JIAMSE

Journal of the International Association of Medical Science Educators

---

Volume 18 Number 1 2008

Medical Students Reaction to Competency-Based Curriculum

Human Spirituality and End-of-Life Care

Learner-Centered Strategies – A Webcast

MS4 Students as PBL Tutors

Computer-Based Examinations in Histology

IAMSE on the Web
www.iamse.org

ISSN: 1550-8897

JIAMSE

The Journal of the International Association of Medical Science Educators

Volume 18 **Number 1** **2008**

Message from the President

Edward P. Finnerty, Ph.D.
President, IAMSE

As we approach our 12th annual meeting this July, I am delighted by the vitality of IAMSE. This is because of the membership and their energy and involvement in the association. The meeting this year in Salt Lake City will mark a new milestone in our development. This year we will incorporate the former ‘Slice of Life’ group into our fold. This group, in which many IAMSE members were also involved, will bring a strong technology perspective to our family. In addition, the Team Based Learning group will be a part of our IAMSE meeting. The TBL group represents another instructional strategy that fits well within our mission of “…sharing current and innovative means to teach the sciences fundamental to medicine and health”. These new additions to our meeting program are built upon the successful relationship we have had for some years with the Pathology educators, GRIPE. The 2008 Program committee has worked diligently to meld all of these into an engaging and productive gathering. We certainly hope all of you will be with this July. Check out the meeting program for details (www.iamse.org/conf/conf12/index.htm)

Also occurring at the Salt Lake meeting will be the installation of our new board members following the Spring election. We are excited to introduce the new members to the Board: Peter de Jong, Kathryn McMahon, Mathew Gwee, Ferhan Girgin Sagin and William Jeffries. They will join the re-elected members: Veronica Michaelsen, Jack Strandhoy, Peter Anderson, and Bruce Newton as well as the current members: Mark A.W. Andrews, Deborah Barr, Floyd Knoop, Susan Pasquale, Frazier Stevenson and John Szarek, Ph.D. They along with the rest of the Board will provide our leadership for the coming years. The new officers will be elected from the Board at the meeting in July. Deserving special thanks go to the ‘retiring’ Board members Sheila W. Chauvin, Jerome Rotgans and Giulia A. Bonaminio, our Past president.

In addition to the changes in the Board and officer selection process, the meeting this July will bring my term as President to an end. As I look at where IAMSE is today, I am filled with pride. We have seen an energy and enthusiasm in our membership through activities and projects of the committees that bodes very well for our future. We have been invited to participate and contribute with a number of other medical education groups, including: AMEE, AAMC, AACOM, CGEA and The Generalists in Medical Education. These collaborations have fostered interactions with other groups as well, such as the Alliance of Clinical Educators. Our project, Flexner Revisited, examining the role and value of the basic sciences in medical education, has increased our credibility and visibility tremendously. We have developed a long relationship with our sister organization, AMEE, and through that have established a presence in Europe. The Essential Skills for Medical Educators (ESME) program, which we offer as part of our annual meeting, is testimony to this collaboration. Building on this international theme, we are well on our way to what looks to be a very exciting IAMSE meeting in Leiden, The Netherlands, in 2009. I addition to a European perspective, we have developed relationships and a presence, again through our active members, in the Middle East and Asia.

Our committee structure has served us well as a vehicle for member involvement. Through their activities, we have developed a collaboration to promote and develop new features for the HEAL resources, which will be showcased at the July meeting in Salt Lake City. Our Webcast audio seminar series has continued to be a success. The Membership and Development committees have initiated some important projects that will be of benefit and enjoyable for all. Note that we are going to once again have the ‘silent’ auction at the Annual meeting with the proceeds to be used for travel support for junior faculty. We will have several award recipients to be recognized for their contributions and excellence as medical educators. Our Journal, JIAMSE, has initiated several changes with the publication of supplemental theme issues. Further, the Editorial and Publication committee are continuing their quest for indexing of the Journal.

As you can see, we have accomplished much and are more than meeting our mission of advancing “medical education through faculty development and to ensure that the teaching and learning of medicine continues to be firmly grounded in science”. Most importantly, none of this could occur without the commitment, efforts and energy of all of those who are IAMSE. We have much to be proud of and even more to do.

Thank you for the opportunity to serve as your President for the past two years- it has been a pleasure and an honor. I am looking forward to seeing all of you at the 12th Annual IAMSE meeting in Salt Lake City this July.

Message from Editor-in-Chief

Uldis N. Streips, Ph.D.

Editor-in-Chief

It is a great pleasure for me to welcome you to volume 18-1 of the Journal of the International Association of Medical Science Educators. This is another robust volume featuring 2 short communications, and 4 articles, which all advance the knowledge in the broad field of medical education. They also illustrate how you can easily interact with this journal for publication of your unique findings in medical education and pedagogy. I am also very pleased that this issue initiates the Case Studies in Medical Education. We will present typical case scenarios which illustrate common problems in medical education. This will be an interactive part of the Journal. Once you have read the case, and if you have a solution or an opinion, please submit it to me as a Letter to the Editor. It will be peer-reviewed and, if accepted, will be published in the next supplement to the journal and will be part of your educational publication portfolio.

Also, if you have interest in becoming an active participant in our journal author collegium, come to the IAMSE meeting in Salt Lake City in July and take part in the workshop on publishing or the session on publication at this meeting. If you choose to take advantage of these opportunities, make sure you bring a laptop as well as any ideas you wish to turn into publication or papers you have already initiated and want our editorial board to examine at the meeting. See you in Salt Lake.

Uldis N. Streips, Ph.D.
Editor-in-Chief, JIAMSE

SHORT COMMUNICATION

An Innovative Course to Introduce Human Spirituality and End-of-Life Care

Kathryn N. Huggett, Ph.D.[1], Marcia Shadle-Cusic, M.A., M.S.[2], Marilyn Crane, M.S.[1],
Amanda S. Lofgreen, M.S.[1], William B. Jeffries, Ph.D. [1]

[1]Office of Medical Education
[2]Office of the Chaplain
Creighton University School of Medicine
2500 California Plaza
Omaha, NE 68178 USA

Phone: (+)1-402-280-2826 Fax: (+)1-402-280-2046 Email: kathrynhuggett@creighton.edu

---

ABSTRACT

Growing attention to end-of-life care has fostered innovation in medical education. We describe an effective model to introduce third-year medical students to principles of end-of-life care, and spirituality and faith traditions in the care of the dying. Many aspects of the curriculum are adaptable for use at other medical schools.

Growing attention to end-of-life care has inspired curricular innovation and change in medical education. Traditionally, medical school curricula advanced curative principles of care. Over the past decade, health professionals, patients, and families have recognized the need to improve care during the final stages of illness. This movement resulted in calls to improve physician education in end-of-life care, including the Institute of Medicine's seminal 1997 report, *Approaching Death.*[1]

To ensure U.S. medical schools address end-of-life care, the Liaison Committee for Medical Education (LCME) "Functions and Structure of a Medical School" provides the following mandate:

> ED-13 Clinical instruction must cover all organ systems, and include the important aspects of preventive, acute, chronic, continuing, rehabilitative, and end-of-life care.[2]

Medical schools have responded by introducing coursework and experiential learning activities. A 2004 review of teaching and learning in palliative care documented considerable variation in curricula and methods.[3] Examples include an intensive, one-day, classroom-based intervention; an interdisciplinary workshop; third-year clerkship experiences; and a student-initiated, elective preceptorship.[4-7] In this paper we describe another variation, an innovative, required course to address end-of-life care and human spirituality.

In 2003, Creighton University School of Medicine introduced Dimensions of Clinical Medicine (DCM): Palliative Care. This half-day course module is required for third-year medical students. The module is part of the Dimensions of Clinical Medicine interclerkship course, and occurs during students' third clerkship**.** DCM began in 2002-2003, and has proved effective for presenting clinically relevant content to third-year students.[8] Consistent with adult learning principles, the course offers students knowledge and skills when they are most likely to need them, i.e., during their first clinical year.[9] The palliative care module was revised in 2006 to also explore how faith and spirituality affect perceptions of death and care of the dying. The course goals reinforce our medical school's institutional values. As a Jesuit Catholic medical school, Creighton University School of Medicine is committed to providing compassionate care of the whole person. This value, known as *cura personalis,* is a hallmark of Jesuit education. *Cura personalis* emphasizes concern for the whole person and dedication to promoting human dignity.[10]

The course is organized around seven objectives (Table 1). The session begins with an overview presented by the Medical Director of Palliative Care Services for the region's largest healthcare system. The presentation reviews the historical origins of palliative care, highlights differences between curative and palliative care, and describes the physician's role in palliative care. Next, students view "The Way We Die: Listening to the Terminally Ill," an award-winning video featuring interviews with patients, family members and doctors.[11] Afterwards, the hospital chaplain facilitates a reflection on the dying.

Table 1. Dimensions of Clinical Medicine: Human Spirituality, Palliative, and End-of-Life Care Learning

After participating in the Dimensions of Clinical Medicine Human Spirituality, Palliative, and End-of-Life Care sessions, students will be able to:

1. Discuss 3-4 objectives of palliative and end-of-life care that might guide a hospice or healthcare team.
2. Describe examples of effective patient and family involvement in end-of-life decision-making.
3. Paraphrase 3-4 common questions about palliative and end-of-life care asked by patients and their families.
4. Describe examples of different faith traditions and propose how these might affect the needs of patients and families.
5. Discuss the role spirituality can play in the life of a person receiving palliative or end-of-life care.
6. Generate a list of 3-4 palliative and end-of-life care resources for student and patient use.
7. Describe the life cycle and explain how death and dying are a part of the life cycle.

The next activity is the Faith Traditions Panel. The panelists, representing multiple faiths, describe beliefs and customs and their significance to patients, families, and health professionals. Two small group sessions follow, and panelists serve as facilitators. The course concludes with the session "The Impact of Spirituality upon the Death of a Child" presented by a pediatric oncologist. Following the course, students critique resources such as publications or multimedia presentations. The objective is to ensure students reflect on the course and the questions that patients and families pose about end-of-life care.

To investigate the effectiveness of the revised course, we examined data from evaluations and pre- and post-course assessments. The Creighton University IRB granted exempt status for this investigation. We used a web-based education management tool to administer the 12-item course evaluation (Table 2). The seven-item pre- and post-course assessment was constructed for the course. Five items asked students to self-assess their knowledge of covered topics. Two items assess student attitudes toward two fundamental principles of palliative care. Both instruments included open-ended questions to probe for prior knowledge and experience and inquire about topics of interest (Table 3).

For both academic years 2006 and 2007, students indicated satisfaction with the revised curriculum and overall experience with the course (Table 2). The highest rated item was "The facilitators were helpful to my learning" (3.98, 4.22). The lowest rated item, "The time allotted for this program was about right" (3.67, 3.96), may be better understood by examining student comments. Some noted that valuable discussions were curtailed due to time constraints, and others requested more time with the faith traditions panelists. For both years, the discussion of religious and cultural issues was the most frequently cited topic in evaluation comments.

Table 2. Mean ratings of course evaluation data for 2006-2007 and 2007-2008 where 1 = *strongly disagree* and 5 = *strongly agree*.

	2006-2007*		2007-2008†	
Item	Mean	SD	Mean	SD
The panel was helpful to my learning.	3.83	.92	4.03	.82
I was pleased with what I learned in this program.	3.90	.77	4.11	.71
This program was well designed and organized.	3.90	.82	4.13	.63
The goals for the program were clear.	3.89	.89	4.07	.67
The time allotted for this program was about right.	3.67	.95	3.96	.80
This approach was an effective format for learning about this aspect of Dimensions of Clinical Medicine.	3.75	.85	4.04	.71
The facilitators were helpful to my learning.	3.98	.80	4.22	.72
What I learned from this program will help me in future clerkships.	3.92	.76	4.04	.73
I had adequate opportunity to participate.	3.83	.75	4.07	.72
I recommend offering this program to next year's Year 3 medical students.	3.79	.89	4.03	.80
The program followed a logical sequence.	3.85	.84	4.15	.63

* N = 123
† N = 120

We compared results from the pre- and post-course assessments using paired-samples *t*-tests. We detected statistically significant gains in student knowledge after completing the session (Table 3). Learning outcomes measured by the pre- and post-course assessment were analyzed using Cohen's d statistic to calculate the effect size (ES).[12] For this matched pair analysis, the effect size was calculated by using the *t* score and dividing it by the square root of the degrees of freedom.[13] By convention, an ES of 0.2 indicates a small, 0.5 a medium, and 0.8 a large effect. For both years, several items produced a large effect, with the largest effect detected for the items "I am aware of spiritual traditions regarding palliative and end-of-life care…" (ES .95, 1.64); "I am knowledgeable about the objectives…" (ES .82, 1.14); and "I have sufficient knowledge to discuss end-of-life issues…" (ES .78, 1.23).

We were pleased that students reported gains in their knowledge for all learning objectives, including the two new objectives addressing faith traditions and human spirituality. We were interested to observe that some student' attitudes toward the role of a physician with a dying patient changed after this brief course. We hypothesize that the non-significant changes, where items had an ES less than .20, reflect students' prior knowledge and beliefs.

Table 3. Results of Pre- and Post-Course Assessment for 2006-2007 and 2007-2008 where 1 = *strongly disagree* and 5 = *strongly agree*.

	Year	Pre Mean	Post Mean	*t**	Cohen's *d*
I am knowledgeable about the objectives for palliative and end-of-life care.	0607	3.35	4.02	8.63†	.82
	0708	3.28	4.07	10.24†	1.14
I am knowledgeable about treatment options.	0607	3.01	3.68	7.09†	.67
	0708	2.98	3.73	9.29†	1.08
I have sufficient knowledge to discuss end-of-life issues (e.g., making decisions about care) with patients and their families.	0607	2.72	3.48	8.20†	.78
	0708	2.65	3.60	9.82†	1.23
I am aware of spiritual traditions regarding palliative and end-of-life care that differ from my own tradition or experience.	0607	2.95	3.81	10.01†	.95
	0708	2.72	3.89	12.90†	1.64
I have sufficient knowledge to discuss issues of spirituality with patients and their families.	0607	2.93	3.57	6.55†	.62
	0708	2.85	3.65	9.26†	1.05
There are times when a physician will need to say "There is nothing more that can be done."	0607	3.10	2.91	1.58	.15
	0708	3.27	3.22	.38	.04
I believe physicians should honor the wishes of the patient even when these wishes conflict with those of the family.	0607	4.30	4.25	.73	.07
	0708	4.04	4.31	3.14	.35

Note. N = 112 for 0607 and 113 for 0708
* Paired Samples *t*-test
† p <.01

Students were satisfied with the course, and in particular, with presenters and facilitators. This is important because the presenters were selected by the course directors for their expertise and experience. With one exception, all were invited from outside the university. Positive student feedback is valuable for course planning and also for sharing with the presenters who take time from their professional practice to participate. Student'requests for additional small group time suggests they find the course content interesting and deserving of extra time for discussion.

Two limitations should be noted. First, data are available for two years only. Although evaluation data from previous years are available, the curriculum changed after 2005, impeding meaningful longitudinal comparisons. Second, the pre- and post-course assessment instrument has not yet been formally validated.

The DCM: Human Spirituality, Palliative, and End-of-Life Care course differs from other approaches described in the literature. This course is required, occurs during the third year of medical school, addresses spirituality, and incorporates small group discussions and a panel presentation. Unlike many courses that draw upon psychiatry faculty, this course includes presenters with expertise in palliative medicine and pediatric oncology. In addition, respected community members are invited to participate.

Our findings suggest that this course is an effective model for teaching medical students about end-of-life care and human spirituality. The curriculum successfully introduced students to new perspectives and accounted for significant knowledge gains. Changes in student attitudes were modest but suggested the course provided new information that fostered reflection on current beliefs. We believe many aspects of the curriculum are adaptable for use at other medical schools.

REFERENCES

1. Institute of Medicine. *Approaching death: Improving care at the end of life*. Washington, DC: IOM, 1997.
2. Functions and structure of a medical school: Standards for accreditation of medical education programs leading to the M.D. degree. (http://www.lcme.org/functions2007feb.pdf). Accessed October 15, 2007. Liaison Committee on Medical Education, 2004 (with updates as of February 2007).
3. Lloyd-Williams, M., and MacLeod, R.D. A systematic review of teaching and learning in palliative care within the medical undergraduate curriculum. *Medical Teacher.* 2004; 8:683-690.
4. Clay, M., Jonassen, J., and Nemitz, A. A one-day interclerkship on end-of-life care. *Academic Medicine.* 2001; 76:517-518.
5. Latimer, E.J., Deakin, A., Ingram, C., O'Brien, L., Smoke, M., and Wishart, L. An interdisciplinary approach to a day-long palliative care course for undergraduate students. *Canadian Medical Association Journal.* 1999; 161:729-731.
6. Leslie, B., Adams, L., and Kutner, J.S. Integrating and end-of-life curriculum into the Internal Medicine clerkship. *Journal of Palliative Medicine.* 2002; 5:752-753.
7. Taylor, L., Hammond, J., DiCarlo, R., Karabatsos, G., and Deblieux, P. A student-initiated elective on end-of-life care: A unique perspective. *Journal of Palliative Medicine.* 2003; 6:86-91.
8. Sakowski, H.A., Markert, R.J., Jeffries, W.B., Coleman, R.M., Houghton, B.L., Kosoko-Lasaki, S., Goodman, M.D., Rich, E.C.: Dimensions in Clinical Medicine: An interclerkship program. *Teaching and Learning in Medicine*. 2005;17(4): 370-375.
9. Knowles, M.S. The adult learner. *Woburn, MA: Butterworth-Heinemann,* 1988.
10. Traub, G.W. Do you speak Ignatian? A glossary of terms used in Ignatian and Jesuit circles. *Cincinnati, OH: Xavier University,* 2004.
11. "The Way We Die: Listening to the Terminally Ill," Jonathan Mednick. *Fanlight Productions*. 1995.
12. Cohen, J. Statistical power analysis for the behavioral sciences. *New York: Academic Press,* 1977.
13. Rosenthal, R., and Rosnow, R. Essentials of behavioral research: methods and data analysis. *New York: McGraw Hill*, 2008.

SHORT COMMUNICATION

The Efficacy of Three Anatomy Instructional Tools: 2D Images, 3D Images, and Models/Prosected Specimens

Donna Newhouse, H.B.P.E., M.Sc., Ph.D. Candidate

Lakehead University
Faculty of Education
Northern Ontario School of Medicine
955 Oliver Road
Thunder Bay, Ontario P7B 5E1
Canada

Phone: (+)1-807-766-7387 Fax: (+)1-807-766-7362 Email: donna.newhouse@normed.ca

ABSTRACT

This study determined efficacy (bellringer exam scores) of three anatomy instructional tools: 2D images, 3D images, and hands on models & prosected specimens (HO). Eighteen undergraduate students participated in this prospective, cross-over controlled, single-blind study. After analysis there was no strong pedagogical evidence to support one instructional tool over another.

The purpose of this study was to determine the efficacy of three anatomy instructional tools: 2D images, 3D images, and hands on models and prosected specimens. This specific question is couched in the broader question of how best to teach gross anatomy. The significance of this line of research has grown dramatically as the capability of computing and communicating techniques to deliver high quality learning experiences to a diverse audience is one of the most promising aspects of computer assisted learning (CAL).[1]

This diverse audience may represent distance learners around the world. At Lakehead University, for example, distance education (DE) courses have grown from 52 courses (1700 registrants) in 2000 to 139 courses (4800 registrants) in 2007[2]. Fuelling this growth is the assumption that high tech 3D graphics or easily accessible 2D graphics have great educational value in gross anatomy instruction, but little evidence exists to support that contention. There is a critical need to test that assumption. Medical educators are facing important decisions about the use of instructional materials (i.e. cadavers, skeletons, plastic models, computer models, and atlas illustrations) and some of these decisions are being based upon financial and accessibility merits. This study brings the pedagogical merits into greater focus. If 2D and 3D images are empirically proven to be as good or better tools for increasing student understanding of human anatomy, then medical educators can embrace this trend to CAL and DE. If 3D images impede learning in some individuals, then this type of learning tool needs cautious application or minimized inclusion in curricula.

Experimental studies examining learning modes in anatomy are limited. Fourteen such studies were identified in the literature and these are summarized (along with the current study) in Table 1. Observations of note include:

- There is no clear evidence that CAL is significantly better than traditional methods
- Although the majority of results favor computer assisted technology, methodological concerns have compromised conclusions drawn. Strength of evidence has been hampered by; a) not controlling or monitoring study time involved with each learning medium[3], b) allowing students to self select their treatment group[3,4] and c) measuring improvement scores when the pre and post tests are quite different.[5]
- Many of the media-comparative studies were of limited value as the critical elements separating the two forms of instruction were not identified.
- The four studies by Garg and colleagues,[6-9], as well as Levinson[10] suggest that multiple views of anatomical images may actually impede learning in students with low spatial ability.

Table 1.

