DECLINE OF GROSS ANATOMY IN MEDICAL EDUCATION: Developing mechanisms to counter the effects of decreased training in Gross Anatomy.

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ABSTRACT: Training of physicians in the basic sciences has been substantially reduced in many medical schools. Compression of instruction in Gross Anatomy, often including elimination of many laboratory dissections, could particularly affect the subset of students who seek to specialize in disciplines that require extensive knowledge of body structure, such as surgery, radiology and obstetrics/gynecology. However, the consequences of curricular compression/revision in Anatomy have not been adequately studied. Our ongoing observational study has sought to 1) develop pedagogical methods to counter the effects of compression of content and reduction in duration of anatomy instruction and 2) to evaluate their effectiveness in conveying information essential to understanding body structure. At the Joan C. Edwards School of Medicine of Marshall University, a proposed approach to re-establishing Gross Anatomy in the curriculum has been to utilize and expand an elective course, Surgical Anatomy, to enhance training in the fourth year of undergraduate medical education. This course has focused upon cadaver dissections and allowed students to review and expand their knowledge of Gross Anatomy, as well as generating prosected specimens for teaching. We have developed a questionnaire to assess the effectiveness of the course in training in the anatomical sciences. Initial data on student responses in a pilot study indicate a strong support for continued laboratory dissection sessions and indicate that further integration of training in Gross Anatomy and Radiology, potentially through faculty-led small group study, could help to counter the curricular changes. We plan both to expand this study and to further develop methods to compensate for the reduction of Gross Anatomy in undergraduate medical education. Supported by NSF Grant CRCNS 2113028.

CURRICULAR REVISION AND COMPRESSION OF DURATION OF ANATOMY INSTRUCTION

NEW INTEGRATED CURRICULUM

PHASE ONE, PART 1 — FOUNDATIONS OF HEALTH AND DISEASE

August → July (12 months)

Molecular and Cellular Foundations	Microbiology and Host Defense	Inter-cession	Hematology and Oncology	The Musculo-skeletal System	The Neural Network	Nutrition and Gastro-enterology	Summer and Research Elective (7 weeks)
6 weeks	6 weeks	1 week	6 weeks	5 weeks	10 weeks	6 weeks	

Physicians in Practice –
Global and Local Issues in Medicine
Humanism and Ethics
Bias Training
Economics and Law of Medicine
Clinical and Translational Science
Portfolio

Patient Care and Clinical Skills
Early Patient Interactions

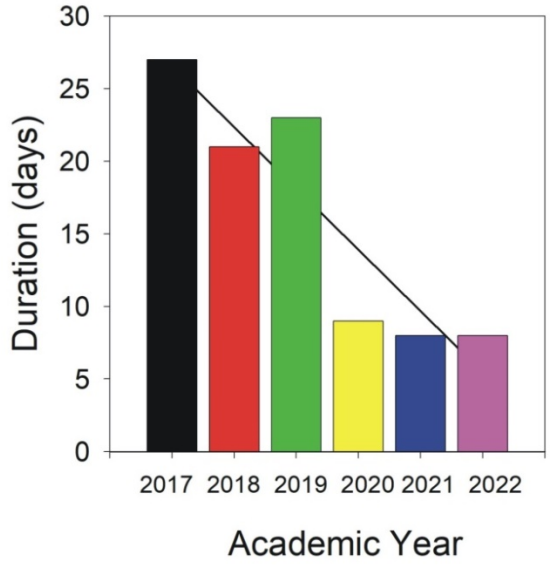
PHASE ONE, PART 2 — FOUNDATIONS OF HEALTH AND DISEASE

July → December (5 months) | December - March

Cardiovascular, Renal and Respiratory Systems	Hormones and Human Reproduction	NBME CBSA
14 weeks	6 weeks	9 weeks

