory. Bones are best cut with a saw. This can be an electric autopsy saw with a vibrating blade or a small hand saw. Electric autopsy saws have two drawbacks: they are very expensive and can only be used on bone surfaces that have been completely cleared of soft tissues. This is because the soft tissues will simply be wiggled back and forth by the vibrating saw, as it can only cut rigid surfaces by eroding them from the vibration. Chisels and hammers are useful for cracking bone, particularly if it has been previously scored by a saw that did not completely cut through its full thickness. Bone cutters resemble small pruning shears and are useful for smaller bone pieces. Larger bones may be cut with a larger bone cutter with longer handles (resembling a lopper) that add leverage and make cutting easier.

Body Prop Blocks

Propping blocks are useful for positioning the body, or various body parts, during dissection. These props can be made of any durable material. Plastic or rubberized props can be easily cleaned and come in a variety of shapes. Some have fingerlike projections that are useful for holding rounded objects, such as a human head. Wooden blocks are a cheap alternative, but are very difficult to clean, as the wood will absorb grease and embalming fluids. However, they can be cut into a variety of lengths to suit different needs and can even double as stools for short dissectors.

Clinical Tools

It may be helpful to allow students to familiarize themselves with simple clinical instruments that they can practice using on a cadaver. Such instruments can include disposable items, such as a syringe and needle. Students can practice aspirating fluids from joints or infusing fluid into a superficial vein. Other clinical tools can be introduced and demonstrated by visiting clinicians (e.g., catheters, central line, various scopes: otoscope, ophthalmoscope, endoscope, bronchoscope, laryngoscope, laparoscope, etc.).

Books

If student dissection teams will have the opportunity to split into two or more cohorts during a dissection, it is recommended that they have multiple copies of the atlas and dissector books. This is because they may not all progress at the same rate, or they may be dissecting different regions simultaneously. There are advantages to atlases with drawings versus photographs. The difference is similar to how one comprehends a map's satellite image versus a drawing of the roads and labeled buildings. Both are useful in different contexts, and thus, it is advisable to have access to both styles.

Miscellaneous Items

Grease pencils are useful for drawing cutting guidelines on human skin. String is useful for tying off the gastrointestinal tract before cutting it, particularly in the sigmoid-rectal area where there tends to be an accumulation of feces in the lumen. String is also useful to affixing label tags for identifying structures. Pins are also useful for identifying structures, particularly during practical examinations. Their use during dissection is discouraged, as they can become buried over time as the dissection progresses and be accidentally discovered when the sharp point injures someone's finger. Plastic bags should be kept handy to wrap smaller organs, thereby preventing desiccation after removal from the body. It is preferred that these be clear bags, so the contents are easily identifiable. Indelible permanent markers are useful for labeling plastic bags, paper tags, and other items, but note that the ink may rub off when exposed to alcohol-based embalming fluids. Large cafeteria-style trays are useful for laying out eviscerated organs and transporting them to another location for closer inspection, particularly when the dissection table is occupied by the remainder of the specimen. Storage racks on wheels, designed to hold many of these trays in a vertical array, are a convenient way to store these specimens. Each tray or rack can be labeled with the table number so the specimens are identified and therefore still linked to the rest of the body. Rehydrating ("wetting") solution should be made available in small refillable spray bottles for each table. It is convenient to have the stock rehydrating solution located over a sink so that refilling overflows are contained in the sink.

The laboratory should be equipped with chemical safety equipment, including: eye wash station, safety shower, first aid kit, chemical spill kit, and a mop and bucket. There are new designs available that combine the eye wash and safety shower into one station (using a flexible hose) to save space. The mop and bucket are not just for janitorial use! Students should learn to use it whenever they make a spill. Paper towels should be handy for drying the spill site to prevent a slipping hazard.

Dissection Instruments

- Cutting and retraction tools: scalpel, scissors, forceps, hemostats, probes, towel clamps, etc.
- Tool kit container
- Carpentry tools: saw, chisels, hammers, bone cutters
- Body prop blocks
- Clinical tools
- Books
- Miscellaneous items: grease pencils, strings, pins, clear plastic bags, trays, storage racks, rehydrating solution, spray bottles, etc.

Safety

Room Safety

The dissection laboratory should have adequate ventilation to exhaust any fumes emanating from the dissection specimens. This can include noxious smells from decomposing flesh and volatile organic compounds used during the embalming process (e.g., alcohol, phenol, formalin). Air turnover should be at a rate acceptable to the Occupational Safety and Health Administration (OSHA), particularly when room occupants may be exposed to potentially dangerous chemicals (e.g., formalin exposure is linked to causing cancer). Employees should be monitored regularly for type and amount of chemical exposure.

Personal Protective Equipment

A proper dress code should be enforced in the laboratory. Bare legs and arms should not be allowed, as this exposes too much skin to chemical contact with preserving fluids and other chemicals. Trousers or long skirts are acceptable. Short-sleeved shirts are preferred, as this prevents loosely hanging sleeves from wicking up fluids from the dissection work area. The rest of the arm and hand should be covered by a fluid barrier (e.g., lab coat, sleeved apron, and dissection gloves). Shoes must be close-toed to prevent accidental puncture from dropped sharp objects (e.g., scalpel, needle probe).

Appropriate outerwear, such as a lab coat or apron, should be worn over personal clothing. This allows a barrier to fluids on the torso as the dissector leans into the workspace. Button-down lab coats are acceptable, but double-breasted designs, which overlap two layers in front of the torso, are preferred for the greater level of protection. Lab coats should have ¾ length sleeves, which provide adequate arm protection while removing the excess sleeve material from the dissection site. The remaining exposed skin (distal forearm, wrist, and hand) will be covered with gloves. Lab coats are usually cloth, which allows breathability. Plastic outer layers, such as long-sleeved plastic aprons, provide better fluid protection to the torso and arms, but are uncomfortable for long dissection periods as they retain body heat and sweat. Sleeveless aprons can be used instead of lab coats. Sleeveless aprons have the advantage of freeing up the arms for greater movement, but of course provide less protection to the arms. Plastic or rubberized sleeve-less butcher-style aprons will give a combination of waterproofing with moderate body ventilation of heat and sweat. Rubberized aprons can be washed and reused, while thin plastic aprons are designed as disposable items for one-time use. Color-coding students and faculty, by assigning different color coats or aprons, may be useful for highlighting where the teaching faculty are located in a large laboratory room.

Gloves are highly recommended. This not only is more hygienic for the dissector, but it will also reduce the incidence of numbness some people experience after prolonged exposure to embalming fluids. Disposable latex gloves are commonly used, but as many people have latex allergies, there is a preference for disposable nitrile or vinyl gloves.

Face protection is recommended when performing procedures that could result in aerosolizing fluids or small tissue pieces. This is particularly true when using an electric saw to cut bone. Plastic safety glasses or goggles are the most practical, as they do not fog up with prolonged wear. Facemasks with fluid shields are more difficult to work with, as the shields tend to fog up, and the facemask needs to be fitted to each face. Paper facemasks that cover the nose and mouth will prevent inspiration of bone dust, but will not prevent inhaling noxious fumes. Dissectors should be trained in how to properly fit their masks to prevent leakage around the edges. Special respirators, with specific cartridges for trapping the chemicals in use, are needed to prevent exposure to dangerous fumes. This should be required for those preparing embalmed specimens and working with concentrated or large amounts of embalming fluids such as formalin.

Fume mitigation is also important. This may be accomplished through room ventilation systems, although most of these systems are inadequate because they operate from the ceiling. They fail to protect the dissector because they bring the vapors up from the specimen and past the dissector's face. A device that directs the flow of exhausted air from the fume source away from the face of the dissector is preferred. This can be accomplished with a ceiling mounted flex-hose suction device, a back draft fume hood adjacent to a counter top work station, or down draft ventilation systems attached to the sides of a dissection table.

Safety

- Room safety: adequate ventilation, chemical safety equipment
- Personal protective equipment: close-toed shoes, lab coat, apron, gloves, face protection

Conclusions

The instruments that facilitate anatomy learning in the laboratory include features of the room, the workstation, the dissection tools, and safety features. When combined, these features should result in a successful, efficient, and safe anatomy teaching environment for both students and faculty.

Part V

Teaching Tools

Role of Image and Cognitive Load in Anatomical Multimedia

27

Timothy D. Wilson

A Brief History

Perhaps the best model in a modern anatomist's teaching arsenal inarguably remains the cadaver [1]. The pedagogic symbiosis of student, facilitator, and cadaver is historically proven and hard to recreate. However, in the last quarter century, multiple iterations of anatomical education reforms [2–5], significant improvements in computing technology (price, ubiquity, software), and an increasing digital revolution in education has created a perfect storm for education. The classic Socratic and/or didactic approach has rapidly changed our "lecture" halls, classrooms, and labs to "shows" which now include visualizations like diagrams, schematics, computer models, animations, videos, and even simulated environments [6]. These learning media form the basis of the more general term multimedia instruction, whereby both words and pictures are used to convey an instructional message [7].

Arguably, all anatomy instruction contains multimedia. Multimedia instruction occurs when educational messages are portrayed as a combination of spoken word and pictures [8]. Multimedia instruction should not be regarded solely as a high-tech phenomenon. Richard Mayer suggests that words can be spoken face-to-face or over speaker, speech can be computer generated, or words can exist as text. Pictures, on the other hand, are visual-spatial representations such as illustrations, drawings, schemata, or photographs delivered on a page or screen, while dynamic representations can exist as video or computer-generated animations that are delivered through a screen to an audience. In all cases, motivation for the use of images, and multimedia in general, is to promote learning. The impact of images (and multimedia in general) on learning may not be immediately evident, but over the course of multiple and ranging experiments, Mayer demonstrates that humans learn better from images and words than from the use of words alone. This is known as the multimedia principle [8].

As the reader will see later in this chapter, what and how we "do," "say," and "show" in our classes can have profound effects on learners through the multimedia principle. Furthermore, with an underlying social and technological current pushing for increasingly complex multimedia in our lectures, labs, and even assessments, educators may not achieve their objectives despite their best efforts.

The Many Dimensions of Instructional Visualizations

Multimedia instruction utilizing visually rich and interactive computer visualizations is a growing trend in anatomical education. From early computer images from A.D.A.M software (Atlanta, GA) to

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the newest incarnations of software designed to present human anatomy to a wide audience, the race to make the "best" software has significantly increased complex visualizations to all students and their educators [9]. Regardless of the software manufacturer or approach the software might use, the images and text are the primary methods information is presented to the user; this is multimedia. Originally, the visualizations were termed virtual reality learning objects [10], and these digital anatomical "models" have become increasingly flexible and complex as researchers, educators, and vendors have all progressed with technological advances. There is a growing momentum that computer visualizations, compared to dissection, offer advantages to learners in terms of accessibility convenience, cost, safety, and versatility [1, 11, 12].

Instructional visualizations, whether in your lecture hall or on your laboratory computers, offer users many visual cues beyond the immediate materials demonstrated. It is imperative instructors are aware that in addition to the explicit information images portray to the learner, there are implicit cues therein which may affect the learning outcomes. Some of the visual information may be superfluous to the topic and objectives, and thus, reduce learning. Please see Table 27.1 for an overview of the characteristics and variability instructional software might take as it pertains to visualization media. The reader should consider where these characteristics occur in his/her own pedagogic approach and how they might affect the learner. As Table 27.1 illustrates, visualizations can vary significantly. Some qualities are apparent like the delivery medium or whether components of the visualization move, but there are deeper perceptual cues that permeate the literature of psychometrics and have been linked, with controversy, to intelligence [13] and definitely to learning. These perceptual cues are important features in anatomical education both for the novice learner and the advanced clinician as they aid observers' perception of orientation, location, and identification of the material presented. Once these wayfindings are achieved, the learner must then determine if the presented image is coherent with existing mental models they have formed. Indeed, as digital media steadily creeps into all aspects of modern anatomical education, it is important that the visualizations included in our teaching materials do not undermine good pedagogic intentions.

Table 27.1 Characteristics of instructional visualizations and the inherent variability with each characteristic

Visualization characteristic	Variability or type of visualization
Delivery medium	Visualizations can be presented on a page, on a large screen for multiple viewers, or on a portable device (laptop, tablets, or smartphones)
Dimensionality	Visualizations can be presented in 2D (line drawing), as a 3D rendered image with shading, apposition, and perspective, or may be stereoscopic 3D rendering requiring apparatus to view appropriately
Realism	Visualizations can be highly realistic (photos or videos) or may be of low realism like line drawings or schemata
Interactivity	Images can be a series of drawings paced by the learner, a movie with pause function, and a computer-generated image where users manipulate information within the image or may simple be a noninteractive movie or drawing
Dynamism	Images may be static or involve moving components

The viewer's spatial visualization ability may significantly influence the quality of information an image presents to the viewer. Importantly, an individual's spatial ability dictates how difficult it is for the viewer to extract pertinent information from the salient features of the visualization. Spatial ability refers to an individual's ability to search the visual field; apprehend the forms, shapes, and positions of objects as visually perceived; create mental representations of those forms, shapes, and positions; and manipulate such representations "mentally" [13]. In other words, an internal representation of a perceived object or scene must be created and maintained in working memory in such a way that mental manipulations are possible [14]. As the reader can imagine, this is not an easy task for all individuals and it can impact learner comprehension. Garg and colleagues investigated how students performed using a digital model of the carpal bones when asked to study and learn from key views versus interactive or multiple rotational views of the model [15]. Their results did not support the concept that students learn better with rotational virtual reality-type models. Indeed, they "cautioned" educators to carefully consider the inherent characteristics of the models before deciding to use virtual reality-type images in a pedagogical approach [15, 16]. Levinson et al. suggest learner control of multiple views in more complex digital models of a structure, such as the brain, may impede learning, particularly for those with relatively poor spatial ability [17]. Despite caution flags, Brewer et al. suggest that learner control of models might attract novice learners, as the idea of "exploration" of virtual models leads to greater spatial comprehension [18]. Nguyen and colleagues suggest that an individual's spatial ability affects comprehension that involves not only object orientation recognition but also understanding how a 3D structure appears both in shape and locality in cross section [19]. Importantly, their results demonstrate that not all images are created equally as persons with lower spatial ability take longer to complete tests and make more mistakes. Finally, even anatomical testing validity may be inadvertently undermined by incorporating questions that utilize images in their answers as image use significantly influences both test item difficulty and the question's discriminatory power [20]. From this sampling of anatomical pedagogic research, it is clear that the old adage "a picture is worth a thousand words" is indeed true! However, not all viewers will form the same words nor divine the same meaning.

Good teachers are constantly exploring different methods to attract the attention of the entire class. In efforts to mediate perplexed students, technology has led us to believe that dynamic multimedia-embedded "PowerPoint" presentations are the best way to exude information and the learner will simply soak it up. Complex images, movies, 3D digital models, and even personal augmented reality are becoming increasingly accessible to the anatomical landscape of the classroom or lab. Are educators moving in the right direction with good pedagogic principles? Or is the development of tools through technology leading our teaching? It is paramount that educators understand the impacts that these sexy, futuristic, and attractive tools of our educational arsenal have on our students. In some cases, effective teaching may require large powerful tools, while at other times more subtle approaches could be much more useful.

Increased Cognitive Load Diminishes Learning

As the field of research in anatomical pedagogy broadens, new research paradigms are emerging which explore previously ignored facets of our educational practice. The concept of learner's cognitive load capacity, and in particular, the consequences on individual's working memory, is one area of image-coupled pedagogy that is receiving increasing attention. The term cognitive load was coined in the late 1970s by John Sweller and has since been the subject of much research and refinement [21, 22]. As digital tools have made their way to the educational mainstream, the theory of cognitive load has undergone changes to incorporate the use of multimedia technologies for learning and instruction.

Richard Mayer is perhaps best known in cognitive psychology for his timely work describing the theory of cognitive load and how it is applied to multimedia intersecting with knowledge translation [23]. Interestingly, even in the early days of multimedia in education, Mayer expresses concern over how much information a learner can process given the novel and increasingly rich methods offered through multimedia channels [24]. Mayer demonstrates that creators and users of multimedia learning should reduce cognitive loads on our learners to enhance learning [25]. But what is cognitive load? Chandler and Sweller [26] suggest that learning can be significantly reduced by multiple drains on the cognitive resources of the learner, hence the electrical analogue of a load. Built on the work of Sweller [27], Mayer [7] suggests a triarchic model of cognitive load highlighting intrinsic, germane, and extraneous cognitive processing, describing how each can separately draw upon the learner's cognitive capacity.

A central tenet of cognitive load theory, as it pertains to multimedia, is that learners engage in different cognitive processing [25, 28, 29] depending on the type and quality of the learning materials presented [30]. Each process draws on the individual's cognitive capacity [23]; thus some information may be quickly understood and organized into long-term memory for one subset of learners but may be arduous for others. The goal for educators is to adopt proven methodologies and translate these approaches into their own specific style in order to make learning easier—yes easier—for the student! Three types of cognitive load are described below. In each case, the goal is to mediate loads appropriately through the purposeful design or use of our teaching materials and pedagogic approach to enhance learning.

The first form of cognitive load is termed *intrinsic*; it arises from cognitive processing required to apprehend and make sense of novel material. Intrinsic load pertains to the perceived complexity of the "stuff" introduced to the learner. The intrinsic load is described as being an integral part of the learning task that results from interactivity among the elements of to-be-learned materials. This component of cognitive load cannot be easily reduced without impacting the learning objectives [25]. In anatomical education, this "essential" processing is often viewed to be a large hurdle for the novice as the plethora of terms relating not only to the nomenclature but also to the orientation, location, and cross-sectional planes, and even function are often overwhelming. All is not lost, however: Table 27.2 illustrates three principles of essential processing that contribute to intrinsic load, and some general applications educators might follow to mediate intrinsic overload. Readers should recognize that despite using images in their anatomical lessons, the principles of modality and segmentation are important guides to effective presentation and can be achieved with attention to dosing of elements in their visualizations. In the latter part of this chapter, an example of segmentation of images is presented. Lastly, the principle of pretraining is often overlooked in anatomy but can be effectively accomplished utilizing good lecturing principles, whereby the leader of the discussion presents a quick plan for the learning activity incorporating concepts from the previous day.

Table 27.2 Principles of essential processing and applications to improve their effects

Principle	Application
Pretraining	Begin lessons with an overview of important terms, overall relationships, and explain any jargon you might use
Segmentation	Present materials in short sections rather than in one continuous unit
Modality	Use images coupled with spoken words rather than a long string of written words during presentations

The next type of cognitive load is termed *germane* or *generative* (Table 27.3), and it is related to cognitive processes dedicated to making sense of the materials, organizing it mentally, and integrating it with any prior knowledge and mental schema the student might already possess [31]. Application of germane processing principles in face-to-face scenarios will foster good generative processing in your students. Generative load is often attributed to learner motivation and preference. Therefore, if the educator can facilitate these applications, learner attention will improve, and more information will be appended to the students' long-term memory as knowledge.

Table 27.3 Principles of generative processing and applications to encourage the process

Principle	Application
Multimedia	Present words and images rather than words alone
Personalization	Use conversational speech rather than formal speech when presenting
Voice	Present speech with natural human voice rather than a computerized one in online scenarios
Image	Include speaker's image on the screen from time to time if materials are being presented online

Table 27.4 Principles of extraneous processing and applications to mitigate overload

Principle	Application
Coherence	Delete extraneous words, sounds, or images
Signaling	Highlight important terms and images
Redundancy	Remove redundant captions from narrated animation
Spatial contiguity	Position critical terms next to images
Temporal contiguity	Present corresponding words and images simultaneously

The last form of cognitive load is called *extraneous* load (Table 27.4). It refers to the cognitive processing that does not serve the objective of the learning exercise and is mostly imposed by inappropriate approaches that ignore working memory limits. As educator's materials surpass thresholds in students' extraneous load capacity, the effects are manifested by learner confusion and/or frustration and therefore need to be minimized. The overall goal of educators is to manage intrinsic loads, reduce extraneous load, and encourage environments that facilitate germane loads.

Methods to Reduce Cognitive Load Using Visualizations

In order to understand cognitive load as it pertains to lectures, presentations, and multimedia in general, three assumptions are made. These assumptions come from cognitive science and form the basis of how the human mind works with respect to information processing [25]. For a complete review, the reader should see Mayer's cognitive model of multimedia learning [7] and refer to Fig. 27.1 for a pictorial overview. Briefly, the first assumption treats the sensory pathways related to seeing and hearing as dual channels where learners process the inherent sensory information in each channel separately yet

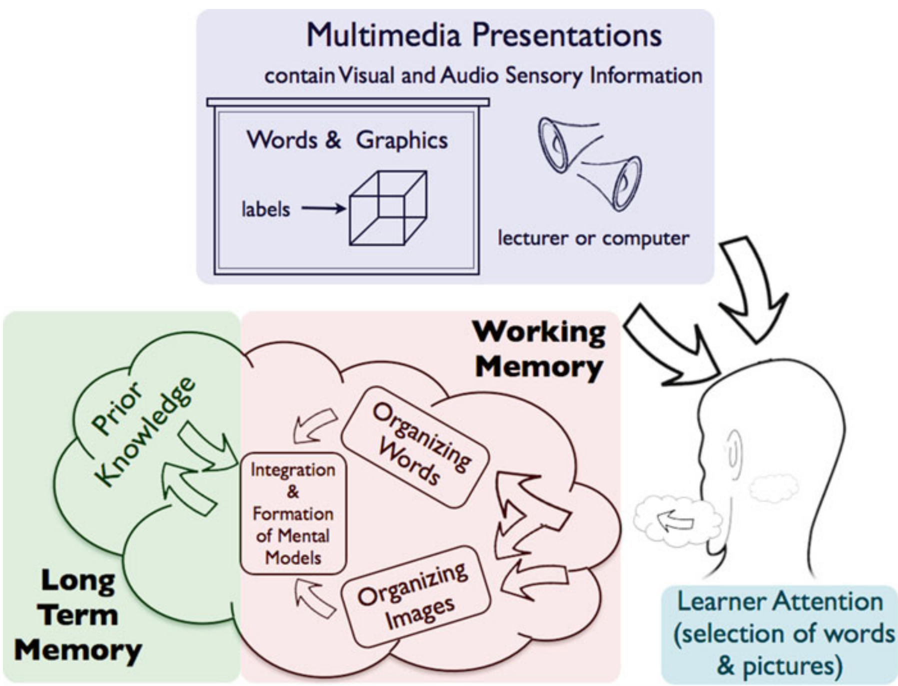


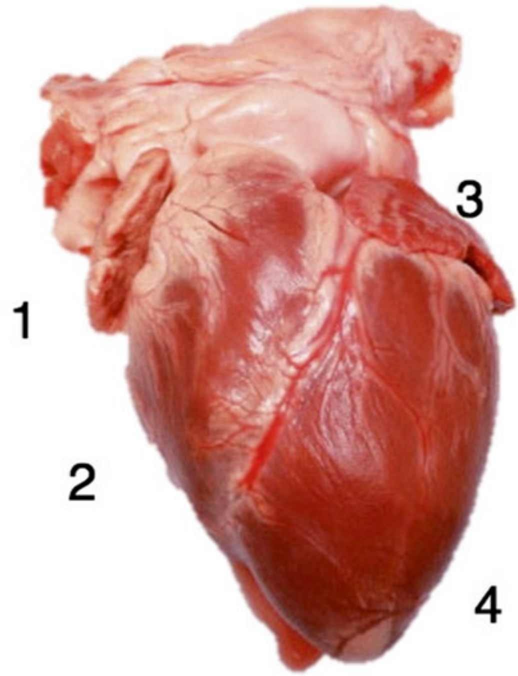
Fig. 27.1 Illustration of the cognitive theory of multimedia learning. The learner (*bottom right*) participates through apprehension of multimedia where dual sensory channels bring sensory information to the working memory of the learner. Information in the working memory must quickly be organized and encoded into mental models for organization in long-term memory

simultaneously. The second assumption is that of capacity; learners have very limited capacity to process information in each channel at one time. Finally, the assumption of active processing indicates that learning is not, and cannot, be a passive process. Importantly, learning will not occur unless attention is given to relevant material [32] using vision and audition in what Mayer refers to as sensory memory. Sensory memory is of very short duration and supposed unlimited capacity that attends to all environmental sounds, images, words, etc. Words and pictures are selected from our attention and brought into the limited working memory component of cognition. The working memory of an individual has temporary and limited storage that temporarily holds and manipulates the selected verbal and visual information. The information in working memory must be rapidly organized, contrasted, compared, and worked into mental models [31]. The mental models are either formed anew or may be integrated with schema, already present in the form of prior knowledge. Prior knowledge of a subject differentiates novices from experts. The learner appends this newly constructed information to their long-term memory, which is thought to be of unlimited capacity [25, 28].

In order to demonstrate methods aiming to decrease cognitive overload, an example of an introductory lesson on the heart is employed. In the accompanying figures, the instructor is giving an overview of the heart chambers and the valves separating them. In Fig. 27.2, examples of potential cognitive overloads are presented, while in Fig. 27.3, the multimedia approach was altered to reduce cognitive load. The following paragraphs outline what the educator can do mechanically with the visualization during a demonstration or lecture. Realize that this is a static picture; the importance of the following paragraphs will be heightened should the educator utilize one of the many software programs available on the market that are dynamic in the sense that they can move or can strip layers off the anatomy, in essence, change in front of the learner.

In Fig. 27.2, the instructor utilizes an actual photograph of the mammalian heart with numbers close to pertinent, but somewhat ambiguous, locations. The numbers then refer to a lengthy legend below where information is presented. It may be tempting in your slides or demonstrations to include dense information but doing so will only serve to increase cognitive load on the learner. The increased extraneous load of Fig. 27.2 will lead to decreased learning as the multimedia principles illustrate low coherence as there is too much information, lack of signaling as the numbers are next to ambiguous structures, and poor spatial contiguity characteristics as explicatory text is distant from the picture (see Table 27.4). The inclusion of excessive information on one's slides is a common mistake and should be avoided at all costs. Instead, the instructor might commence with the photograph to demonstrate how complicated the actual structures appear in vivo (Table 27.2—overview). The instructor would then transition to simplified diagrams (increasing coherence) in a very prescribed and stepwise fashion giving only parts of the diagram sequentially (Table 27.2—segmentation), using good oration (Table 27.2—modality), and present the diagram and perhaps a few key visual examples to learners as demonstrated in Fig. 27.3a, b. Utilizing a "less is more" approach with multimedia takes advantage of both the visual and auditory (dual) channels in the learner and enables better cognitive processing, thus cognitive load reduction. Taking advantage of maximizing essential processing principles (Table 27.2), the learner can then better attend to key information, rather than trying to decipher the message. Utilizing a simplified visualization while making use of the spoken word accompanying these images effectively achieves the effect of modality in a lecture scenario.

In concert with the modality effect, good instructors also know how to pace their messages and visual materials. The first approach affecting pace is the segmentation principle (Table 27.2). Segmentation, sometimes called chunking, can be a temporal factor where the instructor simply needs to slow down to employ purposeful repetition of important information (verbal signaling), highlighting important structures (verbally and visually) or giving pertinent analogy for the students to both see and hear (modality) information presented in chunks. Instead of an overwhelming image (Fig. 27.2),



1) Right Atrium	2) Right Ventricle	3) Left Atrium	4) Left Ventricle
Located in a right anterior superior-lateral aspect of the heart. It receives systemic deoxygenated blood from superior and inferior vena cavae from the upper and lower aspects of the body respectively. It is a thin-walled chamber. The blood within must move through the tricuspid or right atrioventricular (AV) valve.	Located in a right anterior inferior-lateral aspect of the heart. It receives systemic deoxygenated blood from the right atrium. It pressurizes the blood for immediate transfer to the lungs for gas exchange; thus, it has more muscular walls. Blood leaving this chamber passes through the chamber's infundibulum and through the pulmonary valve.	Located in a left superior-lateral aspect of the heart. It receives blood from the lungs, therefore oxygenated, via the pulmonary veins. It is a thin-walled chamber that passes blood through the mitral or left AV valve to the left ventricle. Here, the LA is slightly hidden due to rotation of the heart.	Located in a left anterior inferior-lateral aspect of the heart. It receives blood from the LA. It has the thickest walls since it must pressurize the blood to overcome systemic vascular resistance. Blood leaving this chamber enters the aorta as it passes the aortic valve.

Fig. 27.2 Example of a multimedia slide incurring increased extraneous loads. The use of ambiguous color photographs, lack of cues for the viewer, and much interesting, but superfluous, information will all detract the learner from essential processing through increased extraneous load

educators should consider simplifying visuals and using sequential figure components that parse the learning materials into a step-by-step fashion (Fig. 27.3a, b) matching visual representation with auditory explanation (spatial and temporal contiguity). By combining the principles of segmentation, modality, and contiguity, educators enable learners to "chunk" information more efficiently [6]. For the learner, chunking doses the amount of information present in working memory, aiding information transition to long-term memory (Fig. 27.1).

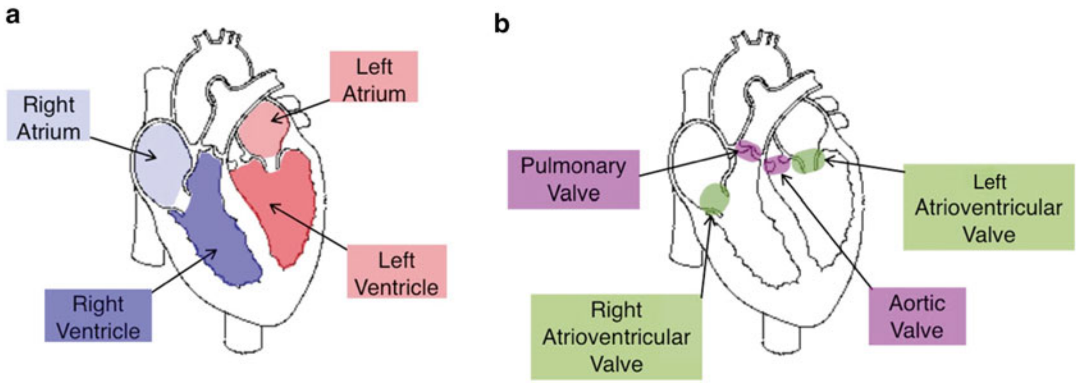


Fig. 27.3 (**a**, **b**) Depiction of a simple heart illustration that might be used in multimedia environment, including lectures. These diagrams incorporate multiple aspects of cognitive load-reducing techniques that affect extraneous processing. This simple set of diagrams would be part of a series of diagrams that are "built" in a stepwise fashion for students that introduce one element (label) at a time. They would be used in concert with good presenter narration with meaningful repetition of the important terms geared to the objectives of the lecture or multimedia exercise. The use of color and transparency should also be incorporated to make borders of adjoining anatomy clearer for the learners. This approach incorporates coherence, signaling, and spatial and temporal contiguity (Table 27.4), enabling students to chunk information and link increasing preknowledge with new information

Often, to reduce cognitive load, multimedia images and accompanying oration need to be simplified and streamlined in a process Mayer and Moreno describe as weeding [25]. The goal of weeding is to eliminate potentially interesting but extraneous material to reduce the processing of the ill-fated extraneous overload. By weeding out many of the words in Fig. 27.2, or potentially distracting materials like background noises, or poor video clips, the coherence principle (Table 27.4) is applied and the learner can move more information from working memory to long-term memory. Contrast the image and accompanying information in Fig. 27.2 with that of the images in Fig. 27.3. This process may be difficult for educators, for as we become proficient in a discipline, the discipline and its intricacies tend to take on an ego of its own, and we convince ourselves that students need every individual detail. This simply is not true and Mayer describes this information as "seductive details" [33], and these details should be removed to enhance learning.

Finally, as many courses are moving to online formats where video and narration is often used, educators need to keep narration in time with the presentation and to avoid overly repetitive delivery. Mayer refers to this approach as the temporal contiguity principle [34] (Table 27.4). Although elaborate digital demonstrations may be tempting, they hold limited quantitative pedagogical support, for by their nature, they introduce additional and different cognitive demands on the novel learner. Students with more advanced base knowledge will not fall victim of high cognitive loads for they already have prior knowledge and append new information to schema in long-term memory [35]. Lowe questions the widely assumed learning edge animated graphics have over static graphics in a learning environment. Lowe suggests that cueing, in the form of "specific strategies and targets," need to be in place in order for learners to create accurate mental representations from interactive animations [36]. If the use of complex visuals or software is deemed necessary with novel anatomists, these visualizations should be well explained within the context of the lesson or used to provide a summary of the material in question rather than a vehicle by which the information is introduced to the students.

Summary

To consider multimedia visualizations as ubiquitous tools for successful pedagogy in anatomical education is overly simplistic and incorrect. Much hinges on the base knowledge of the learners, and the goal of the educator is to meet the objectives of the course or activity while challenging the learner. Uses of multimedia that are too wide in the spectrum between the basal needs or challenges to the learner will result in boredom or confusion, respectively. In either case, learning will decrease. Addressing the pertinent anatomical details in accordance with the objectives is truly important, but it is equally important to apply strategies that will enhance learning. The use of multimedia has complicated the challenge to educators, but enhanced learning can be achieved by careful material preparation and presentation with cognitive load in mind. Good instructional methods can be successful across multiple forms of media (face-to-face and online) and any discipline [33]. These methods can be summarized to four short rules that maximize learning:

1. Pay attention to the cognitive loads generated with your learners. The tools (programs, presentations, pictures, and words) will affect cognitive load. *Less is always more*. That is, less "cognitive load" will yield more "learning."
2. Orate to the ears of the learners and demonstrate to the eyes. Use our two main sensory channels (dual channels) to your pedagogic advantage.
3. Chunk, highlight importance, and pace your presentations using multimedia so the learner is not overwhelmed.
4. Simple visualizations (non-dynamic line drawings) with proximal labels that are color-coded are the best place start with new learners. As the base knowledge of your learners rises, so too can the complexity of your demonstrative tools.

Educators should strive to simplify all aspects of their multimedia use to reduce cognitive load, in particular extraneous load [7] as it is counterproductive to the objectives of their overall mission as a teacher. Multimedia design principles are dynamic and will be heavily influenced by the experience of the learners [37] as advanced learners can draw upon previous knowledge more readily [35], which the instructor should be aware in order to adjust the visualization, language, and pace accordingly. Just as lecturers attend to the verbal detail given to our class, care must be also exercised as to what and, importantly, how we demonstrate to the class as well. By paying attention to the aforementioned principles of multimedia learning, and by organizing visualizations accordingly, regardless of the tool involved, educators will find student satisfaction and success to rise.

As educators in an increasingly fast-paced and digital society, it is important to stay abreast of novel and evidence-driven pedagogic principles and practices. We should constantly weigh ongoing practice with our previous experience in the face of ever-changing student expectations and technology. Until technology is nimble and adaptive to the multitude of learner styles [38], we as educators are the only intelligent buffer that is able to modify our approach to support deep learning in all our learners.

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Essential E-Learning and M-Learning Methods for Teaching Anatomy

28

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Over the past two decades, computer-enhanced learning has evolved rapidly, along with the development and explosive growth of the Internet-based World Wide Web and its associated hyperlinked multimedia methodologies. Early work on "electronic learning" ("e-learning" [1]) focused primarily on establishing effective methods for using educational multimedia on personal computers (PCs) and via the Web. More recent refinements in basic e-learning concepts have included mobile ("m-learning" [2]) and ubiquitous learning ("u-learning" [3]).

M-learning and u-learning methods acknowledge that current-generation students (especially in health sciences) are generally very mobile and relatively experienced in using the Web and self-adopting personal technology, such as smartphones and tablet computers. The u-learning concept in particular recognizes that with ubiquitous computing technologies, students can acquire knowledge virtually anywhere with appropriately designed online educational resources and mobile applications. This chapter will most frequently refer simply to e-learning when discussing computer-based methods for supporting anatomy teaching, with the understanding that appropriately designed learning resources should ideally be equally usable on PCs and mobile devices, in-classroom and without.

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With continuing curricular evolution, innovation, research, and development with new e-learning resources may be the key to successful implementation of new curricula and classes. For the new anatomist, understanding and mastering e-learning methods and tools can provide the basis for career-long innovation in education, as well as a historical share in the progressive application of useful new technology. And although this discussion will refer to anatomy most frequently in the context of medical gross anatomy, it should be understood that these methods and strategies apply equally well to teaching histology, histopathology, neuroanatomy, and embryology at multiple educational levels.

Types of Curricula, Methods, and E-Learning Resources

Whether a new anatomist is entering a long-established school with mature instructional resources management *or* a newer program still building online learning capabilities, it is crucial to understand the context of anatomical e-learning development relative to changing health sciences curricula. Although in absolute terms, e-learning is not that old globally, having appeared and evolved rapidly during the careers of senior anatomists, it will continue to evolve locally with changing curricula and availability of new technologies. *In prognostic terms, it is easier to see how things can change, when you understand where and what they came from.*

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Anatomy E-Learning Legacy and Curricular Change

Legacy basic medical anatomy instruction in the latter twentieth century typically centered around daily and weekly serial lectures on regional topics, coupled with progressive student dissection (and microscopy) laboratories. As PCs became more multimedia-capable and widely available in the early 1990s, the first e-learning resources were developed. These variably included desktop-published lecture notes, early presentation software, computer-based laboratory instructions, and the first, non-networked PCs in anatomy laboratories, equipped with video disc and CD-ROM players and early structural image archives. These disc media were transitory: Other types of technology will have limited lifespans for various reasons.

Digital video became a practical educational tool in the mid-1990s, supporting the recording of lectures and laboratory demonstrations. The ongoing revolution in computer-based clinical imaging modalities (computed tomography, CT; magnetic resonance imaging, MR; and ultrasonography, US) also facilitated increased integration of digital radiology with anatomy instruction. With the advent and rapidly spreading usage of the Web, all these digital media became distributable via networked computers, institutional Web pages, and servers. By the end of the twentieth century, with the stationing of PC workstations at individual dissection stations, what we now recognize as basic e-learning resources became an integral part of classical "lectures plus labs" instruction.

As Western medical school curricular reforms continued to spread, increased time was reallocated for multidisciplinary problem-based learning, early clinical experience components, and patient simulations. Reduced time was allotted for conventional basic sciences classes, especially in the USA, and overall anatomy class time decreased [4–6]. Hours available for lectures and laboratory dissection and microscopy were drastically reduced, forcing greater reliance on prosections, anatomical models, and increasingly capable multimedia software. E-Learning resources became essential for the delivery of anatomy instructional content in these new curricular regimes.

Effective in-class implementation of e-learning methods came to depend on the support and daily use of institutional instructional technology infrastructure, including lecture hall projection systems, network connectivity, and laboratory-based PCs with large-screen displays. Earlier classes of students may have had computer ownership requirements as a condition of admission; current-generation students typically own PCs (or laptops) and personal mobile devices with broadband access, although this may not be the case uniformly throughout the world. Current e-learning involves heavy use of student-owned technology.

Types of Curricula and E-Learning Methods

New anatomists beginning their first teaching assignment in a health sciences school typically find themselves involved in an evolving educational model. Thus, the ongoing task could be to transform or to replace content from existing lectures and laboratories via some new, e-learning technology-enhanced regime. In that context, it is useful to consider briefly some more recent online learning models that have been defined by universities for online instruction or e-learning. The anatomy components of different types of curricula are examined in greater detail in Chapter 34.

A given school may have a spectrum of e-learning or online course methodologies, ranging between the extremes of conventional lectures and laboratories supported by discrete computer-based media to fully online (classroom-free) courses dominated by an integrated digital learning environment.

"Online lecture" can describe a range of content available for Web access, within a continuum extending from text files with simple audio or video-enhanced presentations, to captured lecture videos, to highly produced studio recordings. Lecture capture records an instructor's presentation as it is delivered live in the classroom. When used to record a well-presented, live presentation, lecture capture can be an effective review tool for students, as well as providing media content for transitioning to other types of instruction (see below). Production studio recordings are typically created outside the classroom by multimedia developers and may include features of a highly polished professional video, including split-screens, custom animations, and transitions. As a whole, online lectures can play an important part in a course, but online lectures alone usually do not constitute the entirety of a class. Chapter 9 covers preparation and recording of lectures for online delivery.

In "blended," "hybrid," or "mixed-mode" instruction, critical elements of course content may be delivered online, while student–faculty contact is largely shifted to digital means, with other possible forms of contact [7]. For example, all lectures could be delivered online or in person, while student interactions might be conducted through discussion boards or chat rooms. Perceived institutional benefits of blended instruction might be that physical classroom space and/or faculty and student time can be freed for other uses (e.g., in "asynchronous learning," wherein lectures can be accessed online at virtually any time).

In "inverted" or "flipped" instruction, lectures are prerecorded and provided as online content, while on-campus class time is spent discussing lecture subjects and other course materials in greater depth and scope. It generally differs from blended instruction primarily in that there is no intended saving of physical classroom time: Instructional time is repurposed rather than reduced. Inverted or blended instruction may also employ integrated self-learning modules (see next section).

Other curricular models include problem-based, case-based, and team-based learning. Although these methods are often used in discrete, multidisciplinary class sessions separate from those dedicated primarily to anatomy learning, case- and team-based methods can also be used as a focus for anatomy laboratory exercises. Although e-learning methods can be used to support such small-group learning experiences, they will not be covered here (see Part 3, Chapters 14–16).

Learning Theories and Instructional Design Principles

The design and use of e-learning resources are best guided by established principles of *instructional design*, rooted in cognitive and behavioral research as applied to adult learning. Such principles apply to the organization of specific courses and to delivery methods and tools, including e-learning. Although there are several different models for instructional design [8], perhaps the most simply compelling is that of Gagné and colleagues, which predates the rise of computer-enhanced learning and has since proven its soundness for e-learning [9].

Gagné's theories distinguish nine different instructional events [9] and the associated cognitive processes involved in learning (parenthesized). These are (1) gaining student attention (reception); (2) informing students of the learning objective(s) (expectancy); (3) stimulating recall of prior learning (retrieval); (4) presenting the stimulus [lesson content] (selective perception); (5) providing learning guidance (semantic encoding); (6) eliciting student performance (responding); (7) providing feedback (reinforcement); (8) assessing performance (retrieval); and (9) enhancing retention and transfer (generalization). Comprehensively supporting these processes is the foundation of sound instructional design and effective learning media development. For example, attention-getting e-learning resources should clearly define and focus on discrete learning objectives, recapitulate earlier relevant knowledge, provide self-assessment with feedback, and encourage application of knowledge with clinical content.

Gagné further defines several additional learning principles: (1) different instruction is required for different learning outcomes; (2) events of learning operate on the learner in ways that constitute the conditions of learning; (3) specific operations that constitute instructional events are different for each different type of learning outcome; and (4) learning hierarchies define what intellectual skills are to be learned and a sequence of instruction. In a nutshell, instructional design principles dictate developing and using educational resources appropriate to the type of learning and desired outcomes, with a hierarchical approach to skills acquisition in sequence.

