Active Learning annotated Bibliography
{Subset of Medical teaching bib at: http://sfdc.stanford.edu/literature_db.html}

Freeman, S., et al. (2007). "Prescribed Active Learning Increases Performance in Introductory Biology." CBE-Life Sciences Education **6**(2): 132-139.
http://www.lifescied.org/content/6/2/132.full

We tested five course designs that varied in the structure of daily and weekly active-learning exercises in an attempt to lower the traditionally high failure rate in a gateway course for biology majors. Students were given daily multiple-choice questions and answered with electronic response devices (clickers) or cards. Card responses were ungraded; clicker responses were graded for right/wrong answers or participation. Weekly practice exams were done as an individual or as part of a study group. Compared with previous versions of the same course taught by the same instructor, students in the new course designs performed better: There were significantly lower failure rates, higher total exam points, and higher scores on an identical midterm. Attendance was higher in the clicker versus cards section; attendance and course grade were positively correlated. Students did better on clicker questions if they were graded for right/wrong answers versus participation, although this improvement did not translate into increased scores on exams. In this course, achievement increases when students get regular practice via prescribed (graded) active-learning exercises.

Norman, G., et al. (2007). "The power of the plural: effect of conceptual analogies on successful transfer." Acad Med **82**(10 Suppl): S16-18.

BACKGROUND: Transfer, using a previously learned concept to solve a new, apparently different problem, is difficult. Students who know a concept will typically only be able to access it to solve new problems 10% to 30% of the time. However, one solution is to have students work through parallel, apparently different problems. METHOD: Learning materials for three cardiology-related concepts--Laplace Law, Starling Law, and Right Heart Strain--were devised. One group read a physiological explanation; two other groups read a combination of physiological and mechanical explanations, either paired up or separate. The sample was students in an undergraduate health sciences program (n = 35) who did the study for course credit. Outcomes were measured by accuracy of explanation on a test of nine clinical cases, as rated by one clinician on a seven-point scale. RESULTS: Groups who read two explanations did significantly better on the test, with mean scores of 3.6/5 and 4.1/5 versus 1.8/5 for the single group. Effect sizes were 1.3 and 1.7, respectively, against the single-example group. CONCLUSIONS: Active learning with multiple examples can have large effects on a student's ability to apply concepts to solve new problems.

Van Amburgh, J. A., et al. (2007). "A tool for measuring active learning in the classroom." Am J Pharm Educ **71**(5): 85.

OBJECTIVES: To develop a valid and reliable active-learning inventory tool for use in large classrooms and compare faculty perceptions of active-learning using the Active-Learning Inventory Tool. METHODS: The Active-Learning Inventory Tool was developed using published literature and validated by national experts in educational research. Reliability was established by trained faculty members who used the Active-Learning Inventory Tool to observe 9 pharmacy lectures. Instructors were then interviewed to elicit perceptions regarding active learning and asked to share their perceptions. RESULTS: Per lecture, 13 (range: 4-34) episodes of active learning encompassing 3 (range: 2-5) different types of active learning occurred over 2.2 minutes (0.6-16) per episode. Both interobserver (> or = 87%) and observer-instructor agreement (> or = 68%) were high for these outcomes. CONCLUSIONS: The Active-Learning Inventory Tool is a valid and reliable tool to measure active learning in the classroom. Future studies are needed to determine the impact of the Active-Learning Inventory Tool on teaching and its usefulness in other disciplines.

Bell, B. S. and S. W. Kozlowski (2008). "Active learning: effects of core training design elements on self-regulatory processes, learning, and adaptability." J Appl Psychol **93**(2): 296-316.

This article describes a comprehensive examination of the cognitive, motivational, and emotional processes underlying active learning approaches; their effects on learning and transfer; and the core training design elements (exploration, training frame, emotion control) and individual differences (cognitive ability, trait goal orientation, trait anxiety) that shape these processes. Participants (N = 350) were trained to operate a complex, computer-based simulation. Exploratory learning and error-encouragement framing had a positive effect on adaptive transfer performance and interacted with cognitive ability and dispositional goal orientation to influence trainees' metacognition and state goal orientation. Trainees who received the emotion-control strategy had lower levels of state anxiety. Implications for development of an integrated theory of active learning, learner-centered design, and research extensions are discussed.

