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RECENT TRENDS AND TEACHING METHODS OF ANATOMY

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Abstract

In recent years there is an important evolution in interaction with the environment and information. Anatomy has been a cornerstone, for studying medicine and surgery for hundreds of years. These evolving trends indicate that the assimilation and application of anatomy will metamorphose it from being a dull and passive subject to a more dynamic and collaborative subject. Traditionally, gross anatomy is taught using cadavers, bones, and pedagogy, abstract and dynamic concepts of developmental anatomy, are explained with chalk and board and occasionally with OHP or projection slides, models, etc. as teaching aids. But with globalization a lot of new technology has come to the field of teaching anatomy. Anatomy studios, virtual dissectors, simulation labs, radiology machines, smart boards, etc. are new additions to learning anatomy. Endoscopic anatomy is the latest evolving trend that teaches students beyond anatomical positions and gives a whole new perspective on the body. The article gives a systematic review of the recent trends and teaching methods of Anatomy.

Key words: Anatomy, Recent trends, Teaching methods

Introduction

The purpose of anatomy education is to develop the skills of anatomical reasoning, which is a requirement for performing several clinical tasks.

Anatomical reasoning in two domains:

- Spatial domain-understanding of the three-dimensional geometry of the body and its parts.
- Symbolic domain - understanding of functional, developmental, pathological, and other relationships among anatomic entities.

Educational media have supplemented the anatomy teacher, in his effort to impart knowledge of the complex subject of anatomy. In a study involving the effect of lecture-discussion, teaching methods with or without audiovisual augmentation.[1] it has been established that audiovisual aids help improve communication and contribute significantly to the delayed retention of information. Equipment like the overhead projector, slide projector, and chalkboard, found immediate acceptance and were internalized into the teaching system.[2] In recent years however, media technology has brought in a new generation of devices like videotape, multimedia computers, LCD projection panels, data projectors, and direct projectors - all these seem to hold a promising potential to supplement the anatomy teacher, in efforts to communicate this complex subject of anatomy to medical students.

Also, some of the established media devices are now available in improved designs to suit the requirements of a medical education set up. The objective of this document is to analyze these recent advances and suggest areas of application in anatomy teaching.

An experiment in medical education on a problem-based study program in basic medical sciences revealed that there was little difference between the level of scholastic achievements in two groups of subjects, one which acquired knowledge and skills through self-study and non-formal education and the other in which knowledge and skills were developed through intensive formal coaching. This experiment tells us how little we must teach and how much more we need to guide the students to become self-sufficient.

Traditionally, gross anatomy is taught using cadavers, bones, and pedagogy. Abstract and dynamic concepts of developmental anatomy are explained with chalk and board and occasionally with OHP or projection slides, models, etc. as teaching aids.[3] The vibrant developmental process of life is thus reduced to a lifeless, static, and incomprehensible material. No wonder the student mugs up the "one sentence development" of each organ just one day before the examination.

In general, the teachers are quite tough on muscles and bones. Heavy fact-filled doses of morphology are regularly dispensed. With Damocles Sword of examinations hanging perpetually on their heads, it is no wonder anatomy becomes a nightmare to the students.[4] Actual instances where candidates fail due to the inability to name the structures along the lateral border of the foot in the practical examination, add to further their nightmares.

Existing-time tested technologies

The chalk and the blackboard are an all-time favorite of the anatomy teacher and will probably remain for many decades. Its utility for the step-by-step buildup of simple line diagrams is noteworthy. As an alternate to the black board, green glass ground boards are utilized in most institutions. Complex areas and concepts can be flowcharts using the chalkboard and this is done at a speed at which the audience can take down points.[5] It is still the most reliable teaching aid that can battle power cuts. Technology offers scratch-free boards of different colors, with low reflection and glare-eliminating surfaces. Newer generation chalkboards are unbreakable and retain the chalk impression very well. They are durable in the sense that the surfaces do not fade over the years or develop ugly color patches. Ideally, the board would be resistant to mechanical and chemical action. Stainless steel boards are now available, the surface of which has a porcelain coating, which also acts as magnetic display boards. Boards with light color porcelain coating can also be used for projecting slides and overhead transparencies.[6] Innovation has not spared even the chalk pieces, of which all colors are now available. A variety of marker pens are also available to enable writing or drawing on these boards.

