REVIEW ARTICLE

EFFECTIVE WAYS TO LEARN AND RETAIN GROSS ANATOMY

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ABSTRACT

Anatomy is a basic science subject taught in preclinical years in undergraduate medical education. It is considered a vast, dry and volatile subject that is full of anatomical jargon/nomenclature and factual information to be remembered. By the time students start their clinical attachments, most of anatomy is forgotten. Good knowledge of anatomy is essential to understand other basic and clinical science subjects. It holds pivotal importance to provide effective learning opportunities to the students through active, collaborative and reflective (A-C-R) approach towards teaching for lifelong learning. This guide provides some tips based on principles of learning and cognitive psychology, to learn and retain gross anatomy. It can be useful both for the teachers and students.

Keywords: Anatomy, Medical education, Teaching and learning.

INTRODUCTION

Anatomy provides basis to clinical sciences[1]. However, there has always been a debate about the content and comparative efficacy of different pedagogical tools[2]. This debate also encloses the conflict of "how much is too much to know". However, the objective is to provide learning experience to students that is more effective, meaningful and stimulating[3]. Medical profession demands good knowledge base[4]. Regarding sufficiency of anatomical knowledge, there are varied situations in different parts of the world. On one hand, dedicated time to anatomy has been scaled back[5] and anatomy curriculum is diluted and dispersed. Medical graduates are leaving medical schools with perception of poor anatomical knowledge[6]. On the other hand, in traditional education systems, intensive nature of anatomy course is felt as overwhelming and burdensome. In this context, anatomy educators need to develop and analyze innovative educational strategies to make anatomical instruction efficient and lifelong[4]. This paper suggests tips for learning and retaining anatomy better.

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Received: 07 May 2019; revised received: 30 May 2019; accepted: 03 Jun 2019

Adopt Active Learning

Most of the traditional teaching is focused on mere transfer of information involving first two levels of Biggs' teaching ladder which underpins 'blame-the-student' theory for not learning well[7]. Students don't learn much by mere sitting in class, listening to teacher talk, memorizing and reproducing information[8]. Active learning (AL) engages students with higher levels of cognitive activities like relating, applying and theorizing rather than memorizing and note-taking[7]. Retention of knowledge is increased when students are actively involved in learning[2]. In academic sessions, active and interactive techniques like buzz group discussions, brain storming with questioning or quizzes, incomplete handout, and hearing back from students can be used to improve learning[9].

Value the Visual

From cognitive psychology perspective, if text is joined with visual information in the form of images, it stays longer in the memory and becomes easy to recall as compared to the information that is only heard or read[10]. While studying gross anatomy, learner should relate the text to the visuals like images of atlas/books, models or specimens. Literature supports that Image based active learning has benefit over

text based strategies[11]. Simplifying structural information in a diagram reduce cognitive load and comprehension error[12]. Visual information in the form of images or academic videos is very useful to learn the applied aspects and anatomy of structures which cannot be properly dissected in cadaver, for example, branching and communications of facial nerve in ear. However, the power of visual representations lies in their ability to initiate cognitive processes for deep understanding[12].

Dissect Cadaver

Use of dissection as a teaching tool has been decreased in many medical institutions of UK, US and Australia[5]. However, utility of dissection is still endorsed by anatomists[13] and surgeons[14]. We believe that seeing gross anatomy and having feel of structures using hands, as you do in dissection, can help retain the information longer. According to Smith *et al* sense of touch plays a role in laboratory learning experience which activates a cognitive process of learning through feeling, a process called touch mediated perception (TMP)[3]. Moreover dissection involves 'learning by doing' which allows the use of visual auditory and kinesthetic approaches to learning making it more memorable[3].

Ensure Clinical Contextualization

Core anatomical knowledge, which is mostly declarative type of knowledge, can be learnt and retained well with clinical contextualization. It may be because, for better retrieval, information must be gained in ways that students will be required to retrieve it[10]. Clinical contextualization can be achieved by exposing students to clinical oriented scenarios and to real patients for surface anatomy and physical examination; Or by having clinicians as guest lecturers from other disciplines like surgery or radiology. Even lightly embalmed cadavers can be used to give student a life like experience[15]. Learning gains can be improved if radiological images of real patients are incorporated in anatomy teaching as cause-effect relationship[16], as causal explanations improve storage strength[17].