Patient Care and Clinical Skills
Early Patient Interactions

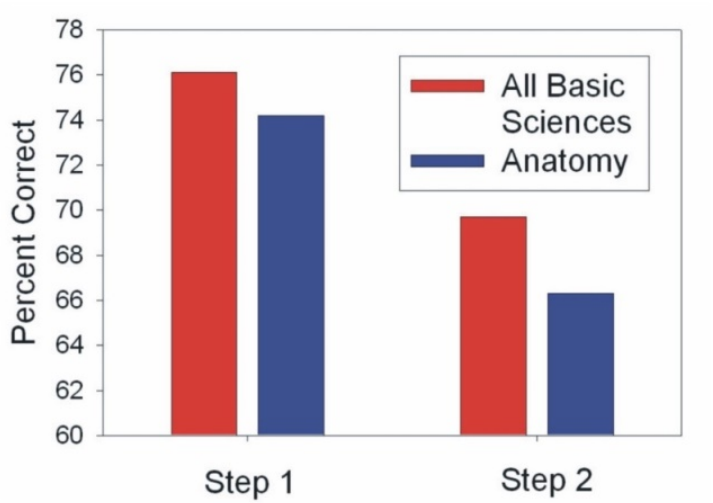
DURATION OF INSTRUCTION IN HEAD AND NECK ANATOMY



PROBLEM: ADAPTING GROSS ANATOMY TO A COMPRESSED TIME FRAME - An integrated curriculum was implemented at the Joan C. Edwards School of Medicine that compressed basic science training to 18 months and reduced the duration study of Gross Anatomy (Head and Neck Anatomy is currently restricted to eight instructional days).

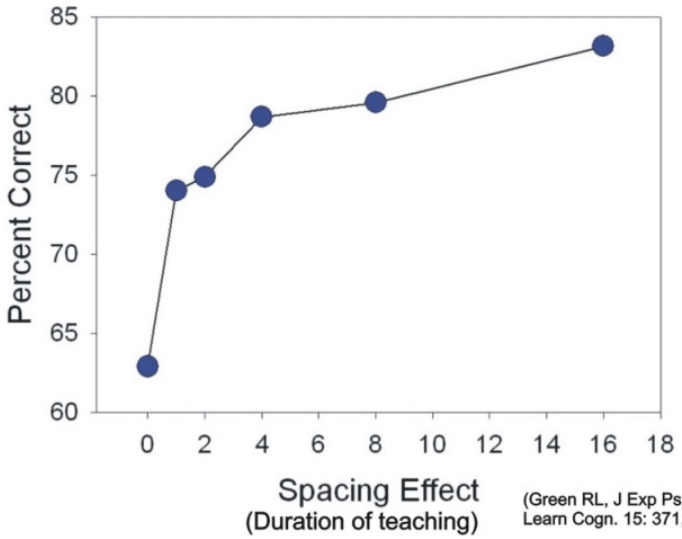
PROBLEM: CURRICULAR COMPRESSION AFFECTS RETENTION

LACK OF RETENTION IS A MAJOR PROBLEM IN MEDICAL EDUCATION



Data plotted from Ling Y, et al., Acad. Med. 83:S82, 2008

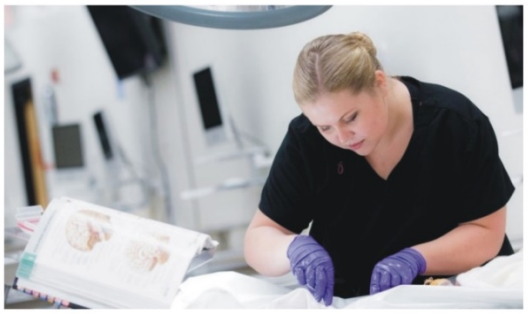
SPACING EFFECT: COMPRESSION DECREASES RETENTION

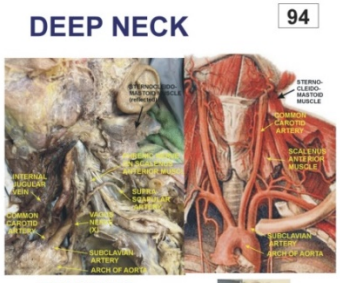


(Green RL, J Exp Psych Learn Cogn. 15: 371, 1989)