An electronic copy board is an improved version of the chalkboard. The advantage is that text and graphics penned on the board can be hard copied, using the attached printer, and the ‘n’ number of copies can be obtained almost instantly. This is useful if complicated line diagrams and large amounts of the script need to be copied.[7] Facilities exist to download information from one or more screens of the copy board into the printer. The time saved can be used to develop the flow of the topic and more information can be delivered in each unit of time. To the students, the practice of jotting down from the chalkboard is obviated - instead, they can concentrate on the lecture. Models range from one to five screen types - the latter is useful for flowcharting, spreadsheet analysis, and for case discussions, integrated teaching modules - or simply handling any topic with a large content base.[8] This also provides the anatomist the scope to draw or write out the points before hand. In multiscreen configurations of the electronic copy board, the material can be referred to the previous screen for reinforcement or to establish continuity- unlike the chalkboard where the information once wiped is lost forever.

The last two decades have seen the increasing role of the overhead projector in anatomy teaching. Technological advancements in this field include models with more light output (higher wattage bulbs with higher power consumption)-culminating in the so-called daylight projectors. Miniaturization was brought in the form of portable overhead projectors and now we have projectors fitted with zoom lens units that can magnify or reduce an area of focus to fit into the screen size appropriately.[9] These high-voltage bulbs also generate heat and appropriate cooling devices (regular blade fans, cylindrical fans, etc) are also fitted in. For more organized presentations we now have transparency feeders with cordless remote control. This releases the teacher from being chained close to the overhead projector and he is now free to move about to establish a more interactive discussion with the audience. Also, there are fewer wires or cables to trip on. These recent advances help the teacher in one way - he can now shift his concentration totally on the topic and forget the equipment, thereby bringing in greater emphasis on subject detail. The transparency feeder can move the OHP inch by inch - a familiar technique of selective display in teaching.[10]

Innovations in slide projector technology parallel those of the OHPs -brighter illumination, better cooling devices, zoom lenses to suit any screen size, automated slide load, and retrieval, spare bulb to replace a fused bulb to enable continuous utility, etc. Cordless remote control with a built-in laser pointer is also available. Also, any slide can be projected not necessarily in a linear order. This provides flexibility in the presentation to cater to the instructor's choice. The facility exists to operate the equipment at a lower illumination (80%) to increase bulb life.

The epidiascope in its original design had its unique utility text and graphics from books, periodicals, and brochures that could be directly projected. The direct projector is a newer version of this equipment-additional images of small three-dimensional objects can also be projected.

The advances in photocopying technology have their application in anatomy teaching. We can now get good quality xerox of both line art as well as the grey tone images on paper in addition to text material. Color and color contrast is crucial factors in communicating a structure-based science like anatomy. Although expensive true-color xerox facility is now available in India it is only a question of time before this technology gets internalized into teaching methodology. Material can also be xeroxed onto OHP sheets and stored for reuse.

Newer technologies: Promising potential

Video-assisted lectures were found to have a higher communication value-both objectively and subjectively. Videotape is excellent for areas like pointing out a detail in a histology slide or a gross anatomy specimen, to show a long-drawn technique in a time-compressed sequence (e.g., the method of preparation of a histology tissue-fixation up to staining). Videotape is not a canned version of a lecture but a visually enhanced learning tool. It is the visuals that make or ruin a videotape. Visuals attract the attention of the audience. Several videotapes on gross anatomy and histology are now commercially available but there also exists an acute need for indigenous production to suit local curricular needs. The blend of visuals, appropriate audio, and meticulously planned flowcharting will render the videotape an effective communication aid.

