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Review article

A paradigm shift from teaching to learning gross anatomy: meta-analysis of implications for instructional methods

Vishram Singh[a,*], Poonam Kharb[b]

[a]Professor & Head, Department of Anatomy, Santosh Medical College, Ghaziabad, Uttar Pradesh
[b]Professor, Department of Anatomy, School of Medical Sciences and Research, Greater Noida, Uttar Pradesh

KEYWORDS

Teaching anatomy, Learner-centered approach, Problem-based learning, Computer-assisted learning, Teaching methodologies.

ABSTRACT

Anatomy teaching in terms of content and methodology has undergone major changes in the recent times due to time constraints, scarcity of cadavers, rapid advances in information technology, and changes in the demands of the medical profession. Moreover, there has been a major paradigm shift in medical education from passive, didactic, and teacher-centered approach to active, clinical-based, and student-centered approach. The debate on how to teach anatomy in the most effective way continues, and there is not yet a workable solution to integrate the two lines of thought (teacher-centered/student-centered) that can resolve the dispute between the two approaches. The present article therefore meta-analyses the role and effectiveness of various instructional modalities in teaching and learning anatomy in the context of the shifting paradigm from teaching to learning. The available literature on the use of various instructional strategies employed for teaching–learning anatomy suggests that the challenge should not be to determine superiority of one methodology over another but to capitalize on the learning benefits offered by the different methods. Learners should be provided opportunity to use multiple resources, thus favoring flexibility in the acquisition of knowledge. Proper amalgamation of traditional teaching methodologies such as lectures and dissection and the newer instructional methods, namely problem-based learning and computer-aided learning, would help to catalyze the shift from pedagogy to andragogy, where educators no longer serve chiefly as the dispensers of the subject content, but act as facilitators of learning and evaluators of competency. The net result should be to produce lifelong learners committed to continuous improvement of skills and knowledge.

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"I never teach my pupils; I only attempt to provide the conditions in which they can learn."
A. Einstein

1. Introduction

Anatomy has been the keystone of medical education for hundreds of years. It provides a platform of knowledge indispensable to all the branches of medicine. The format of teaching anatomy in terms of content and methods has evolved and changed considerably over the last two decades along with changes in the demands of the medical profession. However, there is a continuing debate concerning how much to teach, when to teach, and how to teach gross anatomy. Moreover, the planning of best approach to teach anatomy is further complicated by the fact that the time spent for studying anatomy is reduced and on the other hand, there is an exponential increase in the wealth of information to be learned.[1,2] Therefore, both the teachers and learners need to constantly reinvent themselves to keep pace with the changing demands of the profession and the technological advances.

Over the last few decades, a major paradigm shift in medical education has been to move from passive, didactic, and teacher-centered approach to active, clinical-based, and student-centered approach i.e., from teaching to learning.

*Corresponding author: Tel: +91 (0) 8800534822
E-mail address: drvishramsingh@gmail.com. (Vishram Singh)

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Dupin-Bryant defined the teacher-centered approach as "a style of instruction that is formal controlled, and autocratic in which the instructor directs how, what, and when students learn".[3] On the other hand, Dupin-Bryant defined the learner-centered style as "a style of instruction that is responsive, collaborative, problem-centered, and democratic in which both students and the instructor decide how, what, and when learning occurs". According to Brandes and Ginnes, the main principle of student-centered learning is that the learner is fully responsible for her/his learning and the teacher is a facilitator and resource person.[4] The net result of student-centered approach should be an individual who is empowered to be a life-long learner. The reforms in medical education proposed in "Vision 2015" document of Medical Council of India also advocate adoption of contemporary education technologies such as e-learning, simulations, skill labs, etc. and to put a greater emphasis on self-directed learning (SDL) in order to produce lifelong learners committed to continuous improvement of skills and knowledge.[5] But, is there a general understanding on implementation of the learner-centered approach among the medical educators? The anatomists all over the world are polarized into those who consider the teacher-centered approach in the form of formal didactic lectures followed by dissection of cadavers as central to learning gross anatomy and those who favor replacement of traditional teaching by student-centered approach with newer teaching modalities such as self-directed learning (SDL), team-based learning (TBL), problem-based learning (PBL), and computer-assisted learning (CAL).[6] The debate on the best approach to teach anatomy in the most effective way continues, and there is not yet a workable solution which can integrate the two lines of thought (teacher-centered/student-centered). The present article therefore meta-analyses the role and effectiveness of various instructional modalities in the shifting paradigm from teacher-centered learning to student-centered learning.