While apparently more efficient, extreme compression of duration of instruction has been shown, in a number of studies, to decrease retention

SOLUTION 1: FOURTH YEAR COURSE: SURGICAL ANATOMY ACB 813





TEACHING PROSECTIONS PRODUCED IN SURGICAL ANATOMY COURSE

QUESTIONNAIRE ON DISSECTION AND INTEGRATION OF GROSS ANATOMY AND RADIOLOGY, CURRICULUM ORGANIZATION AND TEACHING METHODS

	NUMERICAL SCALE				
	1	2	3	4	5
LIKERT	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
RATING	Very Poor	Poor	Average	Good	Very Good

PLEASE ANSWER THE FOLLOWING WITH A NUMBER (1, 2, 3, 4 OR 5):
NOTE: 1- STRONGLY DISAGREE, VERY POOR to 5- STRONGLY AGREE, VERY GOOD

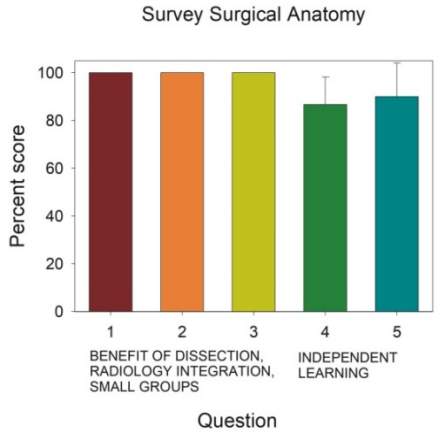
1- _____ Do you agree or disagree? Cadaver dissection helped to enhance or consolidate your ability and knowledge of anatomy.

2- _____ Do you agree or disagree? Increasing integration of anatomy dissections/prosections with Radiology in the curriculum would aid in interpreting images of body structures?

3- _____ Do you agree or disagree? Optional small group laboratory review sessions with faculty in Gross Anatomy could be helpful and should be formally included in the curriculum.

4- _____ Do you agree or disagree? Topics in Embryology should NOT be taught ONLY through independent learning assignments.

5- _____ Do you agree or disagree? Independent learning assignments need to be followed by small group sessions in which students can ask questions of faculty.



One potential solution to this problem is to utilize an elective course (Surgical Anatomy) that permits renewed study of Anatomy later in the curriculum. We have developed a written questionnaire to evaluate student perceptions of the effectiveness of the course in integrating basic (Anatomy, Embryology) and clinical (Radiology) science: to date, students have uniformly reported the course as beneficial but responses were more divergent on curricular use of independent learning.

SOLUTION 2: NEWLY REVISED MULTIMODAL PEDAGOGY FOR COMPRESSED DURATION

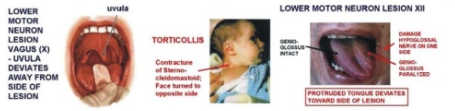
COMPLETELY INTEGRATE INDEPENDENT LEARNING WITH NEAR SIMULTANEOUS LIVE AND ITERATIVE CLASSROOM/ LECTURES DISCUSSION (ALSO RECORDED) IN EIGHT (8) DAYS

REVISION OF PEDAGOGY - Following curricular compression, many students reported difficulties in retaining information about anatomy that was presented in single sessions concurrent with clinical training. There was also a large decrease in attendance at live classes; informal counts of students indicated that no more than 20% were presented at live sessions. We therefore revised the schedule to efficiently and iteratively integrate independent learning with in-class sessions. Videos of lectures that focused upon Anatomy were followed (one day delay) with correlated in-class discussions centering upon Clinical syndromes and how symptoms resulted from disruption of structure/function. These sessions were not mandatory and were video recorded to facilitate student access. Most laboratory sessions involved independent viewing of prosections but two sessions (dissections of brain, orbit) were retained to provide students with direct and guided experience in laboratory dissection