Cardall, S., et al. (2008). "Live lecture versus video-recorded lecture: are students voting with their feet?" Acad Med **83**(12): 1174-1178.

PURPOSE: In light of educators' concerns that lecture attendance in medical school has declined, the authors sought to assess students' perceptions, evaluations, and motivations concerning live lectures compared with accelerated, video-recorded lectures viewed online. METHOD: The authors performed a cross-sectional survey study

of all first- and second-year students at Harvard Medical School. Respondents answered questions regarding their lecture attendance; use of class and personal time; use of accelerated, video-recorded lectures; and reasons for viewing video-recorded and live lectures. Other questions asked students to compare how well live and video-recorded lectures satisfied learning goals. RESULTS: Of the 353 students who received questionnaires, 204 (58%) returned responses. Collectively, students indicated watching 57.2% of lectures live, 29.4% recorded, and 3.8% using both methods. All students have watched recorded lectures, and most (88.5%) have used video-accelerating technologies. When using accelerated, video-recorded lecture as opposed to attending lecture, students felt they were more likely to increase their speed of knowledge acquisition (79.3% of students), look up additional information (67.7%), stay focused (64.8%), and learn more (63.7%). CONCLUSIONS: Live attendance remains the predominant method for viewing lectures. However, students find accelerated, video-recorded lectures equally or more valuable. Although educators may be uncomfortable with the fundamental change in the learning process represented by video-recorded lecture use, students' responses indicate that their decisions to attend lectures or view recorded lectures are motivated primarily by a desire to satisfy their professional goals. A challenge remains for educators to incorporate technologies students find useful while creating an interactive learning culture.

Dyson, B. J. (2008). "Assessing small-scale interventions in large-scale teaching: A general methodology and preliminary data." Active Learn High Educ **9**(3): 265-282.

The use of lectures is ubiquitous in higher-education institutions, but also heavily criticized from an andragogical viewpoint. A current challenge for lecturers is to provide opportunities for active learning during these sessions and to evaluate their impact on student experience. Three one-minute interventions based on the lecture materials (write down one thing you have already learnt, one question you would like answering, and take a break) were introduced approximately 20, 30 and 40 minutes into the lecture and assessed with respect to engagement over a five-week period on a final-year psychology option. Students were invited to record their current level of lecture engagement every 5 minutes. Both between-and within-subject analyses revealed a significant increase in lecture engagement for the first intervention during the first intervention week relative to baseline weeks. The data show an enhancement of student engagement with certain small-scale interventions during large-scale teaching.

Richardson, D. (2008). "Don't dump the didactic lecture; fix it." Adv Physiol Educ **32**(1): 23-24.

Numerous articles have been published on the merits of active learning, and collectively they present a body of compelling evidence that these methods do enhance learning. In

presenting arguments for active learning, it is often suggested that the traditional didactic lecture is more passive in nature and less effective as a teaching tool. However, a well organized lecture remains one of the most effective ways to integrate and present information from multiple sources on complex topics, such as those encountered in the teaching of physiology. This article presents an argument for enhancing lectures by incorporating active learning activities within their framework, and it is noted that engagement of the student is a key element making active learning activities work. Finally, suggestions are provided on the basis of the author's experience of things instructors can do to make lecture-based courses more engaging to students and, hence, promote learning.

Vasan, N. S., et al. (2008). "Modified use of team-based learning for effective delivery of medical gross anatomy and embryology." Anat Sci Educ **1**(1): 3-9.

Team-based learning (TBL) is an instructional strategy that combines independent out-of-class preparation for in-class discussion in small groups. This approach has been successfully adopted by a number of medical educators. This strategy allowed us to eliminate anatomy lectures and incorporate small-group active learning. Although our strategy is a modified use of classical TBL, in the text, we use the standard terminology of TBL for simplicity. We have modified classical TBL to fit our curricular needs and approach. Anatomy lectures were replaced with TBL activities that required pre-class reading of assigned materials, an individual self-assessment quiz, discussion of learning issues derived from the reading assignments, and then the group retaking the same quiz for discussion and deeper learning. Students' performances and their educational experiences in the TBL format were compared with the traditional lecture approach. We offer several in-house unit exams and a final comprehensive subject exam provided by the National Board of Medical Examiners. The students performed better in all exams following the TBL approach compared to traditional lecture-based teaching. Students acknowledged that TBL encouraged them to study regularly, allowed them to actively teach and learn from peers, and this served to improve their own exam performances. We found that a TBL approach in teaching anatomy allowed us to create an active learning environment that helped to improve students' performances. Based on our experience, other preclinical courses are now piloting TBL.