Authors	**Participants**	**Design**	**Independent variables**	**Dependant variables**	**Results**
Devitt & Palmer, 1999[11]	90 2nd yr Med students	4 group, random, stratified, pre-post, 2 wks of study	3 computer assisted modes: problem based, didactic, free text & 1 control	Multiple choice & essay questions on anat/phys of biliary system	Didactic signif better
Garg, Norman, & Sperotable, 2001[8]	146 Med students, 23 yrs, 50% women, 92% rt handed, 10 hrs/wk comp. use	Random, single blind, 2 group, 9 min of study	Student controlled MV vs KV	Spatial knowledge of carpal bones w 50 mult choice questions	High spatial ability and self directed MV improves spatial learning
Garg, Norman, Spero & Maheshwari, 1999[6]	41 female, 23 male anat students, 14 hrs/wk computer use	Random, single blind, 2 group, 90 min of study	KV vs MV	Spatial knowledge of carpal bones w 50 mult choice questions	Men have more computer use & spatial ability. MV had no instructional adv.
Garg, Norman, Eva, Spero & Sharan, 2002[9]	87 1st yr Med students	Random, single blind, 2 group, 9 min of study	Student controlled MV vs KV+ wiggle	Spatial knowledge of carpal bones w 50 mult choice questions	Baseline dif (MV play more 3D computer games, higher spatial, lower writing ability. After controlling for spatial ability, no dif btw groups
Nicholson, Chalk, Funnell & Daniel, 2006[12]	57 1st yr Med students	Random, 2 group ~ 20 min tutorial	Computer 3D vs control (2D)	Length of study time, 15 quiz questions on ear anatomy	3D studied longer and scored better
Garg, Norman, Spero & Taylor, 1999[7]	33 male & 16 female 1st yr Med students	Random, single blind, 2 group, 90 min of study	MV vs KV	Spatial knowledge of carpal bones w 36 mult choice questions	No baseline dif, males higher spatial ability, no dif btw groups
Hariri, Rawn, Srivistava, Youngblood, & Ladd, 2004[13]	29 1st yr Med students	Random, 2 group, 10 min of study	Computer simulator vs textbook	Anatomy knowledge of shoulder joint w 7 identification questions, perceptions of learning experience	No dif btw groups on knowledge, perceptions favored simulators

Pandey & Zimitat, 2007[14]	97 Med students	Correlation	Perceived successful learning vs own approaches to learning	Memorization, understanding & visualization	+ve corr. btw approach to learning and quality of learning
Askell-Williams & Lawson, 2006[15]	7 3rd yr Med students	In-depth interviews about learning	Dimensions & profiling of student responses	NUD*IST test analysis and correspondence analysis	Cognitive models about learning are complex and highly differentiated
McNulty, Halama & Espiritu, 2004[16]	130 1st yr Med students, 47% female	Correlation	Requests for CAI, correl btw grades and CAI use	Utilization data of web based computer aided instruction (CAI) over 2 yrs	Requests for CAI increased, signif corr. btw usage and CAI use
Levinson, Weaver, Garside, McGinn & Norman, 2007[10]	1201st yr Psych students	Random, 2 phases w 4 conditions in phase 1 & 2 conditions in phase 2	Phase 1: 1) learner controlled (L)MV, 2)LKV, 3) program controlled (P)MV, 4) PKV Phase 2: low LKV vs no KV	30 item post test on brain surface anatomy identification	PKV was best and PMV worst. Low spatial ability = 20% lower scores. No dif in phase 2
Hallgren et al. 2002[4]	107 1st yr Med students	3 groups self selected No pre-test	Web-based anatomy inst tool vs intro only vs no treatment	Student achievement on mid and final exams	Web-based did better
Schoenfeld-Tacher et al. 2001[3]	44 upper level Sci students in Histology course	2 groups self selected into online or on campus course sections	On-line vs on-campus instruction	Student achievement final exam, types of interactions	On-line did better and had higher level interactions
Cotter, 1997[5]	242 Med students in Histology course	Random, 2 groups, not blinded	Computer assisted vs control	Student attitude, quiz scores,	Attitudes positive towards CAL, CAL scored better
Newhouse, 2008	18 1st & 2nd yr Kinesiology & Biology students	3 grps, random, single blind, cross-over controlled, 3X1 wk lab units	3 lab modes: hands-on models, 2D and 3D images	Scores on post unit bellringer exams	No difference btw modes

MV= multiple views, KV = key views

- Apart from the current investigation, no study has employed a cross-over design. A cross-over design allows each participant to serve as their own control, thus neutralizing the effect of differing levels of motivation, aptitude and background knowledge.
- The current study was also somewhat unique in using actual course test scores as the dependant variable. This has the dual advantage of promoting a consistent high level of motivation in the participants and applying the

research question to a “real life” setting (i.e. increasing external validity).

After ethics approval, 18 of 25 students enrolled in an undergraduate level Human Anatomy course at Lakehead University consented to participate in the study. Students received 6 hours/week of lecture instruction and 4 hours/week of laboratory time. Data was obtained during the laboratory bellringer exam of the MSK system at the end of each three one week units (head & neck, upper extremity, and lower extremity). No diagnostic images (i.e. CT or MRI) were used. A bellringer exam is a circuit that requires students to identify in writing various tagged anatomical structures at stations in a specified amount of time.

The 3D images used in this study were high resolution stereoscopic images viewed with stereoscopic glasses. Students were unable to manipulate the images. These images were from the Bassett collection of prosected cadaver specimens and bones which were housed on the Stanford University server.

The 2D images were the same prosected cadaver specimens and bones from the Bassett collection but the images were NOT viewed stereoscopically.

The prosected specimens of the limbs were dissected so that students could observe superficial and deep structures of the MSK system. Natural human bones of a disarticulated skeleton were used as well as high quality SOMSO© plastic models to illustrate the various bones and muscles of the MSK system.

Participants were randomly assigned to one of three groups in unit 1 with subsequent treatment placements as noted in Table 2:

Table 2.

Unit 1: MSK Head & Neck		Unit 2: MSK Upper Extremity		Unit 3: MSK Lower Extremity
HO	→	2D	→	3D
2D	→	3D	→	HO
3D	→	HO	→	2D

Placement into groups was done in a blinded manner whereby the Principal Investigator (who was also the Professor) was unaware of the group assignments. This blinding was maintained throughout the course because the Professor, while providing the lecture material, was not present during the laboratory periods. This also allowed all marking to be done by the Professor without potential bias.

All students wrote three separate (HO, 2D and 3D) bellringer exams at the end of each unit. The material in each exam was identical except for the mode of presentation. Each exam consisted of approximately 11 stations with 4 structures to identify at each station and the time allocated to each station was 2 minutes in duration.

Students only had access to the learning materials during their scheduled laboratory times. Supplementary studying, differing motivational levels and learning preferences were not specifically controlled for, however, with the crossover design each student becomes their own control, thus greatly limiting these confounding variables.

All data analysis was performed using SPSS. In studies with crossover design such as in this study it is important to test for a carry-over effect, i.e. to see if a learning effect confounded the scoring in subsequent units. Armitage and Hills[17]also refer to this effect as the "treatment by period" interaction, where "treatment" is the factor representing the HO, 2D, or 3D treatment groups and "period" is the factor representing each of the three units. Prior to testing for the carry-over effect test scores were standardized across units so that the mean score in Units 1,2, and 3 were identical. Individual scores were further transformed to use relative instead of absolute scores. This was accomplished by using change scores relative to individual overall means. The carry over effect was assessed by doing three one-way ANOVAs (i.e. HO at T1 vs HO at T2 vs HO at T3 and then again with 2D and then 3D treatments). Because there were no significant differences with these ANOVAs the carry-over effect was dismissed; justifying pooling of the data across the units. The pooled data was analyzed using a 3X1 ANOVA with an n of 18 in each treatment group.

When assessing a carry-over effect, there was no significant differences between Units for HO, 2D, or 3D treatments (p=.69, p=.58, and p=.07, respectively). This permitted the pooling of data to allow 18 participants in each treatment group. A 3x1 ANOVA between treatment groups found no significant difference as shown in Tables 3a, 3b and Figure 1.

Table 3a. Descriptive Statistics of Pooled Change Scores for the Three Treatments

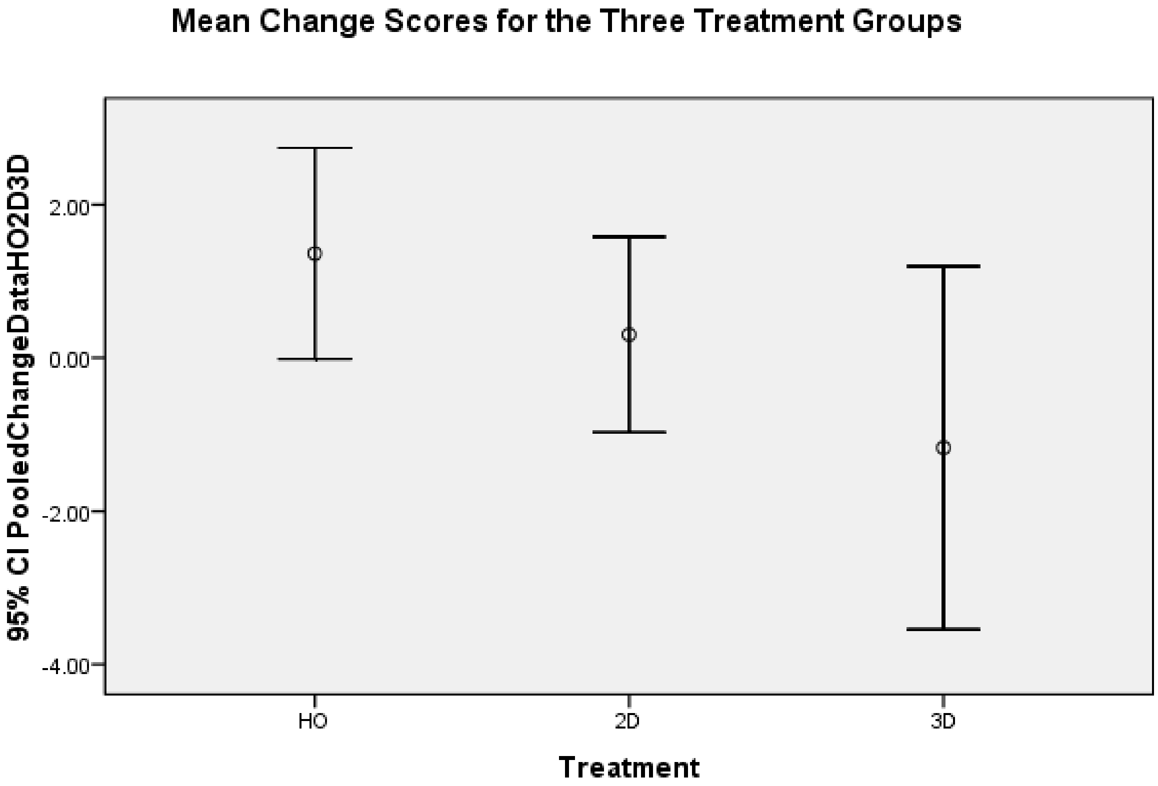
	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
HO	18	1.3609	2.76643	.65205	-3.27	6.84
2D	18	.3028	2.56265	.60402	-4.87	5.62
3D	18	-1.1725	4.76423	1.12294	-10.32	10.63
Total	54	.1637	3.59741	.48955	-10.32	10.63

Table 3b. ANOVA Table for Pooled Change Scores for the Three Treatments

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	58.282	2	29.141	2.368	.104
Within Groups	627.610	51	12.306		
Total	685.892	53			

At face value, this study demonstrates that the use of HO, 2D and 3D anatomy laboratory instruction tools results in roughly similar learning outcomes. A more guarded interpretation of the results may be warranted. It should be kept in mind that this study used undergraduate students in Kinesiology and Biology programs and similar results may not be seen with different learners of different ages. For example these results may not be seen in a more rigorous and comprehensive graduate level course. In addition, test scores on a purely “identify structure” bellringer exam are not the only learning outcomes that could or should be measured in weighing the merits of an anatomy laboratory instructional tool. Methodological limitations should also be considered. Although the cross-over protocol adds strength to the design as each participant serves as their own control, it would be interesting to replicate this study with larger student numbers. The variance in the results also points to the probability that the assets of instructional modalities are learner-dependent. Certain learners may indeed have a preference and aptitude for certain instructional modalities. The work of Garg and colleagues,[6-9] as well as Levinson and colleagues[10] suggest that multiple views of anatomical images may actually impede learning in students with low spatial ability. Spatial ability should thus be an important consideration in designing future studies. It would also be worth exploring the p = .07 finding of this study when doing the ANOVA across units on the 3-D treatments. While p = .07 is not significant, and thus allowed pooling of participants, the treatment by period interaction hints of a more complex relationship between 3-D treatment issues (e.g. spatial ability of the learners) and unit issues (e.g. particular anatomy content or a learning effect from one unit to the next). With these considerations in mind, there is a sense that researchers are just beginning to scratch the surface on assessing the merits of HO, 2-D or 3-D images as anatomy laboratory instructional tools. On the basis of this study though, there are no discernable advantages of one mode over the other.

Figure 1. Mean Change Scores for the Three Treatment Groups



HO=Hands On. 2D = 2D Images. 3D = 3D Images

REFERENCES

1. Florance, V. Better health in 2010: Information technology in 21st century health care, education and research. Association of American Medical Colleges. 2002.
2. Lakehead University, Office of Institutional Analysis, 2007.
3. Schoenfeld-Tacher, R., McConnell, S., and Graham, M..Do no harm-a comparison of the effects of on-line vs. traditional delivery media on a science course. *Journal of Science Education and Technology*. 2001; 10(3): 257-265.
4. Hallgren, R.C., Parkhurst, P., Monson, C., and Crewe, N. An Interactive Web-based tool for Learning Anatomic Landmarks. *Academic Medicine*. 2002; 77(3): 263-265.
5. Cotter, J.R. Computer-assisted Instruction for the Medical Histology Course at SUNY at Buffalo. *Academic Medicine*. Vol. 72, No. 10, Oct. 1997.
6. Garg, A., Norman, G., Spero, L., and Taylor, I. Learning anatomy: do new computer models improve spatial understanding? *Medical Teacher*. 1999; 21(5): 519-522.
7. Garg, A., Norman, G., Spero, L., and Maheshwari, P. Do virtual computer models hinder anatomy learning?. *Academic Medicine*. 1999; 74(10) Suppl: S87-S89.
8. Garg, A., Norman, G., and Sperotable, L. How medical students learn spatial anatomy. *The Lancet*. 2001; 357(2): 363-364.
9. Garg, A., Norman, G., Eva, K., Spero, L., and Sharan, S. Is there any real virtue of virtual reality? The minor role of multiple orientations in learning anatomy form computers. *Academic Medicine*. 2002; 77(10) Suppl: S97-S99.
10. Levinson, A.J., Weaver, B., Garside, S., McGinn, H., and Norman, G.R. Virtual reality and brain anatomy: a randomized trial of e-learning instructional designs. *Medical Education*. 2007; 41: 495-501.

11. Devitt, P., and Palmer, E. Computer-aided learning: an overvalued educational resource? *Medical Education*. 1999; 33: 136-139.
12. Nicolson, D.T., Chalk, C., Funnell, W.R.J. and Daniel, S.J. Can virtual reality improve anatomy education? A randomized controlled study of a computer-generated three dimensional anatomical ear model. *Medical Education*. 2006; 40: 1051-1057.
13. Hariri, S., Rawn, C., Srivastava, S., Youngblood, P., and Ladd, A. Evaluation of a surgical simulator for learning clinical anatomy. *Medical Education*. 2004; 38: 896-902.
14. Pandey, P and Zimitat, C. Medical students' learning of anatomy: memorization, understanding and visualization. *Medical Education*. 2007; 41: 7-14.
15. Askell-Williams, H. and Lawson, M.J. Multidimensional profiling of medical students' cognitive models about learning. *Medical Education*. 2006; 40: 138-145.
16. McNulty, J., Halama, J, Dauzvardis, M., and Espiritu, B. Evaluation of Web-based Computer-aided Instruction in a Basic Science Course. *Academic Medicine*. 2000; 75: 59-65.
17. Armitage, P., and M. Hills. The two-period crossover trial. *The Statistician*. 1982; 31(2):119-131, 1982.

.

MEDICAL EDUCATION CASE STUDY

The case of the "Missing Feedback"

Kathryn K. McMahon, Ph.D.

Department of Medical Education
Paul L. Foster School of Medicine
Texas Tech University Health Sciences Center
5001 El Paso Drive
El Paso, TX 79905 USA

Phone: (+)1-915-783-1700 Fax: (+)1-915-783-1715 Email: kathryn.mcmahon@ttuhsc.edu

At Northern U School of Medicine the faculty has been "asked" to write a higher percentage of exam questions that follow the National Board style where a short clinical vignette is followed by a question with 5 to 10 optional independent answers to chose from. Each question is to have a single correct answer. The answer set is not to have "None of the Above", "All of the above", combinations of two or more of other answer options or other forms of "K-type" variations. Many of the basic science faculty who teach in the "pre-clinical" curriculum feel very uncomfortable about how to write the vignettes and many faculty members, clinicians and basic scientists alike, find it hard to come up with good answer tests for many of the questions they write. Because of heavy demands on their time, the administration (the Curriculum Office) agreed to facilitate the development of a Question Bank with the long term goal of collecting a large assortment of validated questions for faculty to pick from rather than having to write new questions from year to year. To begin to establish this Question Bank it was decided that students of the current year would not be able to see exams except in the testing times.

In the past students could either get copies of the exam questions after the exam was finished or at least be able to view the exam again at some point after the testing time. While allowance to review the exam was designed to allow the students one additional learning opportunity, what was happening was that students handed down exams from one academic year to the next class of students. This practice therefore required the faculty to write new questions every year for all exams.

If a Question Bank was going to be developed, the student practice of "passing down" questions would have to be stopped. The faculty decided the quickest way to develop the Question Bank was to make it so that there would be no opportunity after the scheduled testing period for students to again see the questions. So this year they changed the policy and no courses are to allow any student to see exam questions at any time other than during the test session.

The students are outraged! They spoke strongly that they felt this significantly limited a wonderful learning opportunity. They, by way of the classes' officers, sent an e-mail to the Dean asking that he intervene and override the faculty's decision. What should he do? What is your opinion of the faculty's need and the students' needs in this situation?

Student's Response

Medical school has redefined the word “busy” for me. I find that I work harder and longer now than I ever did during 4 years of engineering study or 10 years as a chemical engineer at a major oil and gas corporation. I understand that medical school is exhausting for faculty as well as students, so I can sympathize with professors who are concerned that the practice of passing down old exams will place extra demands on their time. However, the mounting demands on my time as a student and the pressure to pass National Board exams make it imperative that my study time be as focused and efficient as possible. Being able to review my tests in detail allows me to direct my effort to the right areas and correct any misconceptions I might have had.

Whether you like the term "High Yield" or not, I have come to learn that the phrase has definite application in medical education. Information comes at us by the truck-load with only an evening to digest it, understand it, commit relevant parts to memory, and then prepare for the next day's load. I'm a bit embarrassed to admit that many days go by when I don't even have time to read the textbooks – I may have 4 or 5 power point presentations (each with 60 or so slides) to review from daily lectures, which only leaves time for looking at pictures and tables in the text or for reviewing a board exam preparation book. Given these constraints, when I take a medical school exam I need to know whether or not I have mastered the topics being taught.

In academic circles I hear the words 'summative' and 'formative' used quite often to describe exams. While I know these two words have good qualifying purpose, they get away from the layman's term that describes the real purpose of medical school exams: feedback. If an exam score is all that is provided and that score is anything less than 100%, then it is obvious that concepts are going unmastered, but which ones? Perhaps I am aware that there is a specific fact I do not know, but there is also the possibility that I believe I understand when I really do not.

When I was working as an engineer we had a common practice when a more seasoned engineer was teaching a younger colleague: after the teaching was done, the mentor would then erase what was drawn on the board and hand the chalk to the mentee and say "Now, explain to me everything we just talked about." This was the test, and the feedback was immediate! If the concepts were not learned, then time was wasted and even worse, mistakes could be made. Medical school, or for that matter any academic subject, is no different. Honest and open feedback is the only road to improvement, and the teaching is incomplete without it.

In the case of Northern U School of Medicine, the Dean should meet with the faculty and student representatives to discuss the situation. He/she should encourage that group to come up with an innovative way to allow both the educational needs of the students and the long-term objectives of a Question Bank be achieved. This actually could become a win-win situation rather than the disaster that has developed to this point.

Faculty Member's Response

The issue is complex as described. There are enough problems to insure all parties have an equal opportunity to be incorrect in their handling of the issue. There is also ample room for each group to improve the outcome for the benefit of all concerned.

There are a limited number of ways to write a question and once they are used, we will by necessity start repeating old test questions. The best way to prevent this is – don't return the tests. This also prevents students from trying to learn only what will be on the test instead of learning how to be a successful physician.

Problem for the faculty member:

Students have a right to know what is expected from them in a course or in their clinical rotations. A quick review of CurrMIT clearly indicates a practical problem for the student. Objectives written by faculty across the country are: 1) unclear, 2) do not tell the student what and how their knowledge will be measured, 3) frequently fail to describe the depth of knowledge expected, and 4) often omit material that will most likely be included on the exam (and certainly on STEP exams). If these objectives are all students have to direct their study, their desire to see the exam (and old exams given previously by the professor) is obvious. This is the ONLY way the student can determine what is expected. The objectives do little to help the students and in many cases reinforce the student's belief that medical education is a confrontational (us vs. them) learning environment.

Summary:

We are moving in this direction by requiring students and residents to demonstrated competency in required areas. Once again, this requirement MUST be presented to the student clearly, using well written objectives before the course or clerkship starts. Failure to do so is akin to professional misconduct by the faculty and the school. Telling students what is expected from them in a course of clerkship is not only okay – it is ethically required. It is also ethical to require each student to demonstrate their ability to perform in real life situations. This goes far beyond getting a test question correct. It demands the students demonstrate their ability to provide the quality of care needed by society. Requiring students to critically think rather the memorize information is a great starting point. Requiring students to demonstrate the application of critical thinking skills in patient simulators and supervised clinical settings is even better. When this approach is accepted as a primary teaching methodology in medical schools, the issue of returning exams will become a moot point – and we will all be raised to a new level in medical education.