In contemporary education, Gagné's familiar taxonomies are considered to apply most directly to "transmissive learning," wherein the teacher is viewed as primarily responsible for conveying knowledge directly to students (e.g., in lectures and laboratories). In the last two decades, transmissive approaches have been depreciated in medical school curricular changes, and other theory-based learning methods have been preferentially promoted.

With *constructivist* approaches to learning [8], the meaning of knowledge is assumed to be personally defined ("constructed") by individual students, frequently in groups. Rather than being a knowledge transmitter, an instructor is viewed as a facilitator. Sharing some common principles with *constructive learning*, *situated learning* [10] depends on knowledge and skills being learned in social interactions in practical working contexts. In modern anatomy curricula, problem-based learning and anatomy laboratories can be viewed as instances of both constructive and situated learning. Anatomy learning during clerkship and residency training would be considered situated.

When designing e-learning resources, it is best to support these aforementioned basic adult learning processes, while implementing what *instructional research* has shown works best in practice. Mayer [11] has provided a useful perceptual/cognitive framework practically integrating additional multimedia learning principles with instructional software design objectives. Multimedia learning requires processing both verbal and visual information via separate, limited-capacity cognitive channels, progressively through sensory memory and short-term into long-term memory. In designing instructional multimedia, it is thus important to avoid presentations that interfere with students *selecting* relevant verbal and visual information, cognitively *organizing* and *integrating* it, and processing it through successive, limited short-term and long-term memory channels. Designs that demand *extraneous* processing (e.g., with descriptive text on separate pages from associated images) should be avoided because they interfere with *essential* (representative) and *generative* (integrative/sense-making) cognitive processing. Designs should be avoided that heavily favor a single information channel or overload short-term memory with too much information.

Methods and Software Tools for E-Learning

The beginning teacher of anatomy requires a basic set of computer production tools—software—and methods for creating and using e-learning content, whether intended for live lectures, online presentations, laboratory applications, or integrated self-learning modules. One must also understand best methods for deploying teaching resources files for specific classes, either by direct loading onto PCs or distribution via the Web. Fortunately with prior graduate or medical education or teaching experience, there's a good chance you have mastered many of the basic programs and methods that you need.

The most important complete e-learning production software collection for anatomy faculty includes programs for word processing, image processing, presentation, portable document format (PDF) production, video production, Web development, and Web hosting. With some appropriate planning, the anatomical e-learning resources developed should be usable on legacy PC systems, lecture hall and laboratory presentation systems, as well as on popular mobile devices like tablets and smartphones (m-learning) for functionally ubiquitous learning (u-learning) that is not tied only to classroom settings.

Word and Image Processing for E-Documents

Word processing is an important, foundational part of e-learning, for preparation of distributable lecture notes and learning objectives, laboratory exercise instructions, structural identification lists, and examinations. Well-crafted lecture outlines can be imported into presentation software, to serve as the organizing content for lecture slide production. Microsoft Word by default saves files in the .doc or .docx (XML) formats, which are editable (unless locked) and may not be read uniformly on all mobile devices and PCs due to font differences and other platform-specific restrictions. Word and other Word processing programs are also capable of exporting and importing HTML (hypertext markup language) files, which can assist with developing e-learning Web pages. Furthermore, Word documents can be exported as PDF files or serve as other source for developing e-books (see below).

Image processing is also a necessary part of producing multimedia documents, presentations, and Web pages with embedded pictures. Whether images are obtained from a published collection, digital photos, or Web-distributed images (e.g., from a Google image search), some rudimentary image processing will usually be necessary, such as cropping, color balancing, captioning, or file-type conversion. All these functions are easily and routinely performed with Photoshop or other comparable program.

In general, even if large TIFF (tagged image file format) images are the starting point, e-learning content typically works most efficiently with files output in compressed JPEG (Joint Photographic Experts Group) format. For some Web and mobile applications, the PNG (Portable Network Graphics) files may be preferred, even if they are larger than JPEG files.

Digital Presentations for Lectures, Labs, and Other Uses

Since the mid-1990s, the de facto standard for presentation software on Windows and Apple PCs has been Microsoft PowerPoint (PPT), still useful for developing and giving lectures, for creating laboratory learning module applications, and for designing Web resources. In fact, clever development of PPT and other presentation files can allow the same content to be used in a lecture and in associated laboratory exercises. PowerPoint presentations can also incorporate internal hyperlinks to allow jumping between pages and linking to external Web pages on networked computers. Lecture presentations can be enhanced by embedding videos, audience response system (ARS) technology and in-line quiz pages [12], and slide-based quiz games (e.g., Jeopardy [13]). Lecture content can also serve as the starting point for "inverting" or "blending" instruction or serve as core content in online self-learning modules [14] that can complement existing lectures and laboratories (see below). As an alternative for adventurous anatomists, presentations can be developed and delivered as hyperlinked Web pages and imbedded media. Apple iPad tablets and AirPlay wireless streaming have been used with HDTV monitors to present faculty explanations of dissections in the author's anatomy laboratories.

Portable Document Format

Portable Document Format (PDF) is a multimedia file standard developed by Adobe, based on the PostScript page composition and printing language. At the basic level, it supports formatted text files with embedded images that will display consistently (WYSIWYG) on different PCs platforms as well as most mobile devices (e.g., iPad and Android tablets). It can also support internal navigation hyperlinks and select video file and 3D object embedding, although these advanced features are not generally supported in standard mobile device PDF apps. PDF is the most commonly used, externally loadable e-book format, so basic text + image PDFs can be read on most popular mobile readers (e.g., iBooks, Kindle, and Nook). PDFs can be directly exported from virtually any PC application (e.g., PowerPoint, Word, or Web browser). Specialized features (e.g., enabling User Extended note taking for students in Adobe Reader) require using Acrobat Pro, part of the Adobe Creative Suite that includes Photoshop and the DreamWeaver HTML editor.

Advantages of Exporting Lecture Slides and Notes as PDFs

- Compact, standardized file format for what you see is what you get (WYSISYG) display on any PC or mobile device
- Most commonly used and supported e-book/e-reader format
- Degree of protection against easy, uncredited appropriation and reediting of author's content
- Usable on mobile devices (e.g., iPads and Android tablets)
- Students can make notes with PCs and laptops when document is Saved As Reader Extended PDF (Export setting in Acrobat Pro)
- Students can make notes with iPads and Android tablets using selected PDF apps

E-books

Although books reproduced in digital format—e-books—have been around in some form for nearly two decades, the popularity of e-books began to surge in 2010 with the availability of smartphones and tablets. A Pew Internet and American Life survey in 2012 found that nearly 21 % of the American public had read at least 1 e-book [15]. Although it has been popularly asserted that millennial students read less than their predecessors, given a range of individual differences in learning styles [16], the current widespread availability of popular anatomy texts e-books offers another e-learning option for tablet owners. In addition to collecting all curricular content in PDF format as previously mentioned, distribution in the "unprotected" open EPUB standard or proprietary iBooks formats can offer students additional options for building personal e-learning libraries. Useful free programs for creating these formats include Calibre (multiplatform EPUB and other formats) and iBooks Author (Apple proprietary EPUB3 format). Unprotected PDF and EPUB files can be "side-loaded" into popular PC and mobile e-reader devices and programs.

Video Production and Acquisition

Videos can contribute to e-learning resources in many ways, and digital video has improved greatly since the first Web streaming formats became available in the 1990s. Currently the most widely used high-quality formats are based on the Motion Picture Experts Group MPEG-4 or h.264 standards, which are compatible with PCs and most mobile devices. There are several major methods for producing curricular MPEG-4 video recordings, and perhaps the easiest is the previously mentioned lecture capture, which saves all presenting computer screen displays (including pointers) and audio. Screen capture programs, available for most computing platforms, can easily be used by faculty to record their own live PowerPoint presentations. In more elaborate solutions, lecture capture files can be automatically recorded through a dedicated hardware server integrated with the digital projection system (e.g., as at the author's school).

Offline or production studio video can be created with collected presentation slides, camcorder recordings, audio and video clips, images, and animations using programs like iMovie, Premiere, or Avidemux. Such videos can be extremely sophisticated, presenting visual information in a more dynamic way than captured lectures. Furthermore, with proper permissions, clinical vignettes can be integrated.

"Podcasting" is a more recent, mobile-centric method for online distribution of multimedia, especially video and audio. The essential elements of a podcast are prerecorded media files (which can include documents), an associated descriptive Web page with media links, and an XML file which sets up a "Really Simple Syndication" (RSS) feed with metadata that define and control automatic distribution of media files to subscribers. Lecture podcasts can be linked to a school's learning management system (see *Online Hosting* below).

Before beginning an elaborate video production, it is usually worth doing an online search for available content. Among other sources, Google's Web-based YouTube video service can serve as a source for usable files, and many donated educational videos can be found there [17]. It is an important principle to list full presentation and copyright credits for any such freely accessible and distributable video.

Web Design

The Web has become the essential online infrastructure that integrates all methods of e-learning, just as it integrates most aspects of modern urban life. The Web also provides the means by which integrated course management systems organize curricula and operations for whole schools (see next Section). But even if a course management system is available to organize major functional services and generic learning resources for all classes in a curriculum, having stand-alone Web services for anatomy instruction can be invaluable for supporting laboratories, self-learning modules, and hosting specialized anatomical media distribution. Web based self-learning resources (see below) for online "virtual anatomy" laboratories have been developed and subjected to usability testing with favorable results [18].

Creating Mobile/Ubiquitous E-Learning Web Resources

- Appropriate HTML5 or XHTML coding together with cascading style sheets (CSS) can be used to create adaptive Web pages that display optimally on PCs and mobile devices.
- (X)HTML "meta" statements scale Web page display size appropriately for the screen of the specific connecting device.
- Different CSS parameter sets for PCs and mobile devices set the font and other layout characteristics appropriate for each device.
- Use MPEG-4 (not Flash or other plug-in formats) for video.
- JavaScript programming can be used to replace Flash animation programming and complex 3D media formats.

Although many millennial students and staff may have experience that can be drawn on for educational Web resources design, it is extremely helpful for a new anatomist to learn the essentials of Web development and hosting, including HTML editing. Learning fundamental (or even advanced) Web design should not be an overwhelming challenge: There are numerous high-quality texts available, and free online development courses can be found with a bit of Web searching. Overall, the best teacher is personal experience gained by learning to use an HTML editor. See the next section for additional information about Web hosting and anatomy learning resources.

Virtual Anatomy and Other Simulation Methods

Different types of virtual anatomy or 3D image-based anatomical simulations have been used for instructional purposes for nearly two decades. Although immersive, stereoscopic 3D anatomical resources [19, 20] have not been widely disseminated, screen-based 3D simulations have seen more use as adjuncts to laboratory-based and online learning applications. Although earlier efforts focused on PC-based "screen simulations" requiring proprietary software standards [21, 22], current HTML5 programming methods make "virtual reality learning objects," derived from clinical imaging data, usable on mobile devices [23] (see Fig. 28.1). Similar methods can be applied to producing virtual anatomical models and panoramic virtual microscopy slides.

Other virtual anatomy simulations and commercial learning resources have been successfully developed from the Visible Human dataset [24], which was specifically conceived as a foundation for human simulation efforts [25]. One of the most recent developments of this technology for learning has been the Anatomage system [26], a touch screen table that supports "virtual dissection" of digital human models with integrated medical imaging. It remains to be seen whether such specialized, non-online technology will supplant or complement laboratory exercises

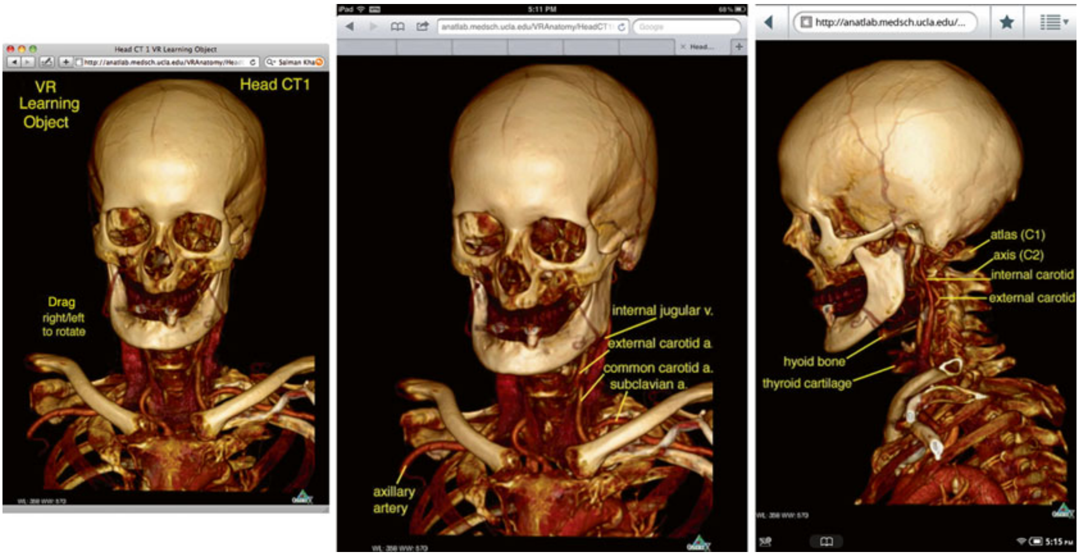

Fig. 28.1 Freely rotating Web-based virtual anatomy learning objects produced from DICOM CT datasets, demonstrating m-learning and u-learning usability on PCs and mobile devices: composite of three screen capture images. *Left*, MacBook Pro laptop with OS X Safari browser; *middle*, Apple iPad with iOS Safari browser; *right*, Barnes and Noble Nook Color tablet, Android 2.2.1 built-in browser. All images are shown at the same pixel resolution

based on human cadavers. Digital human models are covered in Chapter 27.

Other large-scale, more immersive online simulation systems have also been tested, wherein the user's "avatar" explores and interacts with a 3D environment that can include modeled anatomical structures or clinical simulations. The commercial Second Life [27] or the compatible free OpenSimulator [28] environments are currently examples of this technology.

Quizzes and Self-Assessment

Self-testing modules can play a vital role in motivating students to desired levels of performance and in allowing them to gauge their knowledge and progress [29]. Frequently, these functions will be provided online as part of a course management system (see below), and development consists of creating assessment questions that fit the specific system's question and answer boilerplate requirements. Separately, self-assessments can be implemented in lecture presentations using ARS technology [12] or embedded Jeopardy quiz game slides [13], associated with laboratory exercises hosted on an anatomy Web server or integrated in self-learning modules [14].

Integrated Self-Learning Modules

Self-learning modules [14] are comprised of a varying number of linked and interactive software components that students can progress through on their own to learn specific content. These typically include a presentation divided into segments, with self-evaluation at the end of segments, illustrative animations and videos, simulations or game components, and clinical case or problem-based learning components. Adobe's (Shockwave) Flash multimedia programming environment has been a particularly popular tool for producing such self-contained modules for PC usage, since Flash files can be downloaded from Web sites.

However, Web-based alternatives to Flash have become much more popular recently, with the widespread use of tablets and other mobile devices that do not uniformly support browser plug-ins or the Flash Player application. The HTML5 Web standard supports animation and plays common media files without proprietary browser plug-ins. A special advantage of HTML5 and other Web-programmed approaches to self-learning modules is that they may also be set up to use server databases, more easily supporting the collection of student assessment data and other learning performance measures. Implementation tools for Web-based self-learning modules include HTML(5) or XHTML, JavaScript, PHP (hypertext programming language) or Java (programming language), MySQL database server, and MPEG-4 videos.

Online Hosting Methods for E-Learning and M-Learning Resources

As the prime enabling technology for the "revolution" in effective e-learning methods, the Web remains the dominant communications channel or "medium" for the dissemination and sharing of educational resources. It is unusual to encounter a major health sciences school that does not currently use some type of Web-based course or learning management system (CMS or LMS; aka virtual learning environment) to organize the distribution of required content and information in current "clinically integrated" systems or multidisciplinary preclinical curricula.

LMSes are the overall unifying software for online learning resources access in contemporary schools. They integrate password-secured access for students and faculty with database-driven hierarchical organization of course- and year-based curricular content, date-sensitive calendaring, news distribution, small-group communications channels, global/group e-mail capabilities, and other socially networked information exchange in a combined large- and small-group educational environment.

To Do for New Anatomy Teachers

- Find out how an available LMS is being managed and familiarize yourself with how to use it.
- Identify the file standards and Web resource linking protocols supported by the LMS and be prepared to lobby management if you have special format or media needs.
- If LMS and/or anatomy Web services are unavailable, investigate department and administrative support and seek other faculty collaborators for establishing services.
- Learn the basics of Web design and multimedia production via books and online courses.
- If a curricular development group is not available, investigate support for Web-savvy student workers.
- Learn about available laboratory computing and network infrastructure, management, and planning.

Although an LMS may be used to distribute certain specific anatomy learning resources (e.g., lecture notes, slides, videos, and podcasts) uniformly with the other programmatic curricular content, a separate Web server is typically needed for running computing-enhanced anatomy laboratories and for supporting other multimedia resources that cannot be directly hosted by the LMS.

It is worth learning how to run a Web server, in order to facilitate hosting and control of specialized anatomy resources (e.g., virtual anatomy and online simulation archives), and commercial instructional software, as well as to facilitate the development and testing of new visualization and teaching methods. This need not be a forbidding or daunting challenge for scientifically trained anatomists. Web services are easily managed on the most popular Apache HTTP Server software [30], freely installable on networked Windows PCs, and pre-installed on

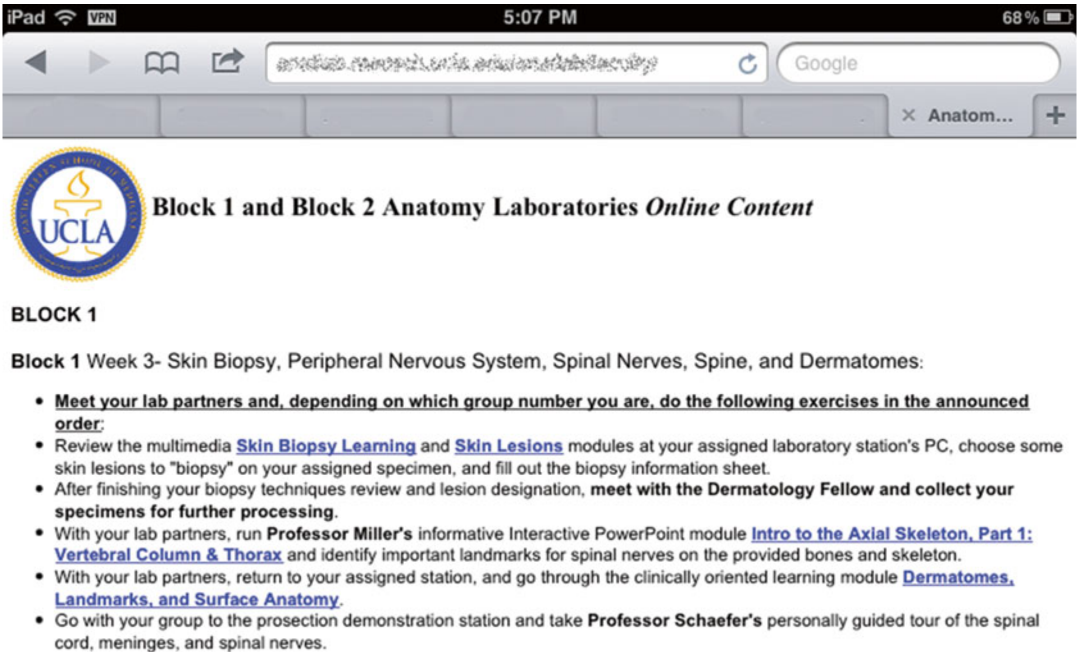

Fig. 28.2 Simple HTML Web page demonstrating how mixed model, cadaver prosection, and computer laboratories can be organized. The *blue* hyperlinks download e-learning media to the users' devices, whether they are PCs in the anatomy laboratory or personal computing devices. iPad screen capture image

recent Apple Macintoshes. For distribution, HTML and other media files are simply loaded into Apache's "home folder." The author has used a number of Web servers extensively and continuously over the last 17 years to provide daily anatomical educational resources access, including integrated embryology simulations and laboratories, basic integrated gross anatomy laboratories session software (see Fig. 28.2), and online laboratory prosection guides for surgery and obstetrics/gynecology clerkship reviews.

Using a dedicated Web server can also support the development and deployment of more complex learning resources linked to databases, such as the previously mentioned self-learning modules, that integrate presentation components with self-assessment components collecting student performance data. Such Web servers should be secured on a virtual private network or behind a firewall, in order to protect student data, faculty intellectual property, copyrights, and any copyrighted commercial media used.

Perspectives for Continuing E-Learning Development and Research

Mastery of instructional design and multimedia software methods can facilitate lifelong innovation, research in education, and publication, as well as provide creative satisfaction in developing new practical ways to enhance learning with technology. Chapter 42 provides more insight into educational research opportunities in anatomy.

In considering the effectiveness of specific e-learning methods, it must be recognized that variations in individual student capabilities and educational habits will affect the implementation and individual usage of e-learning methods. Despite common aggregate perceptions of "millennial" students, research evidence demonstrates considerable diversity in background, personalities, and learning styles, encompassing differences in technological predilection, multitasking, reading, and professional behaviors [16]. Chapter 2 further examines the characteristics of millennial-generation students, while Chapter 3 covers student learning styles.

Nguyen et al. [31] have shown that students demonstrate individual differences in visualization ability that influence the effects of dynamism and interactivity on learning task performance with virtual anatomical models. Furthermore, in studying more conventional e-learning media, McNulty et al. [32, 33] have demonstrated that although most may be familiar with Web-based educational resources, medical student usage of Web-based computer-aided instruction is complexly related to gender, individual learning styles, and personality variables (preferences). For example, one might expect greater elective use of certain kinds of interactive e-learning resources by students with more exploratory learning styles, and less by those with pragmatic behaviors more focused on acquiring itemized core knowledge needed for passing examinations.

Other findings about relevant behavioral and student attributes have been reported by Nieder and Borges [34] in an 8-year study of student use of online lectures. Predictable trends were seen in higher usage related to examinations, but there was also a high degree of individual variability, partially attributed to gender and differences in academic ability. In a more limited study, Nieder et al. [35] have also reported correlations between online lecture use and achievement motivation and VARK learning styles. These lines of evidence demonstrate that it is important to consider a range of individual students' behavioral and cognitive attributes in planning how to use e-learning resources in a specific curriculum.

There are other practical caveats for the development and implementation of new e-learning resources. Faculty need to consider protecting their intellectual property rights in producing e-learning media that might potentially be expropriated with free distribution or be used to eliminate or to downsize faculty teaching positions in favor of online content. Faculty could also be exposed to copyright violation challenges for embedded media, if students share content freely on the Internet. In many US schools, faculty own the copyright to their lectures, so lecture materials should show copyright notices appropriate to their institution, with acknowledgment credits for other included materials. Also, to reduce the risks of expropriation and other copyright violation, online learning materials should be secured on a password-protected Web site and/or on a virtual private network not accessible to the public.

An increasing concern for teachers, related to the increase in e-learning modalities coupled with curricular change, has been the growing conviction on the part of the public and politicians that online lectures and discussion boards can satisfactorily substitute for in-person classes, as exemplified by the growing popularity of massive open online courses (MOOCs). MOOCs largely promote entirely online learning at the low-yield "lecture tip" of the "interactive learning pyramid," with limited network-based student–faculty interaction. American schools in particular are being challenged politically to "revolutionize" their curricula by mass adopting these methods and offering degree credit for them. Certainly, the growing diffusion of blended e-courses in medical schools and the Association of American Medical Colleges hosting MOOC progenitor Salman Khan at their 2012 annual meeting [36] has done little to reassure American medical school professors that their personal teaching roles will not be jeopardized by the continuing increase in curricular e-learning content and asserted administrative ownership of such resources.

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The Use of Low-Tech Models to Enhance the Learning of Anatomy

29

Lap Ki Chan

Thanks to rapid advances in digital technology, highly accurate digital models of the human body are now available [1–4] based on actual sections of the human body or on radiological images [5, 6]. These models may allow scaling, coloring, manipulation, and dissection and have been used extensively in the teaching and learning of anatomy [7–11].

Despite the popularity of digital models, there is evidence that students learn significantly more using plastic three-dimensional models than using three-dimensional computer models [12, 13]. Less technologically advanced physical models are still being invented and effectively used in anatomical education. These physical models have unique educational value despite their low-tech construction [14]. When used appropriately, they can create a learning environment that enables the teacher and learners to interact, the learners to reflect on their knowledge, and the teacher to provide appropriate feedback. This chapter will describe the features and construction of these physical models and how they can be used effectively and enjoyably in the teaching of anatomy.

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Examples of Low-Tech Anatomy Models

The Midgut Rotation Apron

Chan [15] developed a model in the form of an apron for the learning of midgut rotation (Fig. 29.1). When the teacher puts on the apron, he or she represents the developing embryo. On the front of the apron are three tubes made of fabric, which are aligned end to end, representing the foregut, midgut, and hindgut. The midgut tube can be pulled out from behind the apron, representing the elongation of the midgut during embryological development. The teacher then rotates the midgut loop in a counterclockwise direction (when observed from the front), so that the distal limb of the loop lies anterior to the proximal limb, thus demonstrating to the students why the transverse colon lies anterior to the duodenum in adult humans. Another such wearable anatomy model is a T-shirt for demonstrating the organization of the peritoneal cavity [16].

The Perineal Space Model

This is a model for learning the spatial relationship between the pelvic cavity and the superficial and deep perineal spaces (Fig. 29.2). On a hung skeleton, the pelvic diaphragm, the perineal membrane, and the Scarpa's/Colles' fascia are represented by three pieces of paper of different colors and cut to different shapes to fit their anatomical positions.

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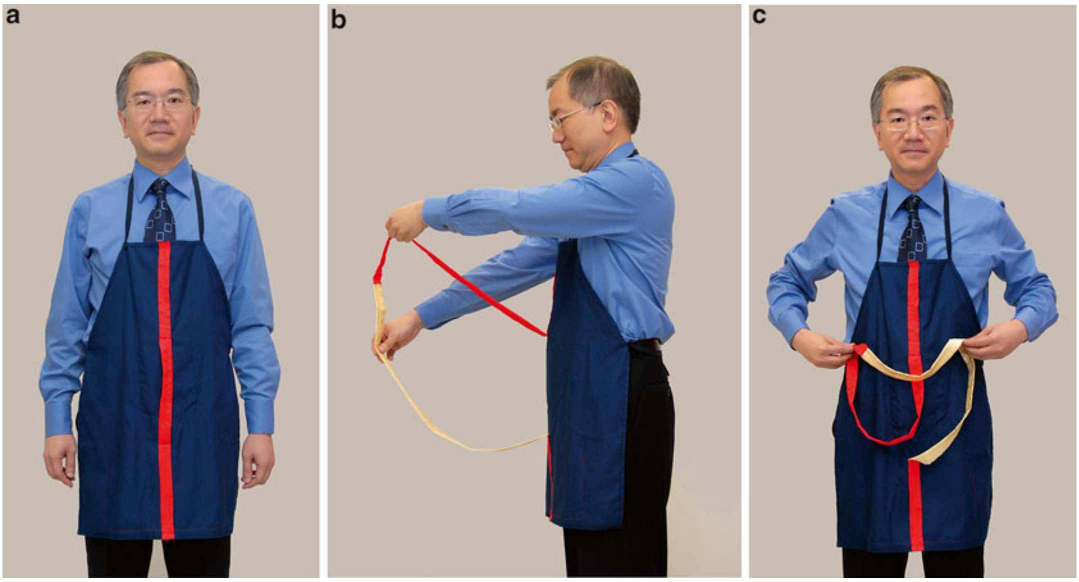

Fig. 29.1 The midgut-rotation apron. (**a**) Foregut, midgut, and hindgut aligned. (**b**) Protrusion of the midgut. (**c**) After rotation of the midgut (based on Fig. 1 in Chan [15])

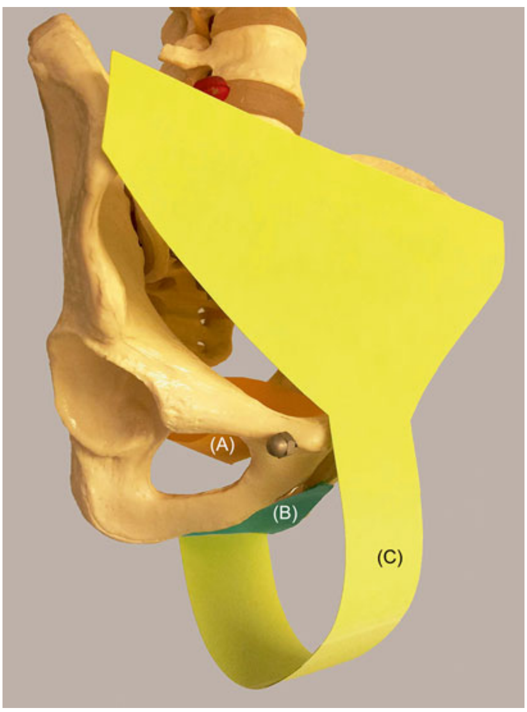

Fig. 29.2 The perineal space model. (**A**) The paper cone representing the pelvic diaphragm. (**B**) The paper representing the perineal membrane. (**C**) The paper representing the Scarpa's and Colles' fasciae

Therefore, the paper representing the pelvic diaphragm is cut and folded into a cone that fits inside the bony pelvis, and the one representing the perineal member is cut into a triangle to fit between the two ischiopubic rami. The remaining piece of paper represents only the inferior portion of the Scarpa's fascia, which stops at the inguinal ligaments on each side but flows over the pubis into the perineum, turns into the Colles' fascia, and eventually attaches to the posterior margin of the paper representing the perineal membrane. The space above the pelvic diaphragm is the pelvic floor, the one between the pelvic diaphragm and the perineal membrane is the deep perineal space, while the one between the perineal membrane and the Colles' fascia is the superficial perineal space. The model can be constructed easily with students, with plenty of opportunities for interaction.

The Hair-Band Model of the Digital Extensor Mechanism

Cloud et al. [17] described an ingenious model of the digital extensor mechanism for demonstrating

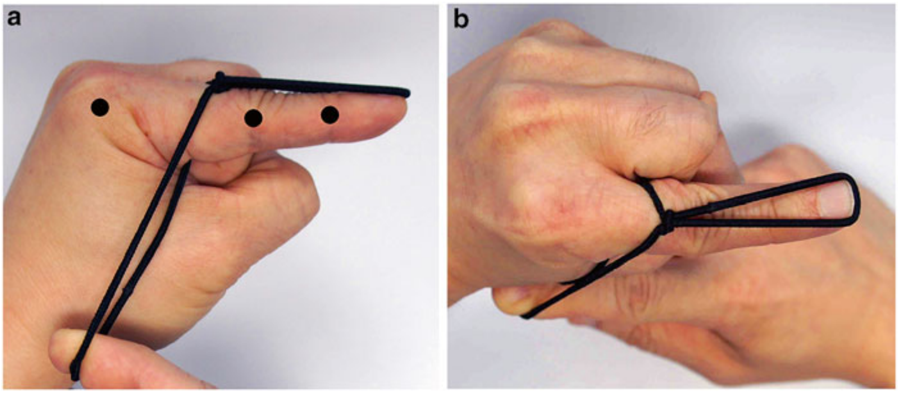

Fig. 29.3 The hair-band model of the digital extensor mechanism. (**a**) *Side view*. The *dark circles* represent the axes of the metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints. The hair bands pass palmar to the metacarpophalangeal joint and dorsal to the proximal interphalangeal and distal interphalangeal joints. (**b**) *Dorsal view* (based on Cloud [17])

the anatomy and function of the intrinsic muscles (Fig. 29.3). Two hair bands are knotted together to form a figure eight. But to complete the model, the hair bands need to be put onto a finger, with the finger going through both loops of the figure eight, and the knot of the figure eight staying on the dorsal side of the proximal phalanx. While the proximal loop is pulled toward the palm, the distal loop is caught just under the fingernail. This completes the model, since the hair bands are now dorsal to both the distal and proximal interphalangeal joints, but palmar to the metacarpophalangeal joint. When the proximal loop of the hair band is pulled toward the palm (representing the contraction of the intrinsic muscles), it causes extension of the interphalangeal joints and flexion of the metacarpophalangeal joint.

The Paper Model of the Muscles

This is a model described by Gangata [18] for students to learn the three-dimensional anatomy of muscles in the human body. Outlines of muscles were printed on paper and then cut out. Students then need to attach the paper muscles onto a human skeleton.

Features of Low-Tech Physical Anatomy Models

The low-tech physical models used in anatomical teaching and learning may not resemble the human body they are representing in the following aspects [14].

Number of Structures

When a model represents a certain region or structure of the human body, it typically includes only a small number of structures from the actual human body. For example, only the gut is represented in the midgut rotation apron [15], while the blood vessels, mesenteries, and ligaments and all the other abdominal organs are left out.

Shape and Surface Details of the Structures

Details are typically lacking in low-tech physical anatomy models. For example, in the hair-band model of the digital extensor mechanism [17], the hair bands do not resemble the extensor expansion or the intrinsic muscles in shape, texture, color, etc.

Dimensionality of the Structures

Sometimes low-tech physical models use two-dimensional structures to represent the three-dimensional human body. For example, Gangata [18] used paper cutouts to represent muscles.

Size of the Structures

The absolute and relative sizes of the structures in a physical model may not follow those of the structures in the human body they are representing. For example, in Chan's [15] "human" model of the uterus, the torso of the person (the body of the uterus) wearing the cloth (the peritoneum around the uterus) is much bigger than the actual uterus.

Anatomical Relationship

The only aspect in which low-tech physical anatomy models always closely resemble the human body is an anatomical relationship. For example, the hair bands in the model of the digital extensor mechanism [17] closely mimic the extensor mechanism in terms of their relationship to the finger joints.

Features of Low-Tech Physical Anatomy Models

- Include only a small number of structures
- Lack shape and surface details
- Can be two-dimensional
- Can have structures of different absolute and relative sizes
- Closely reproduce anatomical relationships

Advantages of Using Low-Tech Physical Anatomy Models

Despite the apparent lack of resemblance between the low-tech physical anatomy models and the human body, these models are welcomed enthusiastically by teachers and students. Some of the advantages of using low-tech models are as follows:

Serve as Memory Aids

By depicting a smaller number of structures and by ignoring many of structural details, low-tech physical models simplify complex anatomical regions into abstract symbolic representations that can be more easily remembered and manipulated mentally. These models contain just enough information to help students to solve problems that involve mental manipulation of three-dimensional anatomy, without being distracted by irrelevant information. The models work by reducing the cognitive load, so that the students can focus on accomplishing specific learning goals, such as deducing cross-sectional anatomy from three-dimensional anatomy [19], or understanding the anatomical basis of some clinical procedures [20]. Another example is the midgut rotation apron, which simplifies the developing gut into a simple tube, ignoring all other details. This allows the students to focus on the manipulation of the rotating gut and how this rotation results in the adult anatomy.

Arouse Students' Enthusiasm and Participation

Students enjoy the simplicity and ingenuity of low-tech physical models [21–23], but this simplicity also means that the models require greater involvement of the teacher (e.g., to establish the resemblance between the model and the parts of the body they are representing). This need for greater teacher involvement can be seen as an advantage of physical models as it provides opportunities for teachers and students to interact, for students to actively participate and reflect, and for teachers to aim teaching at the right level and give feedback; all of these characteristics are important for students to learn effectively and enjoyably.

Easy and Inexpensive to Produce

The low-tech physical models presented here are easy to produce, at very low cost, with materials that are easily obtained. Since damaging these models is of little consequence, students are not afraid to participate in manipulating them in order to learn from them.

> **Advantages of Low-Tech Physical Anatomy Models**
>
> - Serve as memory aids
> - Arouse students' enthusiasm and participation
> - Easy and inexpensive to produce

Constructing Low-Tech Physical Anatomy Models

The construction of a good low-tech physical model involves the four steps in a plan, do, study, act cycle (or the Deming cycle):

Plan: Identify Learning Outcomes and Design the Model

The low-tech physical models are very specific in that one model aims at one, or at most just a few, learning outcomes, which usually involve some anatomical relationships. It helps to be as specific as possible in identifying the learning outcomes of a model. For example, the intended learning outcome of the hair-band model of the digital extensor mechanism is for students to explain the actions of the intrinsic muscles of the hand through an analysis of their spatial relationships with the joints. It is not about the precise attachments of these muscles, their detailed anatomical features, their neurovascular supplies, or their anatomical relationships with the adjacent structures. The model is focused on helping the students to achieve just one outcome.

The design of low-tech physical models is only limited by the creativity of the designer. One important consideration is that the model should be easily contextualized; that is, it should allow students to easily establish the relationship between the model and the human body. For example, the models described by Zumwalt et al. [20] were built on a human skeleton. Such a design allows the students to position the models in the human body, which would otherwise be difficult because of the non-resemblance of the models to the real structures. The midgut rotation apron [15] is worn by the demonstrator, so that the students know the fabric tube being pulled out comes from the abdomen and represents the midgut.

> **To Do**
>
> - Think of an anatomical relationship that students usually find difficult to comprehend.
> - Identify the outcomes you want your students to learn in that anatomical relationship (be specific).
> - Think of a simple model to target these outcomes.

Do: Use the Model

This refers to the actual use of the models in helping students to learn. Some tips are included in the next section.

Study: Evaluate the Use of the Model

After putting a physical model to use in the classroom, the teacher needs to evaluate whether the design of the model aids in the achievement of the intended learning outcomes. Reflection is the starting point of such an evaluation. Useful questions to ask oneself after inventing and using a low-tech physical model in the classroom can include: What went well? Did the students learn what I would like them to learn using the model? Did I establish the resemblance between the model and the human body? Did the students enjoy learning with the model? Did I show the right immediacy behaviors, direct the teaching at the right level, give appropriate feedback, etc.? What can I do differently next time to improve the learning experience for my students?

Act: Improve the Model

Suitable modifications to the model should be made to facilitate the achievement of the intended outcomes. For example, the original design of the midgut rotation apron required the teacher to continue to hold the two ends of the tube representing the transverse colon, which prevented the use of the hands to explain the model and to interact with the students. This can easily be solved by the use of Velcro to attach the two ends of the tube, freeing the hands of the teacher.

What Will You Do?

- You have invented a model for demonstrating the anatomy of the inguinal canal. It consists of just three pieces of paper, one on top of another, representing the three muscles of the anterior abdominal wall of the inguinal region. Each piece of paper has a hole cut into it, being most lateral in the deepest layer and most medial in the most superficial layer. The holes thus represent the inguinal canal.
- Once you start your demonstration, you try to establish the correspondence between the three pieces of paper and the three muscles of the anterior abdominal wall. But instead of telling your students, you ask "Which muscle of the anterior abdominal wall does this most superficial piece of paper represent?" One of the students says transversus abdominis, while the others remain quiet or look blank. What will you do?

Cross-Linking

See also Chapter 23.

Tips for Using Low-Tech Physical Anatomy Models for Teaching and Learning

Use Models in Both Large and Small Group Settings

The use of these models is not limited to small group settings. Even in a lecture, the use of these models can also improve the interaction between the teacher and students and maintain the attention of the students.

Establish the Correlation Between the Model and the Human Body

Many of these models are so simple that it may be difficult for students to realize how they represent the human body. Therefore the first step in using these models is to establish the correspondence between the model and the human body, including clarifying orientation (e.g., anterior/posterior, medial/lateral, etc.) and describing the region and specific anatomical structures represented in the model. This step should be seen as an intrinsic part of the teaching and learning process, since much of the interaction between the teacher and the students can already take place.

Involve the Students

These models should not be used for a one-way demonstration, in which the teacher demonstrates without involving the students. Instead the teacher should make full use of the opportunity for two-way interactions directly with students, which make it possible for the teacher to give feedback on the students' learning, promote reflection by the students, motivate the students, etc.

Pitch at the Right Level

From interactions with the students, the teacher should be able to gauge the knowledge level of the class. The teacher should then adjust the level of subsequent interactions to the level of the students. Teaching at either too high or too low a level can decrease students' learning.

Give Feedback

During interactions with students, the teachers can observe the performance of individual students and appropriate feedback can be given with sensitivity and encouragement.

Promote Student Reflection

During the model demonstration, the teacher should ask questions that stimulate the students to think, reflect on, and integrate what they have learned about the anatomy of the region being explored.

Motivate the Students with Appropriate Immediacy Behaviors

Immediacy behaviors are those shown by the teachers which help to shorten the physical and psychological distance between the teacher and the students [24]. Appropriate immediacy behaviors enable students to feel the enthusiasm of the teacher, which can in turn motivate the students to learn.

Tips on Using Low-Tech Physical Anatomy Models

- Use them in both large and small group settings.
- Establish the correspondence between the model and the human body.
- Involve the students.
- Pitch at the right level.
- Give feedback.
- Promote reflection.
- Motivate with appropriate immediacy behavior.

Conclusions

Low-tech physical anatomy models are useful tools for teaching and learning anatomy. Despite their apparent non-resemblance to the human body, they can accurately depict a targeted anatomical relationship. Low-tech physical models help students to learn anatomy by serving as memory aids, helping them solve three-dimensional anatomical problems, and, best of all, providing opportunities to draw students and teachers closer together for further interactions. To make the best educational use of these interactions, the teacher needs to involve the students, motivate them with the appropriate immediacy behaviors, pitch at the right level, give appropriate feedback, and promote reflection.

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30 The Use of Medical School Museums in Teaching "Anatomy" Within an Integrated Medical Curriculum

Yehia M.A-H. Marreez and Luuk N.A. Willems

The preservation of human anatomical materials for long-term use in anatomical teaching and medical research has historically been a goal of medical schools. One means of preservation, which was popular among old and well-established medical schools for not only teaching and research but also as a source of institutional accreditation and prestige, was medical school museums.

The early medical school museums typically were structured in a full open-floor-space or satellite layout dedicated for housing anatomical and pathological specimens, which were regionally and/or systemically categorized. With the remarkable improvements in the healthcare profession and continuous expansion of medical schools to accommodate increasing numbers of students, there was a dramatic decline in the role of medical school museums as an educational resource for anatomy and other courses. Anatomical and pathological specimens were abandoned and/or distributed among the relevant clinical departments in hospitals in order to free the space for other clinical and research activities with financial benefits.

The decline in medical school museum use stemmed from many factors: the high cost of maintenance of specimens; relegation of the museum to an optional non-curricular activity, making the museum a luxury rather than a necessity; the remarkable advancement in the use of information technology in anatomy teaching and medical education; and technological advancements in anatomical models, medical simulators, and robotics.