2. Lectures

For centuries the traditional didactic lectures have been a popular mode of disseminating information, where an instructor delivers a well-crafted monologue to a group of students who passively receive the information. Although the lectures are thought to be largely passive, they do have their advantages such as they can be particularly effective for disseminating many facts to a large group of learners in a small time, synthesizing information from multiple sources, and clarifying complex concepts.[7,8] As suggested by Nierenberg, lectures also serve an effective way of communicating the enthusiasm of the teacher to the learners, thereby motivating them.[9] Therefore, lectures continue to remain the most common instructional mode in contemporary undergraduate medical education. However, promoting active learning during a lecture and making it student-centered in a large class is challenging and most of the teachers therefore end up delivering information with minimal student involvement within a traditional lecture format. As a result, the traditional lecture format favors memory retention rather than thinking, understanding, and problem solving. Numerous studies have reported that traditional lectures that encourage passive learning are not as effective as active, student-centered learning strategies.[10]

In Indian medical colleges, lectures are still the most common method used for teaching and learning and are here to stay; therefore, it is extremely important that they must be as effective as possible. The most common lecture delivery methods include the usage of overhead projector and transparency (TOHP), PowerPoint presentations (PPT) besides the conventional 'chalk and talk' method, each with certain merits and demerits. Various studies have been conducted to compare the effectiveness of lectures using PPT or TOHP with those using chalk and board.[11–15] The main reasons for liking lectures using chalk board are as follows: (a) the students have adequate time to take down notes and draw diagrams, and (b) the pauses and breaks (e.g., during writing, drawing, or rubbing the blackboard) allow students to follow the material.[15] In teaching anatomy, a drawing is worth thousand words. Therefore, traditional chalkboard lectures using simple diagrams which students can draw are excellent teaching tool ensuring active participation of the learners. In this context, according to Creed, chalkboard is more student-centered, while PPT and TOHP are more teacher-centered.[16] However, some of the disadvantages of chalkboard instruction method are that in some cases, the handwriting is not legible and secondly, more time is required to present the same information as compared to the PPT or TOHP.

The TOHP and PPT both enable the teacher to prepare visual material in advance and to build on this as the lecture proceeds. Well-designed PPT presentations can be graphically impressive. They do create a great deal of interest and make it easier to listen and follow along. Mayer and Anderson reported that in PPT, the ability to integrate the text, pictures, videos, and animations is a big advantage and enhances the learning process.[17] It has been reported that an educator is most effective when the text is placed adjacent to picture/diagrams and is spoken simultaneously (spatial contiguity effect) resulting in better integration and retention of knowledge. But do PPTs encourage interaction? Do they promote critical thinking? Using PPT, in fact may encourage passivity especially when the number of slides is more. In such a case, many students have the tendency to sit back passively and just watch and listen as if they are watching a movie instead of taking notes and asking questions.

Educationists continue to be divided on the superiority of a particular lecture delivery method (chalkboard teaching, PPT, or TOHP). The results of the numerous studies done to determine the effectiveness as well as the preference of students for these lecture delivery modes suggest that the lecture could best be a combination of two or more teaching–learning methods.[11–15] Most importantly, the students' interaction should be encouraged irrespective of the methodology used. The solution to this is to include an activity during the lecture which encourages students to think actively about the topic, or which requires them to respond. Numerous methods advocated by various

researchers and educators are available in the literature describing how faculty members can effectively apply active learning and student-centered approaches within lectures. Inclusion of a few simple active learning strategies can go remarkably a long way in making the traditional lecture student-centered. Some of the activities that can be introduced in the lecture session are as follows: quizzing the students, presenting a clinical problem and asking students to apply what has just been learnt in the class to find its anatomical basis, role playing by students, lecture sketch books where students either draw the diagram or label a diagram, write important points learnt in the session, and use of electronic response systems in lectures such as wireless pads.[18] All these activities have been shown to promote student engagement during lectures and raise long-term retention of the subject. Placing students at the center of instruction shifts the focus from teaching to learning thereby encouraging a learning environment more amenable to the metacognitive development necessary for learners to become self-directed, independent, and critical thinkers.[19]