APPROACH: INSTRUCTION BASED ON CLINICAL SYMPTOMS: DEFICITS ARE MANIFESTATIONS OF STRUCTURE/FUNCTION

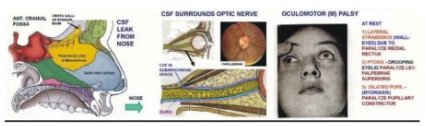
CLINICAL ANATOMY OF HEAD AND NECK

Clinical	Anatomy	Cause	Sign/Symptom
Posterior Cranial Fossa - Cranial Nerves VII-XII, face, ear, pharynx, tongue (cont.)			
Loss of function of IX and X	IX is major sensory nerve to pharynx (oropharynx); X is motor to all muscles of pharynx except Stylopharyngeus; all muscles of palate (except Tensor palati)	**Tumor at Jugular Foramen**	Difficulty in swallowing; **Absence of Gag Reflex**; (Gag reflex - IX sensory, X motor) **Uvula deviates away from side of lesion**
Hoarse voice after thyroid surgery	X is motor to all muscles of larynx; also sensory to larynx; Recurrent Laryngeal nerve passes posterior to Thyroid gland with Inf. Thyroid artery; motor to all laryngeal muscles except Cricothyroid	**Damage Recurrent Laryngeal nerve during Thyroid surgery**	Hoarse voice due to **unilateral paralysis of all laryngeal muscles (except Cricothyroid)**
Torticollis	XI innervates Sternocleidomastoid and Trapezius	Torticollis can be congenital or acquired	Contracture of Sternocleidomastoid - head is rotated with face directed to opposite side (Note: **Trapezius - clinical test for XI - shrug shoulders**)
Cleft Palate (palatoschisis)	**Anterior** - Fusion of medial nasal processes (Primary palate) and maxillary processes (Secondary Palate); **Posterior** - Secondary palate formed by fusion of Maxillary processes of two sides	**Failure of fusion**	**Anterior** - Cleft anterior to Incisive foramen; **Posterior** - Cleft posterior to Incisive foramen Treatment: Surgical repair
Paralysis of muscles of tongue	XII is motor to all muscles of tongue (no sensory component)	XII hypoglossal nerve palsy	Atrophy of muscles of tongue on one side; **protruded tongue deviates toward side of lesion due to Genioglossus) in Lower Motor Neuron Lesion**

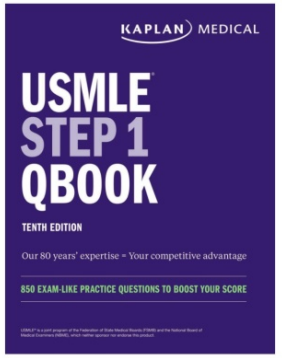


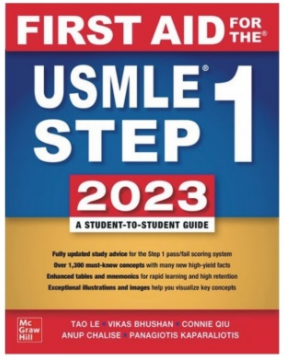
CLINICAL ANATOMY OF HEAD AND NECK PART 1