Videotape has in recent years gained an additional advantage, thanks to the parallel development in computer technology using suitable convertors. It is now possible to print entire computer software into linear videotape and play it on a video cassette recorder and a TV screen. Computer-enhanced videotape production of this kind is more effective communication system and could predictably be the standard teaching aid, especially in areas like embryogenesis, growth, and development, demonstration of clinical skills, and aspects of medical ethics. Its utility in problem-based learning will probably be the most important innovation in medical education in the years to come.

Videotape technology has a greater ramification in its applications in teaching human anatomy. Transferring the understanding of anatomy gained from a dissected cadaver to the living body remains a challenge - this is where videotape technology may have its potential benefit. When linked to a microscope or a TV monitor, it can be a useful demonstration tool. Histological details can be pointed out to groups of students.[11] The same slide can be shown at various magnifications, thereby enhancing communication. In addition, the session can be recorded into a linear videotape or computer hard disk and incorporated into multimedia programs. High-definition video systems have tremendous applications in anatomy teaching-particularly due to their high resolution and better color enrichment capabilities- a common point it shares with the computer.

Computer technology and its utility in anatomy teaching

A videotape can at best be described as an improvement over a traditional passive learning system. At its present stage, it offers an excellent method of introducing programmed learning. Its interactive component makes it an ideal choice to attempt individualized learning. Justifying interactive learning in medical education allows the student to engage in deep cerebral activity in responding to stimuli in the learning context. This is comparatively better than improving teaching with maximum teacher involvement and passive absorption on the part of the student.

The program can be designed to suit specific learning objectives. The software can be developed to suit all types of learners-slow to the fact, low level to advanced levels and to fit into various time schedules. Question-answer sessions can be incorporated into the program to make it evaluation linked. A small installment of information is first presented to the student.[12] As he goes through the program, he can be quizzed to test his learning abilities, and based on this additional relevant data can be presented. If the student fails to answer the question, the computer will draw his attention to the screen, where this information could be found thus making him study the area again and again - until he has understood the topic. The computer prompts him to learn at every stage, step by step. Note that equipment offers emotion-free interactivity. The very useful component in student education. Any number of revision - sessions can be availed of. Programs can also be developed to attempt curiosity-driven learning.

Computer-based methods of knowledge have great potential for promoting anatomical reasoning and integrating the two domains (spatial and symbolic) into meaningful communication.

By their very nature, biomedical sciences cannot be learned or understood without access to pictorial information. Their dynamic nature cannot easily be demonstrated in lectures or textbooks, and they are therefore prime candidates for the development of interactive learning materials incorporating multimedia information. This is where hypermedia technology can be best applied to computers - a concept of nonlinear or non-sequential data presentation-one which offers a branched menu of options-which allows the users to create their routes through the body of information. It is a natural extension of the progress of the interactive video.

Multimedia

Multimedia has brought a giant leap in computer-assisted teaching systems and is the closest substitute to teacher-guided learning. Video, stills, audio, animations, and text are blended into an interactive presentation. Computer animation is an interesting aspect of computer technology used in developing software specific to the subject. For example, all the histology slides can be digitized on the computer without the need for a scanner, and a computer atlas of Histology can be generated. Wheatear's textbook of Histology is now available in the format of a compact discs and will run on any multimedia computer-IBM or MAC.[13] Considered a useful accessory is a CCD camera with a film grabber card attached to the computer.

Computer graphics, therefore, forms the backbone of developing teaching-learning software for anatomy. A large amount of hard disk space is used up for pictures of the human body and this can be very taxing to the computer

speed as well as memory. Advances in digital compression technology together with the arrival of faster processors have helped handle this problem. Factual image compression techniques have come of age and several applications of this in handling anatomical data will be foreseen.

The basic requirement for any anatomical study is

1. Establishing a three-dimensional Atlas of the human body

2. Generating models of symbolic anatomic information and

3. Develop computer programs (user interfaces) that integrate these knowledge sources. Even without displaying the models in 3D space, and without the tactile characteristics of anatomical structures, currently available, computer graphics afford a richer appreciation of the three-dimensional quality of anatomy than is possible with the cadaver.[14] Not being destroyed by their disassembly, as happens with the cadaver, computer models lend themselves to repeated explorations that may be guided by different objectives.