3. Dissection

The pedagogical merits of dissection have passed the test of time. The study of gross anatomy necessitates the use of two learning strategies: memorization of a vast technical terminology and visual recall of three-dimensional (3D) relationship of various structures in the body. Dissection facilitates utilization of both the learning techniques. Dissection not only encourages active involvement of students, but also provides an opportunity for SDL, reciprocal peer teaching (RPT), and small group discussion.[20]

Dissection caters to cognitive, affective, and psychomotor domains of medical students. It not only provides a three-dimensional perspective on the topography of the structures being studied, but also gives the opportunity to the students to confirm their learning, rely on their observations, and appreciate the significance of the concept of variability as it presents itself and not as it is presented to them.[21] Besides knowledge it also offers students hands-on experience and instrument usage. The initial contact of medical students with professional values occurs during the first year in the dissection hall. Professional attitude and skills exercised and learned in the dissection hall include team-building, cooperative learning, and the respect for human life. These skills and competencies are indispensable for physicians. Gross anatomy course is being viewed by many not only as a way to teach the structure of the human body but also as the first link in a long chain of events that teach essential skills and desired competencies to tomorrow's physicians.

In the early days of medical education, the study of gross anatomy was based around cadaveric dissection to such an extent that dissection used to be revered as the very 'essence of anatomy'. This was due to the fact that dissection was the only available method of three-dimensional study of the macroscopic organization of human body structures. Advances in science and information technology, medical diagnostics techniques, and teaching methodologies have led to many changes in medical school curricula. Also included in the new curricula is the introduction of clinical reasoning, physical examination skills, use of PBL, radiographic images, and computer simulations.[22,23] These trends in medical curricula resulted in fading away of conventional dissection in some medical schools. However, availability of innovative methods used in teaching–learning anatomy such as interactive multimedia resources, live body scans, virtual three-dimensional images, plastic models, etc. have not diminished the importance of dissection in the eyes of the medical students.[24] Observations of numerous student studies have revealed that dissection-based learning provides students with a definite authoritative source of knowledge that enables them to master structural knowledge.[24–26] Indeed many students consider dissection essential and indispensable in the study of human anatomy.

As mentioned earlier, the technological innovations and other resources and methodologies available for teaching anatomy have stimulated a discussion about the role of dissection as a teaching tool which has resulted in different points of view. The first maintains that dissection is the best way to teach anatomy and abandoning dissection may breed a generation of 'incompetent anatomists, physicians, and surgeons, leaving patients to face dire consequences'.[27,28] The second point of view upholds that dissection is dispensable.[22,29] Studies comparing the usefulness of cadaveric dissection against the use of multimedia programs, virtual bodies, etc. for learning gross anatomy have suggested retaining dissection supplemented with newer multimedia learning methodologies.[30,31] Amadio reported that the cadaveric dissection is the only tool that gives the students an appreciation of the natural variety of human structure as opposed to 'virtual cadavers.'[30] Moore in his work "To dissect or not to dissect" delineated the various disadvantages associated with non-cadaver-based curriculum.[31] Some of these are that the anatomical features and pathologies are not easily demonstrated using computer-aided programs. He further stressed that the use of computer-aided programs, simulators, audiovisual and radiographic images, etc. in the teaching of gross anatomy should be complementary to cadaver-based study. For the above-mentioned reasons, dissection continues to be the cornerstone of human anatomy instruction in most of the medical schools. Even the medical schools that initially dropped it have been compelled to reinstate it.

The recent trend toward minimal-access surgery and the frequently performed interventional procedures with limited access to various structures and organs further demand a sound knowledge of anatomical relationships. In-depth knowledge of anatomical details is now considered to be critical to the success of a clinical procedure. Therefore, dissection being an essential tool in the training of future physicians and surgeons can neither be undermined nor an adequate substitute is available. Cadaveric dissection allows the first visual and tactile experience of 'human life' for aspiring health professionals.

Some of the challenges faced in cadaver-based teaching include difficulty in procuring cadavers, emotional impact on some students on exposure to the cadavers, and health and

safety issues associated with the use of cadaver[6,32]; however eliminating it from the curriculum is not the solution. Instead, it is recommended that efforts should be made to overcome or reduce these challenges. The case for maintaining dissection in the medical curriculum rests on an appreciation that it not only provides the platform for the active learning, but is also extremely effective in establishing and retaining anatomy concepts.