Clinical	Anatomy	Cause	Sign/Symptom
Anterior Cranial Fossa - Cranial nerve I, Nasal Cavity			
Fracture of cribriform plate of ethmoid bone	Nasal septum continuous with crista galli of ethmoid bone; Olfactory nerve passes through cribriform plate of ethmoid bone	Blow to nose; fracture produces **continuity between subarachnoid space and nasal cavity**	**Leakage of CSF from nose** ('runny nose'); **Decreased sense of smell** (hyposmia)
Middle Cranial Fossa - Cranial nerves II-VI Orbit, Eye Movements, Face			
Rapid loss of vision in one eye	Central artery of retina (branch of Ophthalmic artery from Int. Carotid) is an normally an end artery with no functional anastomoses (exception: Chorioretinal anatomoses)	**Occlusion of Central Artery of Retina**	Sudden onset blindness in one eye (one eye only, sign: artery occlusion visible through ophthalmoscope)
Slow loss of vision in one eye	Dura mater and subarachnoid continue over optic nerve; **Optic nerve function affected by CSF pressure**	**Communicating hydrocephalus** (many causes)	Decreased visual function both eyes; sign: **papilledema** in ophthalmoscope view; also other signs of increased intracranial pressure (headache, etc.)
Abducens nerve palsy	Abducens nerve innervates only Lateral Rectus muscle (action: abduction of eye)	Damage Abducens nerve VI (causes ex. increased intracranial pressure, Cavernous sinus thrombosis)	**Diplopia and Medial strabismus**
Trochlear nerve palsy	Trochlear nerve innervates only Superior Oblique muscle (action: abduct, depress and medially rotate eye)	Damage Trochlear nerve (ex. trauma)	**Inability to look down and out** (difficulty walking down stairs); **Head tilted toward side opposite lesion**
Oculomotor nerve palsy	Oculomotor nerve innervates Superior, Medial and Inferior Rectus and Inferior Oblique; part of Levator palpebrae superioris; also provides parasympathetics to pupillary constrictor, ciliary muscles	Damage Oculomotor nerve (frequently idiopathic)	**Lateral strabismus, dilated pupil, ptosis; also loss of accommodation (near vision) due to paralysis of ciliary muscles**



Clinical syndromes were similar to those found in board review texts but determined without reference to specific texts





MULTIMODAL PEDAGOGY: ANATOMY UNDERLYING CLINICAL SYNDROMES - Instruction in anatomy was based upon core of clinical conditions that were correlated with pathology and neurology and previously tested in Step One Board Examinations. Clinical syndromes were not presented as case studies (many students lack thebackground for meaningful diagnostic analysis) but as correlates of anatomical structure and function.

APPROACH: PARALLEL VIDEO LECTURES IN ANATOMY WITH DISCUSSION OF ANATOMICAL BASIS OF CLINICAL SYMPTOMS

INDEPENDENT LEARNING

VIDEO: BRANCHIAL ARCHES

- ADULT STRUCTURE IS RESULT OF TRANSFORMATION;
- SPECIFIC SYNDROMES OCCUR IF DEVELOPMENT IS ABNORMAL

IN-CLASS DISCUSSION SESSIONS

CLINICAL ANATOMY OF BRANCHIAL SYNDROMES - SYMPTOMS/RESOLUTION ARE BASED UPON ANATOMY

Treacher-Collins Syndrome - First Ach

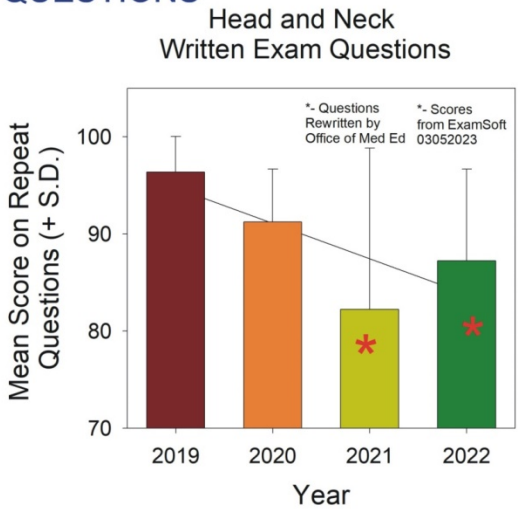
Branchial Cyst - Anterior to Stenocleido-mastoid