Walker, J. D., et al. (2008). "A delicate balance: integrating active learning into a large lecture course." CBE Life Sci Educ **7**(4): 361-367.

A lecture section of introductory biology that historically enrolled more than 500 students was split into two smaller sections of approximately 250 students each. A

traditional lecture format was followed in the "traditional" section; lecture time in the "active" section was drastically reduced in favor of a variety of in-class student-centered activities. Students in both sections took unannounced quizzes and multiple-choice exams. Evaluation consisted of comparisons of student survey responses, scores on standardized teaching evaluation forms, section averages and attendance, and open-ended student comments on end-of-term surveys. Results demonstrate that students perform as well, if not better, in an active versus traditional environment. However, student concerns about instructor expectations indicate that a judicious balance of student-centered activities and presentation-style instruction may be the best approach.

Armbruster, P., et al. (2009). "Active learning and student-centered pedagogy improve student attitudes and performance in introductory biology." CBE Life Sci Educ **8**(3): 203-213.

We describe the development and implementation of an instructional design that focused on bringing multiple forms of active learning and student-centered pedagogies to a one-semester, undergraduate introductory biology course for both majors and nonmajors. Our course redesign consisted of three major elements: 1) reordering the presentation of the course content in an attempt to teach specific content within the context of broad conceptual themes, 2) incorporating active and problem-based learning into every lecture, and 3) adopting strategies to create a more student-centered learning environment. Assessment of our instructional design consisted of a student survey and comparison of final exam performance across 3 years-1 year before our course redesign was implemented (2006) and during two successive years of implementation (2007 and 2008). The course restructuring led to significant improvement of self-reported student engagement and satisfaction and increased academic performance. We discuss the successes and ongoing challenges of our course restructuring and consider issues relevant to institutional change.

Bowe, C. M., et al. (2009). "Case method teaching: an effective approach to integrate the basic and clinical sciences in the preclinical medical curriculum." Med Teach **31**(9): 834-841.

BACKGROUND: Recent efforts to identify the essential skills and competencies required for medical practice have resulted in an expansion of the educational outcomes for which medical schools are accountable. Teachers in the preclinical years, formerly focused on the transmission of biomedical principles and factual information, are now charged with presenting discipline-specific concepts with an emphasis on clinical relevance while advancing active learning, critical thinking, communication skills, and other professional competencies. Problem-based learning has been widely introduced to support these educational goals but other, less resource-intensive, discussion

methodologies have not been extensively explored. AIM: To examine the feasibility of case-method teaching (CMT) during the preclinical curricula to integrate basic science concepts in the management of clinical problems. METHODS: CMT sessions were conducted with students during the first- and second-year of hybrid curricula at two US medical schools. RESULTS: First- and second-year medical classes of 40-95 students prepared for and actively engaged in single session case discussions and were able to productively apply basic science principles in clinical problem-solving. CONCLUSION: CMT represents a feasible and resource-conservative pedagogical format to promote critical thinking and to integrate basic science principles during the preclinical curriculum.

Brands, M. W. and L. Schumacher (2009). "Active learning strategies to teach renal-cardiovascular integration with high student-to-teacher ratios." Adv Physiol Educ **33**(4): 282-285.

To address the challenge of increasing opportunities for active learning into a medical physiology course with approximately 190 students enrolled, we chose an integrated approach. This was facilitated by the availability of a patient simulator facility at the School of Nursing at the Medical College of Georgia, and an approximately 20-min simulation of acute hemorrhage on the simulators comprised the first of three components in our approach. The second component was a small-group problem-solving session that each group conducted immediately after their patient simulator session. It brought in the more complex physiological responses to acute hemorrhage using an exercise we designed using free downloadable simulation software from the Department of Physiology and Biophysics at the University of Mississippi Medical Center. The third component was a student worksheet exercise that was built around data collected from 12 students who volunteered to collect a 24-h urine sample and have blood pressure measured after 3 days on either high or low salt intake. The worksheet was completed independently, and the answers and student data formed the basis for a classroom lecture. The approach has met with increasingly positive reviews due to testing the first two components on second-year medical student volunteers before its implementation, keeping the first component as simple as possible, keeping the second component to <30 min, and continued revision of the third component to increase clinical context of the study questions. An integrated active learning approach can enhance student interest in integrating cardiovascular-renal physiology, particularly if faculty members are willing to revise the approach in response to student feedback.