4. Problem-based learning

The current trend in medical education is to integrate basic science knowledge with clinical application of that knowledge. Majority of the medical schools across the world including those in India have either changed or decided to change the medial curriculum from the conventional discipline-based to an integrated interdisciplinary-based. The assumption is that, if the basic sciences are learnt in relation to each other (horizontal integration) and in relation to the clinical sciences (vertical integration), learning will be enhanced, and hence the students will appreciate the relevance of what is learnt. Problem-based learning is proposed as a method that integrates the knowledge of basic sciences with clinical relevant material and encourages active learning as well as develops self-directed life-long-learning habits.

Problem-based learning is a well-established student-centered approach to learning. It was first employed in 1960s in medical education at McMaster University.[33] Since then, it has been widely used as a learning tool in numerous medical schools. Problem-based learning is defined as an educational format in which learning takes place in a small, self-directed group and the learning results from the process of working toward the understanding or resolution of a case or real clinical problem.[33] Through this learning strategy, students acquire creative thinking skills as they work cooperatively to solve complex open-ended real clinical problems. Generally, PBL is conducted in the following five steps: (a) small group of students is presented with a clinical problem, (b) students discuss with facilitator and each member is assigned responsibility of resolving specific questions pertaining to the problem, (c) students gather information from relevant sources (experts in the field, books, journals, net, etc.), (d) students discuss, analyze the information, and develop hypotheses, and (e) students share the findings with their peers and present an interpretation of the solution.[34] Knowledge acquired via the PBL method is clinically relevant and more likely to be retained longer by the student as it requires active participation of the student in acquiring the information. The most important aspect of PBL is the process of developing a skill that can be utilized when the student is actually confronted with a clinical problem that does not fit the 'textbook'.

From the learning perspective, the advantages of PBL are as follows: (a) independence and freedom in the students' learning, (b) deeper knowledge and comprehension-oriented learning, and (c) personal growth and lifelong learner. The disadvantages are as follows: (a) difficulties in balancing the depth and breadth of the syllabus and (b) difficulties in finding assessment criteria. The disadvantages of PBL from teaching perspective are as follows: (a) the teachers feel that their expertise is not fully exploited; (b) all the fundamental concepts of the courses may not be covered in pure PBL-based curriculum.[35] According to Nayak et al, the integrated curriculum based on organ systems that uses PBL as the major instructional method results in a certain degree of fragmentation of anatomy, and if curriculum planners are not careful, it may result in the omission of some important components of the subject[36]; therefore, a number of anatomists have recommended that the future medical curriculum should be a hybrid of PBL and conventional curricula.[35–37]

5. Computer-assisted learning

Advances in information technology and easy access to the internet are reshaping medical education by providing new learning environments and new ways to teach. With the advent of web-based technology coupled with the increase in availability of educational software and information database through internet, CAL is being incorporated in anatomy as a means to augment or replace the traditional anatomy teaching.[38,39]

Computer-assisted learning provides an important alternative pedagogical tool. It may provide an effective supplement to conventional methods of teaching. Some of the anatomists are of the view that CAL of anatomy offers high hope of overcoming the shortage of cadavers as well as replacing the teachers.[22] However, many anatomy educators are of the opinion that computer-based anatomy resources are valuable tool in anatomy teaching and can be used to supplement the traditional methods, but cannot replace dissection as the primary method of teaching and learning anatomy.[38] According to Ackerman, German undergraduate medical students preferred online anatomy resources as they found them more motivating and fun than textbooks.[40]

Computer-assisted learning is also called e-learning, online learning, web-based learning, distributed learning, computer-assisted instruction, or internet-based learning. The various modes of instructions used in computer-based learning are as follows:

(a) Drill and practice: Teaching material is presented to the student, and the student is evaluated via multiple-choice questions e.g., in an image-based quiz, the student is presented with a dissected part, and is asked to identify the structure marked.
(b) Didactic lecture: The digitized video of the lecture as well as the related slides or other teaching material is made available on computer. This approach has the advantage that relevant background or remedial material can also be made available through links at specific points in the lecture
(c) Construction: One of the most effective approaches, but extremely difficult to implement on the computer, is the constructive approach to learning. A relatively simple example is learning anatomy through reconstructing the human body either by putting together the separated

body parts, or by placing cross sections at the correct location in the body.