Dean's Response

The faculty and the students each have a valid point. Another aspect of this case is that institutional change always creates angst; students hand down more than exam questions, they hand down experiences and any change in that experience is most often met with skepticism. However, in this case, the faculty has it right if they are to offer the students the highest quality testing experience that they can create.

An effort should be made to get the students to understand that it is the in their best interest to be well prepared for licensing exams, as these exams have a significant impact on their future. Writing questions that are of the same quality as the USMLE questions takes much time and effort. The best questions are reviewed, edited and tested before they enter a permanent question bank. The process of writing good questions and the various rules that apply to their construction should be reviewed with students and the commitment to the students to create high quality tests that will better prepare them for their future should be affirmed.

In addition, the students should be assured that materials to help them prepare for the exams will be made widely available through a learning resource center. There are a variety of review materials for USMLE-type questions and a good array of these should be made available to students. Ideally, a site license for a computer-based test bank for the use of all students should also be purchased and installed for use in such a center.

Respondents

1. Student Respondent – Mr. Jason P. Cooper, MSII, Texas Tech University Health Sciences Center, Lubbock TX
2. Faculty Respondent – Dr. Herb Janssen, Ph.D., Professor, Department of Physiology, Texas Tech University Health Sciences Center, Lubbock TX
3. Dean Respondent – Dr. Dani McBeth, Ph.D. Associate Dean for Student Affairs, Associate Professor of Microbiology & Immunology, The Sophie Davis School of Biomedical Education, The City College of New York, New York NY

Learner-Centered Strategies for the Lecture Hall: an IAMSE Webcast Audio Seminar Series

Niamh Kelly Ph.D.[1], Tom Angelo, Ph.D.[2], Ronald Harden, M.D.[3], Jeanne Schlesinger, M.ED.[4], Stephen C. Ehrmann, Ph.D.[5], Carol Nichols, Ph.D.[6]

[1]Department of Pathology and Laboratory Medicine
227-2211 Wesbrook Mall
University of British Columbia
Vancouver, British Columbia V6T 2B5 Canada
[2]University Teaching Development Center
Victoria University of Wellington,
Wellington 6140 New Zealand
[3]Director of Education
International Virtual Medical School (IVIMEDS)
Tay Park House
484 Terth Rod
Dundee, Scotland, UK DD2 1LR
[4]Virginia Commonwealth University
Richmond, Virginia 23284 USA
[5]The Teaching, Learning, and Technology Group
1 Columbia Avenue
Takoma Park, Maryland 20912 USA
[6]Medical College of Georgia
1120 15th Street
Augusta, Georgia 30912 USA

Phone: (+)1- 604-822-0322 Fax: (+)1-604-822-7635 Email: niamh@interchange.ubc.ca

The delivery of higher education is going through a paradigm shift whereby the straightforward transmission of information, such as occurs in a lecture, is being reconsidered in favor of learner-centered approaches. A previous IAMSE Webcast Audio Seminar series explored the theory behind such Learner Centered Education (JIAMSE **16(2)**:48-54. 2006). The importance of a University education is not merely to acquire more information but rather to receive guidance around how to work with the information available. This is particularly important in this age of information overload where students need to learn how to sift through information; how to organise it; how to evaluate and critically assess it. Small group learning forums, such as problem-based learning, are promoted as learner-centered educational modalities wherein one can work with students to guide them in their acquisition, and use of, pertinent information. However, the lecture hall remains central to our Universities not only as a megalithic structure but, because the lecture remains the most efficient way to reach the increasingly large numbers of students that wish to avail of the teaching and learning environments at our Universities. Hence, the fall 2006 Webcast Audio Seminar series combined the theoretical approach to Learner Centered Education with the lecture delivery modality in examining "Learner Centered Strategies for the Lecture Hall".

Classroom Assessment Techniques: Finding out How Well They are Learning What We are Teaching

The series started with Dr. Tom Angelo, presenting from New Zealand, on *'finding out how well students are learning what we are teaching using classroom assessment techniques'*. Tom is eminently qualified to speak to this topic being a well published author, including his seminal publication entitled: "Classroom Assessment techniques: a Handbook for College teachers" as well as a prolific speaker on this topic. Tom is currently a Professor of Higher education and the director of the University Teaching Center at Victoria University of Wellington in New Zealand. At 6:00 am his time and in less than 50 minutes of our time, Tom helped us to understand what Classroom Assessment (CA) is, how it works, and how it can help our students become more independent, effective learners. He demonstrated with examples of simple, practical classroom assessment techniques that can be adapted to assess students' learning in face-to-face and online settings. At the same time, he reviewed practical guidelines for success – Angelo's seven axioms of classroom assessment – based on nearly two decades of field-testing. If you would like to learn more about assessing your students' learning as an integral part of your lecture delivery please avail of Tom's presentation at: www.iamse.org/development/2006/was_2006_fall.htm

Learning Styles and Teaching Approaches in the Physical and Virtual Lecture Hall

Tom was followed by Professor Ronald Harden, a pioneering educator in the Medical Sciences, who has built an International Medical Program offered entirely online, namely the International Virtual Medical School (IVIMEDS). Ron, a world renowned medical educator, who had just recently been awarded the Karolinska Institute Prize for research in Medical Education, spoke to us from his native Scotland. Ron reminded us of the fact that lectures are neither inherently good nor bad, it all depends on how we use them. In pointing out that 'the easiest trap to walk into is to plan the course of lectures *you* would like to hear' he encouraged us to use classroom assessment techniques that would allow us to find out how well our students are learning what we are teaching (referencing our first speaker, Tom Angelo, in the process). Ron's talk introduced us to a variety of techniques that can be used in delivering lectures that are relevant and interesting to our learners. Information about these can be accessed at: www.iamse.org/development/2006/was_2006_fall.htm.

Say No to Boring Lectures Whether Live or Online

After a break in the series to facilitate attendance at the AAMC meeting, we continued our weekly seminars with Dr. Jeanne Schlesinger exalting us to 'say no to boring lectures, whether live or online'. Jeanne spoke to us from Virginia Commonwealth University where she is the Director of Instructional Development. Jeanne has given many University and national level workshops on public speaking and visual media and she regularly coaches faculty and students on these topics. Acknowledging the challenge that the Webcast Audio Seminar format presented in engaging an audience without the use of facial cues, eye contact, or gesticulations, Jeanne used her own photographs, interspersed amongst the slides, to engage her unseen audience. Jeanne's basic message is that successful lecturing involves being prepared. She exalted us to: know our audience, our content, ourselves; to be real and to use relevant stories/case studies. To view some of Jeannes photography (with images which resonate of Georgia O'Keefe's art), along with her seminar, link to: www.iamse.org/development/2006/was_2006_fall.htm

Evaluation of the Effectiveness of Distance Learning

Dr. Steve Ehrman, vice president of The Teaching, Learning, and Technology Group, and director of its Flashlight Program for the Study and Improvement of Educational Uses of Technology spoke to us on 'evaluation of the effectiveness of distance learning'. Dr. Ehrmann has a Ph.D. in management and higher education from the Massachusetts Institute of Technology and has availed of these qualifications throughout his varied career in focusing on two interdependent themes: (1) how best to use technology to improve education; and, (2) how to use research evidence to inform our use of technology in teaching and learning. Dr. Ehrman challenged us to think about the following questions: "What do students do as they study?" "What do faculty do as they teach?" He pointed out how the answers to these questions help determine what students learn, and what they're able to do after the lectures are over. A second governing assumption that he pointed to, when designing an evaluation of a course or a program, is to ask yourself, "No matter what I find, will my findings help people in the program improve what they're doing and feel better about what they're doing? Will some of what I'm asking be, from their point of view, a waste of time or a threat?" He pointed to the fact that if you want people's collaboration in your inquiry, design the inquiry to help reduce important uncertainties that they are facing. For concrete ideas on how to approach this, view Dr. Ehrman's presentation at: www.iamse.org/development/2006/was_2006_fall.htm

Student's Perspective on Lectures

Dr. Carol Nichols brought the seminar series to a close by inviting students from two medical schools to join her in discussing 'student's perspective on lectures'. Carol, a faculty member in the Department of Cellular Biology and Anatomy at the Medical College of Georgia (MCG), had presented aspects of her study which asked, 'what do medical students really think about lectures', at the 2006 IAMSE annual meeting. For this webcast audio seminar series, Carol invited students from both MCG and the University of British Columbia, in Vancouver Canada, to accompany her on the audio- bridge in discussing student's perspectives on lectures. Carol presented the findings from an MCG survey issued to both freshman and sophomores over a three year span, which asked about their ‘interests, attitudes and approaches to learning’. Survey results indicated that:

- 65% of freshmen and 56% of sophomores think lecturing is an effective teaching method for the basic sciences
- students would like to see more discussion of case studies and more independent learning complement lectures
- students appreciate the use of interactive learning strategies during lecture; and
- students’ asked for teaching expertise in addition to content expertise.

In the lively discussion that followed Carol’s presentation, Ian Becker and Tristan Walker (from UBC) and Shannon Klucsarits and David Heinsch (from MCG) cogently answered questions ranging from students attendance at lectures to how students use lecture material in preparing for the exams. Carol had purposefully left a full 30 minutes to allow for discussion. The time was completely filled with question after question directed to the students in what was definitely the best discussion following any of the seminars in this series. We are grateful to the students for their time and candor in allowing the audience to round out this seminar series with a genuinely leaner centered discussion. To hear the discussion that ensued between the audience and the students go to: www.iamse.org/development/2006/was_2006_fall.htm

Medical Students' Reactions to a Competency-Based Curriculum: One School's Experience

Mary Alice Bell, M.S.[1], Wilma J. Griffin, M.S.[2], James Y. Greene, Ph.D.[3], James J. Brokaw, Ph.D., M.P.H.[1]

[1]Office of Medical Student Affairs
[2]Office of Medical Education and Curricular Affairs
Indiana University School of Medicine
635 Barnhill Drive
Indianapolis, IN 46202 USA
[3]Human Dimensions of Health Care
1074 West Buffalo Road
West Jefferson, NC 28694 USA

Phone: (+)1-317-274-7173 Fax: (+)1-317-274-4309 Email: mbell@iupui.edu

ABSTRACT

In 1999, the Indiana University School of Medicine implemented a competency-based curriculum structured around nine core competencies. The students responded to this new curriculum with minimal enthusiasm. We sought to better understand the student perspective in an effort to improve and refine the competency requirements. Accordingly, early in the 2003-2004 academic year, we established four focus groups (6-10 students per group) to systematically analyze student experiences with the competency requirements across four years of medical school. Each of the groups met once to respond to a series of scripted questions about the competencies. Sessions were transcribed and analyzed by three readers using standard protocols for qualitative analysis. Analysis of 525 student comments revealed two major areas of dissatisfaction, as reflected by the frequency: Inconsistent knowledge and use of the competencies by the faculty (39%) and lack of clarity and uniformity in communication about the competencies (26%). Despite these perceived deficiencies, the students generally embraced the important concepts inherent in the nine competencies and recognized their application to the physician role (33%). Sixteen percent of the comments were specific recommendations for improvement, which included competency-specific training for all teachers, clear and consistent communication throughout all four years of the curriculum, and improved methods of feedback and assessment. Many of these recommendations were incorporated into refinements and additions to the competency-based curriculum, which probably contributed to the notable improvement in student acceptance of the competencies measured by end-of-course evaluations. This study has shown that focus groups can provide a rich source of information about student perceptions and attitudes regarding curricular change, and can reveal problems and shortcomings not otherwise apparent. By soliciting student feedback early in the new curriculum, we were able to gather constructive criticisms that led to actionable reforms.

INTRODUCTION

Numerous surveys of the American public have documented a persistent and growing dissatisfaction with the way health care is delivered in this country.[1,2] Of particular concern is a sense of alienation between physician and patient. The technical competence of physicians is not in question, but the abilities to communicate effectively with patients, to convey compassion and respect, and to appreciate the uniqueness of individuals, are perceived by patients as uncommon physician attributes.[3-5]

Partly in response to this public dissatisfaction, medical schools and residency programs around the country have been making a gradual shift to "competency-based" medical education. Although differing in details, all competency-based programs attempt to promote and evaluate those skills, behaviors, and attitudes thought to exemplify well-rounded, compassionate physicians. It is no longer sufficient for a physician-in-training simply to demonstrate an adequate fund of knowledge and acceptable clinical skills; he or she must also demonstrate, for example, the ability to communicate bad news to a patient or to understand the cultural context of patient care.

The Accreditation Council for Graduate Medical Education (ACGME) has defined six general competencies to be incorporated into residency training,[6] and many of the nation's 125 medical schools are in various phases of discussion, review, and implementation of their own competency-based programs. Several reports in the literature have described the challenges educators face in making this shift to competency-based training. Impediments cited include securing faculty and student buy-in, defining benchmarks of competence, developing appropriate assessment tools, and creating interventions for remediation, as well as limited faculty expertise and the substantial investment in time required to develop these resources.[7-13]

Based on the pioneering work of Brown University,[14] Indiana University School of Medicine (IUSM) implemented a competency-based curriculum in 1999, one of the first programs of its kind in the nation.[15,16] IUSM defined nine core competencies that are assessed throughout the four-year medical curriculum. Acceptable performance in all nine competencies is required for graduation. IUSM has an enrollment of over 1100 students and nearly 1200 full-time faculty members distributed among nine separate campuses across the state. Instituting curricular change in a school of this size and complexity does not come easily, and we experienced many of the same hurdles described in the literature.

Recognizing that students can have a powerful influence in the success or failure of curricular change,[17,18] input was sought from representatives of the IUSM student body during the development and implementation of the new curriculum and a close monitoring of student perceptions was made a priority. However, despite repeated attempts to communicate the purpose of the competencies and how their achievement would be documented, the feedback from student course evaluations in the early years of implementation indicated that many students remained unconvinced of the value of the competencies to their education and were dissatisfied with the evaluation process.

To better understand the reasons for this discontent, we used structured focus groups and qualitative analysis to assess the impact of the competency-based curriculum on student satisfaction with their undergraduate educational experience and their perception of how well they were being prepared for the practice of medicine. Our goal was to identify specific areas for improvement that would guide refinement of the competency requirements and enhance the communication regarding curricular goals of the competencies.

.

METHODS

Focus Groups. Early in the 2003-2004 academic year, four focus groups were established, one for each class year. Each group was composed of 6 to 10 students who were not on academic probation and, to assure a common basis for discussion, only students who had attended the main Indianapolis campus. A total of 30 students participated. Each group met once during the academic year to respond to a series of carefully scripted questions about the competency-based curriculum. Participants were invited to describe when and how the competencies had been presented to them, their perceptions of the competencies—both initially and after exposure to the competencies in the curriculum, their satisfaction with feedback and assessment regarding the competencies, how they believed the competencies may have enhanced their skills as physicians, and how the school can make the competency-based curriculum more meaningful and satisfying to students. In addition to these open-ended questions, participants were asked to rank on a five-point scale the importance of the competencies to medical education (5 = "essential" to 1 = "non-essential").

Sessions were transcribed and analyzed by three readers using accepted protocols.[19] Two readers used axial coding to sort the data into large themes, while the third used NVivo software (QSR International Pty Ltd) to perform a line-by-line examination and assign comments to thematic categories. Patterns of comments within categories were identified, and categories collapsed to achieve consensus on four over-arching themes. This research study was approved by the Indiana University Purdue University Indianapolis Institutional Review Board.

Course Evaluations. Beginning with the 2000-2001 academic year, four competency-related items were added to all end-of-course evaluations. These items were intended to evaluate the student awareness and understanding of the competencies. The individual item statements were:

- "*The competencies that were evaluated in this course were clearly defined.*"
- "*The methods for assessing my level of competence were appropriate.*"
- "*Feedback on my level of competence was adequate.*"
- "*Competencies relate to being a physician.*"

Responses were recorded using a five-point Likert scale, with 4 denoting "strongly agree" and 0 denoting "strongly disagree." The mean response to these four items was obtained for each course, and a grand mean was obtained by averaging across all course-specific means for a given academic year (N = 121 to 147 courses).

The aggregate mean of these four items from all courses was compared across six years of evaluation (2000-2006). The return rate was approximately 80% per year. Mean rank responses were compared using the nonparametric Kruskall-

Wallis test. Differences were considered significant if $p < 0.05$.

RESULTS

Focus Group Data. The total number of comments made by the students (stratified by class year) was: MS1 = 110 (8), MS2 = 114 (6), MS3 = 175 (10), MS4 = 126 (6). The number of students is shown in parentheses. Careful examination of the student comments revealed four main themes, as reflected by the frequency:

- Faculty Knowledge and Use of Competencies (39%)
- How Competencies Relate to Being a Physician (33%)
- Communication of Competencies to Students (26%)
- Students' Recommendations for Improvement (16%)

The total percentage exceeds 100% because some individual comments applied to multiple themes. For each of the main themes, we have provided a summary statement that we believe captures the general consensus view, as well as several representative quotations from students.

Faculty Knowledge and Use of Competencies. Students perceived inconsistent knowledge and use of the competencies by the faculty.

- *"You know I pay my [tuition] so if I'm going to be part of the whole competency thing, I would like to know that the people who are assessing me are capable of doing that." MS3*
- *"I say 98% of my staff, residents, and interns don't even know what a competency is." MS3*
- *"[Faculty] just check the box 'good' . . . I wonder if they are aware of it [the competency] themselves. I kind of think it's just another paper and grade sheet that they have to check a box on." MS3*
- *"Some of them just decide that we will not address competencies because it's extra work." MS4*
- *" . . . if my preceptor watches me do an H&P or something like that, it's very good, but I don't think he's thinking about the competencies when he's evaluating these." MS2*

How Competencies Relate to Being a Physician. Students generally embraced the important concepts inherent in the nine competencies and recognized their application to the physician role.

- *"I think there are good doctors out there and I think there are bad doctors out there and I think that there are ones just okay, and I think a lot of it comes back to whether or not they have these characteristics." MS3*
- *"These [the competencies] are tough to assess and I'm glad the School is trying to take it on. You know, it's got to be done and I don't think anybody can really argue [against] these nine things as being important." MS3*
- *If [consumers] know that people are taking the time and effort to identify these things, maybe consumer confidence in medicine will come back." MS3*
- *"We think these things are kind of ridiculous, but that's because we integrate all of them into our daily activities . . . So I guess by that standard, yes, 'mission accomplished'." MS4*
- *"It's just a good way to keep us in check as we are going along. To remind us there's more than just the basic sciences . . . a way to keep us steering toward the type of physicians that we want to be." MS1*

Communication of Competencies to Students. Students perceived a lack of clarity and uniformity in communication about the competencies.

- *"You're thinking to yourself, I'm taking biochemistry and anatomy and what the heck does that have to do with moral reasoning and ethical judgment." MS4*
- *"The first time that I ever heard about [the competencies] was when a [basic science] professor was going through his introduction and said, 'I'm required to say that these are the competencies that will be addressed by this class'." MS2*
- *"[The competencies] are laid out in some 100-page manual on every rotation and nobody really reads those. I guess you can look it up if you wanted to, but it's not specifically addressed." MS3*
- *"You can point out peoples' faults and assess them and say you need to improve on this, but where does it go after that? Who helps you improve?" MS3*
- *"Dr. X got up [in a 3rd-year clerkship] and actually talked about the competencies that were addressed . . . . That was the first time I ever actually understood any of the competencies and I never had any of them specifically explained to me before." MS3*

Student Recommendations for Improvement. For each area of concern, students offered specific recommendations for improving competencies within the curriculum, which included competency-specific training for all teachers, clear and consistent communication throughout all four years of the curriculum, and improved methods of feedback and assessment.

- *"I think that if [a course addresses a particular competency], it should be assessed the entire time. It shouldn't just be one little thing that you do." MS4*
- *"Have this [the competencies] be what they grade us on…because you can't be a medical student and get through without doing these things. You might as well make it part of our grade [because] that's the way we all are going to take something more importantly if it's reflected in our grades." MS4*
- *"Wouldn't it be great if there was a course on ANGEL [course management website] about the competencies where I could see the checkmarks I'm collecting, and then when I get my first checkmarks…voila…they show up on ANGEL…look I'm making progress! This is what I'm going to be expected to do next year and have it laid out right there." MS2*

- *"I think the group [150 students] is too large . . . to assess these things . . . but I would be ok with it being assessed in smaller groups."* *MS2*
- *"We love attention . . . I want someone paying attention to me, telling me what I'm good at, telling me what I'm really bad at, and how I can get better. I want attention!"* *MS2*

In response to the request, *"Please rank, using a five-point scale, how important you think the competencies are to your medical education, with five being essential and one being non-essential,"* focus group participants (stratified by class year) ranked the competencies as follows: MS1 = 4.7 ± 0.5 (8), MS2 = 4.9 ± 0.2 (6), MS3 = 4.8 ± 0.4 (10), MS4 = 4.4 ± 0.7 (6). Data are expressed as the mean ± SD (N).

Course Evaluation Data. Quantitative data from the end-of-course evaluations showed an improvement in student awareness and understanding of the competencies (Figure 1). During the first three years of evaluation, the aggregate mean of the four competency-related items (mean competency score) improved marginally, but still reflected a generally poor student perception of the competencies. Not until the 2003-2004 academic year did the mean competency score increase sufficiently to indicate a generally favorable student perception of the competencies. The score remained elevated during the 2004-2005 and 2005-2006 academic years.