Despite their reduced role in modern medical education, the anatomical and pathological specimens of the museums maintain their value as scientific and pedagogic tools. In this chapter, we will take a closer look at the causes of the reduced role of medical museums in teaching anatomy within the context of medical curriculum. Next we will consider the advantages and disadvantages of medical school museums as an educational tool compared to some of the newer information technology tools. Finally, we will investigate the rationale for preserving already existing museums and modernizing them to play a role in new approaches to medical education.

Introduction and Historical Background

The first appearance of medical school museums housing human anatomical specimens and pathological collections in dedicated spaces for the purpose of medical education was in the sixteenth and seventeenth centuries [1]. During that era,

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medical school museums were essential educational tools, particularly in teaching anatomy, pathology, and surgery to graduate and postgraduate medical students. Also, a medical school museum was a source of recognition, accreditation, and prestige for its medical school. In some countries, such as England, a medical school museum was a way to gain credibility with other medical schools (namely, Oxford and the London teaching hospitals) and to increase funds by attracting future medical students [2]. Therefore, a lot of effort was invested by medical school faculty and administration in creating impressive collections.

Over decades, some medical schools that lacked enough floor space to house full open-space museums instead established "satellite museums," where relevant anatomical and pathological specimens were distributed among multiple departments and hospitals. Whether these museums were of the open-floor-space or satellite layout, they were heavily used for educational purposes, such as tutorial and practical classes and administering examinations. They were well appreciated by the students as learning facilities.

Later on, with the advancement of surgical instrumentation, some medical school museums began displaying surgical instruments along with the anatomical and pathological specimens. These instruments formed an essential component of a teaching museum and provided examples of the historical development of surgical tools. Since 1977, plastinated organs have been incorporated into some medical school museums and, in fact, have considerably enriched their collections by providing an alternative method of preserving and displaying anatomic structures [3].

Decline of the Role of Medical Museums in Anatomy Teaching

A large portion of anatomical and surgical training occurred within medical school museums up until and for some time after the Second World War (WWII) [2]. Since then, the role of medical school museums as a teaching tool has gradually diminished. The increasing number of students enrolled in the medical schools has pushed many institutions to convert their museum space into lecture halls and other classrooms, study rooms, and Objectively Structured Clinical Examination (OSCE) laboratories to accommodate the increase. In recent years, the increasing emphasis on research, especially biomedical research, as an extramural source of funds and means of enhancing the institutional profile, has caused medical schools to replace their museums with research facilities. Since student visits to the medical school museum almost always have been elective classes, some faculty and administrative personnel perceived a museum as a luxury rather than a necessity in medical education, further contributing to the decline in attention to these facilities. Medical school museums are often viewed as expensive facilities without a well-defined role in modern teaching and medical training [4]. Compounding these problems, recent advances in information technology, particularly computer- and web-based educational materials, have revolutionized teaching methods in anatomy and other medical courses.

Medical Museums Versus Information Technology as a Teaching Tool

Information technology now is heavily involved in medical education as an essential learning tool for multiple reasons: flexibility in physical location [5, 6] and time of participation in instruction [7], the ability to accommodate increased class sizes through broadcasting or recording, and as a means of compensating for shortages of qualified faculty and reduced numbers of teaching contact hours [8, 9]. Also, information technology grants students access to many learning resources and allows them to get performance-based feedback [10]. Specifically, web-based anatomy teaching may incorporate state-of-the-art instructional methods not otherwise available, such as high-resolution images, two- and three-dimensional graphics and animations, interactive anatomical models, and anatomical simulations [11]. In addition, the Internet is an easier, quicker, and more efficient mechanism for publicizing updates and changes, particularly in clinical anatomy knowledge and its application to practice, thereby serving as a continuous quality improvement tool [11].

Even with these many perceived advantages of information technology, however, it still remains to be seen if they will outweigh the loss of medical museums, which still offer conspicuous benefits. For example, one reason for the push at many medical schools toward self-directed and independent learning is that more medical students are being taught by fewer teachers. Historically, significant amounts of teaching occurred essentially in the vicinity of medical museums instead of the lecture halls under the guidance of a faculty. Within this environment, the students claimed that they had learned far more in the museum than they ever did in the lecture theater [2]. After that, the museum was always available to the students for optional access for self-guided learning, which offered a unique environment for independent learning. Although web-based modules also facilitate independent learning, the physical space of a medical school museum can encourage small-group learning as students gather around particular exhibits for collective study. Studying in the medical school museum environment may also encourage students to avoid social isolation, which can become a disadvantage of web-based learning [11].

The normal and abnormal anatomical specimen collections of medical school museums allow an appreciation of three-dimensional structural relationships with a physical immediacy and tangible representations not possible with multimedia tools [12, 13]. One study found that the incorporation of materials in medical school museums for self-directed learning and continuing medical education (CME) was superior to and more interesting than the use of multimedia and computer-based materials alone [14].

In addition to their centuries-long role in teaching normal and abnormal anatomy, medical school museums also served to document human anatomical variations, stages of normal embryological development, and congenital anomalies. They provided the earliest means of studying the pathogenesis of multiple disorders at multiple stages of life [12, 15, 16]. The pathological anatomy collections of museums have always been important historical resources for the understanding of disease progression and, more importantly, the reasoning process in clinical medicine [17]. Therefore, medical school museums can provide good conditions for studying normal anatomy, anatomical variations, and gross organ pathology and for preparing graduate and postgraduate medical students for their board exams on a solid basis.

Medical museums had, and perhaps still have, a considerable impact on surgical pedagogy. With the increasing popularity of minimally invasive surgery, including percutaneous and endoscopic approaches, medical museums can play a valuable role in helping trainees develop visual–spatial skills for such operations. Minimally invasive approaches require that the surgeon has a strong and accurate practical knowledge of normal anatomy, anatomical variations, and congenital anomalies so that complex procedures can be performed through small incisions that, by definition, do not allow full visualization of the structures being manipulated. Although high-resolution diagnostic images, three-dimensional illustrations, animations, and streamline videos and recordings provide a hi-tech source for attaining some of this knowledge, they are not as effective at facilitating mastery of the precise topographical relationships of regional anatomy provided by a cadaver or a museum specimen. Therefore, some graduate medical schools require residents and junior surgeons to complete a review course of anatomical relationships in a museum [13] or gross anatomy laboratory with prosected cadavers before they are allowed to practice surgical procedures on living bodies [18]. Sufficient practical anatomical knowledge is important for reasoning in all medical fields; however, it is mandatory in at least three major clinical fields: surgery, radiology, and forensic medicine. For trainees in these fields, medical school museums would offer a permanent and powerful resource for self-directed learning and review at convenient times.

Observational skills are critical to the patient–physician relationship and constitute a cornerstone of a positive therapeutic outcome [19]. Many medical schools have instituted nonmedical curricular programs to improve students' observational and communication skills through exposure to visual artwork and illustrations, such as during visits to art museums [20–23]. These skills can be better learned in a medical school museum, which allows students to enhance their skills within a medical context, rather than through extraneous experiences. Also, the small-group learning environment engendered in a medical school museum promotes the development of interpersonal and communication skills.

For those medical schools that have their students study on prosected cadavers instead of performing dissections, museums may offer a permanent and easily accessible educational resource for teaching anatomy and administering exams. Museums can provide the same resources for teaching anatomy to allied health science programs, where students usually are not required to perform dissections, such as physician assistant, nursing, physical therapy, and occupational therapy programs.

Another major unique advantage of medical school museums over some other approaches to anatomical education is that some museums contain rare collections of preserved normal and abnormal anatomical specimens. To this day, museums continue to provide a record of many anatomical rarities and of abnormal structures in diseases that have been either completely eradicated or are very rare in modern times [14, 24]. These collections allow interested researchers to reinvestigate specimens using contemporary methods, such newer diagnostic imaging methods as well as molecular and genetic techniques, and even more advanced tools that may be developed in the future. State-of-the-art investigative techniques may enable researchers to more effectively analyze the etiology and pathogenesis of diseases and relate them to changes in population composition and socioeconomic conditions [25]. Reinvestigation of certain diseases using more comprehensive pathology collections, as are housed in many medical museums, can lead to new understanding of the chronic effect of environmental and genetic factors on successive generations [12].

The study of anatomy has never been a one-time acquisition or short-term retention of knowledge. Learning anatomy is rather a process of continuous experience that builds upon long-term study and repetition. Ready access to the physical specimens in museum collections would favor the acquisition of the more detailed and comprehensive knowledge of structural anatomical relations required for obtaining early surgical skills and, consequently, reducing the incidence of medical errors. Therefore, medical school museums could be a viable source for this purpose that probably cannot be matched by any other state-of-the-art technology (see Table 30.1).

Table 30.1 Comparison between medical school museums and modern information technology

Criteria to be compared	Medical school museums	Information technology tools
Self-directed learning	+++++	+++++
Group learning	+++++	+
Avoiding social isolation	+++++	–
Physical immediacy	+++++	–
Accurate visual–spatial anatomical correlation	+++++	–
Observational skills	+++++	–
Communication skills	+++++	+++
Physical interdisciplinary research potentials	+++++	–
Replacing prosection anatomy lab for allied health programs	+++++	–

Medical School Museums:

- promote self-directed and group learning *without social isolation.*
- integrate and convey 3D structural relationships *with physical immediacy.*
- provide opportunities for training observational skills and spatial visualization ability.
- offer *tangible representation* of anatomical structures not possible by any other tool.
- contain collections of *rare anatomical variations and anomalies, congenital disorders, and pathologies of rare and/or completely eradicated disorders.*
- document *chronological changes* in the pathogenesis and evolution of many disorders *in response to ecological and genetic factors.*

Medical School Museums' Modernization and Revival of Their Teaching Role

Convincing newer medical schools to establish a medical museum may be difficult considering the initial high costs of building and acquisition, the need for experienced faculty and staff for specimen preparation and maintenance, and the possible need for a large floor space. Meanwhile, it is regrettable that some established institutions such as the College of Medicine of the University of Toronto, Canada, have abandoned their museums as an educational tool when they could make use of their unique attributes via renovation and installation of the state-of-the-art technology.

The arguments for continuing investment in existing medical school museums come from the belief that these museums are irreplaceable tools for motivating self-directed learning and that this learning may exceed that gained from multimedia experiences. As a result of this mindset, the Anatomical Museum of Leiden University Medical Center in the Netherlands has been renovated. Instead of a traditional system-based grouping, anatomical and pathological specimens in the Leiden Museum were rearranged according to the age of the patients and the anatomic origins of their diseases. The museum was redesigned in five sections, representing the various stages of human life: fetal development, childhood, adolescence/young adulthood, adulthood, and the elderly. Each section of the museum houses pathological collections relevant to one life stage, and these are further subdivided into seven etiological categories of diseases. There is a separate booth in each museum section for each of the following etiologies: congenital, inflammatory/infectious, traumatic, circulatory, immunologic, metabolic, and cancerous diseases. Interactive electronic screens guide visitors and students to the different sections and booths throughout the museum. These electronic screens also display educational information about each specimen. As part of the Leiden Medical School

What to Do in Order to Regain an Efficient Role of Medical School Museums in Teaching Anatomy

- Complement and update the museums with the state-of-the-art technological means.
- Make them interesting to and interactive with the students.
- Integrate their contents with other relevant basic and clinical science information and training purposes.
- Organize visits/small-group sessions to museum and make them mandatory and integral part of the medical curriculum.

curriculum, medical students are required to visit the medical museum several times during their undergraduate training. Audio recordings have been prepared by faculty from the different medical specialties at Leiden, and students have the option of downloading these from Blackboard (Blackboard Inc., Washington, DC) to MP3 players, including iPods (Apple Inc., Cupertino, CA), to guide them through their museum visits. Narrations in the familiar voices of their regular faculty comment on each specimen in the museum's various collections. Students are then quizzed on each topic, with correct answers to the quizzes strongly reliant on close observation of the museum specimens. Although the audio recordings do not directly provide students with quiz answers, the tours narrated by the recordings are inclusive of all relevant information. Students' course grades reflect quiz performance, and feedback is provided through a password-secured website or in follow-up faculty lectures.

Since the Leiden Medical School adopted a vertically integrated curriculum in 1999, students in medical school every year have been required to view specific collections at the medical museum. For example, students are directed to the anatomical and pathological specimens of the lungs during the first- and third-year respiratory system courses. Early on, first-year students are able to gain a three-dimensional appreciation for the normal breathing apparatus from the museum's anatomic collection. Later, disruption of the structure–function relationship is clear when third-year students are guided to pathological specimens of lung fibrosis and emphysematous disease. Anatomical and pathological specimens of the heart are also featured in the first and third years of the curriculum. Students are frequently assigned interactive tasks such as, in the third-year cardiovascular course, being required to explain the changes that valvular diseases induce in the cardiac musculature. Students may also be asked to anticipate the various heart sounds associated with valvular diseases and the mechanisms that generate these clinical findings. A survey of Leiden medical students sought to evaluate their experience with the medical museum at their institution. The survey was distributed to 620 students representing the first and third years of the training program. Eighty percent of responding students expressed a desire to have more tours incorporated into the curriculum. With regard to museum upgrades (reorganization around life stages and disease etiologies, electronic display screens, and digital audio tours), all responding students (100 %) agreed that the upgrades were fundamental, practical, and useful and that they provided a clear orientation to the museum and motivated study from different perspectives. Also, 91 % of responding students reported that

Horizontal and Vertical Integration in the Anatomy Museums

Reorganize the museum specimens in a system-based rather than the traditional regional-based arrangement, with considerations to vertical and horizontal integration in order to match the contemporary educational approaches adopted by many medical schools and reflect curricular integration. For example:

- Specimens of thoracic anatomy and pathology are arranged side by side to allow students to study normal anatomical structures and gross pathological pulmonary diseases, to achieve horizontal integration.
- Students then are encouraged to rationally predict/anticipate the expected symptoms and signs due to structure–function disruption in disorders with different gross features, as a vertical integration process.
- To reinforce this process, clinical case scenarios associated with patient images, animations, or video recordings would complete the picture.

the upgrades facilitated their tours in the museum, particularly in finding relevant specimens and managing their time. Student efficiency in study was important since groups of 15 students were scheduled to visit several sections in the museum within 1 or 2 h. Most students (87 %) found the information provided in the audio recordings to be clinically relevant and valuable [26]. Based on student feedback and academic performance, faculty at Leiden concluded that the museum upgrades had been worthwhile and recommended continuing maintenance and upgrades.

Another example of a modern medical museum that successfully demonstrates its potential role in medical education is the Medical Museum of Kawasaki Medical School in Kurashiki, Okayama, Japan [27, 28]. This medical museum was established primarily to address shortages of faculty and to reduce faculty teaching contact hours in a newly established medical school. The founders of this medical school realized that they had a responsibility to facilitate students' access to new and up-to-date medical information in a practical manner. They believed that integrating basic and clinical medical sciences is an attractive way to facilitate understanding and reasoning of modern medicine. Toward that end, they built a medical museum combining traditional anatomical and pathological specimens with information technology and simulation laboratories. They equipped the museum with illustrative panels, organ exhibits, and question and answer boards. They believed this approach would best create an environment of self-directed learning and help to offset the teacher shortage. In their own survey, Shibata et al. (1991) [27] concluded that their modern medical museum was more attractive to medical students and better received than passive audiovisual materials.

Despite the differences in their learning sessions' organizations and objectives, both examples of Leiden Museum and the Medical Museum of Kawasaki are valid models for application or adaptation according to the system and curricular approach of any medical school owning a museum.

Promoting the Use of Anatomy Museums by Students

- Incorporate weekly or monthly museum sessions as a part of the integrated medical curriculum.
- Mandate museum attendance by including museum specimen-based quizzes as an essential part of student assessment.
- Supplement museum exhibits with corresponding imaging such as X-rays, CT scans, and MRIs to enhance anatomical reasoning by encouraging direct link and visual image reconstruction based on observable anatomical features.
- Dedicate special small-group sessions to discuss and review gross and clinical anatomy, pathology, and congenital malformations for preclinical years with practical reference to the corresponding specimens or to enhance students' "observational skills" by asking them to identify specific anatomical variations or anomalies that may be found in some specimens.
- Encourage medical students to communicate with other healthcare program students who are using the museum such as PA, DPT, nursing, and OT to encourage multidisciplinary communications and be familiar with each other's profession, which may positively reflect on the provision of healthcare services.
- Use museum specimens as a base for board exam questions, which can initiate debate between students in order to provoke discussions and stimulate development of communication skills.

Promoting the Use of Anatomy Museums in Postgraduate Training and Research

- Use the museum in a mandatory review course for anatomy and pathological changes for clinical residents, fellows, and postgraduates particularly in surgical specialties as a prerequisite for learning surgical techniques and procedures and also in radiological specialties as a prerequisite for learning how to read and interpret imaging.
- Encourage clinical residents, fellows, and young surgeons in their early career for periodic visits to museums and credit them for these visits as a part of CME-required courses.
- Exploit museums for organizing workshops such as for teaching new surgical techniques, ultrasound, etc., as a reference and as a convenient place for learning and training.
- Encourage museum specimen-based research grants as a source of extramural funds.
- Consider establishing research labs which may depend on the usage of museum specimens, such as ecological, molecular, and genetic labs, in close contact with the museum in order to facilitate easy access to researchers.

Conclusion

The declining role of medical school museums in teaching anatomy and anatomy-related sciences, such as pathology, forensic medicine, and surgery, has been a stimulus to some medical schools to develop strategies to save the precious contents of these museums from vanishing. Many medical museums house irreplaceable materials that display anatomy and disease in three dimensions as no hi-tech teaching methodology can. In addition to the educational role of teaching practical aspects of normal and abnormal anatomy in a traditional or an integrated medical curriculum, the contents of medical museums may function as excellent resources for teaching observational and interpersonal communication skills, which are essential for medical students to learn.

There are good reasons to support and expand the role of medical school museums in teaching anatomy and related sciences, particularly in promoting integrated medical education. Keys to promoting and maintaining the museums' usefulness and vitality within currently developing integrated medical curricula are upgrading them with modern information technology and incorporating mandatory museum-based educational activities.

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Part VI

Assessment

Assessing Anatomy as a Basic Medical Science

31

Dujeepa D. Samarasekera, Ponnampalam Gopalakrishnakone, and Matthew C.E. Gwee

Introduction

> "Assessment Drives Student Learning."
>
> Author unknown

The scientific basis of medicine has been convincingly reaffirmed in several official documents published by leading medical authorities (see Tomorrow's Doctors, GMC, U.K., 1993, 2003; joint publication of the Howard Hughes Medical Institute and AAMC, USA, 2009 [1] and the AFMC, Canada, 2010). Together, these documents serve to underscore the importance of the basic medical sciences (BMSc) in the undergraduate medical curriculum. Disciplines in the BMSc (e.g., anatomy, biochemistry, pharmacology, and microbiology) are *highly content-based* disciplines. Moreover, students were simply *passive* listeners and recipients of abundant *factual* content knowledge delivered through numerous lectures.

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Focus of Traditional Assessment Strategies

In such a traditional learning environment, assessment strategies commonly designed by the disciplines focused more on testing *factual content* that imposed on students the need to "*memorize, recall, and regurgitate*" in exams. Thus, assessments tested mainly the acquisition of lower-order learning outcomes through mere rote memorization and recall. Moreover, assessment scores were used primarily as final (summative) tests without considering their potential as a learning tool. A major concern of such assessment practices is the *negative steering effect* of assessment on student learning, i.e., students tended to undertake *superficial* or *rote learning* rather than *deep* learning with enhanced conceptual understanding. Thus, students are likely to become *knowledge-rich* but *application-poor* with respect to medical problem-solving and critical reasoning. Myers and Jones [2] have clearly expressed that "*What matters…is not what students know but what they can do with what they know. What's at stake is the capacity to perform, to put what one knows into practice*."

L.K. Chan and W. Pawlina (eds.), *Teaching Anatomy: A Practical Guide*,
DOI 10.1007/978-3-319-08930-0_31,

Assessment Strategies for Twenty-First-Century Medical Education

Today, however, there is clear recognition that assessments have excellent potential as learning tools since they will drive how students learn: "…assessment has a major impact on students' learning behaviour [and it is]…for the test maker to capitalise on this behaviour. …the driving influence of assessment is a powerful tool to ensure that students learn what, and how, teachers want them to learn" [3].

Consequently, there is now a major paradigm shift from the assessment *of* learning to assessment for learning. The latter is best achieved through providing students with feedback to explain the "rights" and "wrongs" of test items, preferably, on an individual basis in a reflective dialogue. Feedback is further enhanced through the use of formative assessments as diagnostic tools rather than as test instruments, which is consistent with the paradigm shift to drive student learning behavior through assessments [4].

Thus, today, assessments should not focus predominantly on student acquisition of *lower- order* learning outcomes based primarily on *rote memorization* of factual content knowledge. Instead, assessments should now focus more on the acquisition of higher-order learning outcomes to help students develop their intellectual skills, i.e., their ability to analyze, integrate, evaluate, and apply the foundational knowledge they have acquired. Myers and Jones [2] have stated that "Students learn not by just absorbing content (taking copious notes and studying for exams), but by critically analysing, discussing and using content in meaningful ways."

Thus, major paradigm shifts in assessment practices have made it imperative to strategize the design of test instruments used in the assessment of students in health professional education. Instead of using instruments to test a student's ability to remember a large amount of factual content, testing should now be aimed at how students can *apply* the knowledge and skills which they have acquired to their next level of learning, or to problem-solve in future professional practice [5, 6], including the relevant *domain independent* skills such as communication, teamwork, and professionalism.

Assessment in Anatomy

> "Students can, with difficulty, escape from the effects of poor teaching, they cannot escape the effects of poor assessment."
>
> Boud [7]

Anatomy is the study of the structure of the human body and associated body functions and, therefore, provides fundamental core knowledge in medical, nursing, and other health professional training programs. Thus, students need to acquire a solid *foundational knowledge* of anatomy as a BMSc which would subsequently enable them to apply the knowledge they acquired to what they will learn about associated structural abnormalities occurring in disease processes and also to patient management. When the students graduate, their knowledge of clinical anatomy will become important in their practice as effective healthcare professionals.

However, assessments have many other useful functions, including:

- Motivating students to study
- Diagnosing a student's strengths, limitations, and difficulties
- Measuring student improvement over time and readiness to proceed to the next level of training
- Providing students with feedback about their learning
- Evaluating the effectiveness of teaching and the educational program
- Making decisions on student understanding of subject matter and competency in skills
- Predicting a student's likely success in future learning or exams
- Ensuring students meet the qualification/certification standards

Since anatomy is a highly content-based BMSc discipline, the following guidelines are recommended:

- Closely align assessment strategies to the specific learning outcomes identified for the anatomy course.
- Design assessment strategies which test beyond just factual recall of knowledge and incorporate testing of higher-order learning outcomes.

- Include *formative* assessments as a potential and powerful tool to drive student learning behavior.

Recommended Best Practices for Anatomy Assessment

> "Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted."
>
> Albert Einstein

Constructive Alignment in Anatomy Assessment

For any assessment process to be successful, there is a need to ensure that test items are closely aligned to the expected course and program (learning) outcomes [8]. Anatomy is taught mainly in the early part of the medical course. The assessment modalities used in anatomy exams must, therefore, be constructively aligned to the expected course outcomes in anatomy, i.e., to the graduate outcomes for learning to be effective [9]. Figure 31.1 outlines how best to achieve this close alignment through proper planning in the development of an assessment process.

The close alignment of assessment to learning outcomes (i.e., to requisite future practice competencies) will have a strong *positive* steering effect on students' learning behaviors [10]. The best practice in constructive alignment is to develop an *assessment blueprint* (see Table 31.1 below) which allows assessment developers to have a bird's-eye view of the extent to which the assessment covers the discipline-specific outcomes, as well as the relevant program outcomes (end

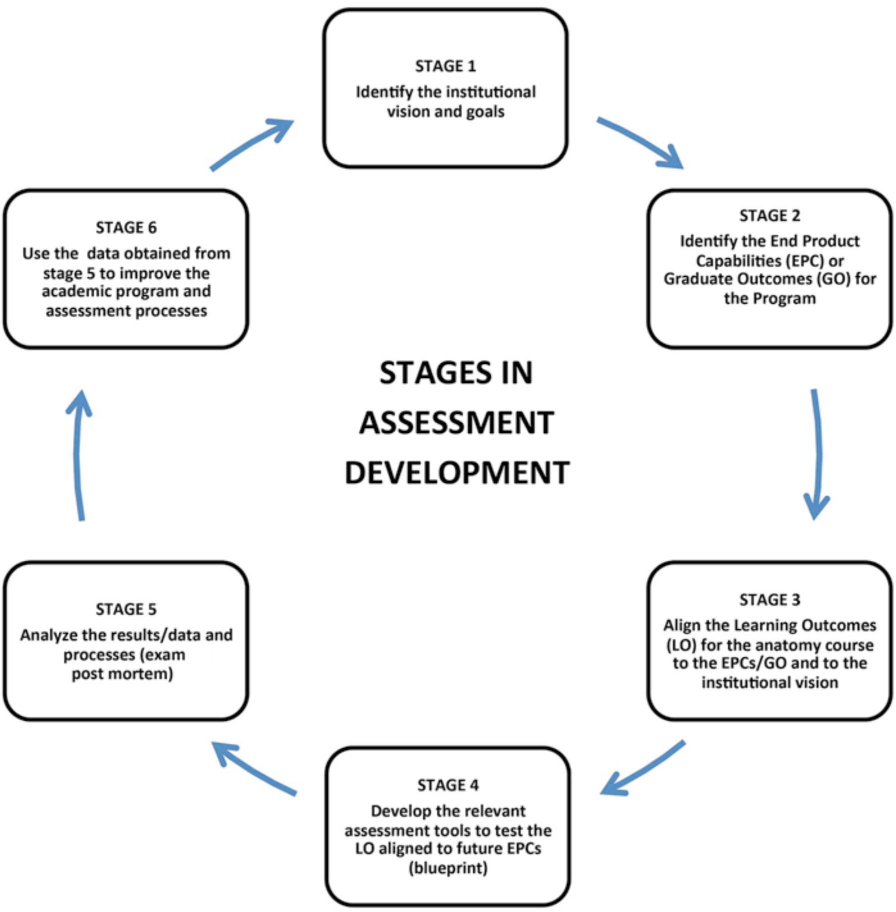

Fig. 31.1 Stages in the development of an assessment process

Table 31.1 Example of a final assessment blueprint for an undergraduate course in anatomy

Outcome capabilities modules	Knowledge				Skills (basic clinical skills/spots)	Professionalism	Teamwork	Communication
	Recall/ comprehension	Application	Analysis	Evaluate				
Musculoskeletal	MCQ	MCQ		MEQ	MSE		MSE	
Respiratory		MCQ	MCQ/MEQ					
Cardiovascular		MCQ	MEQ		MSE			MSE
GIT	MCQ	MCQ/MEQ	MCQ		MSE	MSE		
Neuro/CNS	MCQ	MCQ	MCQ	MEQ	MSE			
Genitourinary		MCQ	MCQ					
Reproductive		MCQ						
Special senses	MCQ	MCQ			MSE			

MCQ: multiple-choice questions, *MEQ*: modified essay questions, *MSE*: multistation examination (e.g., objective structured practical/clinical examination (OSP/CE))

product capabilities). It also serves to inform test developers, teachers, and students how different assessment instruments test the overall learning outcomes. An assessment blueprint also helps to conceptualize the *level* of testing which is especially useful in identifying the level of testing of intellectual skills in the cognitive (knowledge) domain using Bloom's taxonomy. A simple assessment blueprint will facilitate the development of items that test *higher-order* cognitive skills and, consequently, steering students away from *rote learning* (i.e., through testing mainly *recall of factual content knowledge*) [11].

Utility Index of an Assessment System

The *utility index*, described by Cees van der Vleuten in 1996, provides a good foundation to choose and incorporate different assessment instruments when assessing students [12]. The formula is more conceptual than mathematical, highlighting the fact that no single assessment instrument can achieve high utility if used alone. This is because each instrument has its own limitations and strengths with regard to validity, reliability, educational impact, cost (and feasibility), and acceptability by the stakeholders. However, if the assessment planning is done carefully and incorporates multiple instruments strategically into the curriculum at different time points of student learning, the data gathered from the

Assessment Utility Index

U = Utility index
R = Reliability
V = Validity
E = Educational impact
A = Acceptability
C = Cost
W = Weight

$$U = {}_{w_r}R \times {}_{w_v}V \times {}_{w_e}E \times {}_{w_a}A \times {}_{w_c}C$$

instruments will provide useful information about the learner. This will assist to build a profile of the student's abilities and for examiners to decide on whether the learner is ready to progress to the next level of learning [13]. The utility index therefore can also be used simply to demonstrate the compromise necessary in assessment and given the context, one has to optimize the assessment.

Validity

Validity is defined as the extent to which the instrument measures the competency which it is supposed to measure [14]. To achieve high validity, it is best to first define the domain for the competency to be tested and the relevant assessment instrument to be used to test a student's achievement of the competency.

Validity can be affected by several factors, including: poor alignment of test instruments to the competencies and domains assessed, confusing instructions to assessors and students, poor test development leading to low-quality test items/questions, developed test items/questions too difficult or too easy for the students, and poor sampling of testable content/domain areas.

The *validity* of an assessment can be described under different categories or types, including:

- Content Validity: This refers to whether the assessment actually tests the intended subject area. Thus, if the assessment is to test knowledge of gross anatomical structures and their functions in the human body, the questions should be focused on *human* anatomy and its associated functions.
- Construct Validity: This refers to the extent to which the assessment instrument measures a particular behavior or trait. Thus, the 360° evaluation instrument can measure traits such as *teamwork* and *professionalism*. However, it should be noted that achievement of competency in *behavioral constructs,* such as teamwork or professionalism, cannot be measured using only one instrument.
- Predictive Validity: This refers to whether student performance on an assessment instrument could predict his/her future performance. For example, the *predictive validity* of an anatomy multiple-choice question (MCQ) paper in year 1 of a medical program should predict similar performance in the surgery MCQ exam in year 4. The higher the correlation of scores in both tests, the higher the predictive validity.
- Concurrent Validity: This refers to how well the performance in one test correlates with other validated tests administered at the same time. If the student scores obtained for the anatomy MCQ test correlate positively with the scores of the physiology MCQ test in year 1 exams, then the concurrent validity of the anatomy MCQ paper is high.
- Face Validity: This refers to stakeholders' views and perceptions on whether the test measures what it is supposed to measure and the fairness of the assessment. This is also an important aspect to consider since if the students and teachers feel that the assessment is fair and aligned to future practice or assists in further learning, students will be motivated to learn and teachers will engage in depth in teaching–learning activities.

Reliability

Reliability refers to the consistency or reproducibility of student performance. For an assessment to be reliable, a student can be expected to attain the same score if the test, or the same or similar test with the same degree of difficulty, is administered at a later date or over multiple times. If the assessment is unreliable, then the student's score may vary widely, depending on whether other factors are also aligned to the intent of the exam. The reliability can also be affected by several factors such as efficiency of the test administration, inadequate sampling of the content/domain areas tested, and lack of objectivity of scoring by assessors as a consequence of a lack of or poor assessor training.

Reliability also consists of a few categories as outlined below:

- Test–Retest Reliability: This refers to whether a student's performance in an exam will be similar if the test is administered repeatedly at different times. Test–retest reliability measures the consistency of an examination: for example, will the student scores be similar when the final anatomy modified essay exam is administered at the end of year 1 and again at the beginning of year 2?
- Inter-rater Reliability: This refers to the concurrence of scoring among assessors on a single performance. *Inter-rater reliability* is considered good if two assessors independently give similar scores to the same assessment, i.e., either in an anatomy modified essay question (MEQ) or in an OSCE station.
- Split-Half Reliability: This refers to the internal consistency of an assessment. The process involves dividing the exam questions/items into two halves which assess the same knowledge or domain skills. The examination is then administered and the scores for each half are obtained and correlated. The *split-half correlation* is considered reliable if the scores of the two sets correlate positively.

Educational Impact

One of the most important aspects of assessment is its *relevance* to and its *impact* on student learning. Assessments could be used in a strategic way to drive students to learn what is important in the curriculum and for their future learning and practice. This alignment of assessment to students' next level of learning or to future practice is known as the educational impact and is gaining prominence in the design of new assessments. Furthermore, such a close alignment will assist teachers to focus on relevant teaching–learning activities. Incorporating this constructive alignment of learning relevance and future practice relevance to assessment is also called the consequential validity of assessment [15].

If the test item in the anatomy MEQ examination uses contextualized future practice clinical scenarios, then the students, during their learning, will focus on applying knowledge of the gross anatomical structures and the associated functions which they learned to applied clinical anatomy. The teachers can also be expected to emphasize knowledge application to students during their teaching–learning activities.

Acceptability

Acceptability and the perceived fairness by the stakeholders, i.e., teachers, students, administrators, professional and employing bodies, patients, and the communities, regarding the robustness of the assessment and its processes are also important. This forms the basis of the trust placed by these stakeholders with regard to the graduate's effectiveness as a practitioner.

Cost/Feasibility

Another factor that needs careful attention when developing an assessment instrument or a process is the cost of development or the overall feasibility of employing the instrument or the process. The time it takes to develop and operationalize the assessment, the number of test developers and administrators involved, interpreting the scores, and provision of feedback to learners and to the teachers will have an impact on the assessment. If these areas are not carefully considered, as discussed before, the reliability as well as the educational impact will also be affected.

To elaborate this further, if an anatomy multistation examination involves ten stations (at which students spend six minutes each) assessing the practical skill sets of 300 medical students, you need to either set up many stations testing the same skill or develop the assessment over few days with similar skills stations to run smoothly. For this to be operational and practical, the school needs to allocate substantial financial as well as human resources, and planning becomes very critical. If not, the exercise will become laborious and ineffective leading to substandard assessment.

Effective Use of Formative and Summative Assessments

As already discussed, assessment should drive student learning behavior, not only to develop higher-order discipline-specific cognitive skills but also to prepare students to acquire competencies for future professional practice. However, assessing the achievement of competences in all the relevant domains cannot be achieved using a single assessment instrument. The students need to be closely supervised and guided on how to develop their skills and gain knowledge and also to be given feedback on how best to further improve/develop as they progress through the learning program. This is best achieved using formative assessments (FAs). The focus of FA is to provide relevant, specific, and immediate feedback to students on how well they are achieving the necessary knowledge, skills, and attitudes. The student's performance obtained at these assessments will not be used for final grading or pass–fail decisions. Thus, FA allow students to refine, enhance, and optimize their performance before the scheduled summative assessments.

Summative assessments (SAs) are used to evaluate whether students have reached the required level of competency, so that they will be effective learners at the next level of learning, safe to patients, and contributing to team care when applying their acquired skills in practice as healthcare professionals. The FAs are planned usually at the end of a particular period of learning or skills training, so that one can judge the students' level of competence.

Effective Use of Feedback in Assessment

Feedback is the cornerstone of assessment, and in contemporary health professional education, it is becoming one of the critical components of learning and assessment. Providing relevant, focused, and immediate feedback on student performance assists learners to identify areas for improvement and enhances their individual areas of strength.

A typical feedback setting involves a face-to-face verbal discourse between the teacher and student. Students usually get feedback on their skills assessments, whereas only a score is often provided for written assessments. However, increasingly more elaborate feedback is also provided on written assessments, especially for MCQs through the use of technology.

The computer-based online feedback can provide more granular feedback regarding the students' performance by comparing the individual's score relative to the cohort as well as for each content area tested. It can further benchmark the student performance to local or international cohorts taking the same or similar exams.

For face-to-face feedback, the most commonly used format is the modified *Pendleton's* feedback model. The model not only identifies areas of strength and areas for improvement but also improves students' *metacognition* and *empowers* learners to be more self-directed in their learning [16].

Modified Pendleton's Feedback Model [16]

- Ask the learner *what went well* and *why*.
- The teacher says what went well and why.
- Ask the learner *what can be done better* and *how*.
- The teacher says what can be done better and how.
  - Summarize strengths and *list three things to concentrate on.*
  - How you (or your colleagues) could help the learner in achieving the above.

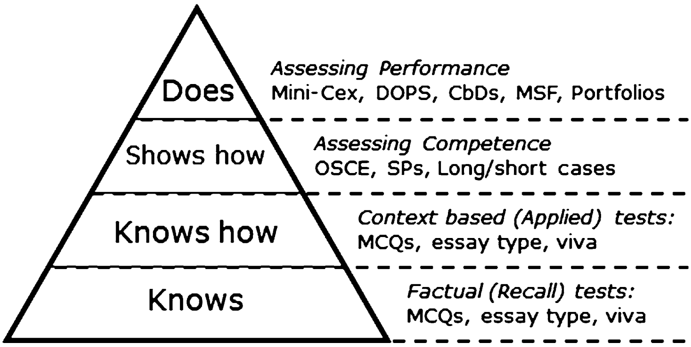

Fig. 31.2 An assessment framework using Miller's pyramid of competence [17]

Assessment Formats in Anatomy

Written Assessment

Written assessments are used mainly to assess knowledge acquisition: the lower-order outcomes of cognitive or knowledge-processing skills of students, relating to the "knows" and "knows how" levels in the Miller's pyramid of competence shown in Fig. 31.2 [17].

Multiple-Choice Question Formats

MCQs are the most common formats of assessment used in medical and health professional programs for anatomy [18]. If the test items are developed properly (see section on various developmental stages) and constructed using blueprinting, MCQ assessments can achieve high psychometric qualities such as high test–retest reliability, content validity, and educational impact [19].

MCQs which are context-rich with a single best response are widely used today. The other formats (e.g., true/false) have now been largely phased out, whereas the extended matching items are increasingly gaining popularity.

Modified Essay Questions

Modified (or structured) essays are commonly used to assess the students' *knows how* level of learning. In most instances, these are best used to assess in-depth knowledge of a particular content area in anatomy. The disadvantage of this format is that it cannot sample widely, and hence, the reliability is generally low.

Long Essays

Long essay questions are no longer used widely today, due to the expected low reliability when testing a subject area like anatomy. The long essays are now limited for use only in special circumstances where students need to develop or synthesize a response to a question relating to a given situation or condition.

Assessing Skills

Multistation Examinations (MSE, e.g., Objective Structured Practical/Clinical Examination, OSPE/OSCE)

The most common format used to assess skills is the MSE such as the OSPE/OSCE. The use of MSE to assess relevant skills acquired using task trainers and simulated participants (SPs) with checklist-based scoring is a popular strategy used in most medical and health professional training programs. The advantage of this format is that it allows assessment of multiple domains in a single test. The domains could be applied knowledge—radiological or anatomical specimen, clinical case vignettes, audiovisual specimen, communication skills station using SPs, etc. See blueprint shown in Table 31.1. Therefore, the MSE, if developed properly and based according to the overall assessment blueprint, can have high validity and educational impact. However, the main disadvantages are that it requires a large amount of resources to develop as well as to conduct and poor reliability due to low sampling of subject content area.

Spot Tests

Anatomy *spot* tests are used for quick identification of anatomical structures. The students are presented with several prosected specimens bearing anatomical structures such as muscles, nerves, blood vessels, etc., which are highlighted for students to identify. The questions may lead to further testing of associated function, or limitation/s due to any dysfunction. The major disadvantage of this assessment strategy is that it promotes a negative steering effect (i.e., *rote memorization* and *recall* of knowledge), and it has largely been replaced by MSE.

Oral Examination

Oral (or viva voce) examinations were used extensively in the past in medical and health professional training programs. Oral examinations (OEs) have been phased out in many assessment settings due to their apparently poor reliability. However, recent studies show that if the OE is well structured (using a blueprint for specific item development), examiners are briefed and trained, and scoring is based on a marking template, the OE can achieve good reliability as well as identify the learner's abilities in higher-order cognitive skills [20].

Portfolio Assessment

The use of *portfolios* to assess student learning during the phase in the BMSc is now gaining in popularity. The portfolio not only assesses different *cognitive* skills such as reflective learning but also evaluates some areas of affective skills [21]. The students need to show achievement of required outcomes in these domains and provide evidence of their learning at multiple time points of the program. Feedback regarding their performance is given by faculty who have been trained to evaluate portfolios. The main advantage of using this modality of assessment in the early part (i.e., BMSc phase) of the curriculum is that the faculty can evaluate, over different phases, how the learners are developing in a discipline and, consequently, can provide immediate feedback for remediation whenever required. Portfolios are also used as summative assessments, especially to make value judgments and high-stakes decisions on a learner's ability to move to the next level of learning or to certify that a learner is fit for practice.

Standard Setting in Assessment

Deciding on whether a learner has achieved the required competency, based on his/her performance in tests, is an important process in deciding whether or not a learner is ready for the next level of learning or professional practice. The score deciding whether a student can pass or fail should be based on relevant and context-specific educational rationale [22]. According to Norcini *"A standard is a special score that serves as a boundary between those who perform well enough and those who do not."* Broadly speaking, there are two types of assessment standards: relative (also known as norm referenced) and absolute (fixed or criterion referenced) [23]. In relative standards, a student's performance is compared with the performance of other students in the cohort, and the pass/fail mark is then set accordingly. For example, this method is used widely on entry tests to programs where the numbers of student vacancies are limited. The advantage is that you can limit the number of passes and failures based on the requirements of the school's program. However, the main disadvantage is that setting pass/fail standard scores will differ from one cohort to the other, since it is based mainly on student performance.

When deciding on a pass/fail score using absolute standards, the passing standard is set before the exam is conducted. The standard set will not, therefore, differ from cohort to cohort. Consequently, an entire cohort can pass or fail the assessment, depending on whether the minimum passing score based on the standard has or has not been achieved. The score is set using a *criterion-based* standard setting process in which experts first define the acceptable minimum passing standard before students sit for the assessment. The major advantage of this method is that the passing score is based on a minimum competency standard and will not vary according to the performance of the cohort. It has also been shown that criterion-based standards promote teamwork and collaborative learning as the passing grade is not set based on cohort performance. The main disadvantage is that it is a time-consuming process as well as being resource intensive. There are few well-established methods of criterion-based standard setting, such as Angoff, Ebel, and Nedelsky [24–26].

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Developing Multiple-Choice Questions for Anatomy Examinations

32

Thomas R. Gest and Webster Francois

One of the teaching activities most dreaded by anatomists is the creation of multiple-choice questions (MCQs) for quizzes and exams. It is truly a labor of love, with a heavy emphasis on the word "labor" and one which very few anatomists "love" to do. However, it is a critically important part of the educational process, and therefore, the subject should be adequately addressed. Hopefully, this chapter will help to ease the pain of writing multiple-choice questions or, if failing that, will allow the question writing efforts to bear sweeter fruit.

Starting Point: What to Test

Many older anatomists can remember a time when multiple-choice questions in anatomy were primarily versions of Anatomical Trivial Pursuit. Many questions dealt with minute details of anatomy that had little or no relevance to the practice of medicine. An example of such a question is shown below:

How many muscles of the hand are innervated by the ulnar nerve?