Computer models can:

- display anatomy which not only forms a regional viewpoint as does cadaver dissection but also by organ systems.
- This display can be generated not only by electronically taking out the model apart (ie. dissecting it), but by building up the body systems or regions from their components.

Of late several software packages on Human Anatomy are available commercially. These are electronic textbooks, and their reviews are on similar lines to that of medical textbooks. Some of these are very well rendered to suit specific objectives of the medical curriculum. The Digital anatomist program at the University of Washington is one such innovative attempt at software development for human anatomy. It offers, for example, a dissection of the brain by digitally peeling from the surface at 1mm intervals, a translucent cerebral cortex, a section showing relations of structures to the ventricles, functional dissection of major long tracts, and a series of cross-sections at various levels. Anatomical dissections applied to medicine (ADAM) is another software with an excellent rendering of anatomical images for various curricular levels including a package for doctor-patient communication. Calling it the electronic Grays anatomy may be an exaggeration, but it certainly offers an integrated blend of structure and function. Cross sections of the human body can be generated at any level together with relevant CT, MRI, and Ultrasound images. Most importantly it offers a virtual platform for attempting dissection of the human body using the keyboard and mouse as surgical tools. The material presented is vast and the medical student must sift through it to get the essentials. Most of this software is designed to not only assist the teacher in his communication but also help the learner to learn at his speed and time. Several areas of improvement are anticipated in computer-assisted learning modules in the years to come-notable of which include better graphics, integration with other specialties, case study-based learning of clinical anatomy, and organogenesis. In addition to these commercially available packages, there is an acute demand for the development of software for anatomy with specific teaching objectives.

Computer-based interactive teaching systems

A pilot investigation by Kathryn H. Roy's team at the University of Wales College of Medicine has applications for anatomy leaching. In this study students in the lecture halls are provided with a handset-each of which is linked to a central computer. Using a series of pre-planned lectures and questionnaires, the teacher asks the students to respond through the handsets answers may be yes or no types, or numerical entries as examples. This feedback-linked to interactive teaching is possibly an early break, from the monotony of passive lecture sessions and helps the lecturer to devise appropriate corrective teaching then and there. At least the teacher has an idea of how many

students can understand the topic. The success of this system of teaching lies, as in all technologies in the training of both the staff and students to utilize this equipment.

The concept of interactive lectures was proposed in the seventies by Charles F. Bridgman et al[15] from the departments of anatomy and medical communication, University of Kansas Medical Center. They predicted a central computer system that can transmit data to various nodal points of the anatomy department, for eg, video clippings of an area of dissection can be sent by cables from the dissection hall direct to the lecture hall where the lecture on the same topic is in progress. Similarly, images of histology slides can be transmitted from the histology lab to the lecture hall as well as the dissection hall. This removes the compartmentalization of information and provides the student with organized and integrated Anatomy information at a single session and site. The Internet can offer inter-institutional data sharing and exchange of educational material. Also, soon we could look forward to a convergence of micro processing. telecommunication and television technology through the internet enable teleconferencing between centers across the world.

New vision-new frontiers

The seventies and eighties saw the dawn of a new era. Meaningful deliberations by curriculum planners, faculty members, experts, and students succeeded in evolving the much-needed reforms and restructuring of the curriculum. The focus was on retaining the relevant, weeding out the redundant, and incorporating the new developments. (Eg. cytogenetics and radiological anatomy). The new need-based curriculum is thus more flexible than what used to be a rigid monument earlier. Having pruned and reshaped the syllabus, the next step is to evolve a plan of action through which the basic and the applied aspects of anatomy are put across to the students most innovatively and effectively in the shortest of time with maximum student participation and minimum pedagogy. It is possible to achieve this objective if an ideal situation is created where motivated students, imaginative teachers, and academically conducive infrastructure co-exist. In the altered scenario the teacher becomes an "Information Manager" rather than an "Information Provider".