(d) Simulation: Instructors can use 3D simulation to demonstrate human anatomy including spatial relationships. Learner can traverse a nerve path, follow the course of a blood vessel, peel away layers of body wall or an organ, hide external features to reveal underlying constructs, or can see the muscles producing movements at a joint.[41]

Numerous websites and software with learning tools for gross anatomy are available and can be used by students for self-directed study or incorporated into classroom teaching. The "Visible Human Project" provides color scans of a middle-aged human male sliced into 1871 cross-sections at 1 mm intervals.[42] The Internet Atlas of Human Gross Anatomy based on the visible human data set provides a wealth of annotated material.[43] "BrainStorm", developed at Stanford University, is an interactive atlas of neuroanatomy, with images of dissections and cross sections, diagrams, and extensive supporting text.[44] The multimedia, interactive "Anatomy Laboratory" software enhances both memorization and visual learning skills and has been shown to be an effective teaching aid.[45] Other popular software, such as "ADAM Interactive Anatomy" or "The Dynamic Human", are good for conveying 3D relationships, through the use of multilayered drawings that can reveal progressively deeper structures and freely rotating 3D renderings of organs or body regions.[46,47]

Research on the effectiveness of computer-aided learning suggests that it can enhance the students' performance in examinations, reduce the time students need to spend studying as well as improve the way students process information. Some of the advantages of computer-based learning include its vast storage capacity which can serve as an extension of the student's memory and quick access to references, a large number of images and videos. The computer can deliver personalized one-on-one education; delivering material appropriate for the learner's needs and interests.[48] In computer-based learning, the learner has the freedom to choose the place, time, pace, and process of learning. In CAL, students assume increasing responsibility for their learning, while teachers become facilitators, guiding and motivating students along the process of learning. Some of the disadvantages of CAL are as follows: (a) compared to live instruction by the faculty, it lacks human contact, which greatly impacts learning; (b) the inability of learner to ask questions during instruction. However, anything that stimulates the interest of student and enhances the process of learning should be promoted. Modern anatomists suggest that anatomy must shake off the image of being old-fashioned and welcome the use of CAL, animated presentations, educational videos, three-dimensional software and multimedia computer programmes, and virtual learning labs developed for the purpose of learning anatomy.[49–54] Educationists have discussed the implications and outcome of the new era of modern technology applications in medical education and are of the opinion that CAL can provide much more information to the teachers and students than ever.[49–51]

The development process of computerized anatomically correct 3D models and virtual anatomy programmes is labor intensive and time-consuming; therefore, appropriate planning is very important to ensure their effectiveness and financial viability. Defining their need in the curriculum is the first step. Currently, most computer-based materials are treated as supplementary material and are used by students on their own initiative. They can be used more effectively by integrating them into the curriculum e.g., they can be assigned as laboratory exercises or used as the basis of a class discussion. Properly integrated into the curriculum, computer-based learning can become a part of the learners' lifelong education. Internet has totally revolutionized the education world; the biggest impact of internet on education is to change the point of view that education is something that can and should be delivered by a teacher. Although computer-based education cannot substitute face-to-face live interaction with the teacher, it provides a new environment of education in the current scenario of rapid growth of information. The integration of CAL into medical education can catalyze the shift toward andragogy, where the emphasis is on the learner and process of learning. Using CAL along with the conventional teaching–learning methodologies would enable the educators to help the learners grow from dependent learners to autonomous self-directed lifelong learners.

6. Conclusion

Anatomy teaching is undergoing major changes due to time constraints, scarcity of cadavers, rapid advances in information technology, and changes in the demands of the medical profession. In this changing scenario of medical education, a continuous debate is on among the educators regarding usefulness and effectiveness of the conventional and newer teaching–learning methodologies. The meta-analysis of the literature available recommends that the challenge should not be to determine superiority of one methodology over another but to capitalize on the learning benefits offered by the different methods. The learners should be provided opportunity to use multiple resources, thus favoring flexibility in the acquisition of knowledge, in other words, the student's ability to apply the acquired knowledge in a variety of different contexts. The teaching material and teaching style must reflect the change in the real world. By placing learners at the heart of the learning process and meeting their needs, educators can ensure that learners are able to learn what is relevant for them in ways that are appropriate.

"*Like everything new, at first people refuse to believe that new way of learning/teaching can be done, then they begin to hope that it can be done, then they see that it can be done.*"

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