(a) 5
(b) 8
(c) 10
(d) 12
(e) 14

Obviously, anatomy students should learn that the ulnar nerve innervates most intrinsic muscles of the hand, but is knowing the precise number of muscles an important component to providing accurate health care? Today's anatomy questions not only need to address foundational anatomical knowledge but they also need to have clinical relevance. Although it is somewhat labor intensive to do so, anatomists should strive to write questions with a realistic clinical scenario in the style of the questions found on licensure exams such as Step 1 of the National Board of Medical Examiners. A realistic clinical scenario helps to guide the question writer toward subjects that occur in medical practice, and for the most part, these are the subjects that appear on licensure exams. One should avoid, for instance, questions that dwell on specifics of origin or insertion of a muscle and instead opt for questions which involve general muscle attachment, primary function, or innervation.

Most anatomy courses (or anatomy classes within an integrated curriculum) provide students with learning objectives. It is essential that test questions are drawn only from these objectives.

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If something is important enough to be tested, then it should be important enough to be included in the learning objectives. Some courses go a step further in providing a list of structures that are to be emphasized throughout any particular session. Students are instructed to concentrate their study on these key terms, from which, ultimately, all exam questions are drawn. This methodology encourages students to focus their studies on essential structures, thus providing them with far more time to truly learn and understand every key structure while avoiding the distraction of anatomical minutiae that could sap their time and energy. Students need to cultivate a sound foundation of knowledge of functions of all essential structures, as well as their spatial, anatomical, and physiological relationships to each other.

Providing students with a clear picture of what they should know also helps to reduce their anxiety concerning the material. To the beginning student, the mastery of anatomy can seem like a Sisyphean task. They get stressed by what they perceive as an impenetrable nebulous quantity of information and get trapped spinning their wheels, unable to gain traction and begin their studies. Other students flit from resource to resource, in a modern version of the one-more-book syndrome, in an effort to find that one book, that "magic elixir of knowledge" that will make it all easy. One of our jobs as anatomy teachers is to help our students realize that they really only need to concentrate on the essential points that we have clearly laid out before them and to ignore (for the time being) the anatomical minutiae that lies outside the scope of their early years of study.

Testing Methods and Sample Sizes

A corollary to defining the subject matter to test is deciding the general method of testing and the number of questions to be asked by each method. Gross anatomy is a science that has both visual and conceptual components. The dichotomy of subject matter in anatomy has resulted in a long-standing tradition in many gross anatomy courses to test students with both practical and "written" exams. The gross anatomy practical exam is usually used to test mastery of the visual component of anatomy. The anatomy practical is one of the most anxiety-producing events for many students. It is usually performed on tagged specimens with timed question stations. The term "written" exam usually means a test of the conceptual material in anatomy, which is primarily composed of functions and key relationships among structures. There are no hard and fast guidelines to help one decide what methods to use in testing, but many courses find a balance between practical and written test questions of one to one.

Once the methodology of testing is decided upon, the next step is to decide the numbers of questions to be asked. This has become more problematic than ever with so many schools changing their curriculum and moving toward more discipline (subject) integration during the basic science years. In most curricula, the numbers of points each discipline receives on a particular quiz or exam reflects, roughly, the number of hours dedicated to a discipline in the portion of the curriculum being tested. With integrated curricula, this may mean that the number of points allotted to gross anatomy may be very few for a particular time period. Few points might translate to few questions, and the fewer the questions, the more likely it is that random chance will factor into the sampling of student knowledge. One possible solution when faced with limited numbers of points is to make each question worth some fraction of a point, depending upon how many questions would make a fair sample. Most students and faculty would agree that a sample size of greater than 20 helps to remove chance from having too great an effect. Of course, giving fractions of points for each question may present a challenge for those administering the exam, but electronic testing software makes assigning fractional credit to any question a fairly trivial task. Using fractional credit for practical exam questions is especially easy, because most practical exams consist of only the single discipline of gross anatomy. Fractional credit questions can be used to increase the numbers of practical exam questions, not only to reduce the effects of chance but also to help students fit into a practical exam room. If you have ten points worth of practical exam questions, one hundred students to test, and one practical exam question station per student, you would need to run the exam ten times to fit in all of the students. However, if you make each question worth a half point and double the number of questions, the exam need only run for five sessions.

Types of Multiple-Choice Questions

The best resource for tips on writing multiple-choice questions and the rationale behind the science of MCQ creation is the excellent book by Case and Swanson of the National Board of Medical Examiners (NBME) [1]. The NBME currently only uses two types of multiple-choice questions: Type A and Type R. It is a great mystery as to where all of the Types B–Q and S–Z have gone, but in one case, that of the dreaded Type K, few tears were shed when it was discontinued by the Board. For those who may be too young to have experienced the horror of Type K questions, they were in the general format of:

Question text:

1. Answer 1
2. Answer 2
3. Answer 3
4. Answer 4

And the Type K key was:

Answer A. If 1, 2, and 3 are correct
Answer B. If only 1 and 3 are correct
Answer C. If only 2 and 4 are correct
Answer D. If only 4 is correct
Answer E. If all are correct

Gladly, because this format lacked reliability and discrimination, it has been discontinued.

Type A questions are the typical single-best-answer-type multiple-choice questions with either 4 (A–D) or 5 (A–E) choices. Type R questions are also known as extended matching questions, which is not a very accurate name. These are actually extended multiple-choice questions, with a single best answer selected from an answer list of up to 26 (A–Z) items. Extended multiple-choice questions are not only useful for textual or concept questions but are very useful for practical exams. Answer sheets of up to 26 choices provide a valid substitute for traditional fill-in-the blank answer sheets (if paper is still being used), with the added benefit of being legible and therefore being able to be computer graded (especially if Scantron forms are used). Most schools have moved or are in the process of moving away from paper exam grading, and extended matching questions work well on computer-based or tablet-based examinations. Removing paper from the examination system not only removes subjectivity and, with it, ample sources of human error from the grading, but also allows for easy modifications in grading and regrading.

How to Make the Perfect Multiple-Choice Question: Setting the Stage

To begin the discussion of creating the perfect anatomy question, it is best to start by dissecting the anatomy and terminology of multiple-choice questions. Each question starts with what is called a stem, followed by the answer choices or options list. Stems are one or a few sentences that set the scenario of the question. Stems typically end with a final sentence or lead-in statement that is often phrased as a question ending with a question mark, but may be a phrase ending with a colon that is to be completed by choosing an answer from the answer choices or options list.

Stem, consisting of a line or several lines that set the stage of the question, ending with a lead-in statement. The lead-in is then followed by the options list:

A. Option A
B. Option B
C. Option C
D. Option D
E. Option E

Many older anatomists were trained with questions that often dealt with anatomical minutiae that held little clinical significance. As a consequence, some of these types of questions linger still, but for the most part, anatomists have embraced the practice of writing clinically based questions. Because anatomy is taught to students of the health sciences who will one day practice their craft with patients, question stems should be posed in a clinical setting. Many of our students are medical students who will face a standardized qualifying examination like the NBME Step 1 at some point in their training, and the questions on such exams are written with a clinical scenario. As teachers, it is our responsibility to prepare our students as well as possible for their qualifying exams. Of course, our primary responsibility to our students and to society in general is to teach anatomy in a way that will enable our students to practice health care as safely and proficiently as is humanly possible. The Step 1 exam and other qualifying exams are designed to assess a student's ability to do exactly that, that is, to enter the clinical phase of their training and to begin to work earnestly with patients, so that these are not competing goals but are completely aligned and complementary.

While most recently developed NBME-format questions use clinical scenarios that include details such as pulse, blood pressure, lab test results, and other clinical data, for an average anatomy exam question, it may not be desirable to add such details. A pseudo-NBME format can be sufficient for most gross anatomy courses, where the effort of question development can be quite onerous. The clinical setting of a question should always be realistic and should usually present common clinical problems rather than extreme exceptions. For example, a shortened clinical scenario could be something like:

As a surgeon, you are operating in the posterior mediastinum in order to gain access to the esophagus and resect a squamous cell carcinoma (aka epidermoid carcinoma). What other structure must you be aware of which also resides in this region?

(a) Aortic arch
(b) Brachiocephalic veins
(c) Descending thoracic aorta
(d) Phrenic nerve
(e) Thymus
(f) Trachea

Adding images to a question, especially diagnostic imaging studies, can dramatically improve its clinical relevance (see the box on next page).

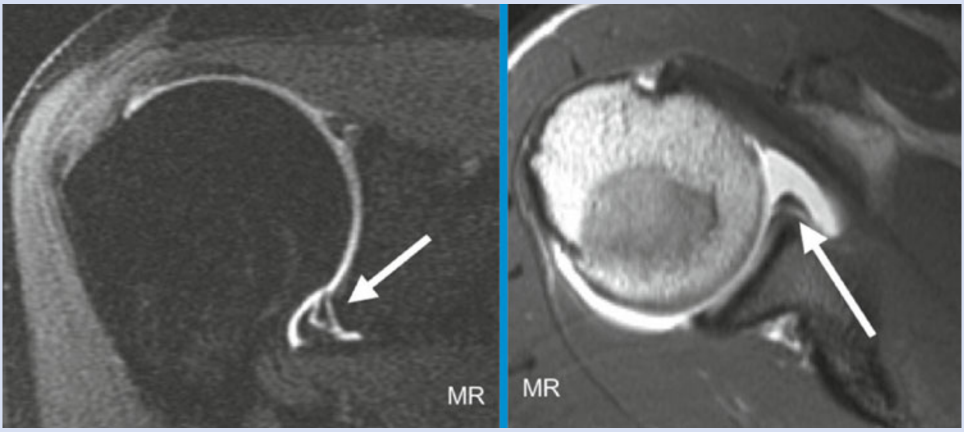
Many of the questions one writes during one's career will eventually become practice questions in a databank of questions somewhere, and these can be made more valuable for student study by making the clinical scenarios apply to commonly encountered problems. Students learn a great amount from practice questions, and they will learn more useful information if the review questions are not esoteric nor questions concerning anatomical trivia.

The final sentence of the question scenario, also called the lead-in, leads to the answer options, and this final sentence should be clear and unambiguous. Negative or "except" statements should be avoided, and this type of wording is discouraged on NBME questions. Lead-in statements that resemble "Which of the following is NOT…" should be avoided. Consider the double negative presented below as an example of a perfectly horrible question:

All of the following statements are false except:

(a) The atrioventricular valves contain fine blood vessels.
(b) The sinuatrial node consists of Purkinje fibers.
(c) The AV bundle is isolated from the cardiac musculature by a sheath of connective tissue.
(d) The "skeleton of the heart" separates the musculature of all four chambers of the heart.
(e) The only surface of the heart devoid of endocardial lining is found over the chordae tendineae.

A football player is struck from behind on his shoulder, driving his humeral head anteroinferiorly out of the glenoid cavity and resulting in an anterior shoulder dislocation. His dislocation is reduced, but a week later, he complains of pain in the affected shoulder, especially with abduction. The MRI studies shown reveal damage to the structure indicated by the arrows, which is the:



A. Acromion process
B. Bicipital (intertubercular) groove
C. Coracoid process
D. Coracoacromial ligament
E. Deltoid tuberosity
F. Glenohumeral band
G. Glenoid labrum
H. Infraglenoid tubercle
I. Infraspinatous fossa
J. Scapular notch

How to Make the Perfect Multiple-Choice Question: Options That Matter

Once the clinical scenario of the question is laid out in the stem, the options or answer choices must be listed. Often, the correct option is simply (and correctly) referred to as the answer, while the incorrect options are called foils or distractors. The most important rule of thumb in constructing the final sentence of the stem (the lead-in) and the options list is: Can the question be answered without the options list? The answer to the question posed in the lead-in should exist in a person's mind without being presented with the list of options and should not be dependent on the wording within the options. Options should never be sets of true or false statements, such as the perfectly horrible question example above. Phrasing the question positively and adding a frame of anatomical reference does very little to improve the quality, such as in the following:

> Which statement regarding the suprarenal glands is correct?
> (a) Entire arterial supply is directly from the abdominal aorta.
> (b) Veins from both glands drain directly into the inferior vena cava.
> (c) Glands are localized in the pararenal space.
> (d) Cells that secrete epinephrine and norepinephrine are innervated by preganglionic fibers from the greater thoracic splanchnic nerve.

Options should be as short and simple as possible, and all options should be as equal in length as possible. The test-wise student will often be drawn to the longest option in the list, such as in the following question:

> During an appendectomy, care should be taken not to disturb the autonomic innervation of the cecum, which reaches it through the:
> (a) anterior vagal trunk.
> (b) celiac plexus.
> (c) lumbar splanchnic nerves.
> (d) pelvic splanchnic nerves.
> (e) perivascular plexus along the ileocolic artery.

Repetitive terms should be eliminated in the options list, such as in the following pairs of questions:

> During an exploratory abdominal surgery, the surgeon passes her finger through the omental foramen into the omental bursa. The ligament situated directly anterior to her finger is called the:
> (a) falciform ligament.
> (b) gastrocolic ligament.
> (c) gastrosplenic ligament.
> (d) hepatoduodenal ligament.
> (e) splenorenal ligament.

The options list in the question above should be simplified to:

> During an exploratory abdominal surgery, the surgeon passes her finger through the omental foramen into the omental bursa. The ligament situated directly anterior to her finger is called the:
> (a) falciform.
> (b) gastrocolic.
> (c) gastrosplenic.
> (d) hepatoduodenal.
> (e) splenorenal.

One should always avoid absolutes like "always" or "never." Vague words such as "usually" should usually be avoided. Options such as "None of the above," "All of the above," and "More than one but not all of the above" should never be used. To be consistent and to help students locate the correct answer as easily as possible, the list of options should always be alphabetized. This is especially true for Type R extending matching options lists, where students might spend considerable time finding the correct answer in a list of randomly arranged options.

Good multiple-choice questions take time and effort to produce. An unseasoned or lazy exam writer may fall into regrettable traps when working on multiple-choice questions. One pitfall in particular is the formulation of multiple-choice questions that give away the correct answer. The test-wise student will look at an option list and select the option that contains the most common items or an item repeated from the stem, such as in the following:

> A 48-year-old male patient complains to his primary care physician of a painful shoulder. Testing reveals that the patient has weakness in lateral rotation and initiation of abduction of his arm. The physician suspects that the ________ nerve is being compressed as it passes beneath the ________ ligament.
>
> (a) axillary; superior transverse scapular
> (b) dorsal scapular; superior transverse scapular
> (c) suprascapular; inferior transverse scapular
> (d) suprascapular; superior transverse scapular
> (e) suprascapular; transverse humeral

A test-wise student would notice that "suprascapular" and "superior transverse scapular" are repeated three times each in the options list and would be wise to choose the answer that contained both of these items.

Students are usually very adept at taking multiple-choice exams, and therefore, it is imperative that the question writer take the time necessary to produce questions that test knowledge rather than test-wiseness or the ability to take multiple-choice exams.

Conclusion

Properly constructed multiple-choice exams may not only serve as fair and impartial measures of competency, but they may also help the beginning student to prepare for the type of questions found on qualification examinations such as the Step 1 exam administered by the National Board of Medical Examiners. Also, students can gain precious knowledge through self-testing from well-written multiple-choice questions found in question banks, such as those found on the University of Michigan Anatomy web site. That university's collection of multiple-choice questions is one of the highest rated features of the anatomy web site, according to student evaluations. The positive evaluation of the Michigan web site question bank supports the work of Karpicke et al. on the effects of retrieval-based learning [2, 3]. This research on retrieval-based learning has demonstrated a positive influence of repeated self-testing on learning. Of course, not everyone has access to thousands of old multiple-choice questions from which to create a question bank. Perhaps this could be the stimulus for the community of anatomists to create a web-based repository of multiple-choice questions that could be made available to students and faculty worldwide. An extensive and comprehensive repository of high-quality multiple-choice questions would help students by providing fruitful retrieval-based learning activities and would also help faculty in putting together quizzes and exams. Some may cringe at the thought that both students and faculty might draw from the same well of questions, but if the question well is made broad and deep enough with a sufficiently large number of well-written questions, then it would not matter. A student who could review and remember several thousand multiple-choice questions would, in the process, also be learning an immense amount of anatomy, which is, after all, our goal as teachers.

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Peer and Faculty Assessment of Nontraditional Discipline-Independent Skills in Gross Anatomy

33

Nirusha Lachman and Wojciech Pawlina

Introduction

Quality improvement and patient safety remain at the forefront of healthcare delivery. As management systems recognize the impact that poorly developed nontechnical skills may have on patient safety, efforts to strengthen leadership and communication skills, situational awareness, teamwork, and professionalism among practicing healthcare workers have increased. The importance of nontechnical skills in healthcare is discussed in the literature [1–4] and improvement in their use requires practice and repetition [5]. In addition, several studies in surgical environment showed that nontechnical skills are linked to surgical skills (technical skills) especially when evaluated during intraoperative crisis management situation. In general, it has been concluded that surgeons who possessed good technical skills also tended to show similar levels of performance in the nontechnical skills domains. The opposite relationship is also observed where poor performers in nontechnical skills domains were often deficient in technical skills [6]. While organizations continue to seek opportunities to build on these skills through formal training sessions [7, 8], medical educators share the responsibility by finding opportunities within medical curricula to promote early development of such nontraditional discipline-independent skill [9, 10]. It is evident that health profession educators must begin to embrace teaching of nontechnical or nontraditional discipline-independent skills both in their medical and allied health curricula and throughout the continuum of professional career [4].

In this chapter, we provide insight into understanding nontraditional discipline-independent skills and how it relates to anatomy education. We highlight opportunities for integration of nontraditional discipline-independent skills within the anatomy curriculum and ways by which these skills may be evaluated in a team-based learning environment and contribute to overall student performance.

In the global context of healthcare delivery, improvement of patient treatment and safety through multidisciplinary teamwork has been strongly recognized. In medical education, teamwork and the skill of working effectively within a professional team has become a valued component of the curriculum embedded within the core competencies of the Accreditation Council for Graduate Medical Education (ACGME) [11] in the USA.

Over the years, many anatomy curricula have evolved to incorporate objectives that allow for the development of skills not directly related to the acquisition of anatomical knowledge. These *nontraditional discipline-independent skills* focus on team interaction, communication, leadership, and other aspects of professionalism that are required for delivery of quality healthcare.

The process of educating medical students however is as intuitive as it is fundamental. Anatomy

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> "Today's physicians must demonstrate both professionalism and leadership skills in order to succeed in largely team-based healthcare environments."
>
> Pawlina et al. [13]

courses that include laboratory experiences are never designed for secluded/individual learning. Just as dissection of the human body is a shared experience, learning anatomy in a curriculum that aligns with principles of healthcare delivery cannot be chalked up to basic factual assimilation of knowledge by an individual student. In today's work culture, collaboration and teamwork underpin a successful work environment. Successful teamwork, however, involves more than just a group of random individuals working together toward a common goal. It involves an understanding of individuals' strengths and weaknesses, of professionalism and openness to sharing and gaining from others' perspectives and experiences.

While incorporating teamwork in the classroom is often challenging for most medical school courses, team-based exercises are central to the learning of anatomy. Lerner and colleagues [12] define teamwork as the "ability of team members to [13] work together [5], communicate effectively [14], anticipate and meet one another's demands, and [1] inspire confidence" which is said to result in effective collective action toward the achievement of a common goal.

Within the context of anatomy courses, students may be provided with opportunities to demonstrate these skills by being formally assigned to teams (within the anatomy laboratory and classroom) [15] with rotational leadership roles within their team and attaching value to peer and faculty assessments by having them contribute toward the final grade. Providing clear objectives and expectations at the beginning of the course with regular short reflective presentations (one to two slides showing examples of good and poor practices through teaching team observations or simply reminding students to be reflective) throughout the course encourages student awareness and subsequent development of nontraditional discipline-independent skills.

Assessing Nontraditional Discipline-Independent Skills

Peer Assessment

The learning process in the anatomy laboratory largely depends on the presence of cohesive learning teams. To achieve that goal, every member of the team needs to be accountable for his or her individual contribution to the team. Dissection teams are in the best position to recognize multiple and different kinds of contributions from their respective members. Some contribute a wealth of creative ideas for the team to consider, others are stronger in analyzing and assessing those ideas, and yet other students are very helpful in managing the group work. Hence, the team members develop a clear understanding of the varied ways in which individual members contribute to the work of the group. Peer assessment is essential because team members are typically the ones who have enough interaction and information to accurately assess one another's contributions.

It is important to remember that most students if not all have little or no experience evaluating peers. For most of them, the task is daunting and often associated with the fear of social

Demonstrating a Good Work Ethic in the Laboratory

Students working with a dissection team:

- are prepared for the day's dissection.
- are reliable and attend laboratory and briefing sessions/classroom activities.
- attend team meetings that occur outside of formal laboratory or class time.
- make positive contributions to team discussions and assignments.
- value and encourage input from fellow team members.
- are respectful in considering cultural differences and diversity within the team.

Guiding Students Through the Peer Evaluation Process

- Introduce the concept of peer evaluation.
- Relate to core objectives and curriculum requirements.
- Teach how to provide useful constructive feedback using examples.
- Demonstrate good examples of student-generated feedback and allow students to analyze and revise poorly constructed comments.

repercussion among fellow students [16–18] (see Chapter 17). As faculty continues to keep in mind that in as much as peer evaluations provide information on student demonstration of nontraditional discipline-independent skills, for students the process of providing the assessment is still a learning activity. Student learning and ability to conduct an evaluation may be enhanced by clarifying goals and objectives for providing feedback, explaining to them how the feedback will be used, setting clear criteria for assessment, and paying attention to the timing of the assessment [19].

As a form of best practice, peer evaluations should be conducted in the middle of the course/block as well as at its conclusion [11]. In addition to assigning grades, students should be asked to provide written comments on the positive and negative aspects of their interactions within the dissection group.

How Do Students Benefit from Performing Peer Assessment?

The benefits of performing peer evaluation are twofold. On the one hand, students are given the opportunity to learn how to critically judge attributes that are demonstrated in the process of fulfilling course objectives, and on the other, students are provided with valuable feedback that directs focus on their own self-improvement [20]. Peer Evaluation:

- *is engaging for students*: Students are held responsible for their contribution toward the success of the team. It creates an awareness for behaviors and characteristics that would otherwise not be considered.
- *is a good source of feedback*: Enables faculty to provide anonymous peer generated constructive commentary to students so that they may improve team performance.
- *promotes student reflection and collaborative learning*: Helps identify areas of weakness in conceptual understanding. Allows students to understand course objectives better and improve knowledge and overall performance.
- *helps develop interpersonal skills*: Allows students the opportunity to work with individuals who may have varying learning styles, cultural backgrounds, and personality traits different from their own.
- *promotes professionalism*: Peer assessment is designed around aspects of professionalism. It promotes increased awareness of expectations and required competencies.
- *promotes accountability*: Student participation becomes incentive based. Encourages fair and equal participation and contribution to the group, thereby limiting "social loafing" [21, 22] of team members.

> "When students develop the capacity to judge their peers' performance, they might improve their capacity to examine their own clinical performance."
>
> Hulsman et al. [14]

Considering that every educational environment may be different, there is no definitive way to conduct peer evaluation. On the spectrum of methods discussed by Michaelsen and colleagues [22], the advantages and disadvantages of these are clearly

GROSS ANATOMY PEER EVALUATION FORM

NAME ______________ TEAM/TABLE # ______

At the end of the Block III, it is necessary for all members of the dissection group to assess the contributions that each member of the group made to the work of the group. This contribution should reflect your judgment on:

- Preparation for the laboratory dissection and other team assignments
- Contribution to the dissection process, group discussions and assignments
- Reliable attendance in the laboratory and other team-based activities
- Flexibility and ability to resolve disagreements
- Personal commitment to honor the choices and rights of other members
- Responsibility for own actions and decisions
- Overall professionalism as demonstrated in the commitment to demonstrate values and attributes that constitute professionalism

Please assign scores that reflect how you really feel about the extent to which the other members of your team contributed to your learning and team performance. This will be your only opportunity to reward the members of your dissection team who worked hard on your behalf. (Note: If you give everyone the same score, you will be hurting those who did the most and helping those who did the least.)

Instructions:

In the space below please rate each of the other members of your team except yourself by distributing 60 points. Each member's peer evaluation score will be the average of the points they receive from the other members of the team. To complete the evaluation you should: 1) List the name of each member of your team except yourself, and 2) assign an average of 20 points to the members of your team (you should assign a total of 60 points in a four member team), and 3) differentiate some in your ratings; eg. You must give at least one score of 21 or higher (maximum = 30) and one score of 19 or lower.

Team Members Scores

1)____________________________

2)____________________________

3)____________________________

Additional Feedback:

In the space below briefly describe your reasons for your highest and lowest ratings. These comments – but not information about who provided them – will be used to provide feedback to students during formal feedback sessions with faculty

Reason(s) for your highest rating(s). (Use back if necessary.)

Reason(s) for your lowest rating(s). (Use back if necessary.)

Fig. 33.1 Gross anatomy peer evaluation form

recognized. The common principle, however, is based on allocation of points through differentiation among team members. In our 7-year experience, we have found the use of a modified version of the Michaelsen's method (Fig. 33.1) [22] in conjunction with formal orientation and dedicated time for teaching students how to recognize positive and poor nontraditional discipline-independent behaviors effective and well accepted among students (Mayo Medical School 2007–2013) [17, 23, 24].

We provide an interpretation for a set of nontraditional discipline-independent skills as they relate to observable behaviors within the anatomy teaching and learning environment (Table 33.1) [23].

One of the strengths of designing the anatomy curriculum within a team-based environment is its potential for emphasizing leadership and the importance of developing leadership skills. Again, students in the early stages of professional development cannot be expected to show natural leadership abilities. While strong leadership may be intuitive, basic leadership skills require effort, reflection, and a commitment to taking on greater responsibility for the purpose of team success. Instituting leadership evaluation following outline of clear expectations for the leadership role is recommended as an adjunct to peer evaluation. We have adapted a student leader evaluation form [25] that is completed for each rotating leader. The evaluation (Fig. 33.2) uses a Likert scale to rate the leader on five of nontraditional discipline-independent skills presented in Table 33.1 below in addition to rating the student leader's problem-solving ability and overall professionalism. Written feedback regarding the leader's strengths and areas for improvement are also required and shared with the leader during formal feedback sessions with faculty (see Chapter 17). Student leadership evaluation also provides opportunity for self-reflection on leadership experience and skills. Unlike with the peer evaluation, the student being evaluated in this case is also required to complete the evaluation form. Scores are then analyzed and presented as a bar graph comparison of peer and self-ratings. The learning impact is significant in the sense that it provides insightful information on the student's ability to criti-

Table 33.1 Observable behaviors related to nontraditional discipline-independent skills in anatomy

1. **Respect** *Shows personal commitment to honoring the choices and rights of others*	• Acknowledges the rights of others in an inclusive and culturally sensitive way • Works consciously with donor bodies to ensure careful and sensitive handling of cadaveric material • Conforms with dress code within the laboratory • Acknowledges and makes accommodation for team members with learning difficulties and physical challenges
2. **Integrity** *Shows commitment to honesty and trustworthiness in evaluating and demonstrating own skills and abilities*	• Assigns realistic grades to peers and provides honest evaluations based on peers contribution to students own learning • Recognizes strengths and weaknesses when contributing to achievement of team outcomes
3. **Responsibility** *Accepts responsibility for own actions and decisions without blaming others*	• Admits to shortcomings in team activities (e.g., dissection quality, team assignments) • Shows commitment to attendance of lectures and laboratory sessions • Keeps team and faculty updated on absences and personal challenges that may affect individual and team performance
4. **Compassion** *Shows adequate appreciation of other person's special needs for comfort and provides support without overt emotional involvement*	• Supports team members by making allowances for unexpected personal challenges during course • Shows understanding when one or more team members are experiencing difficulty with course material • Aware of the importance of wellness for individual team members
5. **Commitment to excellence** *Shows adequate commitment to the pursuit of excellence and continuous quality improvement*	• Providing high-quality dissections for evaluation • Striving for excellence in team presentations (verbal—laboratory "bedside" presentations; written—embryology pamphlets, autopsy reports, etc.) • Ensuring reading assignments are completed on a regular basis to ensure valuable contribution in team-based learning (e.g., ARS, dissection, etc.)

STUDENT LEADER EVALUATION FORM

Please rate the student leader below with whom you have worked. Circle one response per item. Circle the appropriate number between 1 and 9 where 1 is the lowest rating and 9 is the highest rating. If you had insufficient contact to evaluate this student/leader on a particular characteristic, circle UA (unable to evaluate).

Name of Leader ______________________________

Please check one of the following: ☐ I am the leader being assessed (i.e. I am assessing myself)
☐ I am a team member of the leader being assessed

	1	2	3	4	5	6	7	8	9	UA
Respect	1	2	3	4	5	6	7	8	9	UA
	Shows inadequate personal commitment to honoring the choices and rights of other persons.					Always shows exceptional personal commitment to honoring the choices & rights of other persons.				
Integrity	1	2	3	4	5	6	7	8	9	UA
	Shows inadequate commitment to honesty and trustworthiness in evaluating and demonstrating own skills and abilities.					Always shows exceptional commitment to honesty and trustworthiness in evaluating and demonstrating own skills and abilities.				
Responsibility	1	2	3	4	5	6	7	8	9	UA
	Does not accept responsibility for own actions and decisions; blames other professionals.					Fully accepts responsibility for own actions and decisions; does not blame other professionals.				
Compassion	1	2	3	4	5	6	7	8	9	UA
	Shows inadequate appreciation of other person's special needs for comfort and help, or develops inappropriate emotional involvement.					Always appreciates other person's special needs for comfort and help, but avoids inappropriate emotional involvement.				
Problem-Solving	1	2	3	4	5	6	7	8	9	UA
	Fails to critically assess information, risks, and benefits; does not identify major issues or make timely decisions.					Critically assesses information, risks, and benefits; identifies major issues and makes timely decisions.				
Commitment to Excellence	1	2	3	4	5	6	7	8	9	UA
	Shows inadequate commitment to the pursuit of excellence and continuous quality improvement.					Always demonstrates a commitment to the pursuit of excellence and continuous quality improvement.				
Overall Professionalism	1	2	3	4	5	6	7	8	9	UA
	Shows inadequate commitment to the characteristics and attributes that constitute professionalism.					Always demonstrates a commitment to the characteristics and attributes that constitute professionalism.				

ADDITIONAL COMMENTS FOR LEADERS

Leadership Strengths

Suggestions for Improvement

Fig. 33.2 Student leadership evaluation form

> "Early introduction of peer-assessment in medical education would facilitate early acceptance of this mode of evaluation and would promote early on the habit of critical evaluation of professional clinical performance and acceptance of being evaluated critically by peers."
>
> Hulsman et al. [14]

cally assess their own strengths and weaknesses and compare evaluation of themselves with the perception of others (Fig. 33.3).

Faculty Evaluation of Nontraditional Discipline-Independent Skills

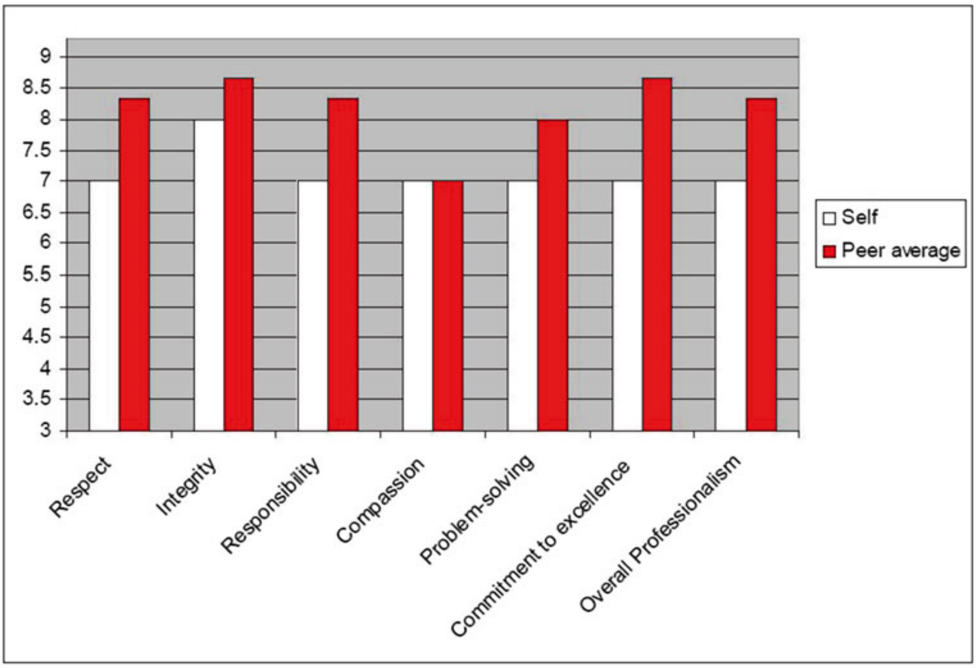
Objective assessment of nontraditional discipline-independent skills is challenging and little can be done to limit subjectivity when assigning formal grades. One method to consider may be to categorize evaluating skills under two broad categories: (1) *cognitive skills,* relating to a student's capacity to think (reason clinically), make decisions, and formulate actions, and (2) *social (interpersonal) skills,* relating to how a student interacts with other individuals

MAYO CLINIC

Mr.
Group Leader

Dear Block III Leader,

I would like to take this opportunity to thank you for being a leader during the Human Structure block. Please find below tabulated results of your self–evaluation and compare them with the results of the evaluation from your peers. I think these evaluations are very valuable exercises in assessment of leadership, teamwork, and professionalism at this stage of your medical career. They provide you with thoughts for self-reflection and with an opportunity for recognizing directions for further self-development.



If you have any comments, please do not hesitate to contact me.

Thanks,

Wojciech Pawlina M.D.

WP:drf

Fig. 33.3 Graphic comparison of peer vs. self-evaluation within the course (peers, near-peers, and faculty) to convey information (Table 33.2) [26]:

1. Faculty should interact with students in the lab as much as possible (moving around to tables to ensure equal interaction, questioning, and guiding through more difficult dissections).
2. Communicate with students during course.
3. Observe students during class (attentiveness to lectures, focused, punctuality, interaction with team members during ARS discussion sessions).
4. Monitor student progress (ARS scores, follow up with students when performance declines).
5. Provide feedback whenever possible (formal sessions mid-block and on the job feedback).
6. Maintain paper trails and records of student interaction with more challenging students.

For a total of 10 % contribution toward the final grade, assign 5 % to cognitive skills and 5 % to social skills. Assuming that all students in general were able to meet expectations, allocate 4/5 to each category and reserve a 5/5 for students who have demonstrated exceptional skills and score 3/5 and below for students who need improvement. In addition, use the same categories to provide written feedback to qualify faculty-generated scores. In addition, faculty evaluations should include submission of a written evaluation of each student at the conclusion of the course (Fig. 33.4). Included in these evaluations are observations on students' professional

Table 33.2 Opportunities for assessment of cognitive and social skills

Cognitive skills	**Opportunities for assessment**
Anticipation of problems	• During dissection and laboratory sessions • Near-peer feedback through faculty debriefing sessions [26] • Faculty interaction
Decision making	• Peer feedback • Leadership evaluation
Situation awareness	• Faculty and near-peer observations during class and laboratory sessions
Problem-solving ability, knowledge retention, and conceptual ability	• ARS performance • Practical tests • Overall performance on knowledge-based evaluations
Flexibility	• Faculty interaction • Peer and leadership evaluations
Adaptive strategies and workload distribution	• Leadership evaluations
Social skills	**Opportunities for assessment**
Communication	• Written communications • Verbal communication • Faculty and near-peer observations of overall disposition • Peer and leadership evaluations • Team presentations (oral and written: e.g., patient communication brochures, autopsy reports, bedside presentations)
Leadership	• Leadership evaluations • Faculty and near-peer observations
Teamwork	• Peer evaluations • Faculty and near-peer observations
Commitment to self-improvement (seeking feedback/advice/learning opportunities)	• Peer evaluations • Faculty and near-peer interactions • Self-evaluations
Commitment to personal well-being	• Multifaceted input including feedback from Medical School Administration
Resource management	• Leadership evaluation

MAYO CLINIC

Memo

Wojciech Pawlina, M.D.
Professor and Chair
Department of Anatomy
Stabile 9-38

DATE: December 3, 2012

TO: Mayo Medical School

FROM: Wojciech Pawlina, M.D.
Chair of Block III Human Structure

RE: Block III Final Course grade

Dear

The purpose of this memo is to inform you of your performance in Block III Human Structure.

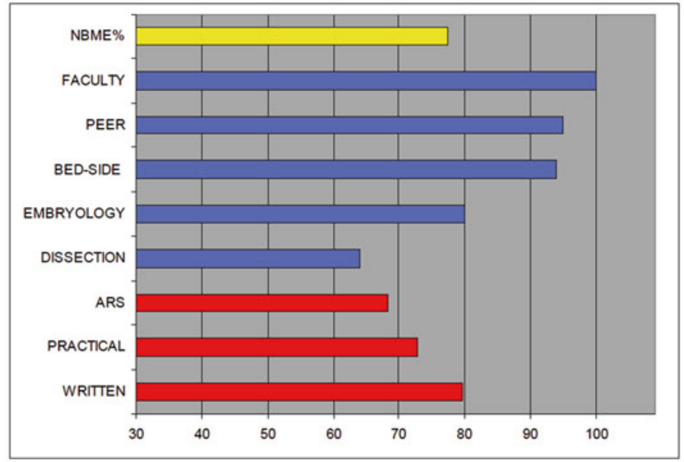
The final grade for Block III Human Structure
80.07% (Pass)

Specific components of your final grade are listed in the table and graph below:

Objective Components:	Your Score	Class Average	Percent of Final Grade	Subjective Components:	Your Score	Percent of Final Grade
Written Examination	79.66%	76.61% (SD ±6.298)	30%	Laboratory Peer-Assessment Score[1]	95.00%	10%
Practical Examination	72.73%	78.62% (SD ±12.92)	20%	Faculty and TAs Evaluation Score	100.00%	10%
Audience Response System Questions	68.23%	74.50% (SD ±5.04)	10%	Anatomy bed-side Presentation	94.00%	5%
Dissection Quality	64.15%	74.24% (SD ±4.58)	2.5%	Embryology brochure	80.00%	2.5%
NBME Examination Gross Anatomy + Embryology	77.47% 580[2]	77.62% (SD ±10.49)	10%	Your NBME US rank	77 percentile rank	
NBME Examination Gross Anatomy only	77.15% 570[2]	77.62% (SD ±10.49)	N/A	Your NBME US rank	68 percentile rank	

[1]This score represents the average percent value calculated from the sum of points assigned by your team members. Twenty (20) points equates to 100% of the laboratory peer-assessment score.
[2]This is your original test score. For example, if your score in Gross Anatomy + Embryology is 500 with the corresponding percentile rank of 53, it indicates that 53% of the national group of examinees who took the Gross Anatomy + Embryology Subject Examination as an end-of-course or end-of-year assessment had scores at or below 500. For detailed explanation see next page.

Here is the graph of your performance (in percentages) on individual components of the Human Structure Block.



The NBME score scale is defined to have *a mean of 500 and a standard deviation of 100* for a group of 4,285 first-time takers from 36 U.S. LCME-accredited medical schools who took the Gross Anatomy and Embryology Subject Examination or a modular component of the exam as an end-of-course exam under standard testing conditions during the 2002-03 and 2003-04 academic years. The vast majority of scores range from 200 to 800. Two sets of norms have been developed to aid in the interpretation of examinee performance: 1) the Gross Anatomy + Embryology score and 2) the Gross Anatomy score.

The mean score for MMS Class 2016 on the NBME Gross Anatomy + Embryology Subject Examination was 581.1 points (SD ±78.5) which corresponds to 77 US percentile rank.
The mean score for MMS Class 2016 on the NBME Gross Anatomy Subject Examination was 573.4 points (SD ±77.5) which corresponds to 69 US percentile rank.

Only your original test score of the NBME Gross Anatomy + Embryology Subject Examination Subject examination was used for calculating 10% of your grade and was normalized to the class average of both the written and practical examinations (77.62%).

If you have any questions or comments regarding your performance, please do not hesitate to contact me.

Thanks,

Wojciech Pawlina M.D.

WP:drf

Fig. 33.4 Student communication of performance attitudes, respect for others, preparation, contributions to team learning, leadership experience, decorum, responsibility, and interest and participation in a variety of course activities (see Chapter 17).

Conclusion

As we move forward in the teaching and learning of anatomy, the dynamic continuum between tradition and change commits educators to incorporate aspects of learning not traditionally associated with its basic science. As the expectations for healthcare professionals continue to evolve, medical educators are obliged to find opportunities within their curricula for the early development of nontraditional discipline-independent skill sets. Applied to this setting, these nontechnical skills translate as nontraditional discipline-independent skills that are recognizable through student interaction, communication, execution of tasks, and overall display of professionalism [24]. While acknowledging its importance, its impact on student learning is best achieved through formal assessment of these skills. In this chapter, we have drawn from a 7-year experience of assessing nontraditional discipline-independent skills. While assessment of nontraditional discipline-independent skills may be best achieved in a team-based learning environment, peer- and faculty-generated feedback may be equally effective in larger group settings. Early exposure to systems of peer-evaluation [16] during the medical curriculum provides an effective means of developing students' confidence in evaluating their peers, while repeated exposure enhances the quality of the evaluations they will be able to provide [27].

> "I liked the emphasis on professionalism, teamwork, and peer evaluation which will be so important down the road!"
>
> Year 1 student, Mayo Medical School, Class 2017

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Part VII

Curriculum Design

34 Anatomy Education in an Innovative Medical School Curriculum

Jennifer M. McBride and Richard L. Drake

You have just accepted the position as Director of Anatomy at a new medical school. The new school has decided on an integrated organ systems-oriented curriculum using a problem-based format interspersed with additional classroom activities. Your challenge is to develop an innovative approach to anatomy education at this forward-thinking institution with limited contact hours.

First Considerations

Whether you find yourself in the situation described in the first paragraph or you have to significantly modify an existing course due to a major curriculum revision, there are three basic guidelines that must be followed.

Match the Curriculum with the Academic Program's Foundation

When a major curricular reform occurs, there is usually a specific curriculum that someone or some group has chosen to institute. Examples would be a discipline-based curriculum, an integrated curriculum, or a mixture of the two. Similarly, when a new institution is being created, there is usually a specific educational philosophy that has been chosen as the basis for the curriculum that will be designed. An example might be student-centered learning versus teacher-centered learning. Whatever the case, these factors are the foundation for the academic program, and the anatomy course that is being developed must seamlessly fit into this environment. If it does not, the success of the program will likely be limited.