Technological Revolution

The day-to-day developments in the field of electronics have revolutionized the lifestyles of people. Medical electronics have percolated every aspect of the health care system. Newer trends in learning and teaching have made mind-boggling progress the world over during, the twentieth century.

Museums-Temples of Self Learning

Modern medical imaging scans like CT, MRI, DSA, PET, Ultrasound, computerized ultra-sonography, and echo-cardiography have captured a permanent place in the anatomy museums side by side with conventional specimens. As a corollary of this, it has been observed that the anatomical details in the images in the radiograph also make the cross-sectional specimens of the body. Thus, museums have become ideal places for self-learning radiological anatomy.

Multimedia and Information Superhighways

The term multimedia is used to denote the integration of text, and graphics. animation, motion video, and audio on a PC. Multimedia PC (MPC) is an instrument of dialogue rather than a monologue like videotape shows. Multimedia is a tool for developing presentations. Creating a multimedia presentation is a specialized job and requires some experience and resources. Its viewer interactive applications have a powerful impact on the minds of the students.

The integrated learning of anatomy and physiology, for example of the heart, is possible by creating 3D video motion images. CT scans, MRIs, Ultrasonographic images, etc, can be digitized and recorded magnetically in the multimedia format along with necessary audio, animation, etc., on a CD-ROM, which can be played interactively on the MPCs. Multimedia offers a tremendous thrust to developing both the teacher and the taught. The teachers and the students themselves can author the multimedia products.[16]

Understanding the anatomical structure at the microscopic level is also possible with the advent of an interactive tool called computer modeling. An example is modeling what goes on in the brain at the neural level. A model of connections between the Purkinje cell and inferior olivary cell throws light on not only the structure but also the functionality.

Information superhighways enable us to transport a huge amount of the latest technological and scientific information at extremely high speed from any part of the world to the user's PCs through the internet. This is the best tool for updating ourselves.

Virtual Reality (VR)

The latest wonder in the educative tools is the VR, the Anatomage virtual dissection table. VR technology can simulate real situations in a virtual environment. VR system consists of a display, a tracking device for interactivity, a computer image generator, a 3D database, and applications software. Using the VR technique, the entire human body can be digitized and can be dissected part by part by the participant used. 3D digital simulation allows more realistic training than that on cadavers. If a trainee pinches a nerve or cuts through a blood vessel, nothing happens in a cadaver. But in a digital video format, if an artery is cut, blood flows out because of the virtual environment. Organs can be taken out and replaced. The same digital format can be used again and again. Digital cadavers seem to be "immortal". [17]A day may not be far off when formalized cadavers will be replaced by Cyberspace Cadavers in dissection halls.

Functional areas of the brain including cognitive areas (which are never organized in the same way from one individual to the next) can be mapped into 3D images of the brain surface created from MRI scans. Functional mapping in the cognitive areas is achieved with the help of sophisticated systems of special electrodes. Virtual reality brain models are thus to the advantage of both patients and science. An anatomically correct 3D image from a live subject, one that students, teachers, surgeons, and researchers can walk around with and poke, with the least botheration to the live subject can be obtained. It also allows a more quantitative evaluation of how cognitive processes are organized within the brain.

Problem-Based Learning (PBL)

PBL started in North America where medical teachers concerned about curriculum overload and inappropriate teaching methods shifted the emphasis of the undergraduate curriculum away from individual disciplines such as Biochemistry, Anatomy, and Physiology towards an integrated holistic approach involving students in problem-solving and independent learning, often from the very first term.

PBL is an interactive and challenging approach to medical education. It is innovative. It is a new way of using clinical material to help students learn and challenge themselves because it requires the medical teacher to use facilitating and supporting skills rather than directive ones. For the student, problem-based learning emphasizes the application of knowledge and skills to the solutions to problems rather than the recall of facts. PBL is concerned with both what students learn and how they; learn it. It uses specially prepared problems, usually written cases derived from clinical experience, as the basis of the curriculum. PBL uses tutorial discussion groups supplemented by traditional teaching methods to stimulate active learning on the part of students. Many teachers see PBL as a

method for developing active and independent learners, reactive and divergent thinkers, and good communicators. The use of small group work, self-directed learning, peer support and feedback, and the development of critical thinking is an ideal preparation for learning as a postgraduate. Its introduction and development and coordination take time, but the resulting material and program promise lasting benefits.