Discuss and Collaborate

Good learning is collaborative and social rather than competitive and isolated; wherein, sharing ones own idea and reacting to what others think sharpens thinking and elicit deeper understanding[8]. Peer assisted learning (PAL)[18] and Team based learning (TBL)[19] are effective ways of promoting collaborative learning. CL offers productive discussions and promote metacognition and reflection. CL involves constructivism that offers interaction between teachers and students[10]. Interactions should pursue understanding of function, interrelation and application of anatomical knowledge[20]. According to Desy *et al*[17], discussion involves verbalization/ articulation which improves retrieval strength, which further enhances meaningful learning and improves consolidation[21]. Dialogically rich teaching and learning activities are time consuming. However, time friendly discussions can be pursued with the help of technology like use of flipped classes or use of online discussion board in virtual learning management system (VLMS), mobile phone apps like whatsapp or facebook.

Bring Knowledge into Action

Students learn better when they talk about what they learn, write about it, and apply it to their daily lives[8]. Learning works best when newly acquired knowledge is used in daily life or to solve current problem[22]. Applying knowledge in different way improves consolidation[3]. For learning anatomy by application, simulations or standardized patients can be used or students can even test muscle action, nerve integrity or joint movements on each other. Students can also apply information by relating the anatomical knowledge to the health problems affecting human body of self, family, friends; patients in clinical rotations, or writing one sown clinical cases[23]. Opportunities given to students, to practice or apply knowledge in a new setting, help improving prior schemata[24].

Practice Mindful / Deep Learning

Students must be encouraged to do mindful learning involving following steps (figure):

Step-1 Know Learning Objectives: Students must be well aware of the knowledge and skills they are expected to attain after any academic session. Knowing what to know is one of the conditions for learning which, according to Biggs[7], provokes educative conceptual change.

Step-2 Activate Prior Knowledge: Activating prior knowledge provides a fertile condition for learning. It helps in organizing new information in working memory and subsequent encoding in long term memory[4]. Learning is

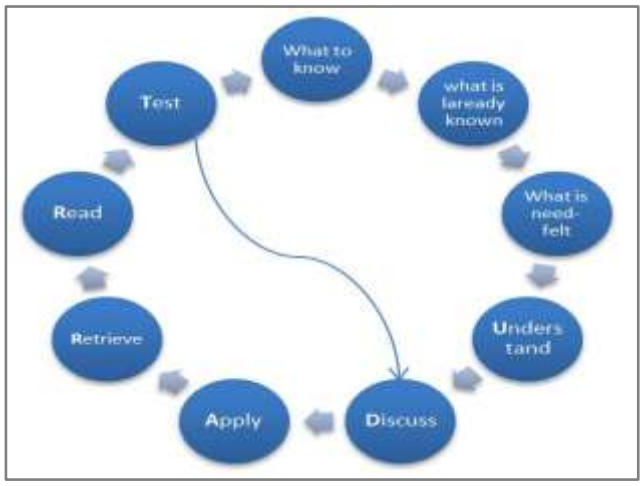

Figure: Mindful learning.

considered to be better when new knowledge is built on the previous understanding of a particular piece of information[22]. It is a useful strategy to organize complex information effectively, and to promote deeper level processing of information[10].

Step-3 Experience Need-felt: Wanting or needing to learn is important element of learning process[25]. Activating prior knowledge helps identify learning needs and engages students with the learning process well. Experiencing the 'need to know' develops metacognitive skills.

Step-4 Be Inquisitive and Curious: Students should be encouraged to read book/text with critical and inquisitive mind. Teachers can make students inquisitive by giving clinically oriented home quizzes; by developing in-class culture of questioning; by fostering habit of generation of question related to the learning task. For example muscles like deltoid, trapezius, temporalis have multiple actions. The main action of deltoid muscle is abduction whereas its anterior and posterior fibers have additional functions. Likewise anterior and posterior fibers of temporalis have different actions. Students must ask 'why' different fibers of particular muscle have particular actions rather than just memorizing those actions. Muscle action can be learnt and retained better if it is related to direction of muscle fibers and line of pull of muscle. Questioning helps better storage and recall[10]. Students must be able to ask questions from one self if they have learned something or need assistance.

Step-5 Identify and Understand Troublesome Knowledge: Troublesome knowledge is information that is problematic or difficult to understand[26]. Some examples include muscle biomechanics and segmental innervation. Some students usually do not ask queries if they are struggling to understand something. In case of novice medical students, it is the responsibility of teacher to help them identify troublesome knowledge so that it can be explained.