Incorporate Faculty into the Planning Process

As a new course is developed, the skills, abilities, and interests of the faculty who will teach this course must be foremost in the considerations of the planners. This also applies when a major curricular reform is being planned. The faculty are the individuals who will have the responsibility of instilling confidence in the students that the course they are taking or the curriculum they are following will meet their needs as they continue their medical training. If a course, or a curriculum, is developed by a small group of individuals who have a vision, but they do not evaluate whether the faculty have the skills, abilities, and much less the interest to carry out the new program, the planning process is severely flawed. The capabilities of the faculty must be considered during the entire planning process and their

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opinions obtained to provide the best opportunity for a successful outcome. A feeling of ownership in the final product is absolutely essential.

Know Your Student Base

The outcome that demonstrates the true success of a new course, or a major curricular reform, is whether student learning has been enhanced. All planning must take into consideration (1) the number of students who will be involved in the new course or curriculum, (2) the academic background of these students, and (3) their capabilities, i.e., can they accomplish what we are asking them to do? Educational approaches and activities that are successful with 30 students may not realize the same success with 130 students. What works at one institution may not be successful at another simply because of the population of students involved. So design a course/curriculum with your consumer in mind.

> **Basic Guidelines of Course Development**
>
> - The course being developed must match the curriculum or philosophy of education at the institution.
> - The course must complement the group of faculty involved in the teaching.
> - The course must be appropriate for the type of students that will be participating.

Current Trends

During the past 15 years, curricular reform has been a major event especially in medical schools in the USA. Driving forces behind these reforms include, but are not limited to, the desire to decrease the number of contact hours and increase the time available for self-directed learning, reducing lectures and increasing the number of activities that involve interactive learning, reducing unnecessary redundancy between courses and increasing the integration of various subjects, increasing the opportunities for early student contact with clinical faculty, and increasing the use of electronic resources when the opportunity presents itself. These issues have led course developers in all subjects, including anatomy, to consider the following guiding principles when designing/planning a course in a modern medical school curriculum.

Use Active Versus Passive Learning

It's well established that learning and retention are improved through the use of more interactive activities in an educational program [1–3]. Examples of interactive approaches include problem-based learning, team-based learning, small-group interactive sessions, peer-facilitated workshops, the use of audience response systems, incorporation of web-based instructional materials, and simulations. While lectures can still play an important role in education, the current trend in course design has been to decrease the number of lectures and increase the use of interactive educational approaches.

Provide Efficient Laboratories

One of the biggest changes has been a decrease in the available contact hours for all courses. This has had a significant impact on anatomy courses since they are nearly the only course in a modern medical school curriculum that maintains a laboratory. Furthermore, this laboratory activity is regarded by many as the most important component of an anatomy course. So in order to maintain this valuable educational experience, it has to become more efficient. An example of some of the types of changes that have been introduced to facilitate a more streamlined experience in the anatomy laboratory include the increased use of prosections or previously dissected specimens, peer-teaching–peer laboratory exercises, and the use of plastinated demonstration specimens. These approaches have resulted in a reduction in course hours, but allowed the unique learning opportunity in the anatomy laboratory to remain a major component of the modern medical school curriculum.

Vary the Educational Experience

Individuals learn in different ways [4], and to take advantage of this situation, current suggestions are to use a variety of educational experiences to enhance and stimulate learning. This multimodality approach has been used in anatomy for many years (lectures and laboratories), but the current trend is to expand these offerings. In anatomy this is easily accomplished by adding imaging, interactive sessions in the classroom, body painting, and a variety of approaches in the laboratory as mentioned in the preceding section [5–7].

Integrate Anatomy with Clinical Medicine

Integrating anatomy with clinical medicine is not new to anatomy courses. Learning in context has been occurring in these programs for several decades. However, the current trend is to increase this activity throughout the course which gives students a reason to learn and understand the subject [8, 9].

Establish Opportunities for Longitudinal Learning

Learning should be longitudinal. Studies have shown that if information is revisited, retention is improved [10]. Make an effort to establish some type of unique educational activity in every aspect of the curriculum where it is appropriate, including upper-level clinical rotations. But always demonstrate how your contribution is an additional opportunity for students to reinforce their understanding of the anatomical sciences, has a positive impact on student learning, is a great example of longitudinal integration, and enhances their training as a future physician. The amount of time you get is not as important as is your presence in other parts of the curriculum [9].

> **Five Guiding Principles of Course Development**
>
> - Use active versus passive learning.
> - Time is limited so the laboratory must be efficient.
> - Use a variety of educational experiences.
> - Integrate anatomy with clinical medicine.
> - Learning should be longitudinal.

Example

The best way to indicate how a course can be designed using the basic guidelines and guiding principles described previously is to provide an example. In this case, the three basic guidelines:

- The course being developed must match the curriculum or the philosophy of education of the institution.
- The course must complement/fit the group of faculty involved in the teaching.
- The course must fit/be appropriate for the type of students that will be participating.

and the five guiding principles:

- Use active versus passive learning.
- Time is limited so the laboratory must be efficient.
- Use a variety of educational experiences—a multimodality approach.
- Integrate anatomy with clinical medicine—learning in context.
- Learning should be longitudinal.

were followed to develop a new program in anatomy education.

The Cleveland Clinic was beginning a new medical school program that would be associated with Case Western Reserve University School of Medicine. It was going to be a 5-year program to train physician scientists, and the initial class was going to enter the program in July 2004. The challenge was to create an anatomy course in the context of a problem-based organ-system-oriented curriculum that stressed small-group interactive learning, with no lecture and no traditional tests or grades. The time available for this class in the first year would be a 2-h time slot every Monday morning for approximately 30 weeks.

Keeping the three basic guidelines and five guiding principles in mind, what emerged from the course development process was an education program in anatomy that was unique in its approach and innovative in its design. The basics of this approach were to use clinical cases to introduce anatomical concepts and facts that would be reinforced using cadavers and imaging. Additionally, this program would be implemented in a longitudinal continuum.

The foundation knowledge in anatomy will be presented to the students in their first year of medical school. The format used throughout the first year is a three-step process: Step 1—Preview a clinical case, Step 2—Acquire basic knowledge, and Step 3—Reinforce knowledge in the weekly session [11].

In the first step of this process, a simple clinical case is made available to the students on the electronic portal. Included with this case are specific learning objectives and clinical questions to focus students' learning on the anatomy relevant to the case. During the second step, basic anatomical knowledge related to the case is acquired by the students through assigned readings in their textbook, *Gray's Anatomy for Students*, and the use of web-based self-study modules. The third step of the process consists of weekly Monday sessions that help students reinforce their knowledge. Each Monday session begins with a presentation and discussion of the case by a clinician, followed by a cadaver laboratory that presents the anatomy related to the case and outlined in the learning objectives, and an imaging workstation demonstrating relevant anatomy. The cadavers are previously dissected or prosected by residents from the various clinical/surgical disciplines and presented to the students by these same individuals.

But learning anatomy does not stop at the end of the first year. Since reinforcement of knowledge through repetitive exposure helps to solidify learning, the anatomy program is longitudinal. During the second year of medical school, students are able to review and strengthen their knowledge of anatomy approximately once every 4 weeks using the same case-directed format during each organ system course. Additionally, prior to the beginning of their surgical rotation in a later year, students are able to review relevant neck, thoracic, and abdominal anatomy on prosected cadavers prepared and presented by residents. Finally, during the student's final year, opportunities exist for the review of anatomy during several surgical anatomy electives that are offered.

Thus, at the Cleveland Clinic Lerner College of Medicine of Case Western Reserve University, an educational program in anatomy has been created that follows the three basic guidelines and five guiding principles stated earlier. It is part of an integrated curriculum, is a good fit with the faculty and students, is efficient and interactive, uses a clinically oriented approach, effectively uses cadavers and imaging, and is longitudinal by design.

Conclusion

In this day of curricular reform and the development of new educational programs, it's important to remember a successful anatomy course should incorporate active versus passive learning, an efficient laboratory since time is limited, use a variety of educational experiences—a multimodality approach, integrate anatomy with clinical medicine—learning in context, and be longitudinal in design.

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35 The Role of the Anatomist in Teaching of Nontraditional Discipline-Independent Skills

Darrell J.R. Evans and Wojciech Pawlina

Anatomy as a basic science has been at the heart of many healthcare curricula including medicine, dentistry, and physical therapy for centuries. However, in the last decade, the role of anatomy as a basic science course in medical curriculum has undergone significant change that has challenged the very existence of anatomy departments and their educational philosophy. It has been shown that a traditional delivery and assessment of anatomy no longer has a place within the modern medical curriculum.

Many medical schools implement competency-based educational systems which assess observable outcomes to judge student competence based on defined course criteria. Whereas course instructors have been historically more accustomed to using learning objectives as the defining criteria for anatomy knowledge in written and practical examinations, many are less familiar with implementing and evaluating competencies not related to concrete anatomical knowledge.

As medical curriculum evolves, conventional courses need to adopt a new system of basic science instruction. Because anatomy courses are often placed early in most medical curricula, they can provide an ideal forum for introducing a range of skills and attributes important for subsequent practice. Teaching discipline-independent subjects in anatomy should be viewed as a bridge between anatomy and clinical disciplines. The overarching objective of the anatomy course has been to provide discipline-specific fundamental scientific theories and concepts for clinical application. However, in the new environment, anatomy courses should incorporate additional objectives that would be revisited in clinical courses. These include discipline-independent subjects such as: leadership, teamwork, professionalism, and effective communication.

Upon entering a healthcare profession curriculum, students begin the process of professional socialization and the development of their professional identity. This process is contingent upon the development of discipline-independent skills related to their chosen career. As a consequence, anatomists are finding that they are being asked to contribute to professional development aspects of the curriculum in collaboration with colleagues from other disciplines. Additionally, in more recent years, students have recognized that anatomy provides effective opportunities for developing many of the attributes and competencies demanded by professional bodies and future employers. Students themselves therefore see anatomy as one of the cornerstones of their medical education.

Anatomy sessions should expose students to an array of skills: dexterity, as students learn and

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practice the art of dissection and palpation; communication, as students develop interpersonal skills within teams; leadership; and the art of effective teamwork. The use of cadavers provides an early focus for examining legal and ethical issues. Cadavers are also an emotional nidus for many students who have an opportunity to learn coping skills and healthy detachment. Students should learn the professional behavior expected within the healthcare professions early in the anatomy lab, with teachers and supervisors serving as role models. The focus on early professionalism has become increasingly prevalent in anatomical education, which adds further onus upon anatomy educators to polish their own skills in leadership, communication, and human sensitivity. This chapter will outline a number of the skills, competencies, and attributes we expect of our healthcare students. We shall describe how these skills can be accommodated and enhanced by the anatomist.

Nontraditional Discipline-Independent Skills, Competencies, and Attributes

The ability to incorporate nontraditional discipline-independent skills, competencies, and attributes in anatomy teaching will depend on the nature of the particular curriculum including the style of the teaching/learning activities, the level and focus of the content, the assessment opportunities, and the time available. In general, skills and competencies in the clinical discipline are referred to as nontechnical skills. They can be divided into cognitive and social (or interpersonal) skills. Cognitive skills refer to a person's clinical reasoning and the ability to make decisions and act upon them. Cognitive skills include situational awareness, mental readiness, assessment of risk, anticipation of problems, decision making, flexibility, and workload distribution. Social skills, on the other hand, relate to how a person interacts with other people to convey information. Examples of social skills include communication, leadership, teamwork, resource management, willingness to seek advice and feedback, and coping under pressure with stress [1]. Many of these discipline-independent skills and attributes are naturally embedded as co-elements in the activities that anatomical learning activities feature.

Nontraditional Discipline-Independent Skills and Attributes That Anatomical Learning Experiences Can Provide Within a Healthcare Curriculum

- Practical skills
- Interpersonal and communication skills
- Teamwork and leadership
- Professionalism including ethical and legal issues
- Teaching skills
- Multidisciplinary interaction
- Additional transferable skills

Practical Skills

Whether the anatomy course is "traditional" or "modern" in its design, practical-based elements are often key features. Dissection has been an integral part of anatomical curricula for centuries, and whilst dissection is geared toward an exploration of the body in situ, it also provides the opportunity for the development of dexterity with an array of different tools for dissecting tissues [2, 3]. Although not all students will decide to enter into surgical or pathology professions where dissection skills are routine practice, most students will still need to be proficiently dexterous to use medical tools and equipment.

If dissection is incorporated as an element in a particular program, it must be accompanied by appropriate training and guidance to ensure hands-on skills are developed appropriately and that additional learning outcomes are achieved. Assessing the quality of students' laboratory work should also be incorporated into the anatomy course evaluation. It helps students focus on their laboratory objectives more efficiently and emphasizes the importance of quality handiwork.

If dissection is not an available element within a program, there are other ways of incorporating laboratory practical skills such as the use of surface anatomy sessions or living anatomy sessions. Students can be given the opportunity to palpate each other and models; they may draw and paint anatomical features [4–7]. In addition to developing practical skills, these methods also introduce students to elements of patient physical examination [8].

Interpersonal and Communication Skills

The success of most anatomy courses relies on students' abilities to communicate and work with others. If classroom activities are designed with communication as outcome in mind, anatomy sessions can provide many opportunities for students to assess and develop appropriate interpersonal skills. In a century where communication has become increasingly global, the imperative to develop our students' skills is changing. Not only must students be able to communicate with cultures and people familiar to themselves, students must gain the skills to interconnect appropriately with widely variable audiences in the global community [9].

Many healthcare-associated professional bodies (e.g., the General Medical Council (GMC) in the UK or the Accreditation Council for Graduate Medical Education (ACGME) in the USA) have also recognized the importance of incorporating directed communication skills training within the medical curriculum and have made this a distinct outcome competency [10, 11]. There is a range of approaches that can be used to provide opportunities for developing different communication skills, and in most cases, these approaches can be appropriately interwoven into existing activities so that the course is not overburdened with content but enhanced by additional outcomes [12–14]. One example might be to have students adapt an oral presentation to a patient audience rather than a presentation directed to student peers [9].

Most anatomy classroom activities naturally involve communication and related skills but these are often informal or "hidden" aspects of a course, and as a result, students may be unaware that communication skills are included as learning outcomes of the sessions. It is therefore essential to set appropriate expectations at the outset of the anatomy course and to highlight opportunities for the development of such skills.

To enhance opportunities for communication skills practice and assessment, practical sessions can be designed so as to include material for discussion. Case studies, checklists, and formative quizzes are all topics that may be assigned as required discussion topics [15, 16]. Students should be assessed for how well they can discuss with others class content such as the identification of specific features through morphology or understanding how anatomy relates to function and what constitutes normal versus abnormal anatomy [13]. Furthermore, interactions with teachers and teaching assistants during anatomy sessions are ideal opportunities for students to debate and discuss, thereby ever developing the interpersonal and communication skills necessary for anyone entering into a healthcare-related profession. The longitudinal nature of the anatomy course is conducive to designing regular cycles of assessment and feedback regarding student communication skills, and students should have a sense that they are able to improve over time.

There are a range of other communication skills training activities that can be incorporated into an anatomy course. Activities emphasizing written communication skills include the creation of patient-focused information, online material (e.g., a student-designed teaching package), popular media-focused material (e.g., news stories, opinion editorials), discussion boards and diary writing, as well as mock paper or grant writing [17–24]. Activities emphasizing oral communication skills and interpersonal opportunities might include using mock interviews, peer observation, simulated interactions, and the creation of audio/visual casts [23, 25–31].

Teamwork and Leadership Skills

Teamwork is a major focus of healthcare. Many people are involved in making the decisions that affect patients. It is hoped that a more progressively holistic attitude toward the teams directing patient care will lead to more optimal patient-centered management. Accordingly, most medical schools have recognized that teamwork and leadership are essential professional competencies that need to be highlighted and developed during training. These leadership skills can be fostered through classroom team-based learning activities where groups of students are able to achieve sets of educational objectives under direction of a designated student team leader. Students are actively immersed in collaborative learning in team settings and, as a team, are responsible for obtaining, sharing, and presenting knowledge to one another.

Recently many curricula have been improved to provide more opportunities for students to hone the skills of working within a team or taking on the role of team leader. Given the nature of the activities that occur within the anatomy practical class, opportunities for collaborative learning are already firmly embedded [2, 32]. Therefore, in recent years, anatomists have looked at ways to introduce and develop approaches that extend further the leadership opportunities in the team-based elements of the anatomy course. The focus on teaching and practicing leadership within teams in anatomy is dramatically increasing. Anatomy will remain a vanguard course in the medical curriculum where teamwork and team-based education is essential [33, 34].

There are a number of ways that leadership and teamwork skills can be developed: (1) the incorporation of reciprocal peer teaching where students alternate roles as teachers and learners [35, 36]; (2) team-based learning with an emphasis on group problem solving for clinical correlates [37, 38]; (3) rotating appointments of student-leaders for each laboratory team [13]; or (4) teamwork encouraged through administering group quizzes, audience response system activities, and team presentations [39]. These strategies all provide opportunities for individuals to be accountable for their contributions to a collective body [40, 41]. The development of teamwork and leadership skills is not just for face-to-face classroom activities but can also be encouraged in extracurricular time via electronic means such as through the provision of online discussion boards and chat rooms for groups of students to work collaboratively on team projects. To encourage teams to "play nice," it is often helpful to explicitly include group peer assessment in students' course grades [24].

Professionalism

Professionalism has been identified as a core competency of medical and other healthcare training, and one of the six areas of competency defined by the ACGME [10]. Curriculum developers have been conscientious to design opportunities for students to develop the appropriate skills and attributes needed not only so that they can meet accreditation requirements but also to develop professional competencies that strengthen students' abilities to uphold their commitment to patient care and public trust [42].

Anatomy has played a central role in educating medical students early on perceived values of professionalism. The dissection laboratory and the use of cadaveric material in particular provides a focus for activities directed at teaching, practicing, and rewarding professional behavior and associated skills including respect, compassion, altruism, autonomy, and ethical principles [12, 32, 40, 41, 43, 44].

The use of donors within anatomy classes provides an early opportunity for students to develop and reinforce attitudes of respect and compassion. Increasingly, body donors are recognized as a student's first patient [41, 43]. The growing emphasis on the donor as patient seems to increase students' curiosity as to the background of their donors including the names, life histories, and the causes of death. Course leaders may desire to disclose such information to students [43]; however, this decision may be complicated by local and national regulations protecting confidentiality. Therefore, when deciding what information to disclose, the consenting wishes and rights of the donor must be protected. Such a situation provides students with insight into the ethical and legal issues of patient confidentiality, even after the patient is no longer living. These issues can be further explored using reflective exercises that present students with cases of compromised donor confidentiality. In some schools, the reflective exercises include meeting the families of donors prior to the dissection or following dissection in student-led convocations [45, 46].

Constituent Components of the ACGME Professionalism Competencies

- Demonstrate respect, compassion, and integrity.
- Demonstrate responsiveness to patient needs that supersedes self-interest.
- Demonstrate accountability to patients, society, and the profession.
- Demonstrate excellence and ongoing professional development.
- Demonstrate adherence to ethical principles.
- Demonstrate sensitivity and responsiveness to diverse patient populations.
- Demonstrate respect for patient privacy and autonomy.

While the use of cadaveric material is key in providing the scientific basis of student knowledge, human bodies also expose students to questions and reflections on human values. For many students, anatomy may be the first time they have had to confront the issues of death and dying, and this can be a particularly challenging experience [47–50]. A number of approaches can be incorporated in anatomy courses to provide students with opportunities to explore their emotions, to be introspective, and to cope with related stress. These include exercises such as: group discussions, orientation and exploratory seminars, debriefing sessions, peer evaluation, portfolios/journals, and creative projects [40, 43, 48–56]. It is important that students are able to cope with the anxiety that they might feel within the dissecting room; however, it is also critical to limit the extent to which students become desensitized over time [45]. Discussion on ethics-related issues concerning dissection and the anatomical donor provides students with opportunities to develop the skills they need to interact with colleagues, teachers, and, where appropriate, donor families on sensitive issues [12, 41].

Students increasingly appreciate the opportunity to formally thank their donor and their families. Many medical schools around the world hold services of thanksgiving, often inviting donor friends and relatives as well as students and staff [56]. When devising such services, depending on whether a program decides to have a more formal (lecture theatres, events halls, and places of religious worship) or less formal event (held in classrooms and laboratories) [52], students should be allowed to decide how they wish to contribute to the proceedings (e.g., simple attendance versus event organization, the reading of poems, reflections, etc.) [41, 47, 48, 57]. Whatever the format, the event affords students an opportunity to bring a sense of closure to an emotionally intense period of training. Convocations of thanks reinforce respectful and compassionate attitudes among students, who will have an opportunity to interact with donor families and acknowledge the human gift they have been given [40, 41, 43, 58].

Some anatomy students inordinately focus too much on knowledge accumulation for forthcoming examinations, in so doing, neglecting the deeper learning objectives, and the discipline-independent competencies that an anatomy course presents. It is the responsibility of the course designers to ensure that the relevance of discipline-independent learning activities to the anatomy course is clearly articulated and that careful attention to professionalism is expected. Other students might focus too little on anatomical content. One way of emphasizing the importance of anatomical knowledge is to demonstrate how poor knowledge of anatomy can lead to serious mistakes and the potential for medical malpractice law suits. In the surgical specialties, for instance, this has been termed “anatomical ignorance,” and recently, there has been a considerable increase in cases of malpractice and litigation as a result [59]. It is important for students to realize that the consequence of such cases leads to a weakening of public trust on the healthcare system. Students, through reflection, must be able to link their efforts on anatomy practicals and exams to the success of their future practice and the safety of their future patients.

Inclusion of opportunities to develop reflective practice and critical thinking allows students to explore experiences and develop new understanding and appreciation [53]. These most commonly include personal reflections on a dissecting experience, extracurricular collaborative learning reflection, online discussion boards and chat rooms, and investigative assignments such as the autopsy report [13, 24, 37, 51, 53, 60]. These additional approaches allow for the integration of theory into practice, for acceptance of professional responsibility, and for the expansion of confidence and self-esteem. Validation instruments have been developed for measuring student reflection on gross anatomy [61].

Teaching Skills

Teaching skills have become increasingly important in the healthcare professions. While healthcare professionals are often experts in their fields, they may not have the ability to share their knowledge and teach their patients effectively. Therefore, appropriate skills training is needed [62]. Until recently, few curricula included any formalized training opportunities for students to develop their own teaching skills. However, formalized teacher training is becoming more prevalent and, in some programs, is a required component of course accreditation. The GMC in the UK, for example, states that medical graduates must be able to function effectively as mentors and teachers and therefore must be given appropriate environments in which to develop and demonstrate such attributes [11].

Several reasons why teaching skills are important for medical students to acquire early in their education are as follows: (1) as future residents and faculty members, students will have teaching roles; (2) teaching is an essential aspect of physician–patient interaction; and (3) medical students who understand teaching and learning principles will become better learners themselves [63].

Anatomists have, for a number of years, played a key role in developing teaching skills within their students and have used a variety of means to provide students with opportunities to have face-to-face contact as teachers and facilitators of anatomical learning. Course leaders can choose strategies such as directed peer teaching, reciprocal peer teaching, near peer teaching, and team-based learning [16, 35, 37, 38, 64, 65]. Through these strategies, a range of primary teaching skills can be included such as: gauging the knowledge level of the learner group, elucidating key information for the learner, demonstrating techniques effectively, providing useful feedback, encouraging, and motivating student learning [66–69]. Providing opportunities for students to act as teachers can result in increased retention of knowledge and deeper subject understanding for the students who assume the teacher role [64, 70, 71].

The provision of student-oriented teaching opportunities results in additional outcomes that relate well to developing the attributes of professionalism as described previously in this chapter. Requiring students to adopt the role of near-peer teaching assistants gives students the opportunity to hone their skills of mentoring. As mentors, students can identify the desirable attributes associated with professional interactions. Both students and near-peer teaching assistants appear to believe that role modeling is an appropriate feature of such programs [72]. Students learn what a good role model is by both seeing one and by being one.

Promoting Multidisciplinary and Interprofessional Interactions

A holistic approach to managing the care of patients requires healthcare workers to demonstrate effective teamwork. Teams most often involve practitioners from a range of specialties coming together to assess, treat, and care for the patient. The teaching and learning of anatomy can also be enhanced by adopting a multidisciplinary approach. Anatomy can be taught by an interprofessional team of radiologists, physical therapists, surgeons, speech therapists, and others [73–75], each bringing a different perspective to the subject area and demonstrating the importance of collaboration between disciplines [76].

Students from different disciplines can also learn together within the anatomy classroom. Dissection sessions can be shared at the same time by students studying medicine, biomedical sciences, nursing, and physical therapy. Intermixing student bodies is an effective method to teach skills in interprofessional learning and collaboration [77, 78].

Bringing together students from different healthcare backgrounds or with different career aspirations is quite common. For instance, some anatomy courses have utilized interactions between physical therapy students, physician assistant students, and medical students as a platform for interprofessional learning. Mixed student cohorts benefit from teaching one another the anatomy of regions receiving different emphasis depending on their program of study. For example, physical therapy students may feel more comfortable teaching musculoskeletal areas of the back and extremities, while medical students may be able to offer better teaching on the hepatobiliary anatomy. Students also have an opportunity to learn about the strengths and limitations of other healthcare specialties while sharing time around the lab table.

Anatomy course directors can also consider bringing even more disparate student bodies together in order to develop specifics skills and attributes. For example, some programs find it useful to pair medical students with art students to work on specific projects and analyze common and differing perspectives. This approach has been shown to develop humanistic sensitivities and more reflection into the classroom [79].

Effective Incorporation of Nontraditional Discipline-Independent Outcomes into an Anatomy Course

The design and implementation of learning and teaching sessions that incorporate nonanatomical skills, competencies, and attributes involves a number of considerations:

What to Consider When Incorporating Nontraditional Discipline-Independent Skills and Attributes

- Identifying outcomes
- Highlighting relevance
- Avoiding curriculum overload
- Establishing need and avoiding repetition
- Ensuring appropriate staffing skills
- Analysis, reflection, and improvement

Identifying Outcomes

The identification of learning outcomes is a key element of curriculum design and, in anatomy, should include aspects directly related to the discipline itself. Further, as this chapter demonstrates, these learning outcomes should also include discipline-independent skills, competencies, and attributes. As has been shown, many sessions can provide ideal opportunities for developing practical, communication, and teamwork skills as well as developing an awareness of ethics, law, and professionalism; however, these can be hidden within the curriculum and are not always obvious to students. It is important that clear expectations are made evident at the beginning of the course, are emphasized on a regular basis, and that any “additional” expected outcomes are defined and well signposted. When additional outcomes are to be assessed, students must be provided with the training and practice to achieve the measurable outcome.

Highlighting Relevance of Skills and Attributes

For students to become engaged in developing nontraditional skills in the context of an anatomy course, it is essential that the relevance to anatomy and to their ultimate educational endpoint is made apparent through learning these discipline-independent skills and attributes. This might be demonstrated by showing how the communication skills exercises are applicable to their future patient interactions or how an ethical debate will likely influence decisions that students will find themselves having to make as they progress in their careers. Therefore, while the context for these discipline-independent skills is the anatomy course for the time being, students need to recognize how the skills they are learning in their teams, through oral presentations, and in their written assignments will apply more broadly to the work they will do for the rest of their lives.

Ensuring the Course Is Not Overloaded

It is easy over a period of time to continually add or extend elements to a teaching session or course of activities. However, this can lead to "curriculum creep"—a tendency to overburden the course or program with extraneous material. More is not necessarily always "more." It is therefore important when considering the inclusion of additional skills or new material that course leaders do not overload their courses with too much content or assessment. A careful balance must be struck to ensure students gain the necessary knowledge and understanding of the subject while also developing other essential associated skills and competencies. In many cases, these elements are already natural parts of an anatomical course and therefore additional time or focus may not be required.

Establishing Need and Avoiding Repetition

While there are plenty of opportunities to incorporate new dimensions into anatomy activities that emphasize additional learning outcomes, it is important that these additions are viewed in the context of the whole curriculum. Inclusion of training that includes development of a particular skill or attribute should have a sound pedagogical basis and should map well to the curriculum for a particular healthcare specialty. While one skill might be important for a particular career route, it may not be relevant for another, and/or a different emphasis on that skill or attribute may be required. The anatomy team may identify additional skills on which to focus, but it is important to check to make sure these skills are not already covered elsewhere in the curriculum. Anatomy teams must therefore engage with colleagues across a range of disciplines so that initiatives are not implemented in isolation and redundancies are minimized, and so the potential for outcome can be fully maximized.

What Will You Do?

- You are designing opportunities for students to demonstrate anatomical knowledge using oral communication skills. How do you balance the training and feedback students receive in terms of learning basic skills of communication versus assessing proficiency on anatomical information?
- You provide a forum for discussing the ethics of dissection as an important tool for learning anatomy, but you become concerned by some of the student views expressed as they appear to be disrespectful to donors. How will you engage with students on this issue without dictating your own ethical position?

Cross-Linking

See also Chapter 37.

Ensuring Appropriate Skills for Teaching Faculty

While the anatomy environment provides some great opportunities for developing additional skills and focusing on different attributes, the anatomist without special training is not necessarily the best person to lead, develop, or assess such initiatives. It is therefore important that anatomy instructors collaborate with colleagues across the curriculum to ensure participation of anatomy teaching faculty in the faculty development programs. In addition, other appropriate experts regarding nontraditional, discipline-independent competencies should be incorporated in the process of such curriculum development.

Analyzing, Reflecting, and Improving

The inclusion of additional skills, competencies, and attributes into anatomy curricula must be accompanied by appropriate analysis to ensure that the approaches used for the development or assessment of new elements are effective for the learners and also that the new elements fit well with the expected course outcomes. This analysis should include informal observation and feedback from students and other stakeholders. Additionally, a more formalized approach including qualitative and quantitative staff and student survey as well as a review of student demonstrable attainment should be obtained. The anatomy teaching staff should reflect on the success of new or redefined initiatives as it is important that all garnered analysis of new initiatives is viewed in light of the whole curriculum to determine whether the additions help to meet the overarching outcomes of the healthcare program and whether further adaptations are necessary.

Conclusions

The anatomy curriculum provides the opportunity for students to develop and demonstrate a range of skills, competencies, and attributes, which may at first glance not be directly related to the discipline of anatomy, but which can help lay a foundation for effective healthcare training. These additional competencies include aspects related to practical skills, interpersonal and communication skills, teamwork and leadership, and professionalism. When devising a course to include such elements, it is important that all opportunities for development are outcomes-based and relevant to the particular profession and well-within the wider context of the healthcare training program. The decision to incorporate a new and distinctive activity within an anatomy course must also be balanced against the tendency to overload the curriculum and should avoid repetition. When appropriately integrated, students should be able to recognize that anatomy not only serves as a fundamental building block for their knowledge and understanding of medical science but is also a fundamental opportunity for developing the interpersonal skills and attributes that are expected of them as professionals.

> "Neither economic incentives nor technology nor administrative control has proved an effective surrogate for the commitment to integrity evoked in the ideal of professionalism."
>
> Sullivan [80]

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36 Role of Anatomists in Building an Integrated Medical Curriculum

Douglas F. Paulsen, Brenda J. Klement, and Lawrence E. Wineski

Introduction

Following the Flexner Report in 1910 [1], most US medical schools adopted a standard curricular model encompassing 4 years of medical education. The first 2 (preclinical) years included basic sciences courses, each administered by an academic department of the same name (e.g., anatomy, biochemistry, etc.). The third and fourth (clinical) years then focused on training in discipline-based clerkships (e.g., medicine, pediatrics, etc.). A shift away from the traditional model and toward an integrated approach arguably began in 1952 with the cross-disciplinary, organ system-based curriculum at Western Reserve University (now Case Western Reserve University) [2]. This model was adopted, to varying degrees, by other schools in the following decades. Another shift occurred in 1975 when McMaster University introduced its problem-based learning model, which promoted further integration of basic and clinical concepts in service to understanding and solving clinical problems [3]. Since then, the uniformity of traditional medical curricula has given way to greater diversity in which each medical school has adopted its own blend of traditional, integrated, and problem-based approaches. Most schools have adopted, modified, and, in some cases, abandoned one or more of these approaches along the way. The result is a rich diversity of approaches that have succeeded in preparing students to participate in a rapidly changing professional landscape.

In recent years, a reconvergence has occurred around the concept of integration, although again in an institution-specific manner. Many medical schools have undertaken curricular modifications to enhance topic integration along both horizontal (e.g., among preclinical subjects) and vertical (preclinical with clinical subjects) lines [4–7]. The rationale for change has varied, but often included enhancing students' appreciation of the need for and their skills in: (1) integrating diverse and complex concepts in support of critical thinking and clinical problem solving, (2) preparing for integrative questions on the United States Medical Licensure Examination (USMLE) Step Examinations, and (3) eliminating unnecessary redundancy to provide more independent study time in a crowded curriculum.

Although the need for integration is increasingly accepted, the process for achieving it has proven a more fractious problem. In early integrated approaches, because a systems-based approach to dissection is impractical, anatomy courses were conducted alongside rather than as components of integrated curricula. Finding a place for dissection in integrated curricula

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remains challenging. This chapter describes an approach to curricular integration involving a sequence of changes which, instead of marginalizing human dissection, incorporate it as a cornerstone of integration. The approach described is noteworthy because it was initiated by anatomists who led the way by first integrating regional dissection of the body with systems-based approaches to histology and embryology.

Human Morphology: Integrating the Anatomical Sciences

In 1995, the first-year curriculum at Morehouse School of Medicine (MSM) focused on normal human structure and function with courses in gross anatomy and embryology, histology and cell biology, neurobiology, biochemistry, and physiology. The second year focused on disease processes and treatments with courses in pathology, pathophysiology, microbiology and immunology, and pharmacology. At that time, anatomy faculty teaching in the "gross anatomy and embryology" and "histology and cell biology" courses chose to integrate their courses by combining the allotted time and adjusting the topic sequence. The aims were to reduce redundancy and encourage integration of knowledge of human structure from the electron-microscopic to the gross-anatomical level and from fertilization to old age. The result was a course entitled human morphology [8] that began a transition to curricular integration.

Initiating Integration

- Take the lead. Begin at the departmental level integrating the anatomical sciences.
- Combine curriculum time allotted and adjust presentation sequence to reduce redundancy.
- Integrate cytology with early embryology and histology of basic tissue types.
- Integrate regional dissection with organ system histology and embryology.

Topic Sequencing in Human Morphology

- Cytology, early embryology, basic tissue types
- Blood and bone marrow, vascular, lymphoid, and skin histology as transitional topics with back dissection
- Limb embryology with upper limb dissection
- Cardiovascular and pulmonary histology and embryology with thoracic cavity dissection
- Digestive, urinary, endocrine, and reproductive system histology and embryology with abdominal and pelvic cavity dissections
- Lower limb dissection
- Head and neck dissection with neurobiology

At the time, all courses were administered by the academic departments. Beginning curricular integration within one department sidestepped the turf battles that plague many attempts at curricular integration. In the anatomy department, there was a common appreciation that despite the systems-based approach common in teaching histology and embryology, course integration would require maintaining regional dissection as a foundation.

Regional dissection traditionally divides the body into seven regions: back, upper limb, lower limb, thorax, abdomen, pelvis and perineum, and head and neck. Overlaying those regions with the body systems best represented in each provided an initial basis for interlacing the topics of gross anatomy, histology, and embryology. The order in which those regions are dissected, and how they are grouped for examinations, varies among institutions. Flexibility in ordering the regions facilitated adjustments from year to year before arriving at the most appropriate sequence. Other principles important in arranging the order included the need to introduce themes and basic principles prior to delving into variations or more complex concepts, the skill required to complete the dissections, and whether key principles were better observed in cadavers, models, or other teaching aids.

Thus, for example, cytology, early embryology, and basic tissue types (epithelium, connective tissue, nerve, and muscle) and their histogenesis were introduced prior to beginning dissection. Dissection began with the back, where students could remove skin and define muscles with little damage from unrefined dissecting skills. Blood, bone marrow, skin, vascular, and lymphoid system histology were covered concurrently as a transition from tissues to organ systems.

Because the upper limb has key elements associated with both the back and the thoracic wall and because thoracic wall structure is appropriately dealt with before entering the thoracic cavity, the upper limb dissection served as an appropriate bridge between the back and the thoracic cavity.

Entering the thoracic cavity after the upper limb provided a welcome change of pace and brought a new level of excitement to the laboratory, refreshing the students' enthusiasm and curiosity. The thoracic unit included the histology and embryology of the cardiovascular and respiratory systems. Although the esophagus is located here, its uncomplicated histology was reserved until the abdominal cavity dissection, where most digestive organs are located and can be presented as a system.

Progressive dissection through the abdominopelvic cavity and perineum dovetailed with the histology and embryology of the digestive, urinary, endocrine, and reproductive systems. This required the students to divide their time nearly equally between gross and microscopic anatomy topics and provided important opportunities to reinforce concept integration. Pituitary histology was covered with the endocrine system during the pelvic cavity unit. This illustrates the need for flexibility in blending systems-based and region-based approaches to course integration.

Study of the lower limb followed that of the pelvis and perineum. These dissections are highly complementary because of the neuromuscular and vascular continuities between these regions. At this point, the histology coursework was complete. The students were able to focus again on their dissections and were happy to return to what they now perceived as a straightforward limb dissection.

The head and neck dissection was reserved for last for two reasons. First, it requires refined dissecting skills to demonstrate the smaller, more delicate, and closely apposed structures. The students were now better prepared to perform this challenging dissection. Second, this sequence provided an excellent opportunity to blend topics with our neuroscience curriculum, facilitating further concept integration in coverage of the brain, cranial nerves, and special senses.

With the integrated human morphology course well established, supported by the faculty and showing clear evidence of positive impact on student performance, the institution began pursuing a more extensive curricular integration in 2006. At this point, because of their extensive experience in subject integration, the anatomy faculty were in an optimal position to assume a leadership role in the larger-scale curricular integration process.

Institutional Governance and Curricular Change

Curricular integration across departmental boundaries is challenging. It requires a clear institutional commitment to change and support by the academic leadership. Ideally, that leadership will provide the requisite mechanisms and resources and a clear rationale for the institution's commitment in ways that encourage commitment by the faculty charged with implementation. At MSM, steps leading to this change included external encouragement from the Liaison Committee on Medical Education (LCME) to shift course governance from the academic departments to a central institutional body. In particular, this reflected the LCME standard for curriculum management under ED-33 stating that "There must be integrated institutional responsibility in a medical education program for the overall design, management, and evaluation of a coherent and coordinated curriculum [9]" and an indication that this function is typically carried out by an institutional curriculum committee, which to be effective will be characterized by, among other things, "empowerment,

Institutional Requirements for Curricular Change

- Institutional commitment to change
- Clear rationale and objectives for the change
- Support by top-level academic leadership
- Central rather than departmental control over the curriculum
- Focus on curricular change as a continuing process rather than a one-time event
- Ongoing course director and faculty engagement in design and implementation

through bylaws or decanal mandate, to work in the best interests of the institution without regard for parochial or political influences or departmental pressures." MSM thus placed control for the design, implementation, and evaluation of the medical curriculum in the hands of the institutional Curriculum and Evaluation Committee (CEC), composed of faculty from most academic departments, academic administrators, and student representatives. The CEC determined that increased integration of the first-year curriculum was needed to accomplish the following objectives:

- Reduce the number of contact hours in the preclinical curriculum to provide more time for self-directed learning by eliminating unnecessary redundancy.
- Increase the students' capacity for cross-disciplinary concept integration to facilitate critical thinking and clinical problem solving.
- Better prepare students for the growing number of integrative questions on USMLE Step and National Board of Medical Examiners (NBME) shelf exams.

The individual serving as both Chair of the Department of Medical Education and Senior Associate Dean for Educational Affairs was charged with facilitating the first-year medical curriculum integration and convened a faculty working group to undertake the integration process.

Human Morphology as a Foundation for Integrating the First-Year Basic Science Courses

Human morphology, which integrated regional gross anatomy dissection with system-based histology and embryology, accounted for approximately half of the first-year curriculum and provided a foundation on which to build the larger curricular integration process. Because the existing first-year curriculum had been successful, there was some initial faculty resistance to changes involving other courses. As a compromise, the faculty working group began full curricular integration by reordering existing lectures to complement the order of systems presentation developed for human morphology. Because there was room for everything in the existing curriculum, there would be room for everything in one that was simply reordered. In the initial version of the integrated curriculum, although the schedule was rearranged, the individual courses remained intact as independent graded entities and the original course directors retained control of their subject areas. Certainly, rearranging the order of subject presentation alone does not constitute integration, but when a culture change is called for, it is a useful place to start.

Achieving Faculty Acceptance

- Culture shifts require incremental change.
- Begin by reordering existing curriculum components without challenging course autonomy.
- Use a scheduling method that allows iterative changes to be proposed, discussed, and revisited as necessary.
- Use working lunches to create a congenial atmosphere and a sense of common purpose.

Scheduling class sessions was achieved by creating a magnetic calendar grid on which each curricular element (e.g., class or lab) could be moved about [7]. With the course faculty gathered, each course director took a turn at the calendar grid proposing and justifying rearrangements to assure appropriate concept sequencing for their discipline and integration with the others. Such scheduling meetings were held weekly during the noon hour and lunch was provided. This added to the collaborative atmosphere needed to overcome *a prior* culture of separation and turf guarding. As the group worked toward its common goal, defensiveness declined and the faculty developed a remarkable camaraderie and investment in the new class sequence. Further, an unprecedented understanding of the content and educational philosophy underlying the prior strengths and weaknesses of each other's courses developed, leading to a broader and more distributed understanding of the curriculum as a whole and of the student experience. This was a valuable resource in moving toward a culture of integration.

Interlacing the biochemistry, physiology, and neurobiology courses with human morphology spread the original one-semester human morphology course across two semesters and created some logistical challenges. For example, associating the many cardiovascular and respiratory physiology lectures with the thoracic cavity dissection, and the relevant anatomy, histology, and embryology lectures involved a significant break in the dissection schedule to accommodate the related topics. This created challenges associated with longer cadaver preservation that were eventually resolved.

Integrating organ system physiology with histology proved straightforward. However, overlapping the biochemistry topics with only cell and tissue histology provided insufficient time for the students to process that material and the duration of biochemistry coverage was later expanded. The experience demonstrated that providing adequate time for students to process new information is an important consideration in an effective plan for integration.

In the second iteration of the integrated curriculum, the department-based course designations were dropped, and the first-year curriculum was divided into four half-semester courses, entitled Basic Principles of Human Biology, and Organ Systems 1, 2, and 3. A new course director was chosen for each course from among the faculty working group. The course directors represented each of the first-year curriculum academic departments and were charged with oversight of course operations, scheduling adjustment, and exam assembly. A new position of First-Year Curriculum Manager was created to oversee all curriculum operations and support the course directors. Prior course directors and other key faculty were appointed as Content Experts for their respective fields and continued to participate in the curriculum operations meetings. This first-year curriculum operations group still meets monthly to review course operations, student performance, and opportunities for further integration.