DISCUSSION

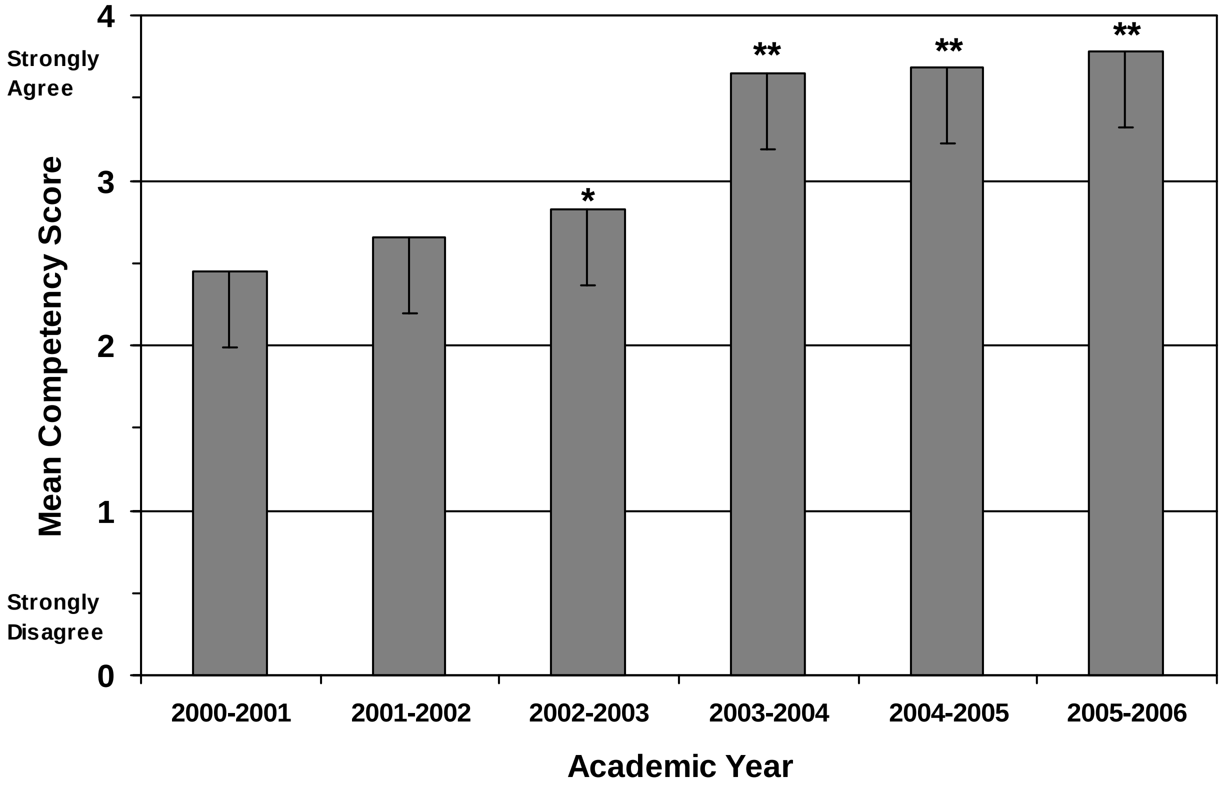
"*Reforming the curriculum without attention to the learning environment, to me, does not serve the students and the public good.*" Kenneth Ludmerer[20]

In 1999, IUSM adopted a competency-based curriculum consisting of nine competencies: *(1) Effective Communication; (2) Basic Clinical Skills; (3) Using Science to Guide Diagnosis, Management, Therapeutics, and Prevention; (4) Lifelong Learning; (5) Self-Awareness, Self-Care, and Personal Growth; (6) The Social and Community Contexts of Health Care; (7) Moral Reasoning and Ethical Judgment; (8) Problem Solving; and (9) Professionalism and Role Recognition.*[15] Assessment and certification of achievement in these competencies are sequentially integrated into all four years of the curriculum, culminating in a competency transcript upon graduation. For each competency, three levels of mastery are defined according to specific performance criteria. Students must demonstrate a beginning level of mastery (Level 1) in all nine competencies by the end of their second year, and an intermediate level (Level 2) by the end of their third year. During their fourth year, students must demonstrate an advanced level (Level 3) in three competencies of their choosing. The graduating class of 2003 was the first to complete the entire four-year, competency-based curriculum. Educational research highlights the importance of including student input into curricular revision,[21,22] because students can exert a powerful influence on the success or failure of such undertakings.[17,18] Although student input was sought throughout the development and implementation of the competency-based curriculum, its initial reception by the IUSM student body was less than enthusiastic. From the 2000-2001 academic year (the first year for which evaluation data were available) until the 2002-2003 academic year, the mean competency score, while gradually improving, nonetheless indicated weak student support. Many of the graduating seniors in this period expressed harsh critiques of the competency-based curriculum on the Association of American Medical Colleges graduation questionnaire. In ways both formal and informal, the students made their dissatisfaction with the competencies known. Corrective action was plainly needed. We believed that an in-depth understanding of the reasons for student dissatisfaction was crucial if the new curriculum was to succeed and thrive. Our use of focus groups provided a way to systematically analyze student experience with the competencies across four years of medical school. Our intent was to provide a clear and accurate summary of the perceptions and experiences of students as they progressed through the competency-based curriculum. The information gleaned from this study helped to identify and correct some of the perceived deficiencies in our new curriculum, and may serve as a cautionary guide for other schools contemplating similar curricular changes.

At the time of this study in early 2003-2004, the competency-based curriculum had entered into its fifth year and virtually all IUSM students had been exposed to the competencies since the start of medical school. This fact alone may have diminished some of the resentment voiced in earlier years by students who felt they were being treated as "guinea pigs" in an untested curriculum. With familiarity comes acceptance, which may partly explain the substantial improvement in mean competency scores observed in 2003-2004 and beyond. Had this study been conducted earlier, we may have heard a different—perhaps less balanced—student perspective. Despite their dissatisfaction with certain aspects of the new curriculum, the students in our study gave strong endorsement to the concepts embodied in the competencies and the practice of medicine. As noted in the Results, all four focus group classes ranked the competencies highly in terms of their importance to medical education. The comments expressed by the focus group participants were not about *whether* the competencies should be taught but *how* they should be taught. Nevertheless, we believe it fair to say that the students took a dim view of how the competency-based curriculum had been implemented, and they questioned whether the competencies were being assessed in a rational and consistent manner.

Of the two major areas of concern identified by the students, the most frequently mentioned was *inconsistent knowledge and use of the competencies by the faculty*. Some professors expressly stated which competencies were being assessed in their course, explained how the students were to

Figure 1. Quantitative data from course evaluations showing an increase in students' awareness and understanding of the competencies.



Each bar represents the School-wide mean ± SD response to four questions obtained by averaging across all courses for a given year (N = 121 to 147 courses). The individual questions were:

1. The competencies that were evaluated in this course were clearly defined.
2. The methods for assessing my level of competence were appropriate.
3. Feedback on my level of competence was adequate.
4. Competencies relate to being a physician.

*p < 0.01 compared to the 2000-2001 academic year
**p < 0.001 compared to the first three academic years

be evaluated, and provided meaningful feedback about their performance. But this was not usually the case. All too often students received little or no guidance about the competencies being assessed or the manner of evaluation. Feedback was vague and unhelpful, if it existed at all. Moreover, the way in which a particular competency was evaluated in one course often seemed inconsistent with the way it was evaluated in another course. For example, a physiology professor might assess *Effective Communication* by examining the legibility of a student's handwriting, whereas an anatomy professor might assess this same competency by critiquing a student's oral presentation. Because there were no generally agreed-upon assessment methods, each faculty member simply did what he or she thought expedient to achieve the goal. All of this lent an air of ambiguity and capriciousness to the competency-assessment process, which the students found very disconcerting.

Another area of concern identified by the students was *lack of clarity and uniformity in communication about the competencies*. Although the school made diligent attempts to educate students about the competencies early in their first year and periodically thereafter, the students continued to express confusion and uncertainty about what was expected of them. That the faculty did not speak with one voice about the competencies probably accounted for much of this confusion. What students heard from one faculty member was often at odds with what they heard from another faculty member. Some professors would highlight the competencies, whereas others would ignore them. From the student perspective, there was no clear and consistent source of information about the competencies, and the faculty was not unanimous in its embrace of the new curriculum.

These insightful observations led naturally to the student principal recommendations for improvement: *competency-specific training for all teachers, clear and consistent communication throughout all four years of the curriculum, and improved methods of feedback and assessment.* Interestingly, these recommendations parallel some of the faculty concerns identified by Broyles et al.[13] in their study of curricular change at an osteopathic medical school. Early in the 2004-2005 academic year, we shared the student comments and recommendations with key administrators and faculty members in charge of the competency-based curriculum. At that time, some of the deficiencies identified by the students—such as the lack of standardization in competency assessment—had already come to the attention of the school's educational administration and were targeted for improvement. To what extent the student voices added to the chorus and motivated specific reforms is uncertain, but we suspect they were a major influence.

Several improvements in the competency-based curriculum have been instituted since we shared our findings. For example, a week-long educational experience was created to expose newly matriculated students to the competencies in a clinical context.[15] During their first week of medical school, students systematically examine a single clinical case from different competency perspectives and learn how the competencies work together to improve patient outcomes. This in-depth introduction is intended to impress upon the students the importance of the competencies and illustrate how they are utilized across the continuum of medical care.

Another notable improvement was the establishment of competency teams.[15] Each of nine teams is organized to support a particular competency, is chaired by a competency director, and includes basic scientists, clinicians, students, and education specialists. Each team is responsible for developing new competency learning experiences and assessments, integrating these competency activities across the four-year curriculum, and improving the communication of competency requirements to the students and faculty. Although the effectiveness of the first-week experience and competency teams have yet to be fully realized, we believe they have gone a long way towards alleviating many of the students' criticisms about the competency-based curriculum.

This study has shown that focus groups can provide a rich source of information about student perceptions and attitudes regarding curricular change, and can reveal problems and shortcomings not otherwise apparent. Owing to their unique perspective, the students themselves can often envision the best ways to correct curricular deficiencies. Our school's experience with curricular change underscores the importance of student feedback at all stages of the process. By soliciting student feedback early in the new curriculum, before student dissatisfaction with the competencies was entrenched, we were able to gather constructive criticisms that led to actionable reforms. The fact that the mean competency score remained elevated for three consecutive academic years suggests that the competency-based curriculum at IUSM survived its growing pains and has now matured to the point where it is well-accepted by the students.

ACKNOWLEDGEMENTS

This work was supported by an Indiana University School of Medicine Educational Research and Development Grant.

REFERENCES

1. Bogart, L.M., Bird, S.T., Walt, L.C., Delahanty, D.L., and Figler, J.L. Association of stereotypes about physicians to health care satisfaction, help-seeking behavior, and adherence to treatment. *Social Science and Medicine*. 2004; 58(6):1049-1058.
2. Zemencuk, J.K., Hayward, R.A., Skarupski, K.A., and Katz, S.J. Patients' desires and expectations for medical care: A challenge to improving patient satisfaction. *American Journal of Medical Quality*. 1999; 14(1):21-27.
3. Williams, S., Weinman, J., and Dale, J. Doctor-patient communication and patient satisfaction: A review. *Family Practice*. 1998; 15(5):480-492.
4. Roter, D.L., Stewart, M., Putnam, S.M., Lipkin Jr., M., Stiles, W., and Inui, T.S. Communication patterns of primary care physicians. *Journal of the American Medical Association.* 1997; 277(4):350-356.
5. Brown, J.B., Boles, M., Mullooly, J.P., and Levinson, W. Effect of clinician communication skills training on patient satisfaction: A randomized, controlled trial. *Annals of Internal Medicine*. 1999; 131(11):822-829.
6. ACGME outcome project: General competencies. *Accreditation Council for Graduate Medical Education*. http://www.acgme.org/outcome/comp/compHome.asp [Accessed November 24, 2006]
7. Carraccio, C., Englander, R., Wolfsthal, S., Martin, C., and Ferentz, K. Educating the pediatrician of the 21st century: Defining and implementing a competency-based system. *Pediatrics*. 2004; 113(2):252-258.
8. Carraccio, C., Wolfsthal, S.D., Englander, R., Ferentz, K., and Martin, C. Shifting paradigms: From Flexner to competencies. *Academic Medicine*. 2002; 77(5):361-367.
9. Folberg, R., Antonioli, D.A., and Alexander, C.B. Competency-based residency training in pathology: Challenges and opportunities. *Human Pathology*. 2002; 33(1):3-6.

10. Mohr, J.J., Randolph, G.D., Laughon, M.M., and Schaff, E. Integrating improvement competencies into residency education: A pilot project from a pediatric continuity clinic. *Ambulatory Pediatrics*. 2003; 3(3):131-136.
11. Reed, V.A., Jernstedt, G.C., Ballow, M., Bush, R.K., Gewurz, A.T., and McGeady, S.J. Developing resources to teach and assess the core competencies: A collaborative approach. *Academic Medicine*. 2004; 79(11):1062-1066.
12. Heard, J.K., Allen, R.M., and Clardy, J. Assessing the needs of residency program directors to meet the ACGME general competencies. *Academic Medicine*. 2002; 77(7):750.
13. Broyles, I., Savidge, M., Schwalenberg-Leip, E., Thompson, K., Lee, R., and Sprafka, S. Stages of concern during curriculum change. *Journal of the International Association of Medical Science Educators*. 2007; 17(1):14-26.
14. An educational blueprint for the Brown University School of Medicine. Smith, S.R., and Fuller, B. *Brown University* 2006. http://biomed.brown.edu/Medicine_Programs/MD2000/Blueprint_for_the_Web_04.pdf [Accessed August 7, 2007]
15. Litzelman, D.K., and Cottingham, A.H. The new formal competency-based curriculum and informal curriculum at Indiana University School of Medicine: Overview and five-year analysis. *Academic Medicine*. 2007; 82(4):410-421.
16. Smith, P.S., and Cushing, H.E. Indiana University School of Medicine. *Academic Medicine*. 2000; 75(9):S118-S121.
17. Bland, C.J., Starnaman, S., Wersal, L., Moorhead-Rosenberg, L., Zonia, S., and Henry, R. Curricular change in medical schools: How to succeed. *Academic Medicine*. 2000; 75(6):575-594.
18. Bernier Jr., G.M., Adler, S., Kanter, S., and Meyer III, W.J. On changing curricula: Lessons learned at two dissimilar medical schools. *Academic Medicine*. 2000; 75(6):595-601.
19. Krueger, R.A. Analyzing and reporting focus group results. Volume 6. *Thousand Oaks: Sage Publications*, 1998.
20. Greene, J. Medical schools: changing times, changing curriculum. amednews.com. 2000; December 11, 2000.
21. Atkins, K.M., Roberts, A.E., and Cochran, N. How medical students can bring about curricular change. *Academic Medicine*. 1998; 73(11):1173-1176.
22. Gerrity, M.S., and Mahaffy, J. Evaluating change in medical school curricula: How did we know where we were going? *Academic Medicine*. 1998; 73(9):S55-S59.

The Pedagogic Impact of Exploring Philosophical Concepts in The Basic Health Sciences: The Students' Perspective

James R. Brawer, Ph.D.[1,2], Colin Chalk, M.D., CM, FRCP [1,3], Peter McLeod, M.D., FRCPC, FACP [1, 4, 5]

[1]Centre for Medical Education
[2]Department of Anatomy and Cell Biology
[3]Department of Neurology and Neurosurgery
[4]Department of Medicine
[5]Department of Pharmacology and Therapeutics
McGill University
3640 University Street
Montreal, Quebec H3A 2B2
Canada

Phone: (+)1-514-398-6331 Fax: (+)1-514-398-5047 Email: james.brawer@mcgill.ca

---

ABSTRACT

We have developed a pedagogic strategy for exposing students to philosophical concepts embedded in the basic medical sciences. The intent of this approach is to stimulate reflection and to cultivate intellectual depth and broadness of outlook. The purpose of the present study was to determine the extent to which these goals are realized.

We asked 202 occupational and physical therapy students and science undergraduates enrolled in a neuroanatomy course to describe, in writing, the impact of addressing philosophical issues on the quality of their educational experience. Thematic content analysis was used to identify specific themes in the 93 responses received.

Fifty nine student responses (63%) were uniformly positive, comprising one or more of the following themes. The inclusion of philosophical material: 1) evoked a nonspecific positive feeling, 2) stimulated reflection, 3) engendered an appreciation of the complexity of reality, and 4) enhanced understanding of the rest of the course material. Twenty six percent of the responses contained one or more of the positive themes, as well as concerns, largely regarding the increase in material to be learned. Eleven percent of the responses were exclusively negative. Our results indicate that periodic exposure to philosophical topics appears to stimulate reflection and provides valuable insight for a significant segment of the class.

INTRODUCTION

Although few would argue that the basic sciences must play a major role in the education of health professionals, there is little agreement as to exactly what that role should be. What, and how much basic science do students really have to know in order to develop into good health care providers? The question invariably focuses on a narrow stratum of information describing the physico-chemical features of molecules, cells and tissues. The deeper dimensions, encompassing the metaphysical and epistemological implications inherent in the biochemistry, cell biology, and physiology are regularly ignored. Indeed, in view of the pressure to inculcate students with clinically pertinent material of high practical utility, there is little incentive to add seemingly superfluous philosophical content. The flaw in this approach lies in the assumption that philosophy is extraneous. By detaching the facts and mechanisms that describe normal biology from their philosophical underpinnings, do we not squander a unique opportunity to instill in students a sense of wonder, inquisitiveness, reflectiveness, appreciation and humility? The importance of cultivating these qualities in future health care professionals is well recognized by educators[1], and it is reflected in the large number of medical faculties that have developed teaching initiatives in the humanities.[2]

A pedagogic strategy for exposing students to philosophical concepts entrenched in the basic medical sciences has recently been reported[3]. The method is simple and easily implemented. It does not require the addition of new subject matter, but rather entails the recognition of concepts latent within existing course material. In any given lecture hour, a single scientific fact, of the lecturer's choosing, is probed for intrinsic philosophical content. The metaphysical or epistemological implications are identified, elaborated, and presented to the students for contemplation. Each such exercise requires no more than ten minutes. An alternative or complementary approach would be to dedicate an entire lecture hour to examining a variety of philosophical themes that occurred throughout the course.

One previously reported[3] example of this strategy is the following. It is introduced at the end of a lecture on hemispheric specialization in the cerebral cortex. A slide is projected in which three faces appear. The top image (A) is a full frontal facial photograph of a colleague. At the lower left is a picture (B) constructed of the left half of face A and its mirror image. At the lower right is face C, assembled from the two right halves of face A. Face C clearly resembles the original (A) far more than does face B. The reason is that when one views a person face on, the neuroanatomy of the visual system is such that the image of the right half of the observed face ends up in the right cerebral hemisphere of the observer whereas the left half is represented in the left hemisphere. Inasmuch as the right hemisphere outperforms the left in analyzing spatial relationships and imagery, the left "defers" to the right and what we see is pretty much what our right hemispheres show us[4].

Although we identify my colleague with face C, she thinks she looks more like face B. Her view of herself is what she sees in a mirror, and in a mirror image, the left half of the face is represented in the right cerebral hemisphere. The question to the students is; what does she look like? The intent of this particular exercise is to awaken the students to the realization that the observer contributes as much to any act of observation as the observed, and that indeterminacy pervades our view of reality at every level from the subatomic domain to that of ordinary daily experience. It further underscores the fact that our use of language is generally perfunctory. Rarely do we consider the complexities and ambiguities underlying the most ordinary of expressions, e.g. "she looks like…"

Although these intermittent forays into the realm of philosophical speculation seem to engage the students and generally elicit a lively response, their pedagogic value is not clear. What impact does exposure to the philosophical dimension of health science have on the intellectual perspective of the student? The intent of these exercises is to stimulate reflection and to cultivate intellectual depth and broadness of outlook. To what extent are these ends actually met? In order to begin to address this question, we have carried out a descriptive exploratory study designed to determine how integration of philosophical content is perceived by health science students enrolled in an undergraduate neuroanatomy course. Our results indicate that the introduction of philosophical material appears to stimulate authentic thought and reflection in many of the students and that the approach is worthy of further investigation.

METHODS

The sample population comprised 202 students enrolled in a course entitled "Circuitry of the Human Brain" (ANAT 321) at McGill University in the fall term of 2005. This course is required for second year physical and occupational therapy students who comprised 51% of the class. Thirty six percent of the enrolment comprised final year students in our undergraduate program in Anatomy and Cell Biology, many of whom hoped to pursue careers in medicine or dentistry. The remaining 25% were final year students in other undergraduate programs, such as Biology and Psychology. Sixty four percent of the class were women.

Philosophical topics that were introduced briefly and periodically over the duration of the course included the unity of consciousness, the nature of perception, innate biases and limitations in modeling neurological phenomena, teleology, the validity of abstraction and generalization, and the ontological status of subjective experience. In addition, an entire lecture hour toward the end of the course was devoted to exploring philosophical issues implicit in cortical neuroanatomy and processing. In order to insure that students would be able to distinguish philosophical topics from the standard didactic neuroscience material, the philosophical themes explored in lectures were specifically identified as such. The lecture hour devoted to the philosophical issues in cortical functioning was likewise introduced as a philosophical presentation.

During the last week of the course, the teacher distributed a questionnaire to the students. The questionnaire had been previously pilot tested for clarity on five students from the course. At the top of the page, the students were given the following instructions.

An effort has been made, in ANAT 321, to explore some of the philosophical implications inherent in the scientific subject matter. This is not generally done in science courses at McGill. In order to assess the value of including the philosophic dimension in university science teaching, it is essential to sample student perceptions. Please use the space on this page to express your views on this issue. Do you think that addressing philosophical concepts adds to the quality of your educational experience, and if so, how and why? Conversely, do you think that including philosophical subjects detracts from the quality of your educational experience, and if so, how and why? Would you like to see more philosophy integrated into science teaching or do you think that philosophy has little to add?