Surgical removal of Second Arch Cyst - trace to Tonsillar fossa

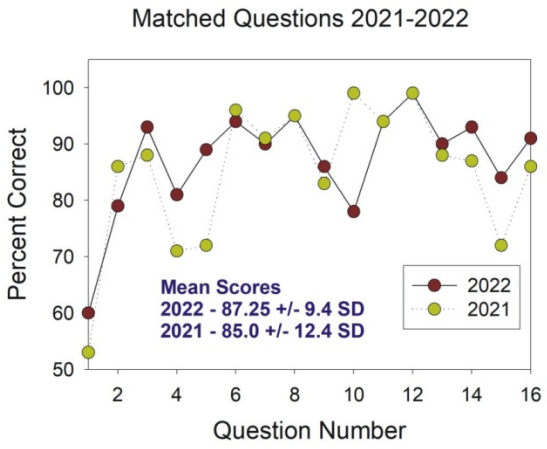
INTEGRATION OF DIGITAL ON-LINE AND IN-CLASS INSTRUCTION - Instruction was organized as parallel 1) on-line videos, which presented basic embryology and anatomy and 2) live in-class sessions which discussed the anatomical basis of clinical syndromes. The example above shows (at left) the first slide of the video on the embryology of the Branchial arches and the first slide from the corresponding discussion of Branchial arch syndromes. In the schedule, the discussions of were delayed by one day to permit students time to view the videos (which had associated handouts, clinical charts) prior to the in-class discussions (videos of the discussion sessions were also posted afterwards) to allow for review of the clinical material

STUDENT PERFORMANCE: RESULTS TO DATE

PERFORMANCE ON ANATOMY QUESTIONS



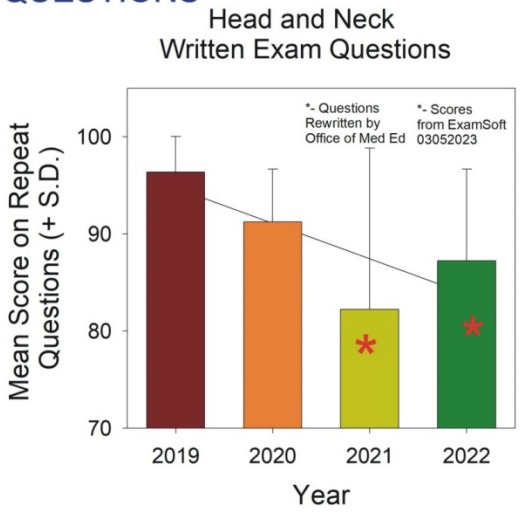
PERFORMANCE ON INDIVIDUAL QUESTIONS (SAME TOPICS)



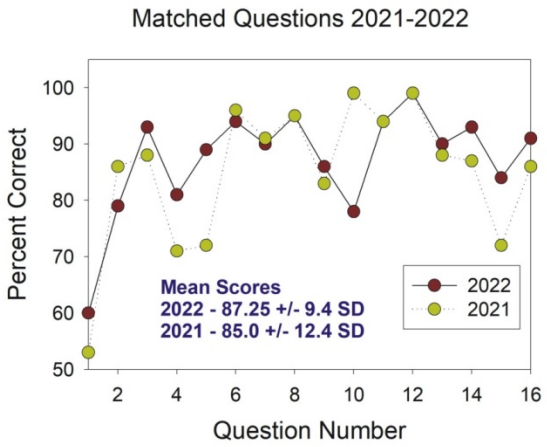
STUDENT PERFORMANCE IN GROSS ANATOMY- These figures show plots of student performance on Gross Anatomy questions in the first block exam (data obtained from ExamSoft). The histogram (left) shows the mean score and standard deviations on exams in the years 2019-2022 (current academic year). Performance on Gross Anatomy declined in years 2019-2020 following the compression of time available for study. There was also a further decrease in 2021 when exam questions in Gross Anatomy were re-written by the Office Medical Education. Results from the latest year (2022) following the pedagogy of complete integration of on-line and in person sessions showed an increase in the mean scores.

STUDENT PERFORMANCE: RESULTS TO DATE

PERFORMANCE ON ANATOMY QUESTIONS



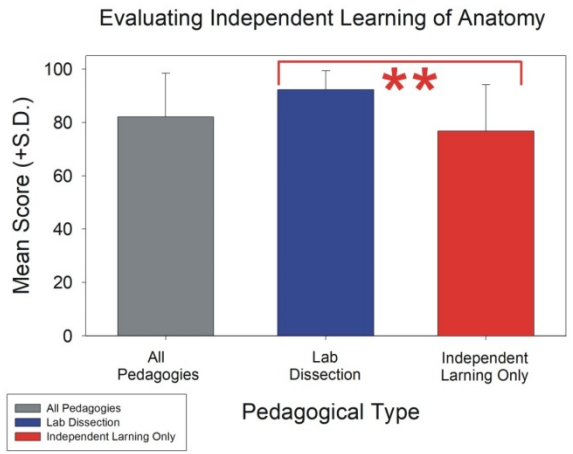
PERFORMANCE ON INDIVIDUAL QUESTIONS (SAME TOPICS)