Doucet, M., et al. (2009). "Effect of using an audience response system on learning

environment, motivation and long-term retention, during case-discussions in a large group of undergraduate veterinary clinical pharmacology students." Med Teach **31**(12): e570-579.

BACKGROUND: Teaching methods that provide an opportunity for individual engagement and focussed feedback are required to create an active learning environment for case-based teaching in large groups. AIMS: A prospective observational controlled study was conducted to evaluate whether the use of an audience response system (ARS) would promote an active learning environment during case-based discussions in large groups, have an impact on student motivation and improve long-term retention. METHODS: Group A (N = 83) participated in large group case discussions where student participation was voluntary, while for group B (N = 86) an ARS was used. Data collection methods included student and teacher surveys, student focus group interviews, independent observations and 1-year post-course testing. RESULTS: Results indicated that the use of an ARS provided an active learning environment during case-based discussions in large groups by favouring engagement, observation and critical reflection and by increasing student and teacher motivation. Although final exam results were significantly improved in group B, long-term retention was not significantly different between groups. CONCLUSIONS: It was concluded that ARS use significantly improved the learning experience associated with case-based discussions in a large group of undergraduate students.

Felder, R. and R. Brent (2009). "Active learning: an introduction." ASQ Higher Education Brief **2**(4).

A short paper that defines active learning, gives examples of activities and formats, and answers frequently-asked questions about the method.

Gauci, S. A., et al. (2009). "Promoting student-centered active learning in lectures with a personal response system." Adv Physiol Educ **33**(1): 60-71.

We investigated whether an active learning approach, facilitated by a personal response system, would lead to improved student engagement and learning outcomes in large-group physiology lectures for undergraduate science students. We focused on encouraging students' active learning in lectures, whereas previous studies have made more use of audience response technology during lectures for formative or summative assessment. Students voluntarily answered questions posed during lectures with their personal response system (clickers), with individual answers automatically collated for immediate histogram display. This feedback then dictated the focus of followup discussions in the lecture. Student and instructor attitudes were surveyed through voluntary interviews with student responses correlated with their degree of clicker participation and individual exam results. Active lectures were found to increase both

student motivation and engagement. Students who participated in answering questions achieved better results than students who chose not to. Students with the lowest scores in a prerequisite course (previous semester physiology exam marks of < 60%) showed significantly better outcomes from the use of clickers than both middle-achieving (60-75%) and high-achieving (>75%) entry students. Significant improvement was evident in both mid- and end-semester exam results compared with student cohorts from preceding years, although this could also be influenced by many other factors. Increased student engagement and the immediate feedback obtained during lectures were advantages commonly noted by lecturing staff.

Gier, V. S. and D. S. Kreiner (2009). "Incorporating Active Learning With PowerPoint-Based Lectures Using Content-Based Questions (vol 36, pg 134, 2009)." Teaching of Psychology **36**(3): 224-224.

Instructors often use Microsoft PowerPoint lectures and handouts as support tools to provide students with the main concepts of the lectures. Some instructors and researchers believe that PowerPoint encourages student passivity. We conducted 2 studies to determine whether the use of content based questions (CBQs) would enhance learning when combined with traditional PowerPoint lectures. Our results indicated significantly higher quiz scores and exam scores when students used CBQs in comparison to using only the traditional PowerPoint lecture and handouts. The results suggest that it is possible to incorporate effective active learning methods into PowerPoint-based lectures.

Larson, R. B. (2009). "Enhancing the recall of presented material." Computers and Education **53**(4): 1278-1284.

Many educators distribute either complete or incomplete handouts so students can follow along with their lectures. This research examines a teaching system that combines computer-generated graphics presentations and detailed outline handouts with blanks added. An experiment found that this system produced significantly higher short-term recall of a presentation when compared with note-taking on lined paper and with no note-taking. Visual design variables, specifically slide typefaces and type, were also manipulated to examine whether they had independent effects on short-term recall or influenced the benefits from note-taking. No significant main effects or interactions were found for the visual aid variables.