Underneath the instructions, space was provided (3/4 of the page) for the students' narrative responses. The students were asked to take the questionnaires home and to submit their responses the following week in class. They were informed that their anonymous responses were to be the subject of a research project the results of which could be submitted for publication. Thematic content analysis of the student responses was performed using a constant comparison technique adapted from grounded theory[5]. In grounded theory, the foundation of qualitative research, one begins with observations "on the ground", as opposed to a hypothesis to be tested. The theoretical framework then evolves from the observations as the data are collected and reviewed. The individual narratives were read by C.C. and P.M. to identify prominent themes. These two investigators met to discuss their results and to reach consensus on the list of themes, which was then corroborated independently by J.B. who checked the list against the student responses. In order to estimate the relative frequency of occurrence of the themes, C.C. and P.M. reread the responses and counted the occurrence of each theme. J.B. searched the responses for common trends and identified representative quotations.

RESULTS

Ninety three (46%) of the 202 questionnaires were returned. The responses varied considerably in length and quality of content. Some comprised no more than a few general phrases, whereas others consisted of substantive, well-structured narratives. Not every response addressed both questions. Moreover, issues were raised that did not relate directly to the questions asked.

Four predominant positive themes emerged. The inclusion of philosophical material: 1) evoked an enjoyable or otherwise nonspecific positive feeling, 2) stimulated thinking and reflection, 3) engendered an appreciation of the complexity of reality, and 4) enhanced understanding of the rest of the course material.

POSITIVE THEMES

1. Enjoyable/Positive Feelings

Words and phrases such as *"interesting"*, *"adds a lot of spice"*, *"nice to see a different side of things"*, *"helps to make the material less dry"*, and *"enriching"* were common and indicate a pervasive, non-specific satisfaction with the philosophical material.

2. Stimulated Thinking and Reflection

The most commonly encountered specific positive reaction (occurring in about 1/3 of all responses) related to intellectual stimulation. Comments reflecting this theme were fairly similar and included: *"…forces us to ask ourselves important questions."*, *"…forces students to think outside the factual box."*, *"…allows you to think rather than memorize."*, *"…allowed students to ask questions like why."*, and *"…helped me to realize that we need to question ourselves."*

3. Appreciation of the Complexity of Reality

Statements emphasizing the value of exposure to a different view of reality were encountered slightly less frequently than those above. They were, however, more diverse, more extensive, and generally expressed in richer language. The following are notable quotes.

"I think that it is important that we at least be aware that our knowledge of the brain isn't rigid facts that are always true and always apply exactly as we learned them".

"It (philosophy) *provides depth and insight to the reasons we are studying science in the first place".*

"Science was invented by human beings, so this is how we mostly perceive reality. But is it the absolute truth?"

"…science doesn't hold all the answers."

"To adequately represent what the science means, or what it might mean is extremely important since it is not a unidimensional discipline".

"…it pushes the student to see the subject from a very different angle."

"It also makes us appreciate the wonders of life".

"It makes me understand that what we learn in class is not the ultimate truth."

4. Enhanced Understanding of the Course Material

The fourth positive theme (identified in 16% of the responses) was that the exposure to the philosophical dimension facilitated the understanding of the rest of the course material. The typically brief reactions included: *"Helps to remember stuff."*, *"Easier to memorize."*, *"Better understanding"*, and *"…helped me drill the visual system better"*

In many instances, one or more of the four positive reactions described above occurred in tandem with an expression of dissatisfaction with the emphasis in science courses on the rote memorization of facts. The intent of these comments was clearly to underscore a perceived defect in the educational process which was, at least partially, addressed by the inclusion of philosophical content. This perception is exemplified in the following statements. *"Science should not be just memorization and regurgitation…"* , *"most anatomy courses are only brainless memorization of facts." "In science …we are bombarded with large chunks of material to memorize…"*, *"…memorize and vomit out as much as you can on the exam."*

MIXED RESPONSES

Whereas 59 of the 93 student responses (63%) were uniformly positive, composed of one or more of the themes detailed above, 24 (26%) were mixed. In addition to the one or more positive themes, these narratives expressed concerns about the inclusion of philosophy in science courses. The most common worry was that the volume of material to be learned in science courses was already excessive, and that the inclusion of new subject matter added to the burden. In many cases students approved of the philosophical content as long as is was not tested (which it was not). Other more sporadic concerns were the following. *"Philosophy might make things a little bit more confusing…", "it could sometimes mix us up…", "…science students aren't taught to think in philosophical terms." "…not much relation to our profession."*

NEGATIVE RESPONSES

Ten of the 93 responses (11%) were exclusively negative, expressing concerns similar to those in the mixed responses, but often worded more aggressively. Examples are the following. *"… to ponder every application of science is a waste of time." "…too much to turn to philosophy issues…" "I don't think that this type of teaching should make its way into an objective science class…" "I think that our university has enough philosophy courses for students to take if they are interested."*

Reactions to the question of whether the students would like to see more philosophy in science courses followed the general response pattern. The positive responses were often affirmative, the mixed responses were less so, and the exclusively critical responses were sharply negative.

DISCUSSION

Our objectives in introducing philosophical material into a basic medical science course were to stimulate reflection and to cultivate intellectual breadth and depth[3]. Inasmuch as this approach was designed to engender insight, rather than to advance factual knowledge or to develop specific intellectual skills, we evaluated its efficacy by assessing its impact on the student ' perceptions. We selected a qualitative research methodology for two reasons. First, it allowed us to canvas student views while minimizing bias. Rather than asking the students to indicate, on a Likert scale, to what extent our particular aims were met, thereby pre-selecting the parameters, the students themselves identified and described the strengths and weaknesses of the strategy. Secondly, the qualitative technique allowed unforeseen and unintended outcomes to surface. In the present study, for example, we did not anticipate that exposure to the philosophical dimension would facilitate the understanding of the rest of the course material for a number of the students.

Limitations of the study include sample population size, heterogeneity of the sample population, and the possibility of subjective bias. While 202 questionnaires were distributed, only 93 (46%) were returned, leaving open the question as to the perceptions of the non-responding students. Although it is likely that these students were too busy to expend effort on a task of no practical importance, it is possible that non- responses could reflect indifference or dissatisfaction. In view of the size of our sample, what conclusions can we draw? It depends on how we view the data. Although 89% of our sample population was positively effected by exposure to philosophical themes, this represents only 41% of the class. We can, therefore, conclude little about the impact of philosophy on the class as a whole. On the other hand, that 41% comprises 83 individual learners for whom the inclusion of philosophical content stimulated reflection and provided valuable insight. Philosophical inquiry is, therefore, of real significance to a sizeable number of students regardless of the percentage of the class that they comprise. Additional data gathered in future studies should provide the basis for a more quantitative approach. The study did not address the question as to whether the physical and occupational therapy students, as a group, might have responded differently from the science students. Classes are heterogeneous in a variety of ways (gender, age, background), and our goal was simply to asses the overall impact of philosophy on a class of health science undergraduates. Finally, teacher popularity is a potential source of bias. In view of the esteem in which the teacher is held, the students, aware of his enthusiasm for teaching philosophic topics, may have weighted their replies accordingly. However, the fact that so many of the narratives were insightful, logical and cogent suggests that the responses , by and large, reflected independent thought.

It was evident, before the present investigation, that a sizeable percentage of the class was positively effected by the presentation of philosophical subject matter. Many students were noticeably attentive and animated. The significance of this apparent enthusiasm was, however, unclear. Were the philosophical interludes merely entertaining, or did they provide something meaningful and substantial? The non-specific positive responses do indeed imply that entertainment contributed to student satisfaction. The prevalence of specific, well thought-out responses, however, suggests that many students perceived the exposure to philosophical issues as a valuable intellectual experience. Thus, the results of the study suggest that the inclusion of philosophical thought in a basic medical science course accomplishes what we had intended for a sizeable segment of the class.

The results also indicate that the beneficial effect of imparting philosophical concepts was associated with the amount and pattern of exposure. Student worries concerning the quantity of material presented in science courses were frequently encountered. The main priority for professional and pre-professional students is the mastery of subject matter immediately relevant to their future careers. In order to be effective, the inclusion of philosophical content should not be perceived as conflicting with that priority. The results, therefore, support the practice of periodic presentation of philosophical subject matter in limited amounts.

CONCLUSIONS

Intermittent exposure to philosophical subjects in a neuroanatomy course is perceived by many of the students as having a positive impact on their educational experience. According to most student narratives, philosophical inquiry stimulates reflection and provides insight into the meaning of scientific knowledge. It remains to be shown whether philosophical thought can be effectively integrated into other health science courses, whether the impact would be similar for other health professional students (medical, dental), and whether the awareness gained contributes to professional development.

ACKNOWLEDGEMENTS

The Authors gratefully acknowledge the advice of Dr. Mary Ellen Macdonald in designing the study and in the preparation of the manuscript.

REFERENCES

1. Evans, M. Reflections on the humanities in medical education. *Medical Education*. 2002; 36**:** 508-513.
2. Strickland, M.A. Gambala, C.T., and Rodenhauser, P. Medical education and the arts: a survey of U.S. medical schools. *Teaching & Learning in Medicine.* 2002; 14: 264-267.
3. Brawer, J.R. The value of a philosophical perspective in teaching the basic medical sciences. *Medical Teacher*. 2006; 28: 472-474.
4. Milner, B.. Complementary functional specializations of the human cerebral hemispheres. In: R. Levi-Montalcini (Ed.). Nerve Cells, Transmitters and Behaviour. (pages 601-625). *Vatican City, Pontificia Academia Scientiarum Scripta Varia*, 1980
5. Glaser, B., and Strauss, A. The Discovery of Grounded Theory: Strategies for Qualitative Research. *Chicago, Aldine Publishing Co.* 1967

.

Fourth-year Medical Students as PBL Tutors

Laurie C. Clark, D.O., M.S., W. Stephen Eddy, D.O., M.P.H., Joan E. Stewart, D.O., M.P.H., Sherril M. Stone, Ph.D., Christopher C. Thurman, D.O.

Oklahoma State University
Center for Health Sciences
1111 W. 17th Street
Tulsa, OK 74107-1898 USA

Phone: (+)1-918-561-1288 Fax: (+)1-918-561-5780 Email: laurie.clark@okstate.edu

ABSTRACT

Problem-based learning (PBL) is a popular teaching method in medical schools, but is resource intensive due to the large number of faculty required to serve as small group tutors. This study 1) compares the effectiveness and student satisfaction of PBL small groups tutored by physicians with groups tutored by 4th year medical students (MSIVs) and 2) examines the effect of tutoring on learning by MSIVs. Sixteen MSIV students were recruited to tutor MSII groups. Seven MSIVs participated in a separate study to analyze the amount of learning that occurred as a result of teaching. The MSII students were given a quiz after each module to measure the amount of information learned, and a satisfaction survey regarding their tutor. Additionally, the tutors completed a pre-test and a post-test of the material they taught. All data was input into SPSS, a statistical analysis package, and analyzed using an Independent Samples t-test. Results indicated that there was no statistically significant difference in mean quiz scores of the MSII students between groups (those tutored by physicians and those tutored by MSIVs). There was also no statistically significant difference between groups on any of the questions on the satisfaction survey. Furthermore, the MSIV student tutor pre- and post-test scores showed no statistically significant difference although the post-test scores were all higher than the pre-test scores. These findings support the use of MSIV students as PBL tutors. The results also indicated that MSIV students may benefit from teaching MSII students. Additionally, the results suggest that MSIV students may be better prepared and more knowledgeable as physicians when they have been in a position to teach medical students.

INTRODUCTION

Problem-based learning is an instructional method which has been described as “the use of patient problems as a context for students to learn problem-solving skills and to acquire knowledge about the basic and clinical sciences”.[1] This method has grown in popularity in medical schools since first introduced in the 1960’s at McMaster medical school in Ontario, Canada.[2]

In the early 1990’s, Oklahoma State University Center for Health Sciences (OSU-CHS) initiated an MSII hybrid course called “Clinical Problem Solving” with four hours of lecture per week combined with an additional four hours of PBL small groups. This has been an effective and popular one with the MSII students, but is extremely resource intensive. The MSII class has had approximately 88 students each year. The optimal number in each small group is considered to be 5-7 students with one tutor (or, facilitator). This size appears to encourage the most active participation of all group members and allows for a sufficient variety of student ability and experiences.[3]

Due to the difficulty in recruitment of an optimal number of physicians to serve as tutors we began using MSIVs two years ago to serve as tutors. The MSIVs facilitate two mornings a week and are allowed to participate during any elective clinical rotations. They are cleared by their preceptors to be off those two mornings. This allows the MSIV students time to study the cases prior to the 2 hours of facilitating. We consider this a “mini” medical education rotation within their elective rotation. All preceptors that have been approached about this have allowed their students to participate.

The study was given exempt status by the Oklahoma State University Center for Health Sciences IRB because it was an educational intervention. The MS IVs were not given an actual grade for their pre- and post-tests. These grades were used for research purposes only and are not individually identified.

The primary objectives of this study were to 1) compare the effectiveness and student satisfaction of problem-based learning (PBL) small groups tutored by physicians with PBL groups tutored by 4th year medical students (MSIVs) and 2) compare the pre-test and post-test knowledge of MSIV students who served as facilitators for second-year medical student (MSII) courses.

Brief Literature Review

The use of fourth year medical students to teach first and second year medical students has been shown to be a practical and effective alternative to professional and faculty teachers. For example, MSIV students have served as peer tutors,[4] patient models for history and physical examinations,[5-7] basic science assistants,[8-10] and problem-based learning facilitators.[11] Furthermore, MSIV's with prior patient model/standardized patient experience were rated higher on interpersonal communications skills such as rapport, support, and patient satisfaction.[7,12]

Academic results of MSI and MSII students revealed that students who were taught by MSIV preceptors did as well as students that were instructed by faculty preceptors. For instance, Haist, Wilson, Brigham, Fosson, and Blue[13] found that the mean GPA of the students with faculty preceptors was 3.48 (SD=.40) while the GPA for those students taught by MSIV's was 3.27 (SD=.36). End of course written examinations of the MSI and MSII students of MSIV preceptors was 81.9% (SD=7.1) and 80.3% (SD=7.6) for the students of the faculty preceptors.[6] The results of a *t*-test analysis revealed that the examination score differences were not significant.

When surveyed about MSIV effectiveness, the MSI and MSII medical students reported that they 1) felt more comfortable with the MSIV preceptors than with a faculty member, 2) did more talking with the MSIV as the teacher, and 3) asked more questions of the MSIV than they would with faculty.[7] Josephson and Whelan[14] studied the effect of allowing a senior medical student to design his own course rather than teach an already developed course. Their results indicated that the MSI students rated the course as a positive experience, appropriate to the topic and level of material, and having an overall effectiveness rating of 9.7 based on a 10-point scale.

Preparing the MSIV for teaching has been low priority of medical schools in the past. However, with the ever increasing demand for physicians, medical schools have recently begun to concentrate on teaching the MSIV student to teach the MSI and MSII students. As indicated previously in this paper, not only is it cost effective to use MSIV students but it takes a burden off of the decreasing number of full-time medical faculty members.[11] However, the majority of medical schools do not provide any teaching training to their students.[15-18] As a result, MSIV students move into their residency programs unprepared for the teaching aspect of their education. Haber, Bardach, Vedanthan, Gillum, Haber, Gurpeet, and Dhaliwal[19] designed a study to examine the effectiveness of providing a course to develop and enhance the teaching skills of MSIV students. The students attended four l-hour lectures in two afternoon sessions. The course presented teaching methods, student evaluation procedures, a panel of residents to answer the student questions regarding teaching, and hands-on exercises to practice their teaching skills. The results of the self-report questionnaires revealed that the students strongly supported the course and 97% agreed that such a course should be required as part of the medical curriculum.

Studies have also shown that the MSIV student benefits from teaching junior medical students. For example, Josephson and Whelan[14] found that MSIV students reported in self-assessment surveys that the experience made them better able to teach when they become attending physicians. Studies examining MSIV students' benefits from teaching indicated that the teaching improved their communications skills,[7] better prepared them to teach in their residencies,[19] allowed them the opportunity to interact with both faculty and residents,[20] and to learn practical tips to enhance their teaching skills.[18]

Streips and Atlas[21] observed that interaction of senior medical students with second year students, whose medical terminology skills were in the early stages, gave them an idea of how they would need to tailor their conversations with future patients.

Empirical evidence of the many social and communication benefits of teaching for the MSIV is growing. However, no studies could be found in the medical literature that quantified the learning of the MSIV students as a result of their teaching experience. The most recent finding of the learning benefits of teaching was published in the psychological literature in the 1970 and 1980's. For example, several studies indicated that the tutor showed greater academic achievement than the student.[22,23] Additionally, Morgan and Toy[24] found that the tutors, when tested on the Wide Range Achievement Test, tested nine months ahead of the other students. Finally, Bargh and Schul[25] found that participants in their study who taught material to others scored higher on later retention tests.

It is unknown if MSIV students learn more information by teaching MSI and MSII students than those MSIV students who do not teach others. Therefore, in addition to comparing the effectiveness and student satisfaction of problem-based learning (PBL) small groups tutored by physicians to PBL groups tutored by MSIV students, our study also compared the pre-test and post-test scores of MSIV students who served as facilitators to determine if the teaching activities of the MSIV facilitators increased their knowledge base.

.

Research Design

A total of 16 MSIV students at OSU-CHS were recruited to tutor Problem Based Learning (PBL) small groups of MSII students enrolled in the Clinical Problem Solving course during the 2005-2006 and 2006-2007 academic years. There were a total of 88 MSII students each academic year, divided into twelve small groups. The four modules taught were: 1) endocrine, central nervous system, musculoskeletal and dermatology, 2) renal, urinary/male and reproductive, 3) hematology and gastrohepatic, and 4) cardiovascular and respiratory. Each module lasted for a half semester, with four one-hour PBL sessions each week. During each module, two PBL groups were facilitated by MSIVs and the rest of the groups were facilitated by faculty members or community physicians.

Prior to the academic year, faculty tutors participated in 1 ½ hours of faculty development. The MSIVs were each given individual instruction on tutoring. Each of the MSIVs had been through this course as MSIIs and were familiar with the cases and PBL process.

In addition to facilitating the PBL small groups, seven of these MSIV students also participated in a separate study to analyze the amount of learning that occurred as a result of teaching. These MSIV tutors completed a pre-test and a post-test of the material they taught to the MSII students. The pre and post tests were identical to each other and contained 10 multiple choice questions. The questions were developed from important themes emphasized during the modules. The quizzes were identical to the quizzes given to MSII students. The pre and post tests were given to the student tutors immediately before and after the modules.

The MSII students were given a 10-question multiple choice quiz at the end of each module to measure the amount of information they learned. Two faculty facilitated groups were randomly selected from each module and the MSII students' quiz scores from these groups were compared to the two MSIV facilitated groups.

The students also completed satisfaction surveys (1 = very dissatisfied, 5 = very satisfied) of the faculty and MSIV tutors.

Data Analysis

The quiz scores and satisfaction with the tutor scores from the MSII students were input into SPSS, a statistical analysis package. The quiz scores were analyzed using an Independent Samples t-test to determine if there was a significant difference in the scores of students who had a faculty tutor versus an MSIV tutor. Additionally, the MSII student tutor satisfaction data was analyzed using a t-test to determine if there was a difference in satisfaction for the faculty versus MSIV tutors.

The MSIV student pre/post tests also were analyzed using a t-test. Specifically, the MSIV post-test scores were compared to their pre-test quiz scores to determine if they knew more information after teaching it to others.

RESULTS

1) Quiz scores. There was no statistically significant difference in mean quiz scores between groups for the two academic years (faculty-tutor M = 82.94%, SE = .0033, MSIV M = 82.71%, SE = .0037p > .05).

2) Satisfaction scores. There was no statistically significant difference in the mean of the total score on the satisfaction survey (faculty M = 4.44, SE = .12, MSIV M = 4.54, SE = .076, p > .05). The comments made by MSIIs on the satisfaction survey regarding the MSIVs as tutors were consistently positive and included the following:

"Outstanding job. Was a doubter about having a student tutor, but have ended up not wanting to leave the group. She probably was a better resource and knew the material better than most of the physician tutors."

"I really enjoyed having a med student as a tutor. She was able to give examples. Also, her knowledge of our lecture material from other classes was fresh. In her spare time she was able to give us pointers for boards and problems she experienced while adjusting to a clinical setting."

"It was a very good experience to have the 4th year students as leaders. Not only were they able to explain material as needed, but they effectively prepared us for CPS exams, rotations, and freely offered advice about residency."

"We should have more 4th years as tutors. Not only do they provide us with knowledge about the cases, they offer lots of information and advice about our clinical rotations as they pertain to our case topic."

"Thoroughly enjoyed and truly appreciated having an MSIV start me off with Clinical Problem Solving. Integrated student and doctor perspective with helpful approaches and hints along the way. EXCELLENT!"

3) MSIV Pre and Post Tests. Finally, the MSIV student pre-test scores were compared to their post-test scores. All of the MSIV students received higher scores on their post-test (M= 97.14, SE = 2.86) than on their pre-test (M = 80.00, SE = 3.00) scores. However, there was no statistically significant difference in quiz scores between the pre and post-tests.

Table 1

	Faculty*		MSIV*	
Scores	Mean	SE	Mean	SE
Quiz **Faculty tutor vs MSIV tutor**	82.94	.0033	82.71	.0037
Satisfaction **Faculty vs MSIV**	4.44**	.12	4.54**	.076

**t*-test results, *p* > .05, **1=very dissatisfied, 5=very satisfied.

Table 2

	Pre-test *		Post-test*	
MSIV tests	80%	3.00	97.14%	2.86

**t*-test results, *p* > .05.

DISCUSSION

This study found that the second year medical students scored the same on quizzes regardless of whether the tutor was a physician or a fourth year medical student. In addition, satisfaction scores indicated that students were as satisfied with MSIV tutors as with faculty tutors. Comments from the MSII students indicated that they enjoyed the MSIV tutors, as well.