In subsequent years, system-specific subgroups of content experts began meeting separately to assess and eliminate unnecessary content overlaps and to refine concept sequencing for each system. Thus, for instance, physiology faculty who had traditionally reviewed the anatomy of an organ system prior to covering system function were relieved of that duty by having physiology lectures follow the lectures and laboratory sessions conducted by the anatomy and histology faculty. In some cases, this led to the discovery and filling of gaps in coverage that one group had assumed that the other had been covering. Again, this facilitated faculty understanding of information covered in each others' lectures, enhanced integration and efficiency, and reduced contact hours. These efforts continue with an eye toward further consolidation and horizontal integration as well as providing time for vertical integration with pathology, pathophysiology, and clinical topics.

Student Assessment

Consolidating the examinations for the various courses was a major step forward in curricular integration and significantly reduced curriculum hours. Previously, each of the multiple courses running concurrently had its own 2-h multiple-choice exam approximately every 3–6 weeks. In the new approach, one exam covering all topics was administered at the same frequency, where logical content breaks occurred. Instead of nearly a full week for exams for each exam period, a reading day and an exam day sufficed. The exam time released was returned to the students for independent study.

To provide exams of reasonable length, the number of test items for each topic was reduced. Four questions were included per class session (with some exceptions, where justified to the group). This provided equitable coverage of each topic. The Department of Medical Education coordinated all exam-related tasks. Examination software (ExamSoft Worldwide) was used to deliver the exams, analyze question performance, and bank questions. The software was also used to monitor and track student performance and to identify subjects needing improved coverage. Gross anatomy laboratory (practical) exams were administered the same day, involving fill-in-the-blank questions for tagged cadavers and prosections with four practical questions per scheduled laboratory session.

Curriculum Integration Considerations

- Establish clear goals and outcomes.
- Establish course and curriculum management team.
- Determine in-course examination scheme (frequency, number of items, delivery process).
- Determine NBME subject examination scheme (when to administer, minimum score, grade).
- Determine course grading structure.
- Evaluate student performance (compared to pre-integration).

Five NBME subject examinations (in biochemistry, gross anatomy and embryology, histology and cell biology, neurobiology, and physiology) were also given each year, each administered after the relevant subject material had been covered. Scores on the subject exams were incorporated into the grade for the course in which each was given and students were required to achieve a predetermined minimum score on each subject exam.

Student Performance in the Integrated First-Year Curriculum

Student performance on the in-course exams was monitored by the course operations group and compared to performances prior to integration. Overall, the students performed as well as or better than they did prior to integration. Students that did not perform well were required to participate in a program of tutoring and academic support and given the option of entering a decelerated program.

Curricular integration has correlated with progressively higher NBME subject exam scores. The class average for all five NBME exams increased with each year. The histology and cell biology subject exam average increased by 7 %, and the gross anatomy and embryology subject exam average increased by 9 % in the first year of integration. The class average for each examination increased by smaller increments in subsequent years. In addition, the number of students scoring in the upper range on these examinations also increased annually. Since the move to curricular integration, the institution has maintained a high USMLE Step 1 pass rate, as well as increased Step 1 exam averages.

Summary

Curricular integration at MSM has been relatively unusual among medical curricula. The process was initiated by anatomy faculty and then followed by broader faculty input building on the template of a dissection-oriented, anatomy-centric curriculum. Elsewhere, systems-based approaches have led to significant difficulties in fitting active dissection by students into an integrated curriculum. Our experience shows that it is not only possible but desirable to blend regional dissection with a systems-based approach to integrating teaching of human structure and function. The entire process was carefully organized and phased-in over several years, with a focus on developing cross-departmental participation and collegiality. The four half-semester integrated courses that emerged from this first-year curriculum integration process are now well established. Faculty acceptance has been exceptional, with most now embracing the changes and fully supportive of the new courses. Exam scores have improved and student satisfaction is high. Overall, the new curriculum is more efficient, has better topic alignment, and is better organized than the previous curriculum.

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37 The Hidden Curriculum and Anatomy Education

Frederic W. Hafferty and Gabrielle M. Finn

Social scientists have long been interested in the impact of anatomy and the dissection experience on the professional formation of medical students [1]. Two of the earliest and most famous studies of undergraduate medical education, Robert K. Merton and colleagues' 1957 study of medical training at Cornell (*The Student Physician*) and Howard Becker and colleagues' 1961 examination of the medical school experience at the University of Kansas (*Boys in White*) highlight anatomy as a formative experience—albeit from contrasting theoretical perspectives. A third publication, *Report of the Fifth Teaching Institute, Association of American Medical Colleges, Atlantic City, New Jersey, October 15–19, 1957*, while not mentioning anatomy,[1] took an ecological and systems approach to the undergraduate training experience along with a focus on how students can be quite sensitive to the difference between what faculty preach versus what faculty practice. Although this report never used the term "hidden curriculum" as an interpretive concept, *The Fifth Teaching Institute* did anticipate, by 40 years, the rise of a hidden curriculum literature within the fields of medicine and medical education.

In this chapter, we will examine the function and framing of anatomy lab and cadaver dissection as a pedagogical space (for faculty) and learning environment (for students)—and do so using the analytical lens of the hidden curriculum. We will begin with a brief look at how lab has been characterized by both social scientists and medical trainees using a variety of resources including academic reference materials and physician autobiographies. With this as our foundation, we then will introduce the hidden curriculum (HC) as an analytical tool to broaden and deepen our understandings of the various types of learning that take place in anatomy. Within this context, we will highlight anatomy as a source of occupational socialization and professional formation. We also will reference, but not review, the spate of new teaching tools currently being used in anatomy teaching in order to link these tools to hidden curriculum issues. We conclude with a challenge for anatomy educators as to how they might encourage other basic sciences courses to build upon their innovations.

[1] Anatomy was featured in an earlier report (*Third Teaching Institute; October 18–22, 1955*) by the same sponsoring organizations.

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Three Case Examples of the Hidden Curriculum: From Lab and Beyond

The White Coat Ceremony

The white coat ceremony (WCC) is one of the more analytically dissected and debated educational events/rituals in medical education. This event brings together first-year students, faculty, and sometimes student families in a celebration of oath taking, related presentations, and the symbolic donning a white coat—all designed to highlight issues of professionalism and humanism in medicine. How a given school identifies its WCC, and thus articulates its function and purpose via announcements, invitations, web pages, and during the ceremony itself, is the WCC's formal curriculum. Such formal pronouncements have nothing to do with right or wrong, good or bad, truth or lies, accuracies or hyperbole. The formal curriculum is what the powers-to-be says it is. If a school identifies its WCC as "a ceremony reflecting medicine's core humanistic principles," or "a welcoming of our students into medicine's culture of healing," or "a celebration that stands at the heart of Here, There, and Everywhere (HTE) Medical School's commitment to patient-centered care," then this is HTE's formal curriculum. However, claiming is one thing. Delivering is another. Even repeated insistences that its WCC is proof-positive of HTE's core commitment to patient-centered care does not make it so. As with any given aspect of the educational enterprise, the difference between what lies on the surface (the claim) and what lies within the underlying swarm of related educational practices and cultural underpinnings (the lived reality) is the object of our inquiry. It could well be, upon examination, that HTE is awash with educational activities and organizational messages that scream "patient-centered care." Conversely, it could well be that there are gaps between what HTE claims for its WWC and what is being practiced (and preached) elsewhere within HTE's broader educational milieu.

Exploring the congruence between what a school *claims* and what it *does* can take several different forms. We can, for example, mimic the above set of questions and ask how the values and principles formally announced as core to HTE's WCC are reflected in other educational activities at the medical school. Do we find alignment—or not? HTE actually may deliver numerous messages about the importance of patient-centered care to students. However, what *alternative* messages are delivered if the ceremony itself is the only time students formally hear any reference to "white coat ceremony" and its "essential messages." In short, the WCC may turn out to be a literal blip on the pedagogical radar of HTE with students left to their own devises to connect—or not—the variety of patient-centered care messages they receive at HTE with what they heard and saw at the WCC. In the end, administration and faculty may be quite sincere in their manifest pronouncements about the WCC being a celebration of HTE's "commitment to patient-centered care," but may remain quite unaware that their WCC structurally functions as an isolated "one-night stand."

Analyzing the HC is not limited to placing a given educational event within the broader context of other educational events taking place at a given medical school. We also can explore the possible range of messages that might be delivered during such a celebration—and do so here by conducting the equivalent of a thought experiment. For example, Wear [2] offers an alternative framing of the WCC in pointing out how messages delivered during WCCs can include those of power and privilege, of "hierarchies of caregiving," of emphasizing the social and economic privilege of physicians, and of aligning students with the values of science and objectification rather than with the needs of patients. Similarly, Russell [3] argues that the WCC "fosters a sense of entitlement" where authority is "based on title and uniform" rather than on physician behaviors as humanistic individuals. Conversely, Huber [4] rebuts such arguments and insists that the WCC is "a contemporary medical ritual that holds a beneficial place in the professional development of a medical student" and thus offers an interpretation of the WCC's impact that is more in keeping with the manifest function of this exercise.

The point of contrasting the views of Wear, Russell, and Huber is not to favor one particular interpretation over another as it is to point out the benefits that might accrue from dissecting a particular educational activity by first identifying its stated and manifest function and then contrasting that stated intent with an exploration of "what else might be going on." In the end, we may conclude that there actually is not that much else lurking beneath the surface and that "what you hear" (and thus the version of things put forth by faculty or administration) is "what you get." However, never to question or explore the possibility of gaps between claims by those in power and how those educational activities actively play themselves out at the level of students is to automatically privilege the voice of faculty and/or administration over that of students. If so, then the student voice becomes even further marginalized in an already hierarchical educational environment.

Think of the hidden curriculum as:

- a heuristic device for exploring the difference between what people and/or organizations say… and what they actually do.
- a tool for reconciling the formal versus the other-than-formal dimensions of organizational life (including anatomy education).
- a form of "gap analysis."

Anatomy and the Importance (or Not) of Dissection

At HTE, students repeatedly are told by faculty that it is "critically important" for students to come into lab to dissect and to engage in self-directed study on their cadavers—because this "hands-on" and "tactile" experience is the best way for them to "really learn" their anatomy. However, students also hear, via the student grapevine, that they can fail the practical exam and still pass the course based solely upon their written exam performance. As a result, many students "get the message" and do not bother to attend lab, even though they also admit that knowledge of anatomy will be quite important once they begin clinical practice.

In High-Stakes Environments Such as Medical Education…

Students constantly are on the lookout for message gaps between what faculty formally tell them about course/learning standards versus what students come to learn (also from faculty) about what they "*really* should be doing" to "pass the course."

In this example, we can see where the long-term benefits of dissection seen by both faculty and students (e.g., clinical expertise) have given way to short-term student "needs" to "pass the test." Extending these rationalizations even further, while students at HTE also believe that if they "really need" the dissection experience, then the skills and knowledge it provides will be resupplied at some future time(s). Students also believe that faculty must actually know that they are passing (grade wise) students who did not dissect and thus students who, according to those same faculty, "really do not know their anatomy." In short, students feel they are told one thing (e.g., "dissection is critical to learning") yet see another (e.g., grading policies) that reinforces a bottom-line message, conveyed via the tacit participation of anatomy faculty, that the most important thing is to "pass the course" rather than "learn the anatomy."

Conflict-of-Interest (COI) Disclosure Statements

Many medical schools now require their faculty, and/or visiting speakers, to include a statement at the beginning of their presentation referencing "outside" financial interests and/or whether the speaker will be referring to "off-label" prescribing. Most often, this requirement is linked to some formal policy covering a range of conflict-of-interest (COI) issues. Similar to our previous WCC and anatomy examples, the formal curriculum is the requirement and/or formal policy—including supporting rationales for why the policy exists. However, and once again referring to our previous examples, there can be rifts or gaps between policy and practice. In other words, how disclosure statements *actually are presented* to an audience represents another set of messages to organizational members such as students and clinical faculty about the importance of COI issues. Over the past 2 years, one of the chapter authors has witnessed disclosures ranging from one that flashed across the screen at the speed of light, accompanied by a mutter of "moving right along," to a faculty member who showed his COI slide, read through it—twice, and then announced that this was the most important slide of his talk. Each COI behavior delivered a distinctly different message to the audience. The former was dismissive. The latter was affirming. In both of these instances, and for all the other instances that fell in between, community members were treated to important messages about how one should think about COI—regardless of the actual policies that lay in the background. In short, while policies/formal curricula may be important, they hardly are the whole story.

Hidden Curriculum and Anatomy Education: A Brief History

Anatomy, particularly with its classic foundation in cadaver dissection, has long been considered *the* iconic first-year medical school experience. Although no longer reserved exclusively for medical trainees, and no longer ubiquitously built around the dissection of human cadavers, it still is considered an important point of transition in the professional formation of trainees as they move from laypeople into a different and distinctive culture of medicine. Outsiders, including the public and social scientists, harbor a certain fascination with anatomy, including its social practices (e.g., what actually does go on in lab), as well as its impact of dissection on trainees and faculty.

Since the 1950s, a number of books and journal articles have given witness to this fascination. For the purposes of this chapter, we group these materials into three overarching categories: (1) trainee–faculty reactions to lab, (2) new approaches to teaching anatomy, and (3) the role of dissection as a necessary (or not) part of the anatomy learning environment. Publications have ranged from observational studies and fieldwork to the administration of various psychometric and learning assessment tools. As perhaps befitting anatomy's enduringly iconic status, conclusions have ranged from: (1) dissection as having no emotional impact to lab as having a "profound effect" on the socioemotional lives of faculty and students, (2) new teaching tools and modalities as having no benefit in stimulating anatomical learning to these tools having an incredible impact, and (3) dissection as essential (or superfluous and/or anachronistic) to learning human anatomy.

In certain instances, this chaos of conclusions can be viewed as rooted in the methodological approaches used and the questions being asked. Thus, and broadly speaking, observational and field-based studies have tended to emphasize the impact (positive and negative) of lab/dissection, while instrument-based studies have tended to advance more of a "no impact" conclusion—whether impact was viewed on a social–psychological plane or in terms of subject matter mastery.

This conundrum brings us to a point fundamental to the integrity of this chapter. As humans move into, and then through, new, unique, and/or novel situations, they move from being acutely aware of differences, nuances, and/or "unusualities" to reframing those same *now-not-new* situations etc., as routine usual, and thus taken for granted. In short, humans go from being hyperaware to hypoaware as their perceptual antennae shift from being erect and quivering to receptors that treat old news as no-news. In this way, learning moves more from more noticed, deliberate, and at times even strategic to a domain that functions more at the tacit and unconscious levels. For these reasons, asking "old timers" to explain "what is happening" or "how things work around here" generates one set of responses, while asking newcomers the same questions often produce a totally different set of responses. It is not that one is correct and the other wrong (particularly to those providing the responses), but rather the existence of two potentially contrasting sets of social realities.

The difference between insider and outsider views on the "nature of things" is of particular relevance to this chapter. With anatomy we have one group (e.g., faculty) who are considered, by insiders and most outsiders alike, as having institutionally sanctioned authority and expertise. Meanwhile, other groups such as trainees, lack not only that authority but also are supposed to adopt the knowledge base, skill sets, and value orientations of those insiders. In short, neophytes are supposed to want to become "just like" insiders. This shift from outsider to "true insider" status is captured in Robert K. Merton's classic definition of socialization in which "…socialization designates the process by which people selectively acquire the values and attitudes, the interests and knowledge—in short the culture—current in the groups of which they are, or seek to become a member" [5], p. 287…as well as Lave and Wenger's concept of legitimate peripheral participation [6].

There is, however, a problem with classic views of socialization such as the one offered by Merton. They tend to frame learners as passive and empty vessels waiting to be filled by the wisdom and expertise of their insider-elders (e.g., faculty). In its extreme form, such a framing tends to discount as callow or naive the views and/or experience of learners. In turn, failures to learn (however this is established) often are attributed to the learners themselves—as opposed to the learning environment. Similarly, solutions often target the student side of the equation by advocating the selection of "better" students or by ramping up teaching hours or the addition of more "rigorous" material. Finally, and as a consequence of such marginalizing strategies, students may construct their own learning environment and do so in ways that negate what they see as the mixed messages of faculty or contradictory teaching practices being delivered by faculty.

As Faculty…

Do not be surprised when the learning environment experienced by your students is at some odds with the anatomy you intended when constructing your course.

The Language and Structure of the Hidden Curriculum

Over the years, and across the fields of education (general), sociology, and medical education, a number of terms have been used to capture the distinctions between the formal and the other-than-formal aspects of the learning environment. Some of these terms are depicted in Fig. 37.1.

As captured in this figure, the basic distinction worth remembering is between the formal versus the other-than-formal aspects of learning. On the left side of Fig. 37.1, we list several terms that have been used to capture this side of the pedagogical coin. For the most part, these terms function as synonyms. On the right side are examples of other-than-formal types of curricula. Here, the terms are not synonymous. Although the term "hidden curriculum" often is used as a catchall descriptor for everything that might fall within the other-than-formal camp, this actually is not the case. Nor is it good analytic practice. For example, there are lots of ways that work gets done in clinical medicine that are quite well understood by all of the participants, but where those practices are quite different from those specified within an organization's formal policies (e.g., the formal curriculum). One term often used to capture these more informal understandings of how work "really happens" versus "how

Cross-Linking

See also Chapters 1, 3, 10, 17, 22, 31, 33, and 35.

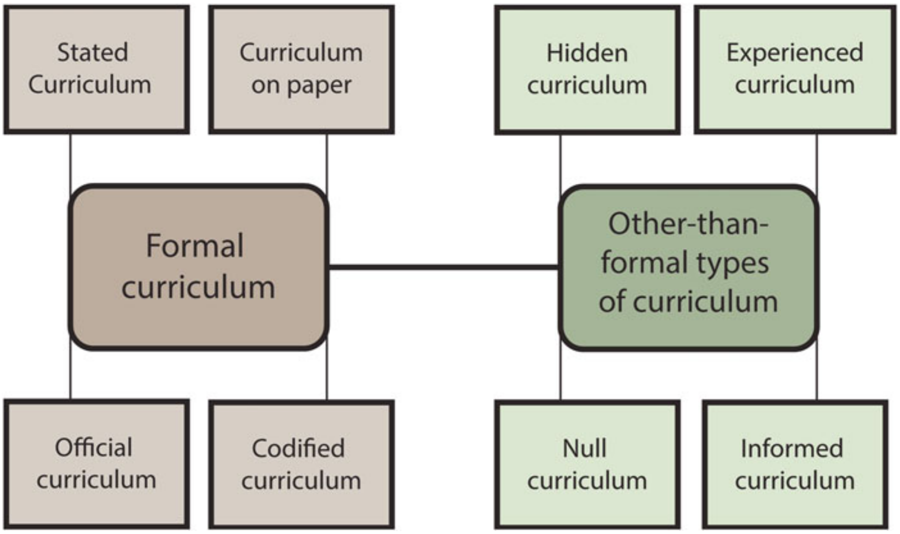

Fig. 37.1 Types of curriculum: a lexicon

things are supposed to take place according to the rules" is work-arounds [7]. There is nothing "hidden" here. Everyone knows these "rules of the road"—including management. It is just that everyone agrees that doing it "the way we do it" is better for the sake of efficiency or good patient care etc., than following the letter of formal policies. The term in Fig. 37.1 that best fits the mechanism that underscores these kinds of open and shared understandings in the case of work-arounds is the *informal curriculum*.

In turn, the *null curriculum* is what gets taught by what is *not* said or done [8]. Once again, students are relentless, at least early in their training, to make sense of things. If within a given anatomy course, certain topics are never mentioned, or certain cadaver body parts are never dissected, then it must be, students reason, that these topics or body parts are not important. The same is true in clinical settings. If members of the clinical staff never sit on the side of a patient's bed, then students may well reason that this is not what clinicians do at the HTE medical center. They may even go one step further and assume that sitting on a patient's bed is something they should never do (e.g., "This just isn't done at HTE!"). Remember, no one directly has told students anything—pro or con. Instead, the absence of something (sitting) is imbued with meaning—and often without faculty having any clue about what is going on.

Finally, the *hidden curriculum* is, technically speaking, hidden. Most often, the HC functions at the level of organizational culture and therefore largely operates at a tacit or unconscious level. The HC largely deals with implicit understandings of "how things are done around here." As such, the HC operates within domains that are taken for granted and thus often fly beneath the reflective radar of both faculty and students. Finally, one underappreciated feature of the HC is that while it need not either be negative or bad, it is primed (as a methodological approach) to identify alternative ways of looking at things—at least alternative to the official or the formal account of what is going on.

In summary, while there is nothing particularly wrong with trying to get a handle on the HC by simply differentiating between the formal versus the other-than-formal aspects of learning, if one wishes to move beyond a simple either–or dichotomy, then one needs to be at least somewhat familiar with some of the various subtypes of other-than-formal learning.

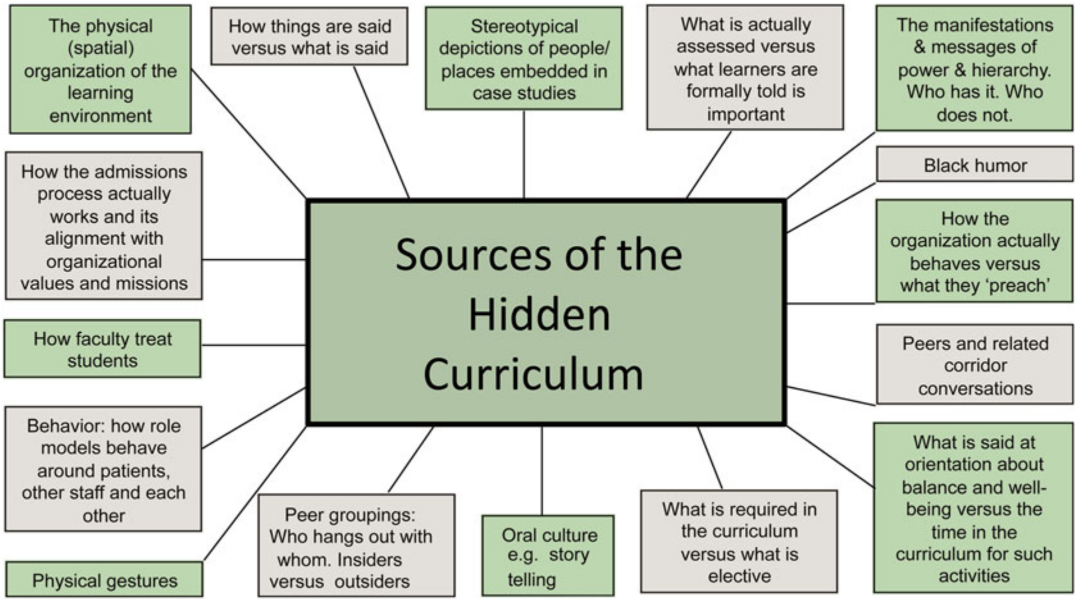

Fig. 37.2 Sources of the hidden curriculum

Where to Find the Hidden Curriculum

While it may be reassuring to think of the HC as a singular overarching and essentially homogeneous domain of learning—and thus a domain that stands in singular contrast to *the* (again, singular) formal curriculum—in point of fact, the other-than-formal curriculum is awash with a complex array of different types of curricula: informal, hidden, null, etc., along with different shades of these subtypes. In this respect, the HC is quite similar to the formal curriculum, which itself is made up of all kinds for formal learning experiences. From this vantage point, it essentially is meaningless—as well as analytically misleading—to list an array of educational practices or events and go down that list, as a checklist, to indicate whether each event falls into the formal, informal, hidden, null, etc., camp. Instead, it is more fruitful to identify a particular pedagogical issue—say patient centeredness, or professionalism, or learning surface anatomy—and at this point begin to explore how different aspects of the formal and the other-than-formal curricula intersect to convey particular messages about the "real importance" of these learning objectives. "Respect for the cadaver" may be formally listed in course materials as the "number one value in lab," but if students are free (e.g., unchecked by faculty) to act however they want at night when instructors are not around, or if instructors routinely refer to the bodies as "learning tools" or as an "it," then students may be receiving another set of messages—no matter what formally is stated in the course description.

In Fig. 37.2, we have attempted to capture some of the places one might look for other-than-formal messages about a particular issue or concern. References to the HC in the medical literature often refer to the "classroom" versus the "clinic" or the classroom versus the "wards" when differentiating between locales of formal versus the hidden curriculum. While this may be a rough guideline, like most guidelines, it is incorrect in its particulars. "The classroom," or a particular course, usually has all kinds of curricula coursing through it. The classroom not only can contain formal curricula but also hidden, informal, null, etc., curricula. The second case example that appears at the beginning of this chapter covering the exhortations of faculty to have students dissect, but with those urgings countered by the course examination policy, is a case in point. There is no "classroom versus clinic" here. Everything is taking place "in class."

How to Explore the Hidden Curriculum: Three Steps

As summarized below, whenever one wants to explore a particular leaning environment, one begins with the formal. It is not that the formal curriculum is a more important source of learning—it actually may constitute a minority, percent wise, of the overall learning going on—but whatever the issue at hand (e.g., patient-centered care, professionalism, learning surface anatomy, etc.), we need to begin with what the powers-to-be say they are doing to promote that issue. Furthermore, we need to be aggressive and exhaustive in pursuing that formal side of the equation. Whatever the official explanation or account offered, we must follow those initial declarations with an array of supplemental questions (e.g., "And what else do you do?" "Why are you doing these things?" "Can you give me another example?"). Thus, when you hear WCC organizers claiming that HTE emphasizes patient-centered care, one also needs to scour the school's website, its student and faculty handbooks, course syllabi, etc., so that when one concludes "*this* is how HTE says it emphasizes patient-centered care in its curriculum," you now are certain you have the formal side of the equation firmly nailed down.

The second step, and a corollary of the first, is not to leave the formal side of things too quickly. Most organizations have a vast array of formal policies and practices, and not all of them, when taken as a whole, send a consistent set of messages to members of the community. In short, we may find mixed messages without ever leaving the formal curriculum. For example, most courses are built around two core activities—the delivery of content and the assessment of that content in terms of learner mastery. However, what faculty teach and what faculty assess may be two different things. Moreover, and as we saw in our second case example above, we not only should be looking at the content of exams but also at how points are distributed across the exam or how much emphasis is given to one topic area rather than another. The difference between what is taught and what is assessed can be rife with contradictions.

Finally, once we have exhausted the formal side of our equation, and only when we have exhausted the formal side of our equation, do we move into exploring the other-than-formal aspects of the learning environment. Here, there are endless venues to be explored, and investigators would do well to restrict the number of avenues they might venture down. For example, early in his fieldwork and interviews, Hafferty found that lab contained a certain oral culture and that students were telling stories to each other, particularly early on in lab, about pranks that students played on each other in lab, or on laypeople using body parts, usually told as happening at some other medical school or at some other time [9]. The issue is not whether these stories depicted actual events or even that students today tell similar "cadaver stories," but rather that in the lab being studied, and at the time of that study (the early 1970s), students told each other a lot of stories about lab and these stories carried important messages (often tacit) about things students were worried or concerned about. Studying the oral culture of students thus became an important part of this study. In another lab or at another time, such "tellings" may not be a part of the environment. In short, the fundamental strategy is to be sensitive to context and to let the setting and/or situation help to dictate the lines of inquiry you wish to take.

The Three Steps to Biopsying the Hidden Curriculum

- Begin with the formal curriculum.
- Next, be exhaustive in exploring this side of the formal/other-than-formal equation.
- Finally, begin to examine the other-than-formal aspects of learning.

Future Challenges

> "I plan to will my body to science. I have wondered on occasion what the med students carving on me would be thinking when cutting into me. Would they make comments about my tattoos? What will they think and say about the various scars I have collected over the yrs from injuries as a motorcycle racer?"
>
> A reader's comment to a *Time* article on anatomy training [10]

Over the years, anatomy has become much more deliberate and reflective in defining and expanding its educational footprint. When the lead author first entered lab in the early 1970s, the manifest function of lab was teaching anatomical form and function. It did so utilizing two principal pedagogical vehicles: lecture and dissection. There was no formal recognition that anatomy might be involved in the emotional socialization of medical students—beyond some vague notions of the cadaver as a "first patient" and the prospect that lab might function to ensure that some "needy" students might attain a level of detachment and objectivity they might otherwise lack when it came to dealing with clinical issues such as disease, disfigurement, dying, and death. There also was little formal discussion about "respecting the body" and no consideration (per the quote that opens this section) that donors might have expectations of students. Today, anatomy has a new face—and a somewhat expanded mission. Today, anatomists teach using a dizzying array of tools including plastinated specimens, plastic models, interactive 3D atlases, virtual dissection, computerized models, body painting, poetry, songs, and spiritual readings. The goal of learning anatomical form and function, in turn, has been joined by the formal teaching and evaluation of issues such as professionalism, leadership, and teamwork [11]. Today, it is not unusual to read how lab can manifestly function to teach compassion and respect and clinical ethics, promote social bonding among students, add to the humanistic goals of medical education, and directly contribute to laying a foundation for more clinical arenas such as end-of-life care [12–16]. In short, and with some degree of irony, the very topics that were off the formal curriculum radar in the 1970s (e.g., compassion, end-of-life care, professionalism) now are key arguments for why anatomy should continue to occupy a key and perhaps even expanded seat at the medical school educational table.

Whether curriculum deans and/or educational policy committees buy such a reformulated face is another matter, but what is clear is that the self-identity of anatomy has changed in the ensuing 40 years.

What has not changed, nor will it ever, is the enduring presence of the hidden curriculum within the landscape of medical education. Recognizing that students who operate in four-person dissection teams have been learning about teamwork since time immemorial—in spite of the fact that teamwork was not a formal part of the course description—is an important insight. Moreover, recognizing that the teamwork being learned by students operating in these teams might not be the teamwork that faculty would hope they might be learning would be an additional insight. Making teamwork a formal part of that course and then explicitly identifying the teamwork competencies students are expected to master thus becomes an important step in shifting one's learning about teamwork from an other-than-formal to the formal curriculum. Nonetheless, while undertaking such restructuring, whether about teamwork, professionalism, or some other learning objective, may make the anatomy experience more pedagogically coherent, it does not erase the HC from the learning milieu. The HC is still there. It may exist around other issues or take on other forms. Once again, we refer the reader to our second case example (above) and once again refer to the gap between formal faculty messages about the importance of dissection and the more tacit yet overwhelming powerful and negating messages students received via faculty examination policies. One does not "fix" the hidden curriculum. Instead, one works with it in conjunction with the formal curriculum to make the learning experience of students as positive and as reinforcing as possible.

For all of anatomy's successes, and there are many, challenges remain—some directly tied to those successes and some tied to the ubiquitous presence of the HC. The fact that anatomy has deliberately broadened its pedagogical base to embrace other learning objectives in addition to anatomical form and function has placed anatomy at some odds with other basic science disciplines. As noted, in some detail by Jones [17], the internal success of building in "additional" topics such as teamwork, leadership, compassion, and professionalism has turned anatomy into a somewhat stand-alone and/or isolated player. Students may well (again referencing Jones) come out of anatomy fired up about the importance of compassion and/or professionalism as being critical to good doctoring, only to find that their other basic science courses never mention these topics. Moreover, students actually may find themselves in clinical settings (e.g., preceptorships etc.) where such topics also remain essentially unaddressed—or if addressed perhaps not assessed. In turn, students, ever searching to make sense of their learning environments as they develop peer-based rules about discriminating between the "unimportant," "somewhat important," and "really important" things they need to learn, may conclude that professionalism, compassion, etc., are "really not all that important after all"—because if they were (the reasoning continues), then they would be covered (via formal teaching and assessment) in these other courses. Students also will remain quite sensitive to what they see as the mixed messages they receive from faculty about their state and status within the educational environment and thus continuously vulnerable to feelings of cynicism, isolation, and burnout.

> "And that's exactly how the hidden curriculum is taking us down—the hardest part about med school is being so isolated. *They* want us to believe that it's 'normal' to bottle up our emotions and power through every struggle. *They* teach that 'humble' is doing good deeds without talking about it. *They* want us to prioritize our own grades over relationships. And the more we stay quiet, the more *they* win. Well [expletives deleted] they."
>
> A Medical Student Blog [18]

The next challenge for anatomy, therefore, is to take its beachhead and seek to have other courses join in anatomy's effort to move beyond "the subject at hand" and begin to explore how the *entire* and *truly integrated* educational enterprise (which extends far beyond the formal curriculum) can be *devoted* to creating better doctors in service to the public. This means, among many other things, an end to subject matter balkanization—long a hallmark of medical education. Anatomy has shown how some of this broadening and integration can be done. Its next challenge, however, is to share that vision and wisdom with the rest of its colleagues.

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Part VIII

Teaching Anatomy to Students in Different Academic Programs

Teaching Anatomical Sciences to Dental Students

38

Stephen McHanwell

Introduction

Dentistry is a surgical science; consequently, there is a strong focus on structural biology throughout a dental degree. Students will typically be undertaking irreversible and potentially painful procedures on patients within 2–3 years of starting their course. There is a need to ensure they are equipped with sufficient anatomy to become safe and effective practitioners. The anatomical subjects studied in dentistry are broad and largely studied within the early years of a program. Dental students will expect to be studying not only gross anatomy but also tooth morphology, embryology, and postnatal development of the head and neck, basic histology, and the specialized histology of dental tissues. They also require an understanding of neuroanatomy including pain and coordination of jaw movements.

These courses will typically occupy a significant fraction of basic sciences teaching in a dental course alongside physiology, metabolism and nutrition, oral physiology, microbiology, and immunology. Usually, these subjects are taught in the early years of a dental program. This is despite the emphasis frequently placed upon the need for vertical integration across the 4 or 5 years of a dental degree which is especially important in relation to anatomy. Dental anatomy will link to many courses in the later years of dental studies including oral surgery, restorative dentistry, temporomandibular disorders, and human diseases.

Though in the past the focus in many dental schools has been upon the training of dental surgeons, the increasing trend towards interprofessional education of the dental team has seen BDS students being taught alongside other members of the dental team. There has been a growth in the profession of dental therapy both in the UK and elsewhere worldwide. Qualified dental therapists are able to perform surgical procedures on patients including restorations requiring the administration of local anesthesia, and so to be safe and effective, practitioners also require knowledge of relevant anatomy. Consequently, gross anatomy is taught to this student group also as part of their professional education. The content of an anatomy course delivered to dental hygienists and therapists will overlap significantly in its content with that taught to dental students, and there are clearly benefits both professional and practical in providing joint teaching to these two student groups during their training.

Many of the issues that confront teachers of anatomy to other groups including medical students present similar challenges to teachers of dental students [1]. Thus, provision of appropriately qualified staff to undertake teaching, the issue of dissection versus prosection versus other

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methods for teaching anatomy, the place of virtual resources and e-learning in an anatomy course, and choice of teaching strategies and the use of alternative resources all feature as issues for dental teachers [1]. Since these are issues are discussed elsewhere in this book, I do not propose to discuss them here except where the teaching of dental students raises special problems. However, one issue that is a frequent cause of concern in medical teaching seems to be less of an issue in dentistry, at least for the present, and that is the time made available for anatomy teaching. Concerns have been frequently raised over the loss of teaching time in anatomy for medical students [1–3], but these pressures do not seem to have been felt to the same degree in dental courses. Whether this will continue to be true, given pressures to provide students with clinical exposure at a much earlier stage than previously, must remain to be seen. Nevertheless, the fact that dentistry is a surgical science, with students performing surgical procedures on patients as part of their training, greatly strengthens the case for adequate exposure to anatomy at all stages of their course.

This chapter will discuss the content of dental gross anatomy courses at undergraduate level, the place of dental gross anatomy in the overall dental curriculum, and how dental anatomy is taught and assessed. Brief mention will be made of anatomy in postgraduate dental teaching and in the teaching of professions complementary to dentistry. This chapter will be confined to an examination of the teaching of gross anatomy, embryology, and neuroanatomy. The teaching of dental anatomy (tooth morphology) is frequently undertaken separately, and recent articles have described some of the features of courses in this subject [4, 5].

The Content of Dental Gross Anatomy Courses

Professional Body Guidelines

There appears to be little disagreement among course designers and teachers of dental courses that a knowledge of gross anatomy is crucial to a qualified dentist though what and how much might be contested [6, 7]. Clearly knowledge of relevant gross anatomy is necessary for the safe administration of local anesthesia, understanding the spread of dental infection and its surgical treatment, undertaking simple surgical procedures such as submandibular sialolith removal or surgical extraction of teeth, or interpreting radiographs just to give selected examples. Such clinical examples stress the relevance of dental anatomy to dental students and provide an important stimulus for students to learn anatomy [7]. The Education Committee of the British Association of Oral and Maxillofacial Surgeons has recognized the importance of anatomy to oral surgery in their survey of undergraduate opinion of the oral surgery training they are receiving [8]. However, in comparison to medicine, there have been relatively few recent attempts to define the detailed content of a dental gross anatomy course [9, 10]. Guidelines in the USA were produced by the American Association of Dental Schools in 1981 and revised in 1993 [11, 12]. There are no similar detailed guidelines in the UK or Europe. The General Dental Council (GDC) in its First 5 Years document sets out only in the broadest terms the content of the basic sciences components of dental course in the UK, and no further detail was provided in the revision of this document Preparing for Practice published in 2012 [13, 14]. In the Preparing for Practice document, the GDC states that relevant members of the dental team will, upon qualification, be able to "identify relevant and appropriate dental, oral, craniofacial and general anatomy and explain their application to patient management" [14]. This statement, though helpful in stressing the importance of relevance when considering the content of the basic science components of a dental curriculum, clearly lacks any other useful detail.

Defining Course Content

Given the absence of detail from professional bodies in the UK or up-to-date detail in case of the USA and without a rigorous survey of current professional opinion on the content of dental gross anatomy courses such as might be afforded by a Delphi analysis, indirect methods have to be resorted to determine the appropriate content of a dental gross anatomy course. A review of four of the standard dental anatomy textbooks shows a degree of consensus. The anatomy of the head and neck is prominent in all three books each advocating detailed coverage of the anatomy in these regions [15–18]. The requirement of dental students to study the head is self-evident, the anatomy of the neck in such detail perhaps slightly less so, but the ability to perform a clinical examination of the neck is a required skill for every dentist, and so a knowledge of the anatomy of the region is not only necessary pedagogically but also on grounds of clinical relevance. However, there is by no means universal agreement between these textbooks on the precise details of coverage in the head and neck. There is less agreement on how much knowledge dental students must know of the anatomy of the rest of the body. Three of the textbooks provide coverage of the anatomy of the thorax, and the anatomy of this region is covered in all UK dental courses with which the author is familiar and in most US courses [15–17, 6]. Typically, some teaching is provided on the upper limb, though this may be as little as simply covering the anatomy relevant to intravenous therapy and on the anatomy of the abdomen. Many courses do not teach pelvis, perineum, or lower limb. Clearly, dental students need to know less about these regions compared to head and neck, but the majority, if not all, of dental courses provide teaching to their students on human diseases. The examination of one of the standard human disease texts for dental students suggests that some anatomy of the whole body is necessary if dental students are to make sense of such a human diseases course [19]. A similar point is made by Guttmann and colleagues though they also stress that underlining relevance is of even greater importance when teaching dental students the anatomy of regions of the body such as the abdomen [7]. This would also depend upon the background of the students entering training. Not all dental schools require students to have basic science knowledge upon entry, and so coverage of the anatomy, and physiology, of other regions of the body would be especially important for them.

The content of a dental gross anatomy syllabus needs to go beyond gross anatomy to include surface anatomy and some limited imaging anatomy. The neck, the face, the temporomandibular joint, and the oral cavity are four very obvious regions whose living anatomy needs to be mastered. While radiology is usually taught as a separate course, the use of appropriate images in the gross anatomy course will deepen the understanding of a region as well as providing preparation for more detailed courses to follow.

One approach to defining the appropriate content aims in the gross anatomy component of a dental programme is to ask about the overall intended aim of the entire dental programme. If that overall aim is to train dental practitioners or technologists, then these content aims might be quite limited. If the overall aim is a broader one of producing dental practitioners educated to degree level who are also dental scientists some of whom might want to carry out dental research then these content aims will be necessarily broader. A similar question about the destination of dental graduates might be posed in relation to possible preparation for future study. The designing of syllabuses for postgraduate study has attracted attention recently [20]. Considerations of the design of postgraduate dental syllabuses raise the issue, as it has done in medicine, of the balance in anatomy teaching between what is needed at the undergraduate level and what should be reserved for postgraduate specialties.

Delivery of Gross Anatomy Teaching

Joint or Independent Teaching

In many dental schools, dental students are taught as a group separate from other students. Where there is joint teaching with other groups, then this is interprofessionally with other members of the dental team, most often with dental therapists and hygienists. In some schools, dental students may be taught in the same classes as medical students for part or all of their teaching especially in the early years. There are advantages to this in both terms of the interprofessional education of medical and dental students and also in cost. There are disadvantages in relation to the marginalization of dental students when taught in a shared program [21]. This author is of the opinion that in anatomy, dental students are best taught separately from medical students as a dental gross anatomy course is distinctive in having far greater emphasis laid upon head and neck anatomy. Clinical examples and scenarios underpinning clinical relevance are also quite different.

Curriculum Structure and the Place of Anatomy

Though many dental courses continue to rely on didactic forms of teaching, an increasing number employ problem-based learning or scenario-based teaching. In virtually all dental schools where there is didactic teaching, anatomy courses are usually taught regionally. This may be as a part of a very traditional discipline-based strategy in which an anatomy course stands alongside other subject-based courses. Such courses are much less frequent and instead systems-based courses are more usual [6]. In such cases, head and neck anatomy may be taught as a separate stand-alone course or as a part of an oral biology or oral functions course. Histology may be taught as part of an anatomy course, within physiology or as a component of the relevant systems-based course. Since engaging students to learn histology is often an issue in the UK where fewer students study histology prior to starting their dental course, stressing functional or clinical relevance will be important. Furthermore, students often have no experience of using a microscope or interpreting the images it produces, and so the barriers to learning histology are greater.

There have been a number of studies that have attempted to assess the effectiveness of traditional, didactic teaching compared to problem-based learning. This is also the case for dentistry. A cross-sectional study by Last and colleagues comparing the basic science knowledge of the final cohort of dental students enrolled on their conventional course, with that of the cohort of students enrolled on the first year of their PBL course that replaced it, found no significant difference between the two cohorts [22]. A similar study looked at perceived preparedness of dental students for dental practice if enrolled on a PBL as compared to a traditional curriculum and again found no differences [23]. The limited conclusion one could draw from these two studies is that PBL courses perform no less well than traditional courses when looking at knowledge retention though they appear to perform no better either. Hattie, in an extensive series of meta-analyses of problem-based learning more widely across the education sector, reached a slightly more elaborated conclusion [24]. Hattie concluded that students on PBL courses performed less well or even negatively on measures of surface knowledge but better on deeper learning and understanding where surface learning has already occurred [24]. This is not a surprising conclusion given the very different aims of the two approaches. It is of significance for anatomy where the burden of surface learning needed before one can manipulate ideas and show evidence of a constructed approach to learning is greater. A recent study with dental students highlights the importance of context in helping students to understand clinical problems and move from the certainty of facts taught in the early part of an anatomy course to the uncertainty encountered in dental practice [25].