Case Based Learning

This is related to early clinical exposure for the freshers when they step into the step of medical science. The students are exposed to applying anatomical knowledge in the diagnosis, understanding the location, normal dimensions, and their related deviations, the direction of pain, assessments of any mass or mega lies by palpation, and utilization of other examination methods like inspection, palpation, percussion.etc. The students will learn surface anatomy and the application of anatomical knowledge to a live person, making a study of anatomy interesting and to the point rather than deducting lectures that will be monotonous and boring. For example, they will come to know where they have to see for McBurney's point, Murphy's sign, Apex beat, Renal angle…etc, and their application.

Discussion

The recent trends in the teaching of Anatomy have affected all levels of the education system i.e. curriculum planning, teaching methodology, and evaluation. An important recent advancement in teaching is thus the introduction of Living Anatomy' for example study of natural contours and actions of muscles, movements on joints, pulsations of various arteries, movements of eyelids and eyeballs, inspection, palpation, percussion and auscultation of thorax and abdomen. All these can be better studied on living individuals. With the development of modern technology for scanning the body by various techniques including ultrasonography, computerized tomography, and magnetic resonance imaging, cross-sectional anatomy needs to be included in the curriculum. It is very important to put the details of the curriculum in black and white to make the teaching uniform all over the country.

Dissection of cadavers has been the time-old method of teaching Anatomy. Due to the curtailment of time allocation for Anatomy, it is becoming difficult to complete the dissection in a limited period. But most anatomists feel that learning anatomy without dissection is also difficult. So, the trend now is to dissect certain parts only. Those areas where dissection is too laborious and time-consuming need not be dissected by the students. These areas can be taught on protected specimens. Shortage of cadavers and specimens is being overcome by techniques like plastination of specimens which prevents deterioration of specimens by repeated handling. Anatomage is the latest technology to teach anatomy very easy and user-friendly. Smartboard is a very effective tool for teaching anatomy as well.

The teaching method of anatomy also includes 1:1 interaction between teacher and student, summary writing cluster studies like a description of bones, group study like identification of features of organs, utilization of paper models in disseminating precise knowledge like inguinal canal and its contents, carotid triangle …etc, involving students in class-based workshops like preparing clay models, fiberglass models, cleaning, bleaching, boiling, scraping, drying, polishing and painting of bones likewise preparation of specimens, functional models that enhance precise knowledge of Anatomy.

Fig 01. Using Smart Board for Undergraduate teaching

Fig 02. Using Anatomage for Undergraduate teaching

Fig 03. cluster classes for undergraduates

Fig 04. 1:1 interaction

Besides the usual audiovisual aids like slide projectors and overhead projectors, recently videos and computers are being used for teaching anatomy in many universities. The major advantage of such methods is that the students can work and learn at their own pace. Still, a recent advancement is the use of interactive video which is computer-assisted learning enhanced with video pictures. This has a computer-based tutorial program that interacts with students by giving information and requiring input. The correct answers from the computer ensue so the students feel as if the teacher is constantly with them. With indigenous programs coming up these modern technologies will spread to other institutes too.

Conclusion

In conclusion, the advances in computer technology have an impact on the teaching of human anatomy. It can be compared to the arrival of printing technology during the renaissance period. Hi-tech media and computer technology are now ready for use.

On the frontiers of recent trends in medical education, the global scenario is much advanced. In the Indian settings quiet, a few leading medical institutions are keeping somewhat abreast with the latest. Otherwise, the Indian scenario, in general is lagging far behind. Central level policy should be introduced to make it mandatory to have at least multimedia centers in all the medical colleges in the country. To establish free flow of information these centers should be networked through internet or ERNet. This can be the first positive step towards meeting the challenges of the emerging trends.

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