The results of this study also indicated that MSIV students may benefit from teaching MSII students. This result supports prior studies which found that greater academic knowledge was achieved by the teaching students. [22-25] These findings, in addition to previous findings of cost effectiveness and reduction of burden on faculty, support the use of MSIV students as tutors.

One of the limitations of this study is the low sample size of MSIV tutors, especially those who took the pre and post tests. Future studies should include a larger sample size. Additionally, the pre-test and post-test were identical in this study. This did not control for a learning effect of pre-exposed material. To control for this effect, future studies should prepare two different tests which cover the same material.

REFERENCES

1. Albanese, M.A., and Mitchell, S. Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*. 1993; 68 (1): 52-80.
2. Norman, G.A., and Schmidt, H.G. The Psychological Basis of Problem-Based Learning: A Review of the Evidence. *Academic Medicine*. 1992; 67 (9):557-65.
3. Barrows, H.S. Practice-Based Learning; Problem-Based Learning Applied to Medical Education. Springfield, IL: Southern Illinois University School of Medicine. 1994.
4. Goodfellow, P.B., and Schofield, E. Peer tutorials amongst medical students. *Medical Education*. 2001; 35:1001-1002.
5. Barnes, H.V., Albanese, M., Schroeder, J., and Reiter, S. Senior medical students teaching the basic skills of history and physical examination. *Journal of Medical Education*. 1978; 53: 432-434.
6. Haist, S.A., Wilson, J.F., Fosson, S.E., and Brigham, N.L. Are fourth-year medical students effective teachers of the physical examination of first-year medical students? *Journal of General Internal Medicine*. 1997; 12:177-181.
7. Blatt, B., and Greenberg, L. A multi-level assessment of a program to teach medical students to teach. *Advances in Health Sciences Education*. 2007; 12:7-18.
8. Carroll, M. Peer tutoring: Can medical students teach biochemistry? *Biochemical Education*. 1996; 34(1):13-15.
9. Trevino, F.M., and Eiland, D.C. Evaluation of a basic science, peer tutorial program for first- and second-year medical students. *Journal of Medical Education*. 1980; 55:952-953.
10. Walker-Bartnick, L.A., Berger, J.H., and Kapelman, M.M. A model for peer tutoring in the medical school setting. *Journal of Medical Education*. 1984; 52:520-522.
11. Clark, L.C, Eddy, W.S., Stone, S.M., Thomason, D.E., and Thurman, C.C. Tutorless PBL groups in a medical school. *Academic Exchange Quarterly*. 2006; 10(4): 205-210.
12. Sasson, V.A, Blatt, B., Kallenberg, G., Delaney, M. and White, F. "Teach 1, Do 1…Better": Superior communication skills in senior medical students serving as standardized patient-examiners for their junior peers. *Academic Medicine*. 1999; 74(8):932-937.
13. Haist, S.A., Wilson, J.F., Brigham, N.L., Fosson, S.E., and Blue, A.V. Comparing fourth year medical students with faculty in the teaching of physical examination skills to first-year students. *Academic Medicine*. 1998; 73(2):198-200.
14. Josephson, S.A., and Whelan, A.J. A new first-year course designed and taught by a senior medical student. *Academic Medicine*. 2002; 77(12):1207-1211.
15. Paiva, R.E.A., Kienzler, L.M., and Anderson, M.B. Preparation for the teaching role in residencies: An elective for medical students. *Journal of Medical Education*. 1982; 57:792-794.
16. Greenberg, L.W., and Jewett, L.S. Preparing medical students to teach: an educational program using three approaches. *Medical Teaching*. 2002; 9:409-414.
17. Pasquale, S.J., and Pugnaire, M.P. Preparing medical students to teach. *Academic Medicine*. 2002; 77:1175-1176.
18. Bardach, N.S., Vedanthan, R., and Haber, R. J. 'Teaching to Teach': enhancing fourth year medical students' teaching skills. Really Good Stuff: Reports of new ideas in medical education. In: M.B. Anderson (Ed.). *Blackwell Publishing Ltd*. 2003.
19. Haber, R.J., Bardach, N.S., Vedanthan, R., Gillum, L.A., Haber, L.A., and Dhaliwal, G.S. Preparing fourth-

year medical students to teach during internship. *Journal of General Internal Medicine*. 2006; 2:518-520.

20. Greenberg, L.W., Goldberg, R.M. and Jewett, L.S. Teaching in the clinical setting: factors influencing residents' perceptions, confidence, and behavior. *Medical Education.* 1984; 18:360-365.
21. Streips, U.N., and Atlas, R. M. Fourth Year Medical Students are Effective Case Discussion Leaders. *Journal of the International Association of Medical Science Educators*. 2001; 10: 23-26.
22. Allen, V.L., and Feldman, R.S. Learning through tutoring: Low achieving children as tutors. *Journal of Experimental Education*. 1973; 42:1-5.
23. Johnson, K.R., Sulzer-Azarolff, B., and Maass, C.A. The effects of internal proctoring upon examination performance in a personalized instruction course. *Journal of Personalized Instruction.* 1977; 1:113-117.
24. Morgan, R.F., and Toy, T.B. Learning by teaching: A student-to-student compensatory tutoring program in a rural school system and its relevance to the educational cooperative. *Psychological Record.* 1970; 20:159-169.

A Computer-Based Examination for Laboratory Programs in Histology

John R. Cotter, Ph.D.[1], Jason S. Crosby, B .S.[2],

[1]Department of Pathology and Anatomical Sciences
[2]Office of Medical Computing
School of Medicine and Biomedical Sciences
University at Buffalo
The State University of New York
206 Farber Hall
Buffalo, NY 14214-3000 USA

Phone: (+)1-716-829-3685 Fax: (+)1-716-829-2911 Email: jrcotter@buffalo.edu

ABSTRACT

An independently-developed, interactive, Web-based examination is used to assess learning in histology. The examination assesses factual information, concepts and whether the examinees recognize the organs of the body and the cells, tissues and structures that are associated with them and the other parts of the body. The method of assessment streamlines the administration and scoring of an examination and overcomes some of the inadequacies of examinations that use a microscope, video, projection slides or projected digital images. The strengths of the examination flow from the delivery of the examination to a computer workstation, the duel display of the questions and the images of the specimens on a computer monitor, and the use of an interactive computer interface. The interface allows the examinees to perform operations that improve the process of test-taking by conventional means. As a result, the examination is less cumbersome than a synchronous laboratory examination. The examinees advance by opening individual question windows. The examinees tag questions for review, view the images of specimens at more than one level of magnification, add notes to a textbox and strikethrough the options of multiple-choice questions that are judged to be erroneous. The evaluation of the computer application by the examinees shows the interactive features of the application are useful. The security of the examination during and following an examination is handled by the computer application and the actions taken by the course director. The security measures make the recycling of the images and questions on future examinations feasible.

INTRODUCTION

An instructional program in the microscopic structure of the body is often taught in medical school under the rubric of histology or microscopic anatomy.[1-2] The program of instruction, which includes lecture and laboratory sessions, begins with the structure of a cell (cytology), continues with the organization of the tissues (histology) and culminates with the morphology of the organs (microscopic anatomy). And at intervals, as a student progresses from cells to organs, his or her mastery of the laboratory work is measured with a special examination.[3-5]

The emergence of the computer as a pedagogic tool for histology over the past fifteen years has been dramatic.[1-2, 6-7] The application of computer technology to histology instruction however is by no means uniform.[2] Some instructors report using computer technology to supplement the activities associated with a traditional microscope experience[3, 5, 8-16]and others report supplanting traditional microscope exercises with computer technologies [4, 13, 17-20] but as far as the authors can ascertain only a few instructors have reported using computer-based testing for the summative assessment of knowledge.[22-23]

There are programs of instruction in histology at the University of Buffalo that utilize digitized photomicrographs of histological materials embedded in computer-guided learning programs.[4] The digital materials are not virtual slides and the programs do not use virtual microscopes, the two terms being reserved for a computer-based system that simulates the traditional microscope experience much as possible.[24] The digitized photomicrographs of the computer-guided programs are images of microscopic fields selected for their superior instructional value. The digital images are static images and unlike virtual slides are not moved or magnified by computer software.[24-26] But, they are accompanied by an insightful explanation of how the objects seen in the histological sections of tissues and organs are identified when viewed with a microscope.

The results of a computer-based examination described in this report contribute a percentage to a student's overall grade in an interdisciplinary medical school module. The content for one module (with 2 examinations) includes tutorials on the light and electron microscopic structure of a typical cell and the morphology of epithelial tissues, blood cells, fibrous connective tissue, muscle tissue, nerve tissue and blood vessels. The examinations contain images never seen by the examinees and images used in the computer-guided tutorials. The computer application that runs the examination has been used continuously since 2001. As of 2006, the database of questions contained 288 image-based questions.

Microscopes, videotapes and print media have been used at various times in a traditional histology course and interdisciplinary modules to assess the students' ability to recognize the microscopic objects seen in histological specimens. The motivation for turning to the computer to deliver an examination was to bring symmetry to the method of learning and assessment in the introductory foundations module. The impetus for doing so was the students' apprehension at taking a print- or video-based examination after using only the computer-guided tutorials.[4] The asymmetry was disconcerting to the students[4] and the state of affairs begged the question: why not expand the uses of computer technology to include the delivery of examinations? At the same time, the thought of utilizing computer technology for assessment was seen as an opportunity to streamline the delivery and scoring of an examination and eliminate some of the factors that make test-taking with microscopes, projected slides, digital images and digital images displayed with videotapes cumbersome. Two of the most restrictive factors are the synchrony with which the questions are presented and the corresponding need to limit the amount of time allotted to answering each of the examination questions.[22]

Two groups report using commercially available authoring software interfaces for summative assessment in histology.[22, 23] The computer-based examinations are described by the students at the Medical University of South Carolina as "'Efficient', 'educational', 'better' and 'helpful'" compared to paper and pencil examinations[22] and the students at the University of Arkansas did not perform differently when tested with paper and pencil or computer-based lecture examinations.[23]

The current report builds on the previous contributions to the literature on the use of computer-based assessment in histology by: (1) outlining the general structure of a computer application that runs a combined lecture and laboratory examination, (2) describing how the interactive features of the application are used and the way the features improve the process of sitting for a laboratory examination, (3) summarizing the results of the students' evaluation of the computer interface and (4) recounting the experience of using a computer-based examination specifically designed for use in a laboratory program in histology.

Computer Application for Examinations

The computer application uses three separate technologies--data management, data display, and user interface. Microsoft® SQL Server 2000® (SQL) running on a Microsoft® Windows 2003 Server® handles the management of all of the information coming into and out of a database. The data is accessed and saved using stored procedures, commonly used routines, run on the SQL Server®. Data display is handled using Active Server Pages (ASP). The ASP utilizes ActiveX Data Objects (ADO) and VBScript. The ADO is the conduit through which the database is accessed.

Data can be requested from or sent to a database using ADO. Once the data is received, it can be manipulated into the necessary format for display using VBScript. For the user interface, the components used are JavaScript, Cascading Style Sheets (CSS), and Hypertext Markup Language (HTML), commonly known as Dynamic HTML (DHTML). JavaScript executes interface interactions with the user, CSS handles formatting and the Web pages are structured with HTML.

In the database, the questions, options, image references and the answer key are stored separately. The separation of the items allows for the reuse of the questions with different options and correct answers. The reuse of the questions with different options and correct answers can often be done with the image-based questions if the question text is brief. Additionally, information is stored in the database relating to general test information: the title and date of the exam and specific user information, such as the users' names and identification numbers, the time an examinee is assigned to take an examination, and the examinees' responses and scores for each examination. One of the benefits of using a relational database is that many statistics can be compiled from the exam results. After an examination, the results can be queried to show the response rate for questions as well as for the users.

Each original digital image used for Web display is converted to an image file that is smaller than the original file. A smaller file size reduces the loading time for an image on the medical school's computer network. One digital image is loaded on a Web page with a question; the maximum height of an image is 200 pixels. Larger graphics push some of the contents of the Web page beyond the limits of the monitor screen; limiting the height of a digital image prevents this from happening and the need for an examinee to scroll the length and /or width of a Web page. When a question requires another image, an alternate image is made available.

How the Computer Application Works

A student logs-on to the application using a unique identifier provided by the University. Having done so, an examinee sees any assignments, i.e., the examination scheduled that day, or previously completed examinations associated with the identifier. The assignments are available to the user at log-on for a defined time period. Once an assignment is selected, the ASP calls the SQL stored procedure to retrieve the appropriate test information. It then builds an external JavaScript file on a server with an array of questions and options for an examination. Each user has a distinct JavaScript file created for loading an examination because the users do not load an examination simultaneously. The JavaScript file is then removed from the server once an examination is loaded.

An examination is loaded from the JavaScript file. The questions are randomized using a second JavaScript array that is unique for each of the examinees as it is loaded. Even though the examination questions are randomized, form element tag names drawn from the database are consistent with the questions no matter the order in which they are displayed. A similar procedure is used to randomize the order of the options. Each of the options maintains the same name as it is loaded, but they are not loaded in the same order at each workstation. Consequently, the same examination questions are not displayed to all of the examinees simultaneously and the order of the options is not displayed in the same order at every workstation even though everyone receives the same images, questions and options.

An examination launches in full screen mode with only one of the examination questions displayed at a time. This display is done by using the CSS property “display: none” for each question after the first question. When an examinee selects a navigation button or a question number from a grid at the top of the screen, a JavaScript changes the display property of the current question to ‘none’ and the selected question to 'inline'.

A JavaScript matches the correct and incorrect responses upon submission of an examination. The responses are submitted to the database through an ASP calling a SQL stored procedure. The grade, with personal information, the date of the examination, the assignment number, and an examinee’s questions and list of answers are saved to a database. All of the questions and options are passed as a single parameter and parsed by the stored procedure. The information is kept in a row-based format. The columns in the response table are unique identifier, assignment number, question name, user response, and user response group number. If necessary, modifications to the correct responses for the questions can be made in the database. Once an option is modified, the database of user responses can be queried and the scores adjusted according to the revised option.

The computer application is dependent on JavaScript for several reasons. Early in its development, the computer application was designed to run without a database and independent of a computer network. Originally, the application could actually be held on a diskette. The design has advantages. It somewhat mimics a traditional paper examination in that the examination is not accepted until it is completed to the satisfaction of the examinee. It also eliminates the need to change the examinees responses in the database as they proceed through the exam and revise the responses. And it limits the network traffic thus making the response time for navigation faster.

The application saves user responses to the local computer as cookies that can be retrieved later and deleted after submission to the database. The computer application is also designed to give immediate feedback to the users, displaying a score and a corrected examination upon submission of an examination, however, this feature can be turned off.

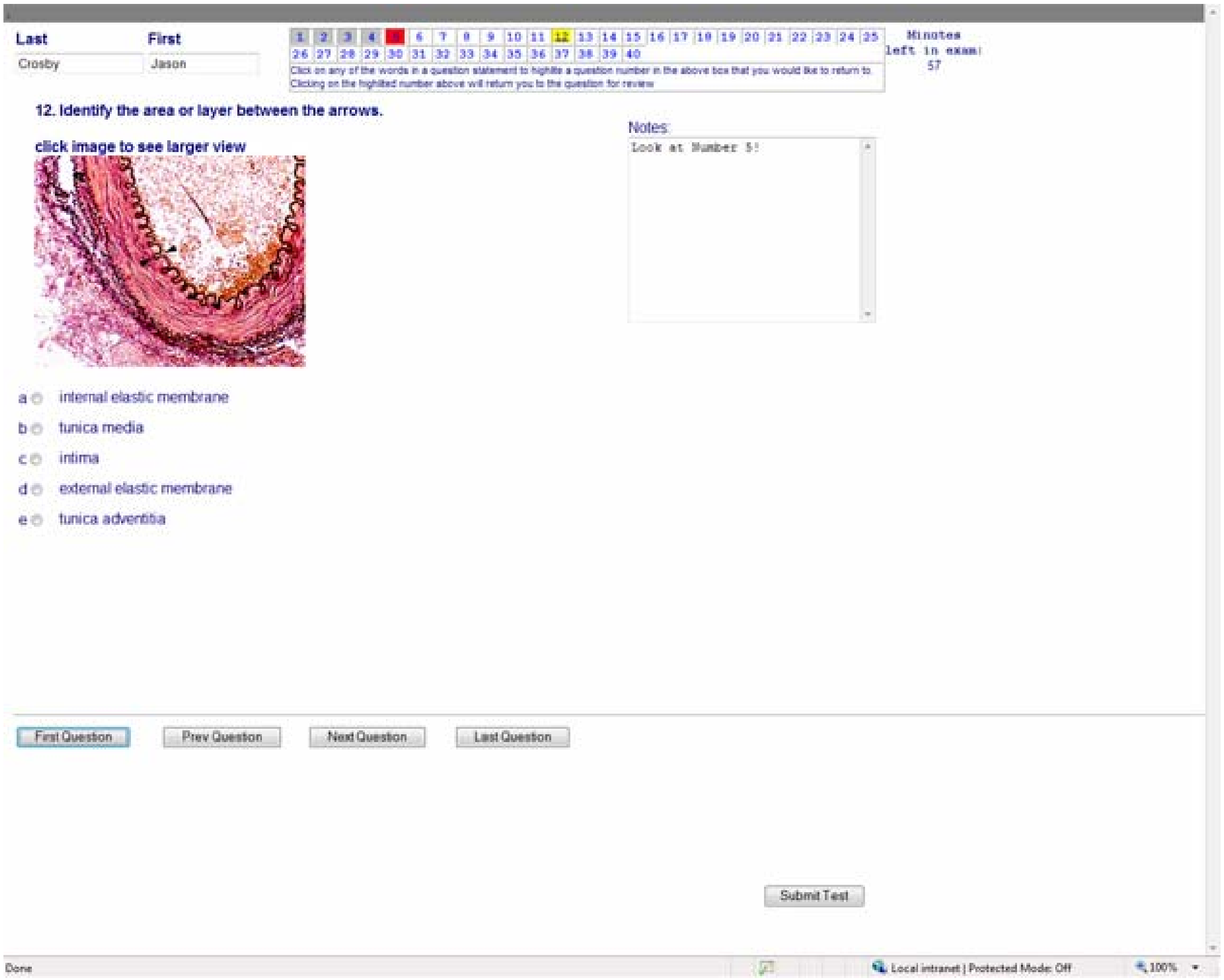
Screen Display and Navigation

Figure 1 illustrates the layout of an examination window. On the left hand side of the window, proceeding along the bottom and to right hand side of the window, are five buttons. The first four buttons, which allow an examinee to navigate to different questions, are named for the actions that they are designed to accomplish: selecting the “First Question”, “Previous Question”, “Next Question” and “Last Question” buttons display the first question, previous question and so on. Selecting the “Submit Test” on the far right hand side of a window submits the answers selected and closes the application.

An examinee can scan the entire examination viewing the examination windows in numerical order by using the “Next Question” button, then return to the beginning of an examination with the “First Question” button before attempting to answer any of the examination questions. Alternately, an examinee can peruse the windows responding to each question as it appears when the “Next Question” button is selected. Or, an examinee can jump to any question using the navigation buttons and the grid of boxes at the top of the question window.

During an examination, an examinee responses are saved locally as a cookie on the computer. To avoid accidental or premature submissions, a prompt asks an examinee to confirm whether he or she intends to submit an examination before it is written to the database. A timer in the upper right-hand corner of the window counts down the number of minutes remaining before the examination closes. Upon the expiration of the time limit for an examination, a JavaScript automatically submits the examination. An examinee is notified of the time limit for an examination when the examination loads (Figure 2) and the amount of time

Figure 1.