Martens, M. J., et al. (2009). "Student views on the effective teaching of physical examination skills: a qualitative study." Med Educ **43**(2): 184-191.

OBJECTIVES: The lack of published studies into effective skills teaching in clinical skills

centres inspired this study of student views of the teaching behaviours of skills teachers. METHODS: We organised focus group discussions with students from Years 1-3 of a 6-year undergraduate medical curriculum. A total of 30 randomly selected students, divided into three groups, took part in two sessions. They discussed what teaching skills helped them to acquire physical examination skills. RESULTS: Students' opinions related to didactic skills, interpersonal and communication skills and preconditions. Students appreciated didactic skills that stimulate deep and active learning. Another significant set of findings referred to teachers' attitudes towards students. Students wanted teachers to be considerate and to take them seriously. This was reflected in student descriptions of positive behaviors, such as: 'responding to students' questions'; 'not exposing students' weaknesses in front of the group', and '[not] putting students in an embarrassing position in skill demonstrations'. They also appreciated enthusiasm in teachers. Important preconditions included: the integration of skills training with basic science teaching; linking of skills training to clinical practice; the presence of clear goals and well-structured sessions; good time management; consistency of teaching, and the appropriate personal appearance of teachers and students. CONCLUSIONS: The teaching skills and behaviors that most facilitate student acquisition of physical examination skills are interpersonal and communication skills, followed by a number of didactic interventions, embedded in several preconditions. Findings related to interpersonal and communication skills are comparable with findings pertaining to the teaching roles of tutors and clinical teachers; however, the didactic skills merit separate attention as teaching skills for use in skills laboratories. The results of this study should be complemented by a study performed in a larger population and a study exploring teachers' views.

McCarroll, M. L., et al. (2009). "Active learning in the classroom: a muscle identification game in a kinesiology course." Adv Physiol Educ **33**(4): 319-322.

It is often difficult for educators to teach a kinesiology and applied anatomy (KAA) course due to the vast amount of information that students are required to learn. In this study, a convenient sample of students (class A) from one section of a KAA course played the speed muscle introduction and matching game, which is loosely based off the premise of the adult game of "speed dating." The game involves student's taking on a "muscle" personality when introducing themselves to potential mates. The experimental group (class A) played the game at two time points throughout the semester after a series of lectures focusing on the body's muscles. A control group (class B) from another section of the KAA course still received the series of lectures but did not play the games throughout the semester. A postgame questionnaire given to class A revealed the following scores: 1) overall perception of the game (score: 4.43 +/- 0.68), whether goals

and objectives were met (score: 4.05 +/- 0.67 to 4.95 +/- 0.22), and perceptions of the organization of the game (score: 3.81 +/- 0.81 to 4.48 +/- 0.60). Overall, the game was well received by class A. When evaluating outcome scores of final grades between the two groups, class A improved final grades by 5.82% for a mean grade of 79.52 +/- 10.0; however, the final grades were not statistically significant (P > 0.05) compared with class B (73.7 +/- 15.6). The results show that an interactive game may contribute to improved final grades in a KAA course and could be an alternative means of disseminating kinesiology information.

Young, M. S., et al. (2009). "Students pay attention!: Combating the vigilance decrement to improve learning during lectures." Active Learning in Higher Education **10**(1): 41-55.

Maintaining student concentration in lectures has long been a challenge for lecturers. Pedagogical research consistently finds a drop in attention between 10 and 30 minutes into the lecture, which has been associated with the passive nature of the standard format, and has consequences for learning approaches and outcomes. A similar phenomenon has been observed in ergonomics for some time, known as the vigilance decrement. In this article, we present an exploratory effort to detect the vigilance decrement in four different lecture formats, by adopting an ergonomics measurement tool which has been related to vigilance, and relating the findings to students' assessment results. It was found that standard lecture formats do induce a vigilance decrement, and this can adversely affect learning of the material. Conversely, vigilance degradation is avoided when presentation is varied, though this is not necessarily associated with interactive participation techniques. Implications for lecturing styles, learning approaches and pedagogical research methods are discussed.

Chan, L. K. (2010). "Pulling my gut out--simple tools for engaging students in gross anatomy lectures." Anat Sci Educ **3**(3): 148-150.