Teaching in the Dissecting Room

An important feature of any gross anatomy course, including dentistry, is the practical component and time spent interacting with materials in an active way. This continues to mean, in most cases, working in a dissecting room examining the human cadaver. In the past, this meant working as a group dissecting a formalin-fixed cadaver. This is not the place to enter the vigorous recent debates over the value of dissection as a teaching tool in anatomy. As syllabuses have developed and time has needed to be found for other subjects, the time available for a full course of dissection has diminished [1, 2, 9]. For dissection to be effective as a teaching tool, adequate time has to be allowed and this is often simply not available. Added to that, many students arrive having no previous experience of dissection and so are far less well equipped to undertake dissection in the dissecting room. Thus, carefully and more professionally prosected specimens will be usually more capable of showing a fuller range of detail than those prepared by students. A recent study found that dental students valued dissecting room experience as a positive part of their course while also stating a preference for prosected specimens [26]. Similar findings were reported in an earlier study [27]. The authors attributed this difference to the fact that dental students predominantly study head and neck which is both more complex and difficult to dissect, and so there would be benefits to providing specimens prosected by experienced staff [27]. One often-cited benefit of dissection is the development of hand skills, but the type of skill developed during dissection seems unlikely to transfer to the skills needed in dental practice. All dental schools provide intensive training in the relevant hand skills prior to students undertaking patient procedures. Some schools are recognizing a key disadvantage of formalin-fixed cadavers is their unrealistic nature and are moving to thiel-fixed cadavers. The softer fixation can allow development of some skills relevant to dentistry such as the administration of inferior alveolar nerve blocks, and this is being employed in at least one school as a part of the pathway to learning this technique.

Benefits of Dissecting Room Teaching

Whether through dissection they undertake themselves or by examination of specimens prepared by experienced staff, exposure to human specimens, though still a simulation, does provide an authenticity and immediacy that no other teaching technique in anatomy can fully replicate. For most, this acts as a powerful stimulus to learning. Students gain other benefits through working in the dissecting room. The same study referred to above also found that students rapidly acquired a high level of professional values in relation to working in the dissecting room [27]. The acquisition of professional values as another outcome of a gross anatomy course has been observed in other settings [28]. This positive and professional attitude of dental students to studying anatomy in the dissecting room is something seen by the present author in the course of many years teaching on a dental course. Studying anatomy partly through the medium of the cadaver has also been shown to have positive effects on the approaches students take to learning. A recent study found that students responding positively to a statement, "that cadaveric teaching was an important part of becoming doctor/dentist or healthcare professional," were more likely to be adopting deep approaches to the learning of anatomy [29]. Thus, working in the dissecting room would appear both to aid in developing professionalism and the ideal of deep learning approaches. Deep approaches to learning when balanced with surface learning are necessary for developing abilities to predict and hypothesize which will, in turn, lead to the development of more constructed understandings that will allow students to develop their own ideas [24]. This will benefit to students as they start to encounter real-life clinical problems later in their training.

Other Resources for Teaching

Cadaveric anatomy is not the only means of teaching anatomy practically. There is a range of software and other virtual resources though, given the relatively smaller size of the dental market and the lower return on investment in developing such packages, fewer of these are written with the needs of dentistry specifically in mind [30]. Radiography is usually studied as a separate dental discipline; consequently, there is little radiology taught within the gross anatomy component. However, students frequently experience conceptual difficulties in interpreting two-dimensional radiographic images in terms of three-dimensional anatomy, and so there are advantages to studying radiology alongside gross anatomy through the intermediary of three-dimensional reconstruction facilities offered by software such as the Visible Man package. Other pedagogical techniques such as body painting have been less fully exploited in dental compared to medical teaching but do offer opportunities for teaching anatomy in different ways. As in gross anatomy courses with other students, some experiments have been made with peer teaching with some success but also not without some difficulties [31]. Similarly dental students, in common with many other students, find formative quizzes delivered during their gross anatomy course an effective way of stimulating learning [32].

When Should Anatomy Be Taught?

In most dental courses, gross anatomy is taught within the first 2 years of the program and then not revisited. This is probably not the best approach to deliver a subject required throughout the program to analyze real-life clinical problems encountered in treating patients [33–35]. When retention of anatomical knowledge among dental students was tested over the duration of their course, it was found that knowledge of anatomy declined in the later years [33]. One study identified as a particular problem the inability of students to apply their anatomical knowledge to actual clinical problems [34]. Finding time in the later stages of a dental course to deliver basic sciences teaching is not easy given the importance of acquiring clinical competence to ensure patient safety. Therefore, in Newcastle a simple online course was devised both to reinforce the basic anatomy taught in the early years and to introduce students to its clinical application. Research showed that it reinforced the basic anatomy by revisiting the material and through emphasizing its relevance by exemplifying the use of anatomy to understand clinical problems [34]. A similar point is made by Hendricson reviewing the ways in which basic sciences might be better integrated with clinical teaching during a dental course [35]. Relevance is important in reinforcing the teaching of anatomy in the early years and as a means of explaining why it is important to learn it at a time when the clinical experience of students is limited. However, in the early years, complex clinical examples can overwhelm students, and so there needs to be progressive elaboration of clinical input as the course progresses, developing learners' understandings of the importance of basic science as part of acquiring clinical competence [35]. Hendricson terms this a "lined-up curriculum" in which basic sciences, pathology, and treatment for the head and neck and for the rest of the body are organized into a coherent story [35]. This underlines the importance of context in helping dental students to understand complex clinical problems and the need to move from the relative certainty of facts presented early on to the uncertainties when real-life patients are encountered [25, 35]. Joining up the curriculum in this way is also the means to ensure that anatomy teaching is integrated horizontally with relevant functional courses such as physiology and also with the relevant pathology such as they taught in a human diseases course [19]. Vertical integration is then a critical step to full engagement with basic sciences. This does not mean simply repetition of taught material. Rather, it means reviewing and summarizing early years of teaching and elaborating upon it through the use of progressively more complex clinical examples. Perhaps, though, the most effective route to vertical integration, where resources permit, is through team teaching where basic and clinical teachers collaborate to deliver case presentations or scenario-based teaching, for example, in both the early and later stages of a course.

Neuroanatomy

Neuroanatomy is an invariable part of any dental anatomy course but students frequently struggle to see its role and purpose in a dental curriculum. Clearly, an understanding of pain requires knowledge of the relevant neuroanatomy, but dental students' knowledge of the neuroanatomy subject needs to extend beyond that to include regulation of vital functions such as control of respiration and the cardiovascular system, mastication, swallowing, speech, and taste [36]. As part of any human diseases course, their knowledge needs to extend even further to understand the more common pathologies they are likely to encounter in their patients which would include, but not be limited to, stroke, trauma, and the more common neurodegenerative diseases such as Alzheimer's and Parkinson's diseases. Curricular guidelines produced in 1992 by the Anatomical Sciences Section of the American Association of Dental Schools identified that a dental neuroscience course should familiarize students with the cellular structure of the nervous system, the structure and function of the peripheral and central nervous systems including major pathways, the innervation, somatic and autonomic, of the head and neck, and apply this knowledge to dental clinical practice [37]. Clearly, there are important areas of overlap between the topics in neuroanatomy as defined by the American Association of Dental Schools as being needed for a dental course and the content of a head and neck anatomy course. Educational benefits could be expected if the teaching of head and neck anatomy and neuroanatomy were coordinated. Klueber has described how such an integrated course might be organized and clearly identified the pedagogic advantages of such a course not least in its ability to engage students more effectively in studying neuroanatomy [38].

Embryology

Similar observations may be made in relation to embryology teaching. Guttman found that the teaching of embryology was delivered in a variety of ways in his survey of dental schools in the USA and Canada. This could be as part of a gross anatomy course, a histology course, and an oral biology course or as an independent course [6]. Clearly, there are important linkages to be made between the development of a region and its adult anatomy. In the case of a dental course, the anatomy of the head and neck is more readily comprehensible if the development of pharyngeal arches and clefts are understood, so there are advantages to be gained by teaching some early development of the embryo alongside that of the relevant gross anatomy. Beyond that, embryology may be best taught as part of a craniofacial development course in which normal development is studied alongside abnormal development of the head and neck, thus allowing appropriate clinical linkages to be made. The importance of stressing relevance in encouraging students to engage with certain topics has been noted elsewhere in this chapter and is a theme of a number of articles cited below [7, 32, 33]. This is no less true of embryology. Indeed, the need to stress relevance when teaching anatomy as one means to engage students in their learning on the way to becoming a professional might be considered a theme running through this chapter and a point at which to conclude discussions about course content.

Assessment of Student Learning

Assessment of student learning is an extremely important part of what we do as teachers so it will seem strange to have left this until last. The reason for this is simply that the modes of assessment used in dental courses are broadly similar to that of other anatomy courses. It will be found that a variety of objective tests are employed ranging from true/false answers at the very simplest through multiple-choice and extended matching item tests to more sophisticated approaches such as single-best-answer-type questions. These tests are increasingly being delivered to students in online formats. Objective tests will require some form of standard setting procedures to be employed when determining an appropriate pass mark. Tests requiring students to write free text responses vary. They can be short-answer-type questions where students' responses to questions can be single words, short phrases, or a few sentences. A more sophisticated approach involves some kind of semi-structured essay developing a theme or scenario. Essays, once the favored approach, are becoming less widely used. Practical examinations of the traditional steeplechase or spotter variety are frequently employed as tests of practical knowledge either using cadaveric specimens or images or a combination. Thus, the range of assessment types in anatomical sciences in dentistry is no less wide than in courses for other groups.

What to Do If You Find You Are Suddenly to Teach a Dental Gross Anatomy Course: Some Practical Advice

- If you can, avoid teaching dental students their anatomy as part of courses delivered to other professional groups (though there is great benefit to be derived from teaching members of the dental team together).
- Think about the content of the course, what is going to distinguish it from other courses that you teach. You are teaching future dental professionals; your course must be relevant yet coherent.
- Talk to members of your dental faculty, gain a sense of what is important, gather relevant clinical examples to illustrate your teaching, and understand how the whole dental course is structured.
- Ensure your course integrates with other relevant courses especially embryology and neuroanatomy if you are not teaching those topics as part of your own course.
- Choose your resources carefully using materials written with the needs of dental students in mind wherever possible.
- If resources permit, undertake some team teaching with dentally qualified staff.
- Try to ensure anatomy is not just taught in year 1 of the program but spirals throughout the course.

Conclusions

1. Courses in anatomy for dental students include head and neck anatomy and anatomy of the thorax as well. Other regions of the body need to be taught for students to be able to understand the anatomical bases of human disease.
2. Courses in anatomy for dental students can be taught successfully in a variety of curricula structures, but in a predominantly didactic course, one successful format can be that where regional anatomy is taught as parts of the relevant integrated systems-based courses with head and neck anatomy delivered either as a stand-alone course or part of an oral structure and functions course.
3. Cadaveric teaching remains an important cornerstone of the teaching of anatomy to dental students not least because dentistry is a surgical science. Given limited time available, prosection-based teaching can be a very effective way for students to study the cadaver.
4. It is important to ensure that the teaching of anatomy is vertically integrated with clinical teaching so that anatomical knowledge is reinforced later in the clinical course when students begin to treat patients and encounter complex clinical cases.
5. Horizontal integration of neuroanatomy teaching with that of the head and neck can enrich student learning and encourage engagement with neuroanatomy as a subject.

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39 Negotiation and Assessment as Tools for Tailoring Anatomy Courses to Allied Health Programs

Lawrence J. Rizzolo, William B. Stewart, Alexandria Garino, and Linda H. Pellico

Three questions perennially confront anatomists: What should be taught? Who should teach it? What pedagogy should be used? At medical schools, different disciplines compete for school resources and time in the curriculum. For allied health programs, there is an added dimension, because the tradition of a strong grounding in anatomy is not firmly established. For example, all accredited physician assistant (PA) programs must teach anatomy, even though 86 % list anatomy as an entrance requirement [1]. However, the instructional hours devoted to anatomy (102.4 ± 56.1) varies greatly [2]. Accelerated graduate nursing programs enable students without a nursing degree to become a registered nurse after 1 year with an advance practice degree 2 years later [3]. Most of the 68 programs in the USA require anatomy as a prerequisite, but it appears only Yale University includes anatomy in its required curriculum. Yale's concern was that undergraduate courses fail to focus on the anatomy needed to be an advanced practice nurse. The common experience of the PA accreditation board and nursing programs [4] is that nonclinical university departments fail to ensure a consistent standard level of knowledge and are costly in terms of student dollars and time.

Each allied health field has its own needs, and there is little standardization within fields. Therefore, anatomists must become skilled negotiators by developing methods to answer the questions posed above [5–9]. Many individuals and groups have a stake in these questions, which means the success of your course depends upon your ability to identify and satisfy conflicting concerns. You will need to (1) reconcile the myriad demands placed on the limited time and resources possessed by you, your students, and your faculty collaborators and (2) negotiate for the time and resources required to build a course that integrates with the rest of the program's curriculum.

We found that negotiation with stakeholders led to course goals and two types of assessment that could shepherd the course towards achieving agreed upon outcomes [9–11]. Year-end summative assessments identify strengths and weaknesses, but often fail to identify the cause of these attributes. Formative assessments

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provide feedback during the course that identifies ways to develop the course, train faculty, and help students progress. We will discuss our medical school and PA programs first, because they are the most comprehensive and were the incubators where we developed and verified these principles [9, 10]. Our graduate nursing course had been a lightly attended elective until we applied the principles learned from redesigning the medical and PA programs. Our stakeholders were so pleased that anatomy has become a required course. A detailed outline of our methodology is available online [8]. Table 39.1 summarizes the various courses we teach, but this chapter will focus on the medical, PA, and nursing programs. We will discuss the needs analysis of our stakeholders, but you are encouraged to use this as a guide for your site-specific negotiations and analysis.

Negotiation Skills
(See References for Complete Citations)

General References [5–7]

Anatomy Specific References [8, 11]

Identifying and Negotiating with Stakeholders: Agreeing on Goals, Cases, and Procedures

You have more stakeholders than you might realize, and their needs can be contradictory. The Dean has concerns that include costs, resources, curricular hours, and overall curriculum. The Dean's vision may include more than the educational mission and those goals compete for the same resources. Department chairs may wish to support the Dean's overarching goals for education, but they also have some goals for their department that conflict with educational goals.

The broader community includes accreditation bodies and licensing boards. Programs for advanced degrees might list your course as a prerequisite with the hope that you will accomplish certain goals. Often information about these goals is hard to obtain. We found it valuable to work backwards by consulting the faculty who teach after our courses. What should a student need to know to graduate? To accomplish that goal, what should a student know before entering their last year, and so forth. The approach reveals the anatomy these faculty stakeholders consider essential, and how to prepare students. It partitions the subject matter into introductory and subsequent courses/clinical training and establishes responsibility for the deferred material.

Students and their anatomy instructors are essential stakeholders. Especially when engaging pedagogies that are foreign to them, students need to know how anatomy integrates with their career goals. Given the many demands placed on their time, are you asking too little or too much of them? How do they define being prepared for class and how does their answer compare to your definition? The faculty has analogous concerns if a new course places new burdens on them. Does your new course structure require training in new pedagogical skills, and if so, how will those new skills be acquired? This problem is especially acute if your faculty has other responsibilities such as maintaining a research laboratory or clinic income. No matter how well designed, the faculty's ability to implement your course will determine success or failure.

The negotiation process is slow. It begins with learning about the needs of the stakeholders and their responsibilities that may impede their desire to collaborate. After you complete this "needs analysis," you will be ready to devise solutions. In the second round of negotiations, your proposals will gain more traction the more stakeholders feel you understand their concerns. As long as you are flexible, they will develop a sense of ownership and provide you the help you need to succeed. Here are some examples of how we did our needs assessment for various programs, and the points of negotiation that we uncovered.

Table 39.1 Anatomy courses for clinical students at Yale University

Students	Curriculum developers	Delivery	Faculty	Laboratory experience	Summative examinations	Content emphasis
Medical	Surgical, medical, radiology, anatomy faculty	108 h. (60 laboratory, 16 small group, 28 lecture, 4 test)	Anatomy, surgical, medical radiologic, medical students, residents	Full-body dissection	Anonymous, two written (pass/fail)	Clinical context, critical observation, problem solving
Physician assistant	Surgical, medical, radiology, anatomy faculty	104 h. (51 laboratory, 7 small group, 40 lecture, 3 laboratory test, 3 written test)	Anatomy	Full-body dissection	Three written/three laboratory (graded)	Clinical context, critical observation, problem solving
Graduate nursing	Nursing/anatomy faculty	30 h. (13 lecture, 8 anatomy laboratory, 6 clinical laboratory)	Anatomy, nursing (co-teaching)	*Anatomy laboratory*: prosection *Clinical laboratory*: skills	Written midterm and final (graded)	Clinical context, physical exam, nursing care/procedures
Surgical PA residents	Anatomy/residency faculty	18 h. (laboratory)	Anatomy	Partial-body dissection	No exam	Clinical procedures
Paramedics	Anatomy, paramedic faculty	15 h. (laboratory)	Anatomy, paramedic (co-teaching)	Partial-body dissection	Anatomy tested in other course	Vital signs, emergency procedures, major organs
High school	Anatomy, clinical, high school faculty	15 h. (laboratory/small group)	Anatomy, medical students	Prosection	Written tests at Yale and at high school—graded exams	Physical exam, disease, exercise

Questions for Stakeholders

- *Interviews*: How is anatomy used in your discipline? How do you wish students were trained? What solutions would you recommend? What circumstances would allow you to help? Can we keep discussing this?
- *Focus groups*: What was your experience of your anatomy course? In what ways did it help your subsequent training? What would have been more helpful?
- *Surveys*: Short-answer questions based on results of interview and focus groups.
- *Follow-up questions for yourself to guide further negotiations*: What do I have that they need? What do they have that I need?
- The answers will help you choose cases and procedures, pedagogical methods, and assessment procedures.

Medicine and Physician Assistant Programs

Physician assistants are taught in the medical model. The basic approach was devised for the medical students and then adapted to the PA students. We first interviewed all of the section chiefs of each surgical department. An example of a conflict that emerged was the Dean's desire to use more surgeons as teachers, which added to the burden of surgical departmental Chairs, whose primary concern was patient care and clinical education. Surgeons wanted to help, because they felt that all students needed a better understanding of surgery and lacked sufficient anatomical training. At the same time, surgeons noted that the pressure to generate clinical income impeded their desire to be part of the solution. We also found that faculty from the medical departments were interested in advancing their own understanding of the anatomical basis of the diagnostic procedures, in order to better instruct trainees. Virtually all the clinicians interviewed favored presenting critical information in the context in which it would be used.

The interview results guided our negotiation strategy. Clinicians would welcome the opportunity to work with students early in their training, if the anatomy curriculum was more relevant to their practice. The opportunity to help design the course made them more willing to teach it. Interviews, focus groups, and surveys revealed that students favored a patient-centered curriculum and a student-centered course, which dovetailed with goals of the clinical faculty. This led to a course design based entirely on common clinical cases that students would certainly see during their clinical training. The new structure focused more on critical reasoning and skillful observation.

The course begins as the clinician begins with a patient by mimicking a physical exam. This is an exercise in surface anatomy. Later, dissection (or reopening the body wall in a prosection course) reveals whether the organs of that particular donor might have been enlarged or displaced due to disease. The problem presented to students is "what anatomy can be learned by physical examination." Think of this as just-in-time learning. More anatomy progressively unfolds as the student engages more complex problems. Subsequent laboratories and workshops are based on the anatomy that underlies the patient's history, physical exam, imaging studies, and medical or surgical resolution. The dissection procedures are modeled on classical, open surgical procedures and are freely accessible on the website "Anatomy Clinic" [12]. The result was a shorter course with more clinician involvement that focused on preparing students for the next step of training. Students were motivated by problem-solving exercises, practical application, and extensive formative assessments. They profited when problem-oriented modalities were integrated, including dissection, prosection, computer exercises, radiology, and small group discussion. Our work with stakeholders has had an added benefit. As each program revised its curriculum, anatomy was viewed as a central feature that integrated well with the whole.

Ongoing negotiation with students revealed concerns about how to prepare and what was expected of them. We learned to develop: (1) a close connection between stated objectives, workshop and laboratory activities, take-home messages for each activity, and exam questions; (2) interactive web activities that required students to make decisions, consult texts/web resources, and process feedback in order to proceed through the activity; and (3) a social structure that fostered teamwork and active participation by all students.

Weekly faculty meetings revealed that faculty shared student anxieties. They were unfamiliar with student-centered techniques. Interactions at the dissection table or small group workshop tended to follow teacher-centered mini-lecture rather than fostering student-centered exploration and group problem solving. To help these essential stakeholders, we invited an educational expert to our faculty meetings to run development sessions that enabled faculty to meet the new demands placed upon them.

The PA course reflects the needs of its administrative stakeholders. PA students have less free time for out-of-class preparation than their medical school colleagues. The PA course is approximately the same length as the medical school course in terms of class hours, but the time is structured differently. PA students have fewer web-based assignments, and some time is shifted from laboratory and workshop to lecture format. Whereas clinical radiology is integrated into the medical school course, PAs have a stand-alone radiology course. The close interaction with the curriculum directors avoided duplication of effort and promoted integration with the rest of the curriculum.

Graduate Nursing Program

Our initial experience is a good example of what happens when you ignore stakeholders. Our course had been an elective, but because it failed to satisfy the needs of students, many dropped the course for lack of interest. We met with the nursing program director to develop a course directed specifically to graduate nursing students. The program director interviewed the directors of the nursing specialties to identify the critical concepts to be taught. Similar to the medical school and PA experience, we learned about the specific ways that anatomy would be used in this career path. Accordingly, lecture and laboratory exercises were based on the following organ systems: respiratory, cardiovascular, alimentary, urogenital, musculoskeletal, and nervous system. Lectures were typically followed by a prosection laboratory where the relevant structures could be examined in coordination with a nursing skills laboratory where the points of clinical care could be highlighted. Skills labs are based on the following diagnostic and invasive procedures: lung exam, airway management, chest tube placement and care, peripheral vascular exam, electrocardiogram, feeding tube placement and maintenance, urinary catheter placement and care, and the cranial nerve exam. Viewing prosections can be a passive, teacher-centered activity, but the integration with the lecture and skills laboratory promotes discussion as students come into the anatomy laboratory with questions in mind.

Team teaching during each class session was a critical component [4]. Advanced Practice Registered Nurses (APRN) and anatomy faculty complemented each other's experience to integrate nursing skills with anatomy. Because clinical faculty and program administration were directly involved in the design and implementation, the course fully integrated with the nursing curriculum. The curriculum committee (another stakeholder) approved the new elective. Once it proved itself to all stakeholders, the course became required.

To Do

- Use the information gained from your stakeholders to develop a vision for your course.
- Design the elements of your course that will achieve your vision.
- Go back to your stakeholders to share your vision for their feedback: Be flexible! The more stakeholders share in a common vision, the more helpful they will be as the project develops.

Selecting Pedagogical Modalities and Assessments

> "To attain knowledge, add things every day. To attain wisdom, remove things every day."
>
> Lao Tzu, mystic philosopher of ancient China and founder of Taoism

Many factors go into the selection of modalities and assessments. These will emerge from your negotiations with stakeholders. Students have different learning styles, but research indicates that students need to transition to the learning style favored by most professionals [13, 14]. Similarly, teachers have a preferred pedagogy, but they should be comfortable with all methods. Multiple pedagogies allow faculty to meet the students where they are and guide them towards the learning styles favored by clinicians. Is your course trying to transmit information or ask students to process information in a new way, e.g., three-dimensional reasoning? The first goal is suited to teacher-centered pedagogies, e.g., lectures and demonstrations. The second goal involves helping students gain comfort with unfamiliar learning styles and is more suited to student-centered pedagogies, e.g., workshops, dissection labs, and open discussions. Often a course is a balance between these goals and entails two challenges: (1) giving students clear expectations and the tools to achieve them and (2) helping faculty develop new skills.

Two types of assessment are required to evaluate your selections: (1) formative assessments to understand how your selections are working in real-time and (2) summative assessments to determine whether you achieved the goals of your stakeholders. Both need to be designed at the time you are designing the course. Assessments are often designed as an afterthought, but such assessments are of minimal help to improve the course and tend to be unconvincing for your stakeholders.

Formative assessments address the problem that new courses are often flawed. Instead of asking whether a course element is working, a well-designed formative assessment identifies underlying problems and reveals feasible solutions while the course is running and changes can be made. Performance on class exams provides clues, but these need to be supplemented by surveys and focus groups that ask what students and faculty were experiencing and how they tried to resolve their anxieties and concerns. To facilitate group work, instructors used weekly faculty meetings to share experiences and brainstorm solutions. The meetings focused on techniques that foster and manage discussion in place of mini-lecture. A rubric was developed to help students and faculty identify the factors that promote group process. The approach provided both an assessment and fodder for the faculty development program. To facilitate group work among students in the medical school, students were grouped into "Learning Societies." A society consisted of five dissection teams of four students and a mentor. Societies worked together in laboratory and workshop. As one example, we made novel use of ungraded practical exams. Students were encouraged to take the exams in teams where they could discuss their logic and consult with an instructor when necessary. The approach was valued by faculty, because by listening to students discuss their problem solving, faculty learned whether their focus on observation skills and reasoning-with-data was effective. It was valued by students, because peer-teaching honed reasoning skills, and they learned how well they understood concepts relative to their peers.

To develop summative assessments that will convince your stakeholders, you need to know how they define a successful outcome and what assessment criteria would convince them of success. In our case, we needed written exams, based on clinical vignettes that tested the course goals of critical observation and interpretation. The exams used short essay questions that required students to interpret patient data and imaging studies, extended matching questions that required students to combine data from multiple images, and standard multiple answer questions. You may need to collect new data on student behaviors, attitudes, and performance in your current course, as you are designing your new one. If you wait too long, you may find that you missed the opportunity to collect the necessary pre-intervention data. This approach allowed us to demonstrate that long-term recall of anatomy increased for both medical and PA students [9, 10]. Designing your summative assessment concurrent with the design of the course will help you define course objectives and inform your choice of pedagogy.

To Do

- Use stakeholder assessments to design formative and summative assessments that will convince stakeholders that you satisfied their needs. Do this before your course begins!
- Initially, avoid asking whether each course element works or not. Instead ask: What are students experiencing and how are they behaving? What are faculty experiencing and how are they behaving? For example, how do they prepare for sessions? Which resources do they use? What frustrations are participants experiencing and how do they overcome them?
- Use the answers to understand *why* successful elements worked and *why* unsuccessful elements failed. Revise your course accordingly until each element works properly. The cycle of revision and re-evaluation can take 3–5 years. Stick with it!

Medicine and Physician Assistant Programs

The Yale School of Medicine emphasizes independent learning, "honors system" exams, and professional responsibility. It puts a premium on small group, collaborative learning. The absence of grades puts a great burden on students and faculty to define and achieve success. The students are given substantial out-of-class time for independent study. By contrast, the PA program is run more along the lines of a college curriculum. For the anatomy course, both programs use "Anatomy Clinic" [12] to provide dissection instructions, but the pedagogy had to be modified to suit the environments of the medical and PA program.

The medical school environment required that we give students the tools and direction that foster productive use of their independent-study time. "Anatomy Clinic" is a research guide with highly interactive features [9, 12]. Students analyze physical exam or imaging data and receive instant feedback on short essay questions. Rather than present and quiz information, "Anatomy Clinic" is designed to develop habits-of-mind for problem solving and processing spatial information. It provides students a sense of what it means to be prepared for a given workshop or laboratory session. Instructors follow a Socratic method and facilitate discussions rather than lecture. Students struggle with and master a related set of problems over a block of sessions. Lectures are more content and concept driven and are used to either introduce topics or consolidate a block of web, workshop, and dissection activities.

To adapt the course to the PA environment, the number of laboratory hours was decreased to allow more of that material to be presented in a lecture format. These laboratory-specific lectures were in addition to the standard 1-h lectures. More direction is given in the laboratory in the form of "must-see" lists. There is less reliance on web activities and workshop discussions. Although full-body dissection is still done, students work in groups of six instead of groups of four. Accordingly, there is a partial shift from student-centered towards teacher-centered pedagogy. This is mitigated by the small class size (36 students), which allows lectures to be more interactive.

PA students' mastery and long-term recall of the material was less substantive than the medical course, but far superior to the previous PA course [10]. As with all choices, there are gains and losses. In this case, the changes from the medical school course resulted in less depth, but the gains were that students met programmatic goals with greater success and without compromising their attention to the other basic science courses.

Graduate Nursing Program

The hallmark of the program that emerged is coordinated nursing and anatomy labs. The shared interaction of an anatomist and an APRN in lecture and anatomy laboratory resulted in a unique opportunity to better understand how structure and structural relationships relate to clinical presentations and predictions of disease. In the anatomy labs, students view prosected donors to explore the anatomy that underlay the skills that had been presented in lecture. Because the laboratory groups were small and the corresponding nursing skills laboratory was taught the same day, the students were full of anatomical questions. This enabled the laboratory faculty to blend teacher-centered and student-centered pedagogies. The value of the APRN/anatomist collaboration cannot be overemphasized.

To Do

- Determine which pedagogies are best suited to your goals.
- Take an inventory of the strengths and weaknesses of you and your faculty with regard to these pedagogies.
- Find support through your school's Department of Education or Faculty Development for training that will address those weaknesses.

Conclusions

Implicit in this discussion is the need to approach the task of creating/revising a course with a bit of humility. Rather than presume you know what students need to know, find out. By learning about the common concerns and procedures that engage practitioners, you enhance your ability to recommend course content. After working on a gait activity with a rheumatologist, we learned about the issues that most concerned him, and he in turn was reminded of the anatomical basis of his trade. He concluded "Now I understand why it is I do what I do, and can now be a better instructor for my residents!" Negotiation with stakeholders is a two-way street where the sharing of information benefits everyone. You will earn the enthusiastic support of your administration and colleagues that will enable you to teach in the context that will benefit students' future needs. Armed with actual cases and procedures, you will be able to design hands-on activities that highlight critical anatomy. Team teaching with clinical partners will provide continuity of instruction and convince students that they are focused on essential content. Perhaps the most important outcome of this work is that you will develop a clear path from course objectives to class activities to assessment procedures. By examining how students and faculty engage these three elements, you will have a method for continually reassessing and improving your course(s).

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Teaching Anatomy to Students in a Physical Therapy Education Program

40

James W. Youdas, David A. Krause, and Nathan J. Hellyer

Gross human anatomy is a foundational course within the academic curriculum of all physical therapy (PT) programs in the USA, and the preferred teaching method is human cadaveric dissection [1, 2]. The Commission on Accreditation in Physical Therapy Education (CAPTE) accredits physical therapy programs to assure quality [3]. CAPTE presumes a PT professional curriculum includes content and learning experiences in anatomy that prepare students for subsequent physical therapy courses and for clinical practice. Year 1 students at the Mayo Clinic Program in Physical Therapy are enrolled in a six-credit "Anatomy for Physical Therapists" course that meets daily during a 16-week fall semester. Lectures last for 1 h and are held 3 days per week, whereas laboratory dissection sessions last for 3 h twice a week. The laboratory sessions account for 67 % of the course's contact hours with the major emphasis directed to anatomy of the limbs and back. The primary educational objective is to provide the physical therapy student with a broad understanding of functional anatomy so he or she can examine the musculoskeletal system and identify structures responsible for movement dysfunction.

Today's changing landscape in anatomy education has fostered a variety of active learning techniques designed to promote student engagement while learning a large body of information [4]. A majority of our students were born between 1981 and 2000 and are called "Millennials" or the "Net Generation." Millennials are described as persons who prefer a variety of active learning schemes including fewer lectures, more multimedia presentations, and the opportunity to collaborate with classmates [5]. This chapter will describe how various dynamic learning activities can be used in the anatomy dissection laboratory to facilitate teaching and learning.

Reciprocal Peer Teaching

The term reciprocal peer teaching (RPT) was first used by Allen and Boraks [6] to describe an educational system where fellow classmates alternate roles between teacher and student. Anatomy students can alternate roles as both student and teacher and practice RPT in the gross anatomy classroom or laboratory while trying to master anatomical relationships [7]. To supplement lecture and dissection experiences, groups of three or four students present a weekly demonstration to fellow classmates. The RPT assignment augments anatomical concepts presented 2 or 3 days before in the classroom and subsequently observed at the dissection table. The demonstration topics may be created by the anatomy instructor prior to the start of the course. For each RPT session, groups of students acting as teachers are

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given three or four learning objectives by the course faculty. Student teachers review the learning objectives with a faculty member prior to the scheduled demonstration. A faculty member might offer suggestions about how the group might illustrate an anatomical concept on a prosected cadaver, skeleton, or plastic model. For example, one RPT exercise involved illustrating the six fibro-osseous compartments on the dorsal aspect of the wrist. A faculty member recommended the student group begin their teaching presentation by reviewing the osteology of the dorsum of the distal radius and ulna using a skeleton. A piece of masking tape running transversely from the styloid process of radius to the styloid process of ulna represented the extensor retinaculum. Using the skeleton, student teachers were advised to point out the locations of the six extensor compartments and name the contents of each compartment. Next, the faculty member recommended the student teachers use the cadaver to illustrate the contents of each extensor compartment to their classmates. During the RPT experience, the student teachers circulated throughout the laboratory and presented their demonstration until all dissection groups had been adequately taught [8, 9]. Upon completion of the RPT experience, the students returned to their dissection table and began that day's dissection assignment.

Another example of RPT occurs when students teach peers about muscle action. Students can use a piece of string to visualize the action line of a muscle when learning attachments and actions [10]. By holding the string at a muscle's attachment sites, a student teacher can help a large group of learners readily observe the relationship of the muscle to a joint's axis of motion. For example, students often have difficulty visualizing the obturator internus as a hip external rotator. Using a string or rolled up paper towel and a human skeleton, a student acting as teacher can hold one end of the string or paper towel on the obturator foramen within the pelvis and the other end on the medial aspect of the greater trochanter. The string or paper towel is deflected as it traverses the lesser sciatic notch and heads for the lateral attachment site on the greater trochanter. The simulated muscle action line is posterior to the hip joint's longitudinal axis. This simple model helps a large group of anatomy students visualize and understand how the obturator internus can move the femur-on-pelvis or pelvis-on-femur both of which result in hip external rotation.

With respect to teaching, students perceive RPT sessions as enjoyable, because group members assemble beforehand to pool ideas to form creative ways to teach their classmates. Groups of physical therapy students acting as teachers reported they "dug a bit deeper" for the clinical relevance of anatomical relationships when preparing for their RPT demonstration. This supplementary preparation time was useful because the students as teachers formulated a plan of instruction that promoted confidence when instructing their classmates. Verbal interactions among laboratory teammates while preparing for the RPT demonstrations promoted cooperative learning among a team of classmates. For example, a student as teacher might share an acrostic or acronym with his or her group members that he or she found useful when learning anatomical facts. Because of this sharing process, classmates experienced a novel way to store and retrieve new information. Furthermore, students as learners also were exposed to a variety of anatomical models which their teacher classmates selected upon the advice of a faculty member to help promote learning during the brief RPT session. After both teaching and learning from one another, students reported that it became less intimidating for a classmate to summon assistance from a peer regarding an anatomical concept.

Near-Peer Teaching

Educators contend that near-peer teaching is successful because peer tutors and tutees communicate more effectively than do teachers and students [6]. Peer teaching was incorporated into the 16-week semester course, Anatomy for Physical Therapists, as an educational method to enhance learning of anatomical concepts by Year 1 Doctor of Physical Therapy (DPT) students. Four Year 2 DPT students were selected by the course coordinator to serve as near-peer teachers for

Year 1 DPT students. Peer teaching review sessions occurred weekly and were each 90 min in length. The theme for each near-peer teaching session was developed based upon weekly terminal behavioral and instructional objectives contained in the course syllabus. The four peer teachers were familiar with the anatomy course resources. Materials used at each session included articulated skeletons or individual bones, cadaveric tissue dissected by Year 1 DPT students, anatomical atlases, a variety of prosected joints, and the course textbooks.

The distinctive feature of the weekly near-peer teaching review session was a packet assembled by one of the peer teachers. The packet's uniqueness stemmed from a variety of learning resources including prominent anatomical relationships gathered from class notes, textbook descriptions, or a tutor's own successful study strategies developed when he/she was a Year 1 student. Approximately 80 % of the study questions required a three- to five-sentence explanation, whereas 20 % asked the Year 1 student to fill in the blank, label a diagram, or identify a structure on a cadaveric specimen or skeleton. The primary task of preparing the learning packet was rotated on a weekly basis among the four near-peer teachers, yet it remained collaborative. The tutor responsible for preparing the learning packet would request critical comments from his/her peers about the most appropriate way to assemble the learning materials. A day or two prior to the weekly review session, the lead tutor would distribute a packet without answers to his/her classmates for their review and completion. Development of the learning packet required 2–3 h of the peer teacher's time and involved selecting appropriate resources, reading and reviewing chapters from course textbooks, perusing previous anatomy notes, preparing review questions and answers, and then photocopying the materials. Near-peer teachers selected "big concept" anatomical relationships they deemed foundational for understanding concepts covered in subsequent courses during the remainder of the DPT curriculum. Near-peer teachers did not lecture during the review sessions. Review sheets provided talking points for Year 1 student groups by stimulating critical thinking and discussion of anatomical topics. All four near-peer teachers circulated among student groups and provided individual attention to students or groups by answering questions or reviewing key concepts.

One of the most popular near-peer teaching sessions occurred when Year 2 tutors designed a simulated anatomy laboratory practical for Year 1 students identical to the format used for the actual graded practical. A class of 30 Year 1 students sequentially rotated among 30 separate stations with structures identified on human cadaveric specimens by paper merchandise tags or bones with chalk markings, respectively. Year 1 students were permitted 90 s per station to identify tagged structures and record the answers on a piece of paper before a timer sounded and the class advanced to the next station. At the completion of the exam, an answer key was available so Year 1 students could check their answers. By setting up a simulated laboratory practical, Year 2 near-peer teachers prepared their Year 1 counterparts for a challenging test experience and simultaneously reduced Year 1 students' test anxiety.

Year 1 students perceived the peer teaching review sessions were well organized and informative. Year 2 near-peer tutors successfully reinforced anatomical concepts presented previously by the anatomy course faculty, because peer tutors designed the review packets according to weekly themes printed in the anatomy course syllabus. Year 1 students commented that Year 2 tutors introduced mnemonic devices that facilitated retrieval of functional anatomical relationships. Another strategy used by Year 2 near-peer tutors involved a variety of visual aids. Using a whiteboard and colored markers, Year 2 tutors would request Year 1 students to diagram the pathway of common peripheral nerves from their respective origin in the brachial or lumbosacral plexus to their terminal attachments in the extremity. Year 1 students would be asked to list specific muscles and cutaneous regions supplied by each nerve. On another occasion, Year 2 tutors would distribute rubber gloves to Year 1 students. Using colored markers, Year 1 students would practice drawing the cutaneous distribution of the median, ulnar, and radial nerve on the palmar and dorsal surface of their gloved hand. This exercise was helpful because the Year 1 students could better visualize the two-dimensional overlap of the cutaneous innervation to the hand.

Communication and teaching skills acquired during the anatomy near-peer teaching experience by Year 2 tutors enhanced the student physical therapist's professional interaction with patients. The four Year 2 students recognized the weekly peer review sessions provided valuable opportunities to engage Year 1 students. Year 2 students used words such as "awesome," "empowering," "beneficial," and "two-way learning experience" to describe the benefits of near-peer teaching. The professional growth the peer teachers perceived from this semester-long near-peer teaching experience could be partially attributed to their improved ability to communicate with the Year 1 students. Additionally, all near-peer tutors acknowledged that peer teaching experiences provided an opportunity to (1) accrue teaching experience, (2) deepen their understanding of gross anatomy, (3) assemble meaningful learning materials, and (4) strengthen time management skills. Furthermore, near-peer teaching is believed to ease the demands of modern curricula by using smaller groups despite the existence of low faculty-to-student ratios [11].

The Use of "Clickers"

An audience response system (ARS) or "clicker" has become popular among educators in medicine and the health professions because of the system's ability to engage listeners during a presentation [12–16]. The educator can periodically display a question using a multiple-choice or true–false answer format, and each member of the audience can respond anonymously using an ARS keypad. ARS keypad technology has been used with positive feedback among medical students, medical residents, and physicians during continuing medical education programs, nurses, and physical therapy students. Proponents of the ARS contend that the technology (1) enhances student attention and learning during a lecture; (2) motivates reluctant students to interact since responses are anonymous; and (3) permits the presenter to rapidly assess the audience's knowledge, attitudes, or opinions [17]. According to the literature, the primary setting for the use of the interactive ARS system has been a classroom during a didactic presentation. Recently, we reported the usefulness of "clickers" during weekly planned non-lecture interactive near-peer teaching sessions during a semester course in gross anatomy for physical therapists [18].

The unique feature of each peer teaching/tutoring session was a nongraded 12–15 question quiz strategically placed at the beginning of the review session and taken by those Year 1 students in attendance. Six Year 2 physical therapy students served as peer teachers/tutors. These students constructed the quiz using ARS technology and instructional objectives located in the course syllabus. Questions were factual in nature and focused upon key anatomical relationships covered during the most recent lecture and laboratory sessions. One peer tutor was responsible for formatting the questions using the TurningPoint software (Turning Technologies, Youngstown, OH). During the 30-min ARS quiz, each peer teacher individually provided clarification and further instruction for his/her authored questions when indicated by the response results or prompted by questions from Year 1 DPT students.

Utilizations of Audience Response System

- Help students to review anatomical facts.
- Create interactive experience.
- Provide nongraded quizzes as formative feedback.
- Provide feedback to teachers on students' comprehension of important anatomical concepts.

Inserting the ARS quiz at the onset of a 90-min peer teaching session provided a student with immediate formative feedback regarding his/her mastery of key anatomical relationships emphasized during the most recent classroom lectures and laboratory sessions. These self-assessment features permitted each student to measure his/her preparedness for an examination and compare his/her performance to that of classmates. The majority of Year 1 DPT students perceived the anatomy peer teaching sessions to be appealing because the ARS quiz made effective use of their time and promoted verbal interaction between themselves and Year 2 peer teachers. Peer teachers recognized that an ARS quiz provided an opportunity to (1) estimate Year 1 students' level of understanding of anatomical concepts, (2) gain confidence in personal preparation for subsequent peer teaching sessions, and (3) acquire indispensable teaching skills for subsequent use in the physical therapy clinical setting.