Step-6 DARRT: Discuss-Apply-Retrieve-Read-Test: The educational value of the discussion, application, active retrieval and testing is mentioned in the relevant tips given in this paper. Students must get engaged in the discuss-apply-retrieve-read-test cycle (fig-1). After testing self, students should discuss about their misunderstandings and mistakes and reflect on it before they start new cycle. DARRT cycle ensures active participation, collaboration through discussion and reflection.

Organize Information

If information is ineffectively organized or integrated in long term memory, it is either not learned or forgotten[17]. Students can organize simple information in a simplified way using mnemonics (table-I) or imagery techniques, and complex information through linking or questioning[10]. Effective information processing increases retrieval strength[17]. In this context, students can use strategies like summarizing,

drawing, mapping or imagining to process the learned information[27].

If information is long then students can make a small interesting story of the information to be remembered (table-II).

Ensure Frequent Retrieval

Frequent retrieval of the learnt information is crucial for anatomy. However, repetition or retrieval does not mean mere rote learning. Students usually engage with repeated reading rather than repeated active retrieval[28]. As compared with reading repeatedly, active retrieval produces meaningful and long term learning rather than mere rote learning and moreover, if it is followed by rereading, long term learning gets better[21]. Retrieval strength can be increased by providing opportunities for retrieval practice through self-testing, verbalizing and application. Retrieval practice is helpful in learning both the conceptual and factual knowledge[22].

Table-I: Examples of mnemonics.

Mnemonic	Explanation
OATs are good for eyes	OculomotorAbducent and Trochlear nerves supply eye muscles
Diana and Ember are Good Friends	Arrangement of cerebellar nuclei from lateral to medial: Dentate, Emboliform, Globose, Festigial
Vagabond in Los Angeles	Vagus nerve that becomes Anterior vagal trunk is the Left one and vice versa
Olivia Operates Sensational Violin	Pure Sensory nerves Olfactory, Optic, Vestibulocochlear

Table-II: Example of story based mnemonic.

Functions of Gluteal Maximus	Story
Gluteus Maximus causes Extension and Lateral Rotation at Hip while through Iliotibial Tract it supports the extended knee. It is particularly active as extensor of Hip joint at the extremes of Hip movements as Running and Climbing stairs. It has a little role in mid position of hip joint as in Quiet Walking, when the main Extensors of hip are Hamstrings. It is the chief antigravity muscle of hip during the act of Sitting down from standing.	General ordered Max, to Explore Long Route and Sit Down after Running and Climbing rather than Walking Quietly with Haris and plan to Support Knicki in Extensive IT Trial.

Draw to Learn and Consolidate

Making drawings of anatomical structures can be useful tool to learn anatomy[29,30]. Learning by doing, either through body painting, clay modeling or drawing; Activate visual and kinesthetic learning, which is more engaging and memorable[3]. Literature support that learning anatomy through drawing is not only more engaging and fun but also encourages students to visualize and better understand planes of structures[30]. Live drawing offers "freeze frame" of time which can be used for pointing out something or a clinical consideration[29]. However, it is argued that drawing must be done with explanations and comments rather than for sake of mere ornamental value. From perspective of cognitive psychology, images/sketches engages visual memory system and may improves imagery value of the morphological information, which is better retained[10]. Moreover, drawing increase generative learning through the act of translating information from text into pictorial form, which provokes learner to find relevant information from the text; show spatial details in the drawing; and use prior knowledge to clarify the link between text and drawing[27].

Use Assessments for Learning Through Feedback and Reflection

Learning is improved when assessments are used for learning (Assessments for Learning, AFL) rather than just measurement of learning (Assessment of Learning, AOL). Assessments must be used to promote deep learning rather than just long hours of ineffective memorization. Students can also do informal self-assessment by asking questions from self or peers, playing learning games or quizzes etc. and assess their learning needs. The recall benefit of 'testing

effect' is well documented[21,22]. However, frequent testing is double edged sword, if badly designed, in the terms of time on task, content to be assessed, spacing, grading and feedback strategies, can promote surface learning.

Assessments without timely feedback add little to learning[8]. For best learning outcomes, feedback should be sufficient, performance based, non-judgmental, timely, appropriate to students' understanding, received and acted upon[31]. Monitoring and evaluating the task learning are important components of cognitive regulation for better learning[4]. Feedback after formal or informal testing improves benefit of retrieval[22] and develops storage strength[17].