A lecture is not necessarily a monologue, promoting only passive learning. If appropriate techniques are used, a lecture can stimulate active learning too. One such method is demonstration, which can engage learners' attention and increase the interaction between the lecturer and the learners. This article describes two simple and useful tools for demonstration during gross anatomy lectures. One is an apron for demonstrating midgut rotation and the other is a simple "human" model for demonstrating the relationship between the uterus and the peritoneum.

Gahutu, J. B. (2010). "Physiology teaching and learning experience in a new modular curriculum at the National University of Rwanda." Adv Physiol Educ **34**(1): 11-14.

In the present article, I report on my experience in teaching and learning physiology in

the first year of a new modular curriculum at the Faculty of Medicine of the National University of Rwanda. With self-reported questionnaires, I collected learning experience perceptions from 112 students who attended the module of physiology in 2008. The results showed satisfaction with active learning methods but complaints about the limited contact hours allocated to classroom lectures and practical classes. Student-centered learning was handicapped by the limited computer and internet access for students and by the limited number of textbooks in the library. In conclusion, the new teaching and learning style was appreciated by the students, but problems related to limited human and material resources need to be solved.

Jack, M. C., et al. (2010). "Improving education under work-hour restrictions: Comparing learning and teaching preferences of faculty, residents, and students." Journal of Surgical Education **67**(5): 290-296.

Background Faced with work-hour restrictions, educators are mandated to improve the efficiency of resident and medical student education. Few studies have assessed learning styles in medicine; none have compared teaching and learning preferences. Validated tools exist to study these deficiencies. Kolb describes 4 learning styles: converging (practical), diverging (imaginative), assimilating (inductive), and accommodating (active). Grasha Teaching Styles are categorized into "clusters": 1 (teacher-centered, knowledge acquisition), 2 (teacher-centered, role modeling), 3 (student-centered, problem-solving), and 4 (student-centered, facilitative). Study Design Kolb's Learning Style Inventory (HayGroup, Philadelphia, Pennsylvania) and Grasha-Riechmann's TSS were administered to surgical faculty (n = 61), residents (n = 96), and medical students (n = 183) at a tertiary academic medical center, after informed consent was obtained (IRB # 06-0612). Statistical analysis was performed using œá2 and Fisher exact tests. Results Surgical residents preferred active learning (p = 0.053), whereas faculty preferred reflective learning (p < 0.01). As a result of a comparison of teaching preferences, although both groups preferred student-centered, facilitative teaching, faculty preferred teacher-centered, role-modeling instruction (p = 0.02) more often. Residents had no dominant teaching style more often than surgical faculty (p = 0.01). Medical students preferred converging learning (42%) and cluster 4 teaching (35%). Statistical significance was unchanged when corrected for gender, resident training level, and subspecialization. Conclusions Significant differences exist between faculty and residents in both learning and teaching preferences; this finding suggests inefficiency in resident education, as previous research suggests that learning styles parallel teaching styles. Absence of a predominant teaching style in residents suggests these individuals are learning to be teachers. The adaptation of faculty teaching methods to account for variations in resident learning styles may promote a

better learning environment and more efficient facultyresident interaction. Additional, multi-institutional studies using these tools are needed to elucidate these findings fully. ¬© 2010 Association of Program Directors in Surgery.

Moravec, M., et al. (2010). "Learn before Lecture: A Strategy That Improves Learning Outcomes in a Large Introductory Biology Class." CBE-Life Sciences Education **9**(4): 473-481.

Actively engaging students in lecture has been shown to increase learning gains. To create time for active learning without displacing content we used two strategies for introducing material before class in a large introductory biology course. Four to five slides from 2007/8 were removed from each of three lectures in 2009 and the information introduced in preclass worksheets or narrated PowerPoint videos. In class, time created by shifting lecture material to learn before lecture (LBL) assignments was used to engage students in application of their new knowledge. Learning was evaluated by comparing student performance in 2009 versus 2007/8 on LBL-related question pairs, matched by level and format. The percentage of students who correctly answered five of six LBL-related exam questions was significantly higher ($p < 0.001$) in 2009 versus 2007/8. The mean increase in performance was 21% across the six LBL-related questions compared with <3% on all non-LBL exam questions. The worksheet and video LBL formats were equally effective based on a cross-over experimental design. These results demonstrate that LBLs combined with interactive exercises can be implemented incrementally and result in significant increases in learning gains in large introductory biology classes.