Clinical Skills in the Human Anatomy Laboratory

Performing specific clinical examination skills in gross anatomy can reinforce anatomical concepts. Learning of anatomy is a process of initial exposure to material followed by deeper understanding as a result of application [19]. Performing clinical tests learned in patient skills classes on human cadavers can challenge students to consider the association of anatomy with the specific tests with learning activities designed to guide students. To illustrate the process, a clinical test is presented to the entire class. The mechanics of the test along with findings representing a positive or negative test are discussed. Next, laboratory activities are discussed. Students then break into small groups to conduct the specific activities related to presented clinical tests. As a specific example, varus and valgus stress tests and the anterior drawer and Lachman's test are demonstrated to the class and discussed. Students then break into smaller groups at their assigned cadaver. Given that the anterior cruciate ligament serves as a primary restraint to anterior translation of the tibia on the femur and as a secondary restraint to a valgus stress at the knee, structures can be sectioned in a sequential manner to demonstrate this function. After review of the regional anatomy, students identify ligaments of the knee. Valgus stress testing in 0° and 30° and the anterior drawer and Lachman's test are performed to demonstrate how the ligamentous structures are positioned to maintain stability of the knee with performance of the clinical tests. Next, the medial collateral ligament is sectioned. The same tests are performed, and the student is able to see that in extension, there is minimal increased medial opening with a valgus-producing force but at 30° there is marked opening. This illustrates the role of the anterior cruciate ligament as a secondary restraint to medial laxity. Lastly, the anterior cruciate ligament can be sectioned, and now medial opening with a valgus stress test occurs at both 0° and 30°, and both anterior drawer and Lachman's tests are positive.

Performance of the clinical tests requires the student to review the pertinent anatomy, expose the anatomy through detailed dissection, and finally section ligamentous structures involved in the specific clinical test. In clinical skills classes, students typically perform tests on each other. This experience provides an excellent opportunity to experience a "normal" test; however, students have limited opportunities to experience pathology. While performing tests on cadavers is not the same as a patient in the clinical setting, students are able to get an appreciation of anatomic deficiencies which contribute to a positive test. In addition to the knee, this activity works well for ligament tests at the shoulder, elbow, thumb and fingers, and the ankle.

Painting/Drawing

Body painting is an activity used to facilitate understanding of anatomical concepts. Painting may be done on the skin or on clothing. Students tend to see body painting as an enjoyable and useful activity [20, 21]. Body painting for more sensitive regions of the body may be uncomfortable for some. We have used a combination of body painting and simple board drawings to reinforce anatomical relationships. The hand is an anatomic region that is challenging for some. We have utilized body painting on disposable gloves for learning purposes. Activities we have used include drawing the relationship of the extensor tendons coursing through the tunnels on the dorsum of the wrist and drawing the carpal bones, the vascular supply to the hand, nerve distribution in the hand, the intrinsic muscles of the hand, and the extensor mechanism. Each student can draw on their own "hand" or a partner's while the instructor presents the anatomy of the hand and provides guidance in the drawing activity. One advantage of using gloves is the ability to "erase" marking by simply applying a new glove.

Areas such as the face, chest, and proximal thigh are more sensitive regions which may make students uncomfortable during body painting. Other regions may be difficult to draw on the skin. For these regions, we opt to use a whiteboard or drawing paper. Examples of these drawing activities include the femoral triangle with the associated boundaries and contents, drawing the entire vascular supply to the lower extremity starting at the external iliac artery, drawing the anterior and medial thigh musculature, and drawing the compartments of the leg and their respective contents. These activities challenge the student to consider anatomy in terms of how structures relate to each other as they create their drawings.

Body painting may also be used to demonstrate the relationship of anatomy with orthopedic clinical tests and as a competency check for palpation skills as these skills are presented in the classroom setting. As an example, students can draw the lateral ligaments of the ankle on a partner's skin. Instructors can readily check if the placement of the markings is correct to confirm that a student's palpation is correct. With the accurate placement of the markings, the student is able to visualize the rationale behind specific technique tests such as the anterior drawer to test the anterior talofibular ligament and the inversion stress test to test the calcaneofibular ligament.

Interprofessional Education

Interprofessional education (IPE) in anatomy is joint learning between students in different health professions. IPE proposes to indoctrinate or engage students in collaborative learning in order to prepare them for collaborative practice [22]. Since collaborative practice is an essential component of health-care reform, incorporation into entry-level education makes sense. Gross anatomy is particularly favorable for joint and reciprocal learning between medical and physical therapy students as both are required to take similar hours of coursework for their entry-level degrees. Medical and physical therapy students in general may apply anatomical knowledge differently in their practice settings with general medical practitioners more focused on vital organs and therapists focused on the various systems contributing to movement. As both practitioners must ultimately have knowledge of all systems, the education setting provides a prime opportunity to share expertise on complimentary areas and to learn from other professionals in a mutually respectful manner. For example, physical therapists are required to practice with an extensive knowledge of the musculoskeletal and peripheral nervous system anatomy, while physicians are to be more familiar with the inner workings of the intestinal organs. Therefore, students will have stronger emphasis placed on each of their respective areas. Peer learning allows each group of students to not only learn opposing areas of expertise but to develop confidence in teaching in their area of expertise. We have discovered that this fosters mutual respect and knowledge of the other's repertoire of anatomical knowledge and passion. Most students acknowledge that IPE will help them to work interprofessionally in their careers. A major benefit of IPE in anatomy may be cost-effectiveness as space, faulty, and resources may be shared [23]. However, we recommend that adequate space, similar timing of schedules, and a shared enthusiasm between faculties should be present to ensure success.

IPE begins with interdisciplinary faculty planning. Faculty teamwork is essential, not only in terms of modeling teamwork for students but also to foster successful experiences. Early tasks include identifying strengths and weaknesses of individual programs, considering faculty, space, and laboratory resources. Clear identification of overlapping and unique knowledge within individual disciplines reveals opportunities for new objectives that may be achieved through joint interaction. Planning, assessment, and objectives together help to shape and organize the desired learning environment and experience. An introduction and orientation of interdisciplinary students through an informal social event may be used to encourage cross interaction and collegiality between students [22]. We recommend collecting student feedback through post-course surveys to elicit student reflection and attitudes on their experience. Post-course surveys additionally assist faculty in planning future experiences.

There are several practical ways in which to employ IPE in a gross anatomy course. One way, if space and curricula allow, is to simply have both groups of students enroll in the same lecture and laboratory course. However, this is often difficult to coordinate so other approaches can be taken. An excellent and flexible approach is to provide students with side-by-side peer learning opportunities in which students concurrently dissect selected body regions. Alternatively, one student group can prosect a body area and then provide an introductory tutorial to the other group before their dissection. For example, physical therapy students who have dissected the complex anatomy of the hand can demonstrate this to the medical students who may cover this area very quickly in didactic fashion. In return, the medical students can prosect the digestive organs and teach this area of anatomy to the physical therapy students.

Opportunity for IPE also exists through the use of licensed professionals from differing disciplines. With physical therapy students, we have been fortunate to provide interaction with pathologists and surgeons who can bring not only expertise to the anatomy lab but a unique professional perspective. For example, pathologists are able to provide opportunistic insight into the abnormal structures of a pathological kidney which otherwise may be unappreciated by the student. Upon learning of the pathology on their cadaver, students are able to discuss with the pathologist clinical features of the pathology. Therefore, students will not only gain understanding of the clinical diagnosis but acquire insight into how pathologists assist in making the diagnosis. A second medical practitioner, a surgeon, may relate their approach to repairing a hernia through the inguinal canal or performing a total knee arthroplasty. The student is energized by anticipating a condition that he or she may later treat in the clinic. If questions arise in the rehabilitation of the patient, the new therapy professional may feel more comfortable discussing possible issues knowing generally how the repair was performed. Likewise, the seasoned surgeon is able to see the enthusiasm of the future therapy students for rehabilitating the surgical repair and at the same time caution the students on their concerns for the postsurgical patient.

Implementing Interprofessional Education

- Identify strengths and weaknesses of individual programs.
- Identify opportunities for shared learning.
- Derive learning objectives.
- Organize experience to meet objectives.
- Orientate students to interdisciplinary teams or experience.
- Collect student feedback.

Conclusions

Teaching anatomy to physical therapy students involves a variety of teaching pedagogies whereby students teach anatomical concepts and relationships to classmates and students from other health professions using readily available resources. Practical teaching sessions incorporated information previously provided within a formal lecture format. During the semester course in gross anatomy, physical therapy students perceived the teaching opportunities valuable because they fostered communication skills with future patients and professional colleagues.

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Part IX

Educational Research

Research Methods in Anatomy Education

41

Zubair Amin and Hamza Mohammad Abdulghani

Context of Research in Anatomy Education

The traditional view of scholarship with an inclination towards pure biomedical research and scientific publications in peer reviewed journals has been challenged by many [1, 2]. A widely acclaimed expanded view of scholarship includes, in addition to scholarship of discovery or scientific research in common sense, scholarship of integration, scholarship of application, and scholarship of teaching [1]. Major universities now promote educational scholarship through a variety of means including teaching innovation funds, teaching awards, and creation of a separate career track for educators [2].

Anatomy educators form distinct groups with different yet somewhat overlapping needs and orientation to research. In a typical academic anatomy department affiliated with a university or a medical school, there are biomedical researchers with a secondary interest in educational research and anatomy educators with a primary focus in educational research. It is important to recognize that the needs, intensity, and expectations of educational research from these two groups are different and are higher for the anatomy educators.

An anatomy educator needs to prove his/her worth in scholarship through substantial educational research and might be expected to develop a planned, programmatic educational research on a long-term, sustainable basis. He/she might start with manageable, locally relevant studies and progress to more rigorous research methodologies that would allow generalization of study findings beyond his/her institute. In other words, the findings and conclusions from the research should generate interest from academics outside the researcher's own institute. The applicability of findings and conclusions therefore must be able to stand rigorous scrutiny.

We propose that action research and needs-driven developmental research is an attractive starting point for the vast majority of anatomy educators who are about to embark on educational scholarship. Educational action research is highly relevant to the local context and easily accessible to beginners as well as advanced researchers. We would argue that this should form an essential element of one's research scholarship repertoire. Therefore, the major focus in this chapter would be on educational action research with specific reference to the broad discipline of anatomy.

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The primary purpose of educational action research is to "systematically investigate one's own teaching/learning facilitation practice, with the dual aim of improving that practice and contributing to theoretical knowledge in order to benefit student learning" [3]. Institutions and disciplines always value systematic analysis and review of teaching and learning to further improve educational practices and to inform others of such improvements. Such research provides academics an opportunity to engage in deeper pedagogical exploration to understand the process of learning and teaching.

Therefore, it is useful for researchers in this field to start with an introspection and critical reflection to identify our own and institutional needs, relationship with other peers, and possible utility and applicability of the attempted research. How we relate to a larger ecosystem, be it an institution or the subject domain, is important to determine how our research can contribute to the knowledge in anatomy education. A systematic investigation might provide results beneficial to an individual (e.g., Why are my students not attending anatomy dissections?), to the department or discipline (e.g., Does integration of anatomy with other subjects dilute students' core knowledge in clinical anatomy?), or to a larger organizational issue (e.g., Can the impact from shortage of anatomy educators be minimized through employment of students trained as teachers?). It is imperative that we, as budding researchers, define the target audience or stakeholders of the action research. Early determination of the target would allow us to channel the message appropriately and to bring organizational changes necessary for long-term improvement.

Possible Targets of Educational Action Research

- Student: an individual or a class
- Teacher: an individual or peers
- Curriculum: module or global, instructional and assessment methods, impact, and quality assurance issues
- Organization: departments, institutions, or professional bodies

Methodological Considerations in Educational Research

Educational research might include qualitative methods, semiqualitative methods, quantitative methods, or a combination of them. Qualitative methods include interviews, focus group discussion, narratives, observation, nominal group technique, and others. Although in pure biomedical science literature, qualitative research is relatively uncommon, for many research questions in education, qualitative research methodologies are the only feasible way to conduct research. For logistic, pedagogical, and ethical reasons, it may not be possible to conduct quasi-experimental and experimental research whereby students are exposed to a possibly inferior educational intervention.

Quantitative methods are more familiar to biomedical researchers working with natural sciences. Quantitative research methods typically include experimental or quasi-experimental design with narrower research questions, stricter control of variables, standardized interventions, and numeric data as outcomes. Methodological choice would depend upon the nature of the questions to be answered in the research, feasibility of the study, ethical and legal considerations, and familiarity of the researcher with a particular method. It is imperative to note that qualitative and quantitative research methods are not exclusionary; both research methods can be used together in parallel or in sequence to ask similar questions.

Sampling is an important issue in a qualitative as well as quantitative research. In a qualitative research, the emphasis is not on the number of the participants who will be included in the study, but on the appropriateness of the sample to be included in the study. As the sample size in qualitative study is relatively small, the effect of having a biased group of participants in the sample is likely to be more magnified in qualitative research methods. Thus, exclusion and inclusion criteria of the participants need to be clearly defined. The validity and applicability of data generated from the qualitative research are very much dependent on the careful selection of the participants. See Table 41.1 for relative comparison between qualitative and quantitative methods.

Table 41.1 Differences between qualitative and quantitative methods

	Qualitative methods	Quantitative methods
Question	Exploratory	Confirmatory
Scope	Wide	Narrow
Hypothesis	Ill-defined	Well-defined
Setting	Naturalistic	Experimental
Variables	Uncontrolled	Manipulated
Sample size	Small	Large
Data	Texts	Numeric
Conclusion	Investigate causality	Suggest causality

From Exploration to Confirmation

Educational research can be diverse; the classification and categorization depend on the nature of the research, context of research, and target participants. It is natural that in some situations more than one classification can be employed.

A useful approach to understand the nature of educational research might be based on the types of research questions that the researchers aim to address: whether the question is exploratory or confirmatory in nature. An exploratory research is often an appropriate starting point when the phenomenology under investigation is poorly understood or there is no strong theoretical underpinning. In the absence of such grounding, exploratory research deals with uncontrolled variables; there are no fixed educational interventions that can be employed in the research. As an extension, there could not be a hypothesis. Therefore, exploratory research is useful for emerging phenomena where a suitable educational intervention does not exist.

Let us consider an example from the literature. Pandey and Zimitat reported a research exploring medical students' approach to learning anatomy [4]. Students' own description of successful approaches to learning was correlated with their own approach to learning and quality of learning. This was a single institution-based study. They used multiple tools and data sources including study process questionnaire, structure of observed learning outcomes, and grades. They found that students' learning of anatomy involves various combinations of memorization, understanding, and visualization. This study could not have a strong theoretical model at the inception as there were little published data regarding students' approach to learning anatomy. Their research opens up the further possibility of confirmatory research from other institutes with similar situations.

Confirmatory research, on the other hand, aims to further validate an already known intervention. Researchers are already aware of potential educational interventions, the controlled and uncontrolled variables, and a possible hypothesis. The idea of confirmatory research often originates from exploratory studies or studies with limited number of participants or studies that originate in one or few institutes. Therefore, there is a need to field test the hypothesis with larger cohort of research participants with more diverse background.

Qualitative Research Methodologies

- Action research
- Historical method/narrative research
- Ethnography
- Phenomenology
- Discourse analysis
- Grounded theory

Qualitative Research Data Collection Methods

- Nominal group
- Interviews
- Focus groups
- Case studies
- Text analysis
- Observation

Examples of Qualitative Research Questions

- How can teachers emphasize the importance of anatomy to their students?
- How do new medical students perceive cadaveric dissection?
- What do students think about the benefits of learning anatomy for future practice?
- How do students learn anatomy in a small group with problem-based learning scenarios?
- How does linguistic ability of the students influence learning anatomy?
- How do students react to difficult anatomical terminology?

Let's consider an example of confirmatory research from the anatomy education. Nnodim explored the superiority of prosection over more conventional cadaveric dissection with first-year preclinical students [5]. The control group dissected the cadaver and learned anatomy in a conventional manner, whereas the experimental group was excluded from dissection. The experimental group worked with prosected specimens using other innovative learning methods. The outcome measures include knowledge and practical tests and an opinion survey. The researcher also tracked the time spent on the learning. The researcher found that the experimental group, despite spending less time in learning anatomy, had better outcomes as measured by knowledge and practical tests. The hypothesis was expected from similar prior studies and confirmed again in this study.

To further illustrate the nature of exploratory and confirmatory research and how they can be applied in anatomy education, we have included two scenarios. In the first, SMA, a young educator, was confronted with the problem of students' unwillingness to access e-learning materials. In the second, BZA, an established educator, wanted to demonstrate superiority or at least equivalence of e-learning over conventional teaching and learning.

Example 1: SMA recently joined the anatomy department of a renowned university. Soon after joining the department, she was introduced to the vast body of e-learning materials in anatomy that are available freely in the web. Despite being in an institute with off and on campus Internet connectivity and a high laptop and smartphone usage, SMA was intrigued by the fact that students tend to favor printed books over e-learning materials. As she started to ponder the issue, she decided to engage in informal discussions with colleagues and students. Soon she realized that students have very different reasons not to prefer e-learning materials over printed books. She joined hands with an educator to explore the phenomenon in greater detail. Together, they decided to employ focus group discussion with an invited group of students and teachers to understand the barriers, enablers, and potential motivators for e-learning materials usages in her institute.

In SMA's situation, the primary driver for research is exploratory in nature. The phenomenon in question is ill-defined; the variables and their relationship are poorly understood. There is no fixed hypothesis. Moreover, although there are similar studies in existing literature from other countries and institutes, she was reasonably hesitant to extrapolate the findings to her own situation as she recognizes from her discussions with students and teachers that there are certain unique cultural and sociological norms that cannot be ignored. For example, students' prior experience, validation from the teachers, relationship to the curriculum, and suitability of e-learning materials to the assessment are among some of the factors that determine students' usage of web-based e-learning.

Example 2: BZA has developed an e-learning module on locomotion with her colleagues. The newly developed module has self-study materials in the form of texts, audiovisuals, and self-assessment questions. The module adheres to the existing curriculum in terms of content coverage, sequence, and end-of-module assessment. She is interested to find out whether this e-learning module is better than the conventional classroom-based learning experience of the students. Her background literature search revealed many similar studies with variable results. She decides to conduct a confirmatory study with two experimental cohorts. There are several possible outcomes that can be measured to prove the worthiness of an e-learning module over the existing curriculum. Potential outcome measures might include:

(a) Usage rate of e-learning module over traditionally delivered module
(b) User satisfaction data comparing e-learning module and traditionally delivered module
(c) Result of end-of-module assessment between the two groups
(d) Extracted result on locomotion system from standardized national or international exam
(e) Performance of students on OSCE stations on locomotion during orthopedics posting

BZA decides to use a composite of several outcome measures as she is interested not only to know how students like her module but also how they perform in standardized examinations.

BZA's experimental design also calls for controlling of several variables such as comparability of prior academic performance between e-learning group and conventional module group. Can you identify other variables? How can you control these variables?

Ethical Considerations

Educational research, whether it is qualitative and quantitative, typically involves human subjects. As such, ethical consideration and approval from competent authority prior to the start of data collection is mandatory. An institutional review board may determine that a particular educational research proposal does not warrant a thorough review and may expedite the review process. However, that is a judgment of the institutional review board that the educational researcher must respect.

There are other ethical considerations to take note of. For example, student-related data such as test results, psychological profile, and socioeconomic data are highly sensitive in nature, and confidentiality must be maintained throughout. Students may feel compelled to participate in a study especially if the study is conducted by a faculty member of the same university. Direct observation and interview may open up many sensitive topics that should not be made public without prior consent. Finally, reputable medical educational journals now require ethical considerations and approval, if needed, prior to publication.

Descriptive, Correlational, and Causal Questions

Descriptive Questions

Descriptive questions are important in educational planning, resources identification, and allocation. For example, descriptive questions might compare the status of education in an individual institute or a selected group to a normative reference group or an international benchmark. Methods that are employed to answer descriptive questions might include semi-structured or structured interviews, internally or externally developed questionnaires, and attitudinal scales such as Likert's.

Examples of descriptive questions in anatomy education can include:

- How has the allocation of teaching hours in anatomy education evolved since the introduction of problem-based learning (PBL) curriculum in various medical schools? How does the allocation of teaching hours in anatomy vary between PBL and traditional medical schools? Do PBL-based medical schools employ more clinicians to teach anatomy as compared to non-PBL medical schools? Do the clinicians teaching in the anatomy course teach pure morphological anatomy or applied anatomy?
- How many medical schools in a given country routinely use cadavers and cadaveric dissection to teach anatomy? Is there a difference between

private medical schools and public (governmental) in terms of their intensity of usages of cadavers in anatomy education? In case of a shortage of cadavers, how do the medical schools substitute cadaver-based dissections?
- What is the role of anatomy education in an integrated curriculum? How has anatomy education responded to curricular integration? What are some of the new roles adopted by the anatomy departments in anatomy education? How does the faculty perceive attempted curriculum integration? What motivates anatomy teachers towards greater curricular integration?

Correlational Questions

Correlational questions often try to establish correlation between two variables. The correlation could be either positive, negative, or zero. While conducting a correlational research, as a researcher, we might be interested to ask first:

1. Is this correlation expected?
2. Can this be explained by our contemporary understanding of education?
3. Are there any unexpected findings? If so, what are possible sources of biases?

Correlational questions can be answered by qualitative methods (e.g., naturalistic observation where researchers collect data unobtrusively without interfering or controlling variables), semiquantitative methods (e.g., survey instruments), or quantitative methods (e.g., examination performance on a standardized test).

We have to be careful in determining causation from correlation. A correlation or an association merely suggests that two variables are related; it does not prove that one variable resulted in change in the other. For example, an association can be found between students' performance in medical schools and the presence of a well-equipped anatomy museum. One can reasonably argue that although an association exists between the two variables, it might have resulted from other confounding factors. For example, medical schools with well-equipped anatomy museums are more likely to have a favorable student–teacher ratio, better dissection room, and students from higher socioeconomic background. Unless these, and other confounders, are addressed, the proposed causation could be merely speculative and often counterproductive.

Examples of correlational questions in anatomy education can include:

- Do students in PBL-based curriculum tend to have poorer knowledge in clinical anatomy compared to those in traditional curriculum?
- Does student satisfaction in medical education correlate with the availability and intensity of cadaveric dissection during anatomy teaching? Does student performance in relevant practical examinations improve with increased exposure to cadavers?
- Do the medical schools which employ clinicians to teach anatomy have students who are better in clinical anatomy? Is there a positive correlation between the number of integrated lectures and student performance in integrated examination?

Causal Questions

Causal research questions often try to establish cause-and-effect relationship in educational interventions. We can employ a variety of tools such as surveys, standardized assessments, and observations to evaluate outcomes of intervention. In causal design, researchers are interested to find out comparative efficiency of an intervention over another. Sometimes, the interest might be in finding out the efficiency of an intervention over no intervention.

It is important to recognize that educational outcomes rarely result from a single intervention. Educational outcomes are often dependent on multiple factors which might or might not originate in school or formal classroom settings. For example, we are interested to find out whether introduction of an innovative learning strategy, such as a web-based self-learning module, resulted in better knowledge acquisition as compared to naturalistic state. We can randomize the class into an intervention or a no-intervention group. However, it is very likely that any short-coming of web-based learning would be compensated by the students through more rigorous learning utilizing other resources. There will be frequent and inevitable contamination between the two groups as well.

Examples of causal questions in anatomy education can include:

- Does student knowledge in clinical anatomy improve with the introduction of case-based discussion as compared to no case-based discussion? The hypothesis is that introduction of case-based discussion would result in better knowledge in clinical anatomy.
- Is student satisfaction in classroom teaching, as measured by a standardized questionnaire, similar between professional anatomy teachers and trained student-teachers? The hypothesis is that the trained student-teachers deliver equally satisfying teaching to the students as compared to professional teachers.
- Does an anatomy teaching module designed around prosected specimens result in equivalent test scores in standardized assessment as compared to the cadaveric dissection-based module? The hypothesis is that the two modules lead to similar results and thereby the prosection-based module can be an alternative to the dissection-based module.

To Do

- Think of your local context; talk to the colleagues and students.
- Identify issues that need further exploration.
- Perform an extensive literature search and gather evidence related to the issues under investigation.
- Develop relevant questions and classify them according to the above-mentioned schema.
- Choose the most appropriate method for the questions.
- Consider the logistics and other requirements and refine the questions and method, if needed.

Conclusions

The changing landscape of anatomy education provides us with an exciting opportunity to engage in meaningful and impactful scholarly research. For the vast majority of anatomy educators, need-driven action research is a pragmatic and logical stepping stone. Contextual variables and uniqueness are important considerations to explore before devising most pertinent research questions for the stakeholders. The nature of research questions is the most important factor to determine the choice of research methodology.

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42 Scholarship of Teaching and Learning in Anatomy

Valerie Dean O'Loughlin

Ernest Boyer's 1990 publication, *Scholarship Reconsidered*: *Priorities of the Professoriate* [1], was among the first to state that academic scholarship should be defined more broadly than just the traditional research contributions. He listed four separate, yet overlapping, criteria or functions of the professoriate:

- The scholarship of discovery (i.e., what is traditionally defined as "research")
- The scholarship of integration (whereby connections are made across disciplines and how research and subject matter fit into a larger picture) (Note: some consider this criterion to be an extension of the scholarship of discovery)
- The scholarship of application (which includes service to the discipline and applying the knowledge gained to real-life problems)
- The scholarship of teaching (whereby excellent teachers utilize effective pedagogical techniques to assist their students in becoming critical, lifelong learners)

Boyer emphasized that all four criteria (and not just the single "discovery" criterion) should be used when evaluating the academic.

Boyer noted that the scholarship of teaching also should refer to the review and assessment of teaching and the public dissemination of those findings. And in fact, in order for educational research to be viewed equal to more traditional scientific research, Boyer [1] stated that educational research must be presented publicly and/or published in peer-reviewed journals.

Since Boyer's original work, many academics have tried to further define the scholarship of teaching and develop models for its assessment. Glassick et al. [2] refined the description of exemplar scholarship of teaching works to include the following characteristics: clear goals, appropriate and rigorous methods, clear results, and reflective critique. Lee Shulman, former president of the Carnegie Foundation for the Advancement of Teaching, referred to "teaching as community property" [3] and has used this phrase to encourage educators to present their educational research findings both within and across disciplines. Trigwell et al. [4] surveyed 20 academics at a variety of Australian universities and through these responses developed a model to describe scholarship of teaching. This model states that individuals engaging in the scholarship of teaching are well informed by the general and discipline-specific literature on teaching, assess their own teaching, reflect on their teaching from the view of the student, and communicate their findings to their peers. Recently, the phrase "scholarship of teaching" has been expanded to "scholarship of teaching and learning (SoTL)" [5, 6] to include assessment and understanding of student learning.

Thus, an anatomy educator is not considered a scholar of teaching and learning unless she/he

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assesses the educational process and makes these findings public in the form of a presentation or a publication [5–9]. The previous chapter in this text and other publications [10, 11] provide extensive information about how an anatomy teaching question may be developed into an educational research project. In this chapter, I provide information about local, national, and international research opportunities in anatomy educational research. I describe and compare professional societies active in anatomy education. The chapter ends with a list of journals known to publish anatomy education research manuscripts and guidelines for developing a suitable manuscript for review.

Local Educational Research Opportunities

Academics are familiar with the research methods for their specific discipline, but may be less comfortable with developing an educational research project. If your institution has a Faculty Development center or a Center for Teaching and Learning, contact them and ask them for advice as to how to proceed with your project. The faculty and staff affiliated with these centers are trained to help faculty assess their teaching and may be valuable collaborators. In addition, these centers may offer workshops on assessing teaching or even host scholarship of teaching talks. For example, Indiana University's Center for Innovative Teaching and Learning (CITL) has multiple instructional consultants on staff to assist with assessing student learning and developing an educational research project [12]. In addition, CITL oversees the university's scholarship of teaching and learning (SoTL) program [13], which brings in national SoTL speakers and offers faculty grants for educational research projects. The SoTL program also has invited local faculty members to present their educational research findings. A Center for Teaching and Learning may present you with previously unknown resources on your campus and help introduce you to individuals from other disciplines that may help you with your educational research [11].

A well-developed educational research project often requires the collaboration with individuals from other disciplines [14, 15]. If your institution has a School of Education, consider contacting some of the faculty there for advice regarding your project. The education faculty also may have graduate students who are looking for research projects on which to collaborate, and so you may find an enthusiastic coauthor. They may introduce you to qualitative research methods of which you may have been previously unaware. Your school's librarian may assist you with refining your background literature search [10] for your project. The math or statistics department may have faculty or graduate students willing to help you analyze your quantitative data.

To Do

- Contact your institution's Teaching and Learning Center (or Faculty Development center) and meet with a consultant to discuss your project.
- Determine if there are departments and faculty at your institution with whom you could collaborate, such as the Math Department or the School of Education.
- Work with a librarian at your institution to help run a thorough and efficient literature search related to your educational research project.

Once you have completed your anatomy educational research project, consider presenting your findings to your department. Perhaps your department has a weekly colloquium; this would be an ideal first arena to present your findings. If your institution has teaching workshops and teaching presentations (ask your Teaching and Learning Center—they will know!), consider presenting in this forum as well. Educators from other disciplines will be interested in your work and will want to apply your findings to their own classrooms.

National and International Educational Research Opportunities

There are a variety of professional societies, and independent conferences support the dissemination of educational research. In this section, I subdivide these opportunities into societies active specifically in anatomy educational research and societies/conferences involved with the scholarship of teaching and learning in general.

Societies Active in Anatomy Educational Research

Within the past 15 years, a variety of new professional organizations have come into existence whose missions involve anatomy teaching and anatomy educational research. In addition, several anatomy societies with a much more extended history have recently expanded their foci to include anatomy education. Below is a list and descriptions of the main national and international societies that are heavily involved in anatomy education research. (Please note that this list is not all inclusive and does not mention those anatomy societies that are active primarily in traditional scientific research rather than educational research.)

American Association of Anatomists (AAA) (http://www.anatomy.org)

AAA celebrated its 125th anniversary in 2013, and it continues to be a vibrant organization for both traditional scientific research and anatomy education. Its international membership consists of faculty from medical and professional schools as well as undergraduate institutions. AAA is one of the participating societies in the multidisciplinary Experimental Biology (EB) meeting, typically held every April. The AAA meetings have both scientific research and education tracks. Its anatomy education articles formerly were published in the *Anatomical Record, Part B: The New Anatomist*. More recently, AAA's education journal is *Anatomical Sciences Education*, which is published in cooperation with the American Association of Clinical Anatomists and the Human Anatomy and Physiology Society. The journal's aim is to publish teaching innovations, review articles, viewpoints, and research in the anatomies [16].

American Association of Clinical Anatomists (AACA) (http://www.clinical-anatomy.org)

AACA encourages excellence in the teaching of anatomy and in developing research in clinical anatomy. Its first annual meeting was in 1984 and the society typically meets yearly in June or July. Its official journal, *Clinical Anatomy*, publishes ten times yearly and publishes articles for both clinicians and medical educators. (This journal is also the official journal of the British Association of Clinical Anatomists, the Anatomical Society of Southern Africa, and the Australian and New Zealand Association of Clinical Anatomists.)

Anatomical Society (AS) (http://www.anatsoc.org.uk)

The AS was founded in 1887 but more recently promotes the study of both traditional (bench) research and anatomy educational research. Many of its members are from the United Kingdom and are involved in teaching and/or research in higher education. They host numerous symposia and an annual meeting in the UK, usually in July.

Australian and New Zealand Association of Clinical Anatomists (ANZACA) (http://anzaca.otago.ac.nz)

ANZACA promotes the science, teaching and scholarship of clinical anatomy in southeast Asia. Their annual meeting is held in late November or early December in Australia and New Zealand. Their 2013 conference theme explores technology-enhanced anatomy learning and research. Their journal is *Clinical Anatomy* (described previously with AACA).

British Association of Clinical Anatomists (BACA) (http://www.liv.ac.uk/HumanAnatomy/phd/baca)

BACA's mission is to advance the study and research of clinical anatomy. Founded in 1977,

Which Professional Societies Are the Best Fit for You?

- Visit the organization's website and read its mission: Does it have educators that are similar to you in terms of student populations? Can you see yourself interacting with members of this organization?
- Examine the society's journal (if they have one): Does this journal publish manuscripts that align with your specific anatomy education interests? Can you see yourself publishing in this journal?
- Find out when and where a society holds its annual meeting. Would you be able to regularly attend their meetings and be an active participant?

Keep in mind many anatomists involved in educational research are members of multiple societies, because no one society addresses all of their interests. In this case, what may limit you is simply the cost of multiple memberships and attending multiple meetings.

the organization hosts summer (July) and winter (December) meetings in the United Kingdom. Their journal is *Clinical Anatomy* (described previously with AACA).

Human Anatomy and Physiology Society (HAPS) (http://www.hapsweb.org)

HAPS' mission is to promote excellence in the teaching of human anatomy and physiology. Founded in 1989, its international membership consists of educators from 2- to 4-year colleges, universities, medical schools, and high schools. The majority of educators teach premedical and allied health (undergraduate) students. Their annual conference is held in late May in either the United States or Canada. HAPS also holds several regional conferences throughout the year in the United States. Their quarterly publication is *HAPS-Educator* and the most recent editions are available to members only.

International Association of Medical Sciences Educators (IAMSE) (http://www.iamse.org)

IAMSE originated in the late 1980s as part of a special interest group of the Association of American Medical Colleges. This special interest group developed into an independent society in 1997 and now boasts members from over 40 countries. IAMSE's vision is to ensure that medical education is grounded in science and to provide a multidisciplinary forum to discuss teaching innovations. Their meetings typically are held in mid-June to mid-July every year in either North American or international locales. The organization's journal is *Medical Science Educator*, and encourages publication about basic science education, clinical teaching, and implementation of educational technology.

Societies Active in Scholarship of Teaching and Learning and Educational Research in General

You should not limit the dissemination of your anatomy educational research to just the anatomical societies. There are several international societies that encourage interdisciplinary communication of educational research. In so doing, these organizations promote the scholarship of teaching and learning (or SoTL) by not only making the educational research findings public but also by encouraging discussion of these topics among disciplines [5, 6].

Association for Medical Education in Europe (AMEE) (http://www.amee.org)

Founded in 1972, AMEE's mission is to promote communication and collaboration among medical educators in Europe. Its membership consists of faculty, physicians, administrators, and students in healthcare professions from over 90 countries. Their annual meeting is held in late August or early September in a European city. Their official journal, titled *Medical Teacher*, is published monthly. It disseminates information about curricular development and assessment in medical education, teaching methods, as well as medical education research.

International Society for the Scholarship of Teaching and Learning (IS-SOTL) (http://www.issotl.org)

IS-SOTL was founded in 2004 in order to publicize and promote the discussion of scholarship of teaching and learning across national boundaries. The board of directors is composed of members from the United States, United Kingdom, Europe, Canada, and southeast Asia and Australia. Their journal, *Teaching and Learning Inquiry*, is published twice a year and disseminates educational research across an international forum. Their conference is held every October and alternates between a North American location and an Asian or European location.

Society for Teaching and Learning in Higher Education (STHLE) (http://www.stlhe.ca)

STHLE is centered within Canada, although membership is available to non-Canadians. The mission of this organization is to enhance teaching and learning in postsecondary education both within Canada and beyond. They support and promote educational research in a multitude of disciplines. STHLE has an annual conference every June in Canada.

In addition to these professional societies, there are several international educational conferences not associated with any one particular organization. For example, the Lilly International Conference in College Teaching [17] is held every November at Miami University in Oxford, Ohio. This interdisciplinary conference is attended by both faculty and faculty developers involved in the scholarship of teaching and learning. In addition, smaller versions of the Lilly Conference are held in different US locations throughout the year [18].

Asian Medical Education Association (AMEA) (http://www.med.hku.hk/amea/)

AMEA, founded in 2001, is an institution-based association of mainly Asian medical schools. Its mission is to strengthen and promote good pedagogy and research on medical education, through the sharing of information and experience. It organizes an AMEA Symposium once every 2 years (conference dates vary) in different cities in the Asia-Pacific region.

Other Conferences That Showcase Medical Education Research

In addition to the conferences associated with the societies mentioned in the previous sections, there are other conferences (not affiliated with a single society) that also showcase medical education research. These conferences offer additional opportunities to present your scholarship of teaching research.

American Association of Medical Colleges (AAMC); Research in Medical Education Conference (RIME) (https://www.aamc.org/members/gea/)

The RIME conference is held within the larger AAMC conference every fall in the United States. It is organized by the AAMC Group on Educational Affairs (GEA) and examines medical education and education research. (*Note: the GEA also offers several US regional conferences on medical education as well.*)

Asia Pacific Medical Education Conference (APMEC) (http://medicine.nus.edu.sg/meu/apmec10)

This international conference, founded in 2003, is hosted by the Yong Loo Lin School of Medicine at the National University of Singapore. The conference typically is held in January and is designed to provide an international perspective of medical education.

Frontiers in Medical and Health Sciences Education (http://www.imhse.hku.hk/)

The Frontiers Conference is organized and hosted annually by the Institute of Medical and Health Sciences Education at the Li Ka Shing Faculty of Medicine of The University of Hong Kong. This international conference typically is held every

December and has a theme each year, such as opportunities and challenges in e-learning.

Ottawa Conferences on the Assessment of Competence in Medicine and the Healthcare Professions (http://www.ottawaconference.org)

The Ottawa conference was first established in 1985 and brought presenters from around the world to discuss the assessment of competence in both clinical and nonclinical domains throughout medical education. Contrary to its name, this conference has been held biennially at various international locations since its inception.

Publishing Opportunities in Anatomy Educational Research

In addition to making educational research public via posters and presentations, consider publishing scholarly work so it may be disseminated to an even larger audience [1–5]. Chapter 41 of this text and other publications [8, 10, 11] provide guidelines for educational research methods and developing the final publication. Table 42.1 lists the main journals that have published anatomy educational research and scholarship of teaching manuscripts.

> **Advantages of Publishing Your Anatomy Educational Research**
>
> - You disseminate your findings to a wider audience than an oral presentation or poster would.
> - Your research becomes part of the permanent record for scholars.
> - Your publication is considered "scholarly work" for promotion and tenure.

Closely read the aims and scope of the journal (described on the journal's website) and scan through the past publications from several issues to determine if your manuscript is suitable for the journal in question. The decision of where to publish also will depend on the scope of your specific anatomy education project and the audience you wish to reach. Some journals are specific to medical education (e.g., *Medical Education*), while others such as *Anatomical Sciences Education* publish educational research articles from undergraduate (premedical), medical, and professional schools. Some journals may focus on anatomy projects from a particular geographic region of the world or be more suited to administrators rather than anatomy faculty. If your educational research project has important findings for other disciplines, consider publishing in an interdisciplinary journal such as *Bioscience* or *Advances in Health Sciences Education*. In addition, don't assume a journal has to have "anatomy" in its title in order to publish anatomy educational research. For example, *Advances in Physiology Education* publishes research not only in physiology but also in anatomy, biochemistry, and other health professions fields.

Make sure you carefully read the "instructions to authors" section on the journal's website prior to submitting your manuscript. There the editors will provide you with specific information such as how references and tables should be formatted, any length restrictions for the manuscript, and any other guidelines about acceptable publications. Manuscripts that are not in proper format and do not follow the guidelines will be returned to the author without publishing. Most, if not all, of the journals listed above only allow for online submission of the manuscript. In addition, make sure you have at least one other colleague read over your manuscript prior to submission, to check for grammatical errors, and to ensure the overall flow of the manuscript is acceptable. If your institution has a Teaching and Learning Center or a School of Education, consider asking individuals in these places to review your manuscript as well. These individuals likely have critiqued many similar manuscripts and may provide you with valuable suggestions you may not have considered.

The review process for your manuscript may take as little as a few weeks to as long as a few months or longer, depending on the journal and the manuscript in question. Journal editors typically have at least two or more individuals review a manuscript and give comments for the author. If your manuscript is rejected, do not despair. Carefully review the editor and reviewer

Table 42.1 Journals that publish anatomy educational research manuscripts

Journal title	Journal Website and instructions for authors
Academic Medicine	http://www.academicmedicine.org/
Advances in Health Sciences Education	http://link.springer.com/journal/10459
Advances in Physiology Education	http://advan.physiology.org/
American Biology Teacher	http://www.nabt.org/websites/institution/index.php?p=26
Anatomical Sciences Education	http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1935-9780
Bioscience	http://www.aibs.org/publications/ (click on the BioScience link)
Clinical Anatomy	http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1098-2353
Innovative Higher Education	http://link.springer.com/journal/10755
International Journal of Science Education	http://www.tandf.co.uk/journals/titles/09500693.asp
Journal of College Science Teaching	http://www.nsta.org/college
Journal of Computers in Mathematics and Science Teaching	http://www.aace.org/pubs/jcmst/
Journal of Nursing Education	http://www.journalofnursingeducation.com/
Journal of Research in Science Teaching	http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1098-2736
Journal on Excellence in College Teaching	http://ject.lib.muohio.edu/
Medical Education	http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1365-2923
Medical Education Online	http://med-ed-online.net/index.php/meo
Medical Science Educator	http://www.medicalscienceeducator.org/
Medical Teacher	http://www.medicalteacher.org/
Science Education	http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1098-237X
Teaching and Learning in Medicine	http://www.tandfonline.com/toc/htlm20/current

comments to see how you may improve the publication. Have multiple local colleagues read your manuscript for further guidance. After you make the edits these individuals suggest, then consider submitting the manuscript to a different journal that may be more appropriate. If the editor has not rejected the paper but does want edits, make sure you address all reviewer concerns and document how and where in the manuscript these concerns were addressed.

Checklist Prior to Submitting Your Manuscript to a Journal

- Determine the aims and scope of the journal are aligned with my research project.
- The journal in question publishes educational research projects similar to mine.
- Read the "Instructions for authors" section of the journal website.
- Have at least one other colleague read my manuscript for general flow, grammatical issues, and whether the research questions were adequately addressed.
- Double-check the "Instructions for authors" section to determine all journal guidelines were followed.

Conclusions

As you develop your anatomy educational research project, take advantage of the resources available to you. Contact faculty and staff from other departments and consult with your Center for Teaching and Learning to assist you in your project. Join one or more professional societies involved in educational research and be active in the society's meetings. Consider presenting your research at a variety of local, national, and international venues. Finally, write up your research findings and submit them for publication, so the field of anatomy education may learn from your research.

In order for your research to be considered scholarship of teaching and learning (SoTL), you must methodically assess your teaching and student learning and present your findings in the form of an oral presentation or written publication.

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Index

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