Make Effective use of Technology

Technology enhanced learning is thought to give flexibility and choice[3]. There are multiple new technological advances for teaching anatomy which include virtual reality using simulated objects in 3D space, laser hand held scanners, anatomage table 3D dissection platform, open graphics library and augmented reality (AR)[5]. However, technology can be used as an adjunct rather than as replacement to traditional educational strategies. These technologies are not available everywhere. In that case, dissection tables with overhead LEDs, atlas display on multimedia screen in dissection halls or mobile devices, use of social media for academic activities, provision of e-lectures, flipping of classes, use of 3D animations and educational videos etc. can be used to establish technology enhanced learning environment to facilitate the net generation. However, emphasis on learning must not be missed in mist of technology; and must be used carefully and precociously.

DISCUSSION

Anatomy is one of the corner stones in medical education[5]. Anatomy is taught with region based approach or system based approach in traditional curricula and through spiral approach in problem based curricula[1]. The debate on efficacy of teaching practice in anatomy continues and no single method has earned consensus[5]. However, this is frequently being voiced that teaching and learning practices in anatomy must focus on the attainment of sufficient, clinically relevant and transferable anatomical knowledge for clinically competent medical and dental graduates. According to Bergman[2], rather than focusing on acquiring larger amount of knowledge, educational strategies must enforce transfer of knowledge to new problems, application of basic science concepts to clinical problems, intrinsic interest in subject matter, and on the development of skills like learning how to learn, problem solving, self-directed learning, motivation for lifelong learning. Today, there is noticeable shift from traditional teacher centered education, where students are passive recipients; to innovative more active student-centered self-directed learning either individually or in groups. The constructive process of learning is further optimized when students actively discuss, elaborate on, and explain in group of peers[2]. Educators must provide active, constructive, collaborative and reflective opportunities for better learning and retention of anatomical knowledge.

By the time students join clinical placements they forget a lot of anatomy. Instructional designs can be tailored to improve retrieval strength. According to Desy *et al*[17] creating similarity between learning context and retrieval context improves retrieval strength. In order to form a bridge between anatomy and clinical sciences and to increase vocational relevance of the subject, medical students must be appropriately advised to comprehend application and to study human structure and function in context of clinical application which is important for better retention of knowledge[1].

For example, knowing the anatomy of veins of lower limb and mechanism of perforator and venous return is important to understand the development of varicose leg veins. Likewise, a student cannot understand development of hematemesis, caput medusea, hemorrhoids in case of hepatitis related portal hypertension without knowing the anatomy of portosystemic

anastomosis. Providing such causal explanations are also useful for increasing storage strength[17].

Visualization is appreciated as an important element in anatomy learning by students[13]. Visual element of learning is involved in dissection, drawing, applied and technology enhanced learning. The difference is that 'reality' based dissection involves engagement of multiple senses which is not offered by virtual reality (VR) or computer based learning (CBL)[5]. Information that is gained or revised through involving both the motor and sensory systems is better understood and retained longer. Cadaveric dissection is still considered one of the best ways to learn anatomy[13]. Although digital advances have attained considerable attention, however, technology can be a good adjunct rather than a sole effective replacement to traditional teaching methods[5].

Nonetheless, knowing what to know and knowing how to learn are important elements which develop metacognitive skills in students. The mindful learning framework suggested in this paper is based on constructivism and metacognitive theory. The educational implications of metacognitive theory offers opportunities to self-testing, self-reflection, and self-regulation through planning/goal setting, monitoring performance and evaluating outcomes[4]. Skilled learners exhibit cognitive regulatory competence[4]. However, the rate limiting step to effective learning is intent. For engagement with learning, the learning tasks must be clear and students must be interested to engage with them[1]. Moreover, how we design assessments also influences students' behaviors towards learning, hence quality of learning[31]. Learning is improved when assessments are used for learning (Assessments for Learning, AFL) rather than just measurement of learning (Assessment of Learning, AOL). Formative assessments with effective feedback may let students know whether they are weak in conceptual knowledge or recall level (Factual) knowledge of anatomy so that they can reflect and act upon accordingly. Providing effective feedback also improves storage strength[17].

As far as theoretical underpinning of the educational strategies are concerned, no single theory is likely to achieve broad range of educational outcomes[4]. This may provide justification why students learn better with multimodality teaching and learning practice in anatomy[5].

CONCLUSION

This paper suggests some tips for teaching and learning anatomy for better learning and retention. There is no single recommended method to learn anatomy. Combination of strategies may be more useful. Owing to the substantial diversity among students population, students may have different preferences for learning. However, they must be explicitly guided about how to learn better and appropriate scaffold should be provided.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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