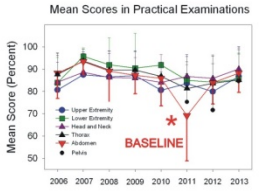
STUDENT PERFORMANCE IN GROSS ANATOMY- The plot at right shows the mean scores on individual Gross Anatomy questions from the exams given in 2021 and 2022 that were matched according to the specific topic tested. Although performance on individual questions varied, the mean score on these questions was quite high and increased in that period (from mean 85.0 +/-12.4 SD for 2021 to 87.25 +/- 9.0 for 2022). These preliminary data indicate that the pedagogy has been effective and further analysis of the data is planned.

INDEPENDENT LEARNING ALONE IS NOT EFFECTIVE IN ANATOMY INSTRUCTION

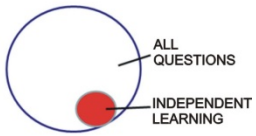
HIGHER STUDENT EXAM PERFORMANCE WITH MULTI-MODAL INSTRUCTION

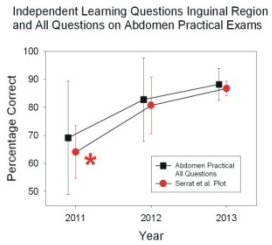


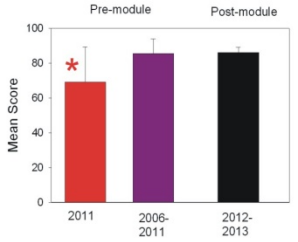
FLAWED DATA IN STUDY DONE AT JCESOM: ON INDEPENDENTLEARNING DONE AT JCESOM



DATA SELECTION ERROR- 'CHERRY PICKING'







DATA NOT INCLUDED IN STUDY: PERFORMANCE IMPROVED ON ALL QUESTIONS, NOT ONLY INDEPENDENT LEARNING

EFFECTS OF INDEPENDENT LEARNING RECONSIDERED - Analysis (plot at left) of student scores on questions in which instruction was multi-modal vs restricted to independent learning showed that performance was higher when information was presented in diverse modalities. Independent learning has a number of institutional advantages (inexpensive, requires few trained faculty) but its effectiveness has not been rigorously examine. A previous study from our school (Serrat et al., Anat. Sci. Educ. 7:406-16, 2014) evaluated the effectiveness of independent learning modules and concluded that their use improved performance. However, study of a more extensive data base showed that the practical exam used as a baseline (2010-2011) was an outlier in which the entire class had a failing average and that no increase in performance was seen when a longer baseline was considered.

CONCLUSIONS

1- Two approaches were proposed/applied to compensate for teaching of Gross Anatomy in a highly compressed time frame: a) utilize and potentially expand an existing 4th year elective course (Surgical Anatomy) and b) closely integrate independent learning and live class interactions in the curriculum.

2- Instruction was organized to parallel subjects students were studying in preparation for the Step 1 national board exam (rather than attending scheduled classes). A foundation of Gross Anatomy was presented in on-line videos, while live class sessions discussed clinical syndromes, focusing upon symptoms that resulted from disruption of relations of structure and function.

3- Preliminary analysis of test scores and student feedback support the idea that the curricular changes were beneficial. Further, our data support the idea that independent learning alone is not as effective as a pedagogy utilizing multiple modalities of instruction.

DISCUSSION: THE AMERICAN ASSOCIATION FOR ANATOMY FIDDLES WHILE GROSS ANATOMY BURNS

GROSS ANATOMY IN MEDICAL EDUCATION

AMERICAN ASSOCIATION FOR ANATOMY ('ANATOMY NOW' HAS ZERO ARTICLES ON THE DECLINE as of 02/2023)