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40										

Last: Crosby
First: Jason

Click on any of the words in a question statement to highlite a question number in the above box that you would like to return to.
Clicking on the highlited number above will return you to the question for review

Minutes left in exam: 57

12. Identify the area or layer between the arrows.

click image to see larger view

a ○ internal elastic membrane
b ○ tunica media
c ○ intima
d ○ external elastic membrane
e ○ tunica adventitia

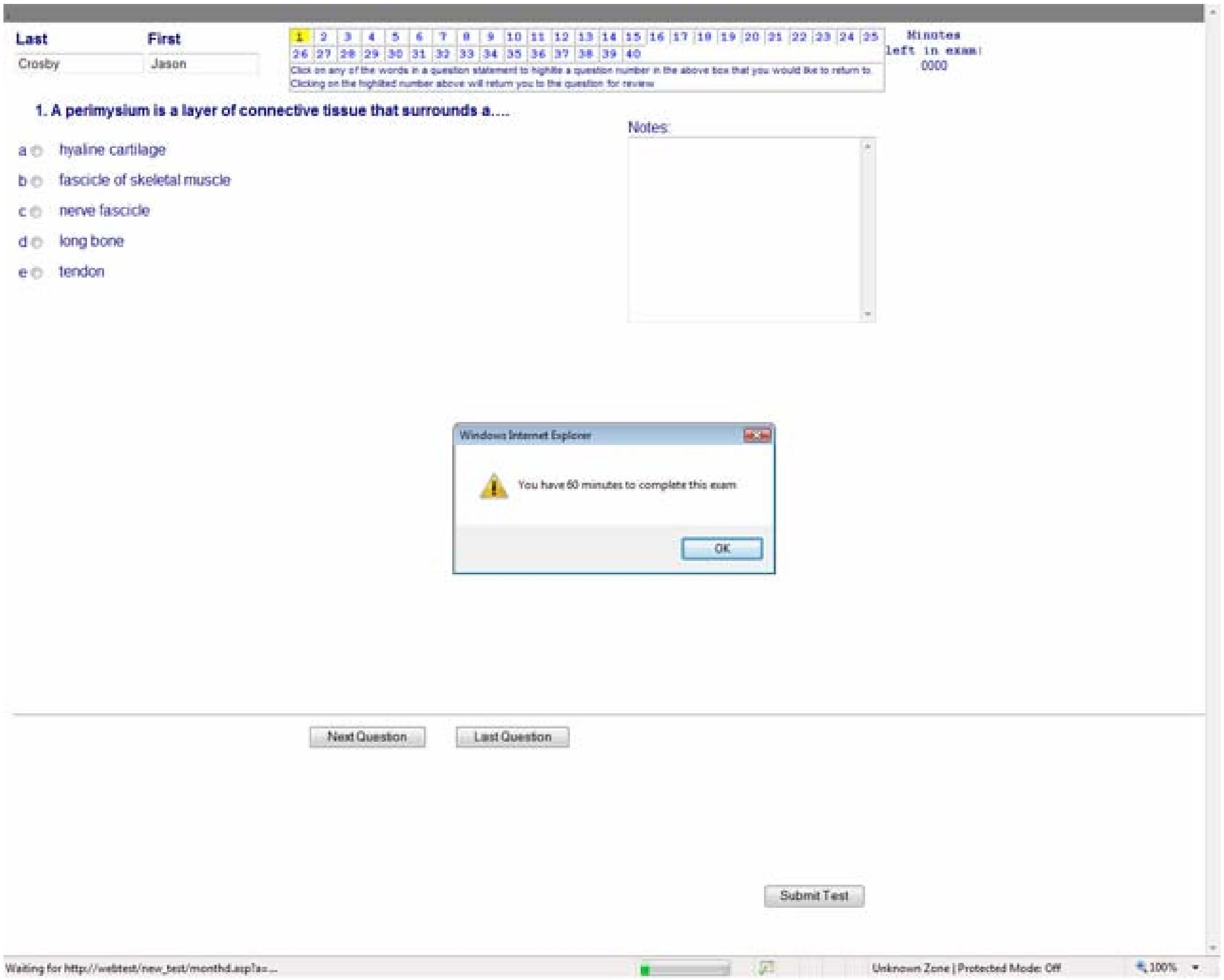
Notes:
Look at Number 5!

A screen shot of a typical image-based examination question. Notice the grid of boxes: box number 12 is highlighted (in yellow) to indicate the number of the question displayed on the monitor screen and box number 5 (highlighted in red) is an example of a tag that reminds the examinee to return to the question before quitting the examination.

remaining at five minutes and at one minute before the program automatically terminates and submits the examination.

The name of an examinee is posted in the top left hand corner of the question windows. Immediately to the right, a grid of boxes lists the numbers assigned to the questions. The color of a box changes from white to yellow when an examination window corresponding to the question number in the grid of boxes is displayed on a monitor screen. In figure 1, a user advanced to question 12; therefore, the background of box number 12 is highlighted in yellow. The boxes for which an answer is selected are highlighted in grey. In this way, an examinee can keep tract of his or her progress toward completing the examination. The change in the color of a box is done using the CSS 'background-color' property and JavaScript.

Figure 2.



Last: Crosby

First: Jason

Click on any of the words in a question statement to highlite a question number in the above box that you would like to return to. Clicking on the highlited number above will return you to the question for review

1. A perimysium is a layer of connective tissue that surrounds a....

a ○ hyaline cartilage
b ○ fascicle of skeletal muscle
c ○ nerve fascicle
d ○ long bone
e ○ tendon

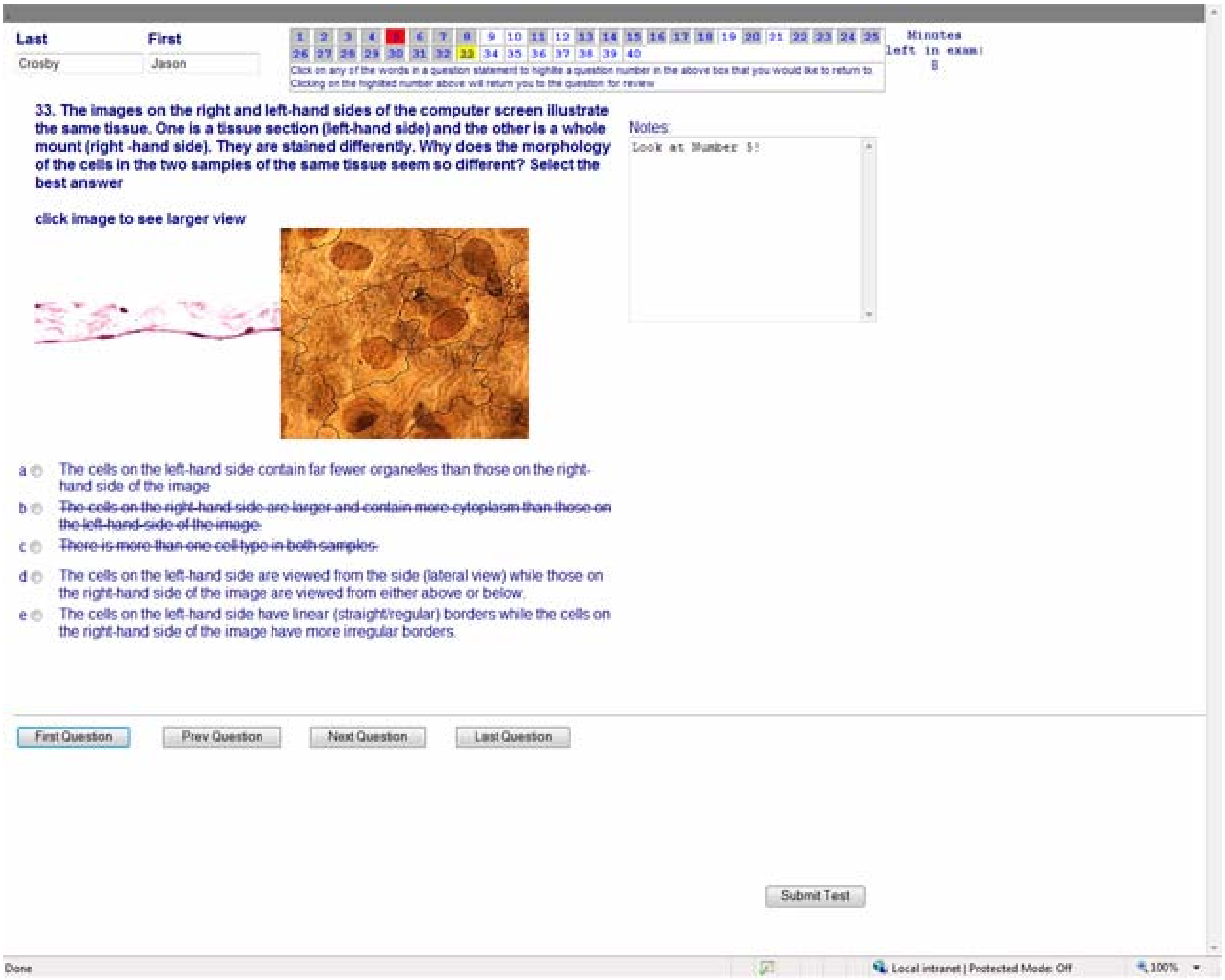
You have 60 minutes to complete this exam

Waiting for http://webtest/new_test/monthd.asp?a=...

A screen shot of a lecture-based examination question. An examination does not begin until an examinee acknowledges the time allotted by selecting the “OK” button in the response box. A warning that the time allocated for an examination is about to expire appears in a similar box before the computer application automatically submits the examination. A counter in the upper right-hand corner of the computer screen tracks the amount of time remaining once the examinee begins the examination.

Placing the cursor over the text of a question and left mouse clicking once changes the color of a box from yellow to red (Figures 1 and 3). If the examinee proceeds to another question, the box remains highlighted in red. The boxes tagged in red comprise a subset of the questions an examinee wishes to postpone answering or reevaluate before submitting the examination. Clicking on a red color coded box in the grid of boxes, returns an examinee to the specific question window. Upon returning to the question, the color of the box corresponding to the question selected changes from red to yellow indicating the number of the question displayed on the monitor screen. When the examinee moves on to another question, the color reverts to the prior color. However, if the examinee answers the tagged question by making a selection from the list of options, the background color for the appropriate question box in the grid of boxes is highlighted in grey to indicate the question has been answered. The question can be marked again for review by clicking on the text of the question. The red tag is only turned off and the box highlighted in grey when the current selection is verified by selecting it again or choosing an alternate answer from the list of options.

Figure 3.



Last: Crosby
First: Jason

Click on any of the words in a question statement to highlite a question number in the above box that you would like to return to.
Clicking on the highlited number above will return you to the question for review

Minutes left in exam:
8

33. The images on the right and left-hand sides of the computer screen illustrate the same tissue. One is a tissue section (left-hand side) and the other is a whole mount (right -hand side). They are stained differently. Why does the morphology of the cells in the two samples of the same tissue seem so different? Select the best answer

click image to see larger view

Notes:
Look at Number 5!

a ○ The cells on the left-hand side contain far fewer organelles than those on the right-hand side of the image

b ○ ~~The cells on the right-hand side are larger and contain more cytoplasm than those on the left-hand side of the image.~~

c ○ ~~There is more than one cell type in both samples.~~

d ○ The cells on the left-hand side are viewed from the side (lateral view) while those on the right-hand side of the image are viewed from either above or below.

e ○ The cells on the left-hand side have linear (straight/regular) borders while the cells on the right-hand side of the image have more irregular borders.

A screen shot of a laboratory-based examination question that uses two images. Notice that the examinees can strikethrough the options.

An examination question occupies the left hand side of an examination window (Figures 1-4). The question is located beneath an examinee's name and the grid of color coded boxes. The examination questions are one-best-answer questions.[27] They consist of (1) a question and a list of options consisting of one correct answer and four distracters (Figure 2); (2) a statement or instruction for handling a question, an image and options (Figure 3); or (3) an examination question, an image and options (Figure 1). Up to five possible options with radio buttons are listed beneath an image.

A structure or the structures that are related to a question are marked by an arrow or arrows (Figures 1) or outlined (Figure 4). The color of the graphic is chosen for its ability to draw the gaze of an examinee to the location of the structures. The use of color improves the chances of this happening in an image of a specimen that is stained with a dye of contrasting color.

Two images may be needed to adequately illustrate the histology of a specimen. The first image usually illustrates the morphological features that can not be seen in a more limited field of view (Figure 4A). A second more greatly magnified image then focuses on a more limited field in order to reveal the morphological details of the objects in a specimen that are not easily discerned or can not be discerned in the wider field of view (Figure 4B).

Figure 4.

Last Crosby
First Jason

Click on any of the words in a question statement to highlite a question number in the above box that you would like to return to.
Clicking on the highlited number above will return you to the question for review

Minutes left in exam: 60

3. Identify the outlined tissue.

click image to see larger view

Notes:

a ○ tendon at insertion of muscle
b ○ smooth muscle cells
c ○ conducting pathway cells of the heart
d ○ muscle cells of the heart whose primary function is the contraction of the ventricles
e ○ fibrous skeleton of the heart

Last Crosby
First Jason

Click on any of the words in a question statement to highlite a question number in the above box that you would like to return to.
Clicking on the highlited number above will return you to the question for review

Minutes left in exam: 60

3. Identify the outlined tissue.

Notes:

a ○ tendon at insertion of muscle
b ○ smooth muscle cells
c ○ conducting pathway cells of the heart

A pair of screen shots of a laboratory-based question that uses an enlargement. Placing the cursor over an image (A) and clicking with a mouse opens another window containing a more highly magnified image of the original specimen (B). In this instance, an examinee must scroll the window to view the options and navigation buttons.

The statement "click image to see larger view" (Figures 1, 3-4) indicates a larger image or an enlargement of a critical area of the original specimen is available. Choosing a larger image may push the options and the control buttons to the bottom and the textbox of notes farther to the right-hand side of the Web page (Figure 4B). Changing the image is done by using a JavaScript to swap the CSS display tag between 'inline' and 'none' for the initial and enlarged images. The initial image reappears and the second image is removed when the user mouse-clicks on the enlarged image.

An examinee can keep track of the options that he or she believes do not answer a question correctly by placing a line through any of the five options (Figure 3). The strikethrough of an option is accomplished by moving the cursor over an option and left clicking with a mouse. If desired, the line can be removed by repeating the procedure. Setting the CSS text-decoration property to strikethrough allows a user to place a line through the text of any of the options.

A textbox (Figures 1- 4) was added to the right hand side of an examination window in response to the student request for note paper. In figures 1 and 3, the reminder "Look at Number 5!" typed into the textbox serves to illustrate an entry. In practice, the examinees enter the facts they can recall and believe are relevant to answering a question. The information is referred to while trying to reach a decision regarding the best possible option if the option is not recognized or immediately known. During an examination, the entries to the textbox are saved while the program is running and available should an examinee need to return to a question to reexamine the logic or information used in choosing an answer.

While an examination is open, the options selected by an examinee are saved in a cookie on the system. If an examinee needs to reload the examination, the radio buttons chosen by an examinee are filled in. However, neither the notes nor the question numbers tagged for review in the grid of boxes at the top of the monitor screen can be restored. The cookie has a unique name based on the user who is logged-in to the application. It is deleted from the computer system once an examination is submitted or when the computer system is rebooted.

Laboratory-Based Questions

The ability to recognize the microscopic structures is assessed by having the examinees identify objects that at are seen in the digital images of histological specimens (Figures 1 and 4). There are also questions for which the recognition of an object is the first step in selecting an answer to a question. Thus, a structure serves as the basis for a question and an examinee must select a function or relevant point regarding the structure from the list of would-be answers. The breadth of the questions can be expanded by grouping two or more images together (Figure 3). An examinee must then recognize the content of each of the images and answer a question that relates one of the images to the other one.

Before the use of computer-based examinations, multiple-choice questions had replaced fill-in-the-blank questions, even for the examinations that were microscope-based. After several years of computer-based testing, the authors were reminded that fill-in-the-blank questions are handled differently.[5] The propensity of the students to respond to a question with a correct but different answer, inadvertently confuse terms and misspell words complicates the scoring of an examination. The situation can be resolved with a database that takes all of the possible answers into account. Or, an examination can be rescored after the unanticipated answers become known. It is also possible to have the examinees select an answer from an extensive list of possible options.[28] In the end, the authors were more comfortable with multiple-choice questions and continued to use them.

Limitations Imposed by the Number of Computer Workstations and Class Size

An examination is not administered to all of the students in one sitting because the number of students in the class outnumbers the computer workstations by approximately 2 to 1. The disparity is handled by dividing the class into two groups: one-half of the class sits for an examination immediately after the other half finishes an identical examination. While one group is finishing the first session of the examination, the other group is sequestered in a nearby room shortly before the end of the first examination. To ensure the content of the examination is not revealed to anyone in the second group, all of the students in the first group remain in the computer laboratory until all students in the second group are assembled and accounted for. Therefore, all of the students sitting in the first session, even those who submit the examination early, can not leave the examination room before the second group is ready to take the place of the first group. At the close of the first examination, the first group is released and the second group moved into the room. The system is not popular with the students because the examinees are not permitted to leave or use the computers after submitting the examination. The procedure ensures the students from the two groups do not come into contact with one another to discuss the contents of the examination in the interval between the examinations.

Starting, Ending and Reviewing the Results of an Examination

Once seated, the examinees are briefly introduced to the graphic display and features of the computer interface. They are shown how to move through the examination using the navigation buttons and how to select the enlargements, strikethrough the options, make textbox entries and submit the examination. The examinees are told the examination will be submitted automatically once the time allotted expires and about the count down timer and time warnings that appear toward the end of the examination. The color code for the grid of question numbers and the method of tagging questions for review is explained and demonstrated using several of the examination questions. The security features for randomizing the order of the questions and the response options are made clear to them.

The computer application can display the results of an examination anytime after the examination has been submitted. To view the results of an examination, a student logs-on to the same application Web interface using his or her unique identifier. Once logged-on, the score and a composite of an individual's examination--the questions, digital images, options and answers and the answers chosen by the examinee --are displayed.

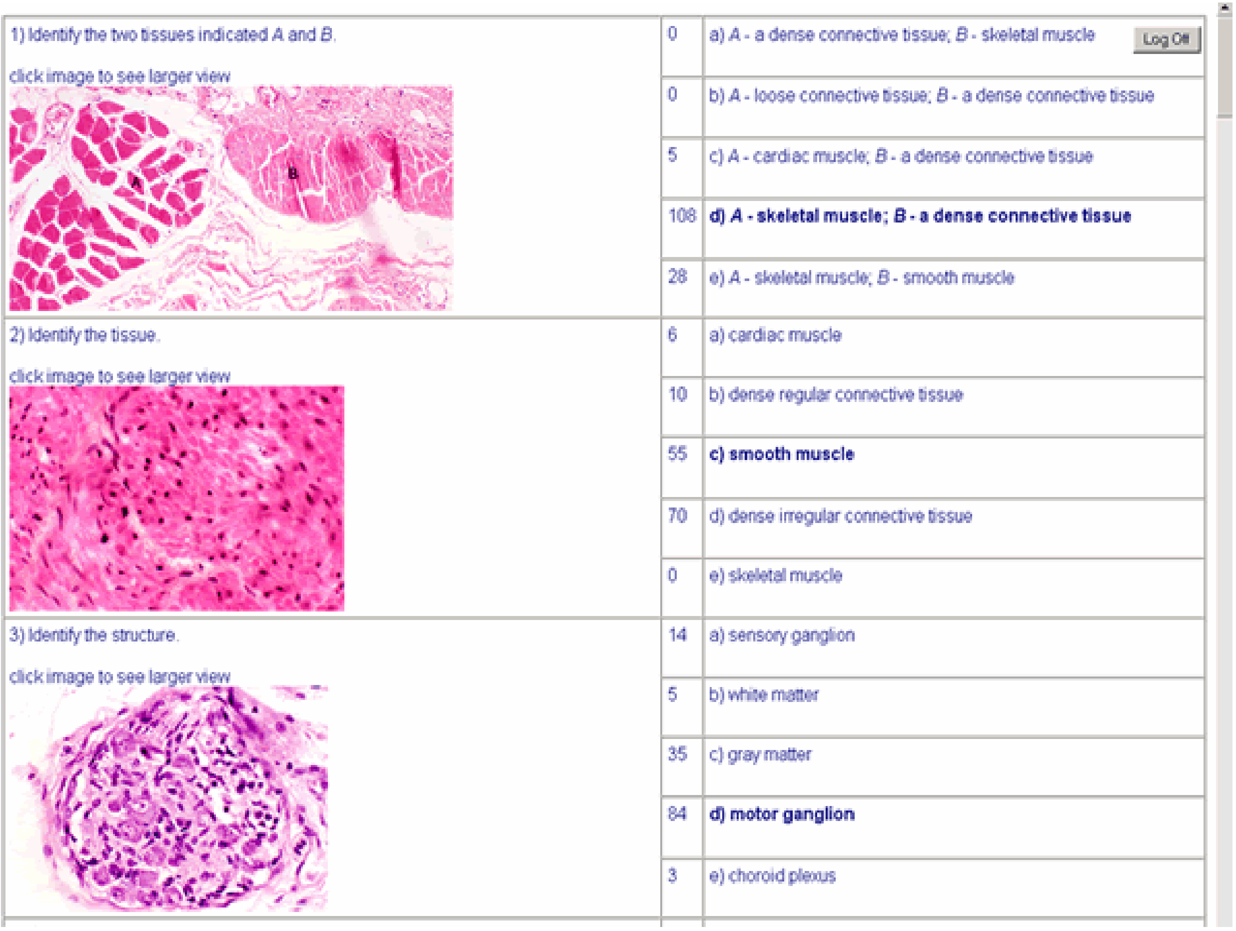
The summary of the examination can be displayed at the workstation upon submission of an examination. However, the speed with which the scoring and the results can be returned to the students is not used for the following reasons: all of the students do not finish at the same time and immediate feedback could be distracting to those who have not finished the examination; the faculty which is busy proctoring, answering questions or preparing for the second group of examines are unable to speak to students who may need to discuss the results of the examination; and when the students are asked about immediate feedback, some have stated they would prefer to review the results of an examination in a less public setting or at least when there are fewer people in the computer laboratory.

For the purposes of security (see below), the course policy is to deny direct access to electronic copy of the examination. Also, a hard copy and answer key are not posted. A student, who wishes to see his or her "examination paper" and the way it was scored, and discuss his or her performance must meet privately with the course director. The student is shown the computer generated summary of the examination. The computer application also generates a Web page that differs from the student examination paper only in that it summarizes the distribution of the options chosen by the entire class for each of the questions (Figure 5).

Examination Security

Several steps are taken to secure the examination during and after the administration of an examination. The sequestering of the two examination groups and the scrambling of the questions and options has been mentioned. During an examination, the examination is proctored by the faculty and the examinee line of sight restricted to the sight lines immediately in front of a computer monitor by a 3M^{TM} Privacy Filter fitted to the size of the monitor screens. The input from the keyboard is limited to the typing of notes in the textbox and input from the mouse is limited to the left mouse button. At computer log-in, a standard user profile limits the usability of the computer system and restricts the user to the testing venue.

Figure 5.



1) Identify the two tissues indicated *A* and *B*. click image to see larger view	0	a) *A* - a dense connective tissue; *B* - skeletal muscle
	0	b) *A* - loose connective tissue; *B* - a dense connective tissue
	5	c) *A* - cardiac muscle; *B* - a dense connective tissue
	108	**d) *A* - skeletal muscle; *B* - a dense connective tissue**
	28	e) *A* - skeletal muscle; *B* - smooth muscle
2) Identify the tissue. click image to see larger view	6	a) cardiac muscle
	10	b) dense regular connective tissue
	55	**c) smooth muscle**
	70	d) dense irregular connective tissue
	0	e) skeletal muscle
3) Identify the structure. click image to see larger view	14	a) sensory ganglion
	5	b) white matter
	35	c) gray matter
	84	**d) motor ganglion**
	3	e) choroid plexus

A summary of an examination results is displayed in a single window. The screen shot illustrates only the first three questions of an examination. The options for answering each question are listed to the right. The number of students that selected each choice is shown to the left of the options. The correct answer is highlighted in bold print.

A computer program (Deep Freeze / Faronics Corporation) installed on all of the computers prohibits changes to the computer system. Following an examination, rebooting the computers removes any cookies, images, or residual files left in the cache or history of the computers and prevents the inadvertent release and unauthorized copying of the images. As an alternative, a secure browser may also be used to prevent the copying of an examination.

Backup System

A redundant system backs up the primary system in the event of a system failure. The alternate system duplicates the testing application, along with the database and graphics. Any of the primary systems (testing application and database) can be utilized with the corresponding backup system giving four possibilities for successfully presenting an examination. As a result, the primary test application can be used with either the primary or secondary database. Likewise, the secondary test application can be used with either the primary or secondary database. The change in databases is made by directing the application to the appropriate database. Both testing applications are reached through a host file on a local computer.

Collaborations

The computer application and computer-based examination described in this report are the result of collaboration between the faculty in the module and a computer programmer (JSC). The latter is responsible for the computer application and input of the database and initially the former along with his colleagues in histology (Drs. Cynthia Dlugos, Chester Glomski, Roberta Pentney and Herbert Schuel) were responsible for the content of an examination. With the loss of faculty due to retirement or reassignment, two members of the faculty are now responsible for all of the content. The Office of Medical Computing (OMC) oversees the use of the central computer facility and an ancillary site which together house 82 computers. The OMC also provides the technical assistance needed at start-up and during the conduct of the examinations.

Normally the two faculty members supervise and proctor the examination when it is given in the larger of the two computer laboratories (70 workstations). Three to four computer specialists from OMC help with the set up of the workstations before an examination. During an examination two aides are present in the larger room to accompany students who must leave the room during an examination. Between the examinations, two more aides assist organizing the second group of examinees and moving the first and second groups into and out of computer laboratory. If there are more than 140 examinees, a smaller computer laboratory with 12 workstations is staffed by an aide and proctored by a member of the faculty. The OMC also helps with the set up of the computers in the smaller room.

Student Evaluations

Immediately following an examination, the medical school classes of 2007 and 2010 were asked about their experience with computer-based examinations; their comfort level with the examination and the questions used on the examination; and about the computer interface used for the examination. Out of 140 students, 131 or 93.5% of class the 2007 and 136 students or 97.1% of the class of 2010 responded to the questions contained in the evaluation instrument.

Most of the students (84.7% and 87.5%), had never taken a course that used computer-based testing (Figure 6A). (Note: in this and the examples that follow, the first % of students enclosed by brackets corresponds to the % of students responding in 2003 and the second % of students corresponds to the % of students responding in 2006.) The majority of the students (67.9% and 68.4%) strongly agreed or agreed they were comfortable with the method of testing (Figure 6B) and the format of the questions (67.9% and 76.7%) used on the examination (Figure 6C). Well before an examination, the students were given examples that illustrated the form of the questions used in previous years. The question about the format of the questions evaluated whether the examinees were prepared for the formats actually used.

Forty-four percent of the students in 2003 and 55% of the students in 2006 strongly agreed or agreed that “the quality of the images…was adequate to answer questions that were paired with images” (Figure 6D). Despite using images that were judged by the faculty to be of superior quality and to have faithfully replicated the original microscopic materials, approximately a quarter of each class (23% and 24%) did not agreed or disagreed with the statement and 32% and 21% disagreed or strongly disagreed. In both years, the students were asked to comment on the strengths and weaknesses of the application and the students often referred to the quality of the images. Some students described the images as being “unclear”, “fuzzy”, “blurry” and “of poor quality” while others characterized the images as “clear”, “good”, “great” and “of the highest quality”. The polarity of opinion was a concern given the importance of the images to the validity of a laboratory examination and it was during the dialogue with students after an examination that we were made aware of the specific images that were objectionable to them. Normally, this amounted to 1-2 images out of approximately 12 -15 of the images used. In speaking to students about the polarity of opinion, it was clear the objectivity of the students who considered the images to be of inadequate quality was clouded by their inability to recognize structures contained in an image or their inability to interpret what was demonstrated by an image and not the sharpness or quality of the images.

Nearly all of the students (95.4% and 97.8%) felt the computer application was easy to navigate (Figure 6E) and nearly all (96.2% and 97.8%) supported the use of enlargements (Figure 6H). A somewhat smaller percentage of students (88.6% and 94.1%) “thought marking questions for review was a useful feature of the application” (Figure 6F).

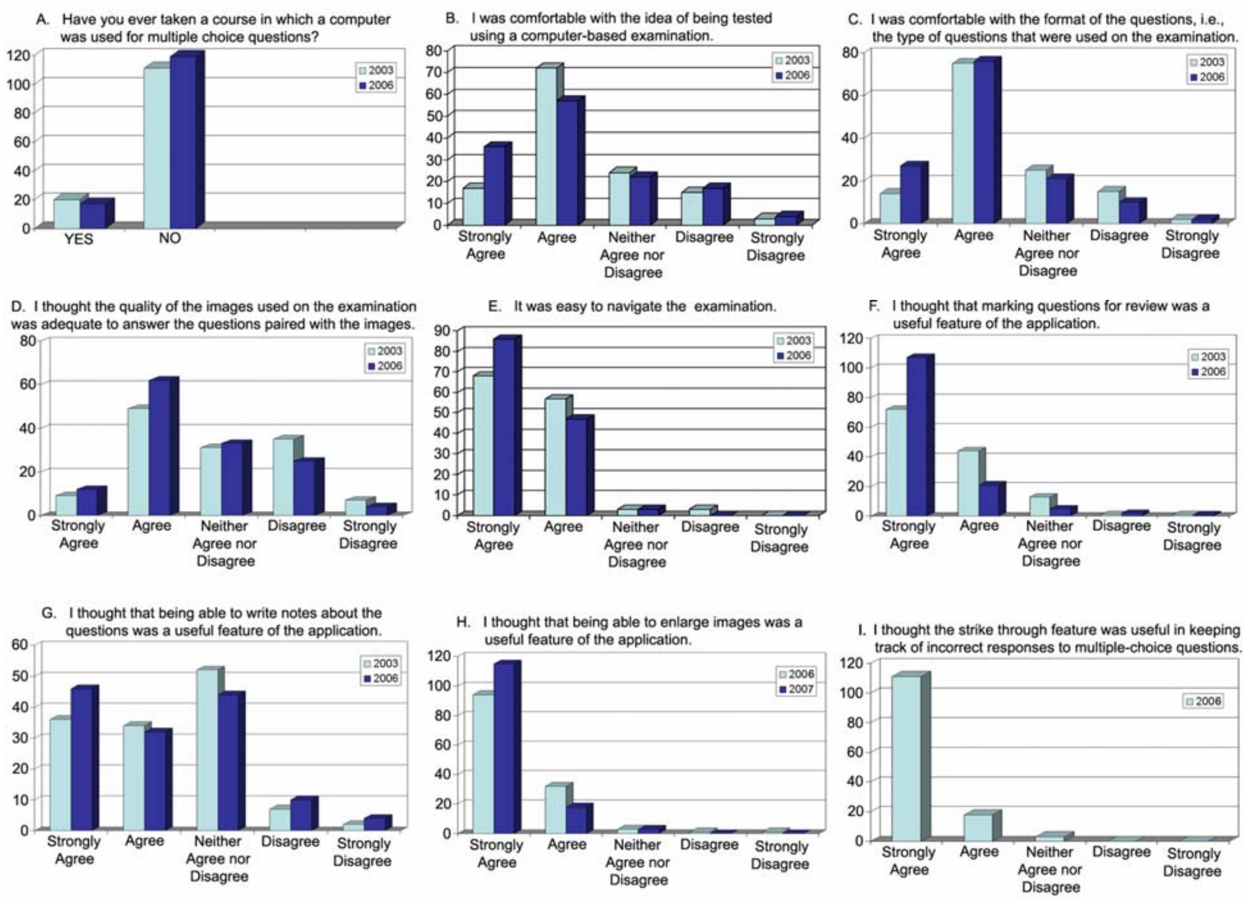
At the suggestion of the students, several of the features were added to the computer application. A textbox was intended to eliminate the need to distribute and collect pieces of note paper. However, only approximately one-half of either class strongly agreed or agreed that being able to write notes (53.4 % - 57.4%) in the textbox was a useful feature of the application (Figure 6G). The half hearted support for the textbox was reinforced by written comments that requested scrap paper the students could write or draw on.

The ability to strikethrough the options to multiple-choice questions was also added in response to the student suggestions for improving the application (Figure 6I). The addition, which was evaluated in 2006, was popular. Ninety-five percent of the students strongly agreed this was a useful feature of the computer application.

Discussion

The computer-based laboratory examination described in this report assesses the facts and concepts contained in the

Figure 6.


A. Have you ever taken a course in which a computer was used for multiple choice questions?

B. I was comfortable with the idea of being tested using a computer-based examination.

C. I was comfortable with the format of the questions, i.e., the type of questions that were used on the examination.

D. I thought the quality of the images used on the examination was adequate to answer the questions paired with the images.

E. It was easy to navigate the examination.

F. I thought that marking questions for review was a useful feature of the application.

G. I thought that being able to write notes about the questions was a useful feature of the application.

H. I thought that being able to enlarge images was a useful feature of the application.

I. I thought the strike through feature was useful in keeping track of incorrect responses to multiple-choice questions.

Student evaluations of a computer-based examination and the computer application. Most of the students had never taken a course that used a computer for multiple-choice examinations (A) but they were comfortable using a computer to take the examination (B) and with the format of the questions used on the examination (C). The students also responded positively to the navigational features (E) of the application; the ability to mark questions for review (F); the note taking capability of the application (G); the use of enlargements in the examination (H); and the ability to strike through the distracters used in multiple-choice questions (I) . Although many students thought that the quality of images used in the examination was adequate to answer questions that were paired with images (D), 32% of the respondents in 2003 and 21% of the respondents in 2006 indicated the image quality was inadequate to answer questions that were paired with images.

lecture and laboratory sections of a histology course, overcomes some of the inadequacies of conventional histology examinations and matches the method of learning to the method of assessment in a program of laboratory instruction carried out with computer-guided tutorials. The computer application, which was developed internally, generates and delivers the examinations from databases once the contents for the examination are in place. Once an examination begins, the faculty is only needed to proctor and answer questions, if questions are permitted. And being a paperless examination, paper is conserved and there are no examination papers to either handle or score after an examination.

The scoring of the examination is more convenient than Scantron scoring (bubble in answer sheets) or grading by hand: a server rather than the faculty scores an examination, the scoring of the examination is accomplished the moment the examination is submitted and an individual’s score can be displayed, if desired, on the monitor screen upon submission of the examination. The students prefer not seeing a score immediately but are aware the scores are readily available and therefore expect the results to be posted within a few days. If an item is scored improperly, the error is easily rectified and the examination for the entire cohort of examinees is automatically rescored. The server also stores the results in the memory of the computer along with student and examination information.

As pointed out by Dr. Daniel Emmer, instructional software developer with the School of Dental Medicine and Dr. Frank Schimpfhauser of the Office of Medical Education, the digital images and the questions can be recycled or a new examination made by mixing old images and questions with a selection of new ones. But, recycling is viable only if the examination questions and images are not posted or released to the students. Withholding the images from the students is viewed as a practical necessity for two reasons: first, the preparation of a laboratory examination *de novo* involves, in large measure, the time consuming and challenging task of acquiring and customizing the digital images; and second, and more importantly, withholding the images protects the uniqueness of the examination. Unlike microscope, video, and project slide examinations, the digital images of computer-based examinations and questions may be copied and distributed if an electronic from of the examination is released to the students. If this were to repeatedly occur, at some point it would be impossible to create a genuine laboratory examination and eventually the examinations would assess only the ability to associate a structure with an image--not the ability to apply knowledge.

Matching the method of assessment to the method of learning was expected to lessen the uneasiness of the students in the time leading up to an examination. Unfortunately, it did not. "Like many other students … students become apprehensive at exam time. In part this is due a loss of perspective, but a major contributing factor is that they do not know what to expect on the exams."[5] When two University of Buffalo students were asked what not knowing to expect might mean, one explained that students do not know how they were going to perform and another explained that the students have never been tested with a computer. The student insights are supported by student surveys done in 2003 and 2004. The surveys showed only 7 % of the students entered the school with training in histology and only 14.3% and 12.5% of the students in 2003 and 2006 respectively had taken a course in which a computer was used for multiple-choice examinations (Figure 6A).

Over a period of four years, a practice examination introduced the students to the mechanics of taking a computer-based examination, the interactive features of the computer application and the types of questions used on an examination. The exercise did not mitigate the uneasiness of the students and only raised the expectation the questions used on the practice examination were the same as those used on the real examination or of the same difficulty. It appears the uneasiness observed in individuals and the class as whole can only be quelled by having them sitting for a meaningful (actual) examination. To help prepare the students, they are now given sample questions that resemble the type and difficulty of the questions used on the examinations and directed to Web sites on the Internet where they can practice identifying structures.

The student-screen interactions that a graphical computer interface make possible enable an examinee to perform operations that improve the process of sitting for a laboratory-based test. One of the most important improvements is the flexibility with which an examinee can navigate the examination windows. An examinee can scrutinize a window--even one previously opened--and do so as many times as necessary during an examination. Thus, within the restriction imposed by the overall time limit for an examination, the amount of time and effort expended on a particular question is determined by the examinee. The pacing of oneself is thought to explain the student enthusiasm for computer-based testing in histology at the Medical University of South Carolina.[22]

Unlike a microscope examination in which the magnification and the field of view are usually fixed, another question window allows an examinee to view more than one field of view or level of magnification. This is in keeping with the practice of using a range of magnifications when studying specimens with a microscope[4, 29-30] and comparable to the way histology is presented in the computer-guided tutorials. The process of answering questions is also facilitated by being able to tag questions for review, add notes to a textbox and striking through the options. The interactions lead to or replicate many of the strategies used by students in testing situations.[28] The performance of students tested with computer-based examinations and other kinds of examinations is being assessed.

In academia, the development of computer-based examinations may be "hindered or abandoned due to time and funding restrictions, or reliance on an individual academic."[31] In this instance, computer-based testing would not have been possible had it not been for the cooperation of the Office of Medical Education (OMC) in scheduling the school's central computer facility for histology instruction and testing during class time, the technical expertise of the OMC staff and the construction of a common medical computing laboratory with enough computer workstations for half of the medical school class.

REFERENCES

1. Hightower, J.A., Boockfor, F.R., Blake, C.A., and Millette, C.F. The standard medical microscopic anatomy course: histology circa 1998. *The Anatomical Record (The New Anatomists)*. 1999; 257 (3): 96-101.
2. Bloodgood, R.A., and Ogilvie, R.W. Trends in histology laboratory teaching in United States medical schools. *The Anatomical Record (The New Anatomist)*. 2006; 289B (5): 169-175.

3. Lehmann, H.P., Freedman, J.A., Massad, J., and Dintzis, R.E. An ethnographic, controlled study of the use of a computer-based histology atlas during a laboratory course. *Journal of the American Medical Informatics Association*. 1999; 6 (1): 38-52.
4. Cotter, J.R. Laboratory instruction in histology at the University at Buffalo: recent replacement of microscope exercises with computer applications. *The Anatomical Record (The New Anatomist)*. 2001; 265 (5): 212- 221.
5. Heidger, Jr., P.M., Dee, F., Consoer, D., Leaven, T., Duncan, J., and Kreiter, C. Integrated approach to teaching and testing in histology with real and virtual imaging. *The Anatomical Record (The New Anatomists)*. 2002; 269 (2): 107-112.
6. Painter, S.D. Microanatomy courses in U.S. and Canadian medical schools, 1991-92. *Academic Medicine*. 1994; 69 (2):143-147.
7. Drake, R.L., Lowrie, D.J., and Prewitt, C.M. Survey of gross anatomy, microscopic anatomy, neuroscience, and embryology courses in medical school curricula in the United States. *The Anatomical Record (The New Anatomists)*. 2002; 269 (2):118-122.
8. Blystone, R.V., and Blystone, D.M. Digital video microscopy for the undergraduate histology laboratory. *Journal of Visual Communication in Medicine*. 1994; 17 (3): 125- 131.
9. Mclean, M. Introducing computer-aided instruction into a traditional histology course: student evaluation of the educational value. *Journal of Audiovisual Media in Medicine*. 2000; 23 (4): 153-160.
10. Harris, T., Leaven, T., Heidger, P., Kreiter, C., Duncan, J., and Dick, F. Comparison of a virtual microscope laboratory to a regular microscope laboratory for teaching histology. *The Anatomical Record (The New Anatomists)*. 2001; 265 (1): 10-14.
11. Brueckner, J. A digital approach to cellular ultrastructure in medical histology: creation and implementation of an interactive atlas of electron microscopy. *Journal of the International Association of Medical Science Educators*. 2003; 13 (1): 30- 35.
12. Black, V.H., and Smith, P.R. Increasing active student participation in histology. *The Anatomical Record (The New Anatomist)*. 2004; 278B (1): 14-17.
13. Lei, L-W., Winn, W., Scott, C., and Farr A. Evaluation of computer-assisted instruction in histology: effect of interaction on learning outcome. *The Anatomical Record (The New Anatomists)*. 2005; 284B (1): 28-34.
14. Michaels, J.E., Allred, K., Bruns, C., Lim, W., Lowrie, Jr., D.J., and Hedgren, W. Virtual laboratory manual for microscopic anatomy. *The Anatomical Record (The New Anatomists)*. 2005; 284B (1): 17-21.
15. Rosenbaum, B.P., Patel, S.G., and Lambert, H.W. Atlas for medical students: implementation of database technology. *Journal of the International Association of Medical Science Educators*. 2007; 17 (1): 58- 66.
16. Rosenbaum, B.P., Patel, S.G., and Lambert, H.W. Development of a database to streamline access and manipulation of images in a web-based histology atlas. *Journal of the International Association of Medical Science Educators*. 2007; 17 (1S): 3-4.
17. Downing, S.W. A multimedia-based histology laboratory course: elimination of the traditional microscope laboratory. *MedInfo*. 1995; 8 (2):1995.
18. Brisbourne, M.A.S., Chin, S.S.-L., Melnyk, E., and Begg, D.A. Using web-based animations to teach histology. *The Anatomical Record (The New Anatomist)*. 2002; 269 (1): 11-19.
19. Blake, C.A., Lavoie, H.A., and Millette, C.F. Teaching medical histology at the University of South Carolina School of Medicine: transition to virtual slides and virtual microscopes. *The Anatomical Record (The New Anatomist)*. 2003; 275B (1): 196-206.
20. Krippendorf, B.B., and Lough, J. Complete and rapid switch from light microscopy to virtual microscopy for teaching medical histology. *The Anatomical Record (The New Anatomists)*. 2005; 285B (1), 19-25.
21. Kumar, R.K., Freeman, B., Velan, G.M., and de Permentier, P. J. Integrating histology and histopathology teaching in practical classes using virtual slides. *The Anatomical Record (The New Anatomists)*. 2006; 289B (4): 128-133.
22. Ogilvie, R.W., Trusk, T.C., and Blue, A.V. Students' attitudes towards computer testing in a basic science course. *Medical Education*. 1999; 33 (11): 828-831.
23. Kane, C.J.M., Burns, E.R., O'Sullivan, P.S., Hart, T.J., Thomas, J.R., and Pearsall, I.A. Design, implementation, and evaluation of the transition from paper and pencil to computer assessment in the medical microscopic anatomy curriculum. *Journal of the International Association of Medical Science Educators*. 2007; 17 (1): 38-44.
24. Bloodgood, R.A. The use of microscopic images in medical education: In: Gu, J., and Ogilvie, RW. (Eds). Virtual Microscopy and Virtual Slides in Teaching, Diagnosis, and Research. Chapter 8 (pages 111-140). *Boca Raton, Florida: CRC Press*. 2005.
25. Dee, F.R., and Heidger, P. Virtual slides for teaching histology and pathology: In: Gu, J., and Ogilvie, RW. (Eds). Virtual Microscopy and Virtual Slides in Teaching, Diagnosis, and Research. Chapter 9 (pages 141-149). *Boca Raton, Florida: CRC Press*. 2005.
26. Ogilvie, R.W. Implementing virtual microscopy in medical education. *International Association of Medical Science Educators*. 2006. http://www.iamse.org/development/2006/was_2006_spring.htm Accessed November 1, 2007.
27. Case, S.M., and Swanson, D.B. Constructing Written Test Questions for the Basic and Clinical Sciences. *National Board of Medical Examiners*. 2002.
28. Peterson, M.W., Gordon, J., Elliott, S., and Kreiter, C. Computer-based testing: initial report of extensive use in a medical school curriculum. *Teaching and Learning in Medicine*. 2004; 16 (1): 51-59.
29. Stiles, K.A. Handbook of histology. *New York, New York: McGraw-Hill Book Company, Inc.* 1950.
30. Krause, W.J. The art of examining and interpreting histological preparations. *Pearl River, New York: The Parthenon Publishing Group*. 2001.
31. Bull, J. Computer-Assisted Assessment: Impact on Higher Education Institutions, *Educational Technology &*

Society. 1999; 2(3): 123-126. <http://www.ifets.info/journals/2_3/joanna_bull.html>.

Accessed November 21, 2006.