Southwick, F., et al. (2010). "Commentary: IDSA guidelines for improving the teaching of preclinical medical microbiology and infectious diseases." Acad Med **85**(1): 19-22.

Preclinical microbiology and infectious diseases courses too often primarily depend on PowerPoint lectures and notes, combined with multiple-choice tests, as their primary teaching tools. This strategy sets low expectations for students, encouraging short-term memory and discouraging understanding and long-term memory. These methods also fail to stimulate active participation, collaborative learning, and two-way communication with the professor, and they do not respect the students' diverse talents and ways of learning. The Infectious Diseases Society of America Preclinical Curriculum Committee proposes a new approach that emphasizes active learning and understanding and that addresses all of these failures. It consists of five components: (1) "Just-in-time" teaching that requires students to e-mail the answers to two general questions as well as any areas of misunderstanding to the instructor several hours before each lecture, (2) peer instruction or large-group sessions consisting of student teams of four who electronically answer a conceptual question before each major

section of the lecture, (3) teaching from edited textbooks and Internet sources, (4) small-group discussions that emphasize pathogenesis and differential diagnosis, and (5) essay questions that encourage and test understanding in addition to recognition. A national consensus on factual content is proposed, with the goals of reducing information overload and minimizing requirements for excessive memorization. These strategies promise to enhance learning and rekindle interest in the field of infectious diseases. Other subspecialty organizations should create similar teaching guidelines that will encourage future medical students to bring a richer understanding of clinical and basic science to the bedside.

Andrews, T. M., et al. (2011). "Active learning not associated with student learning in a random sample of college biology courses." CBE Life Sci Educ **10**(4): 394-405.

Previous research has suggested that adding active learning to traditional college science lectures substantially improves student learning. However, this research predominantly studied courses taught by science education researchers, who are likely to have exceptional teaching expertise. The present study investigated introductory biology courses randomly selected from a list of prominent colleges and universities to include instructors representing a broader population. We examined the relationship between active learning and student learning in the subject area of natural selection. We found no association between student learning gains and the use of active-learning instruction. Although active learning has the potential to substantially improve student learning, this research suggests that active learning, as used by typical college biology instructors, is not associated with greater learning gains. We contend that most instructors lack the rich and nuanced understanding of teaching and learning that science education researchers have developed. Therefore, active learning as designed and implemented by typical college biology instructors may superficially resemble active learning used by education researchers, but lacks the constructivist elements necessary for improving learning.

Brooks, D. C. (2011). "Space matters: The impact of formal learning environments on student learning." Br J Educ Technol **42**(5): 719-726.

The objective of this research is to identify the relationship between formal learning spaces and student learning outcomes. Using a quasi-experimental design, researchers partnered with an instructor who taught identical sections of the same course in two radically different formal learning environments to isolate the impact of the physical environment on student learning. The results of the study reveal that, holding all factors excepting the learning spaces constant, students taking the course in a technologically enhanced environment conducive to active learning techniques outperformed their

peers who were taking the same course in a more traditional classroom setting. The evidence suggests strongly that technologically enhanced learning environments, independent of all other factors, have a significant and positive impact on student learning.

Hsieh, S.-W., et al. (2011). "Effects of teaching and learning styles on students' reflection levels for ubiquitous learning." Computers & Education **57**(1): 1194-1201.

Ubiquitous learning (u-learning), in conjunction with supports from the digital world, is recognized as an effective approach for situating students in real-world learning environments. Earlier studies concerning u-learning have mainly focused on investigating the learning attitudes and learning achievements of students, while the causations such as learning style and teaching style were usually ignored. This study aims to investigate the effects of teaching styles and learning styles on reflection levels of students within the context of u-learning. In particular, we investigated the teaching styles at the dimensions of brainstorming and instruction and recall and the learning styles at the dimensions of active and reflective learning. The experiment was conducted with 39 fifth grader students at an elementary school in southern Taiwan. A u-learning environment was established at a butterfly ecology garden to conduct experiments for natural science courses. The experimental results of one-way ANCOVA show that those students who received a matching teaching-learning style presented a significant improvement in their reflection level. That is, matching the learning styles of students with the appropriate teaching styles can significantly improve students' reflection levels in a u-learning environment.

Melo Prado, H., et al. (2011). "Active learning on the ward: outcomes from a comparative trial with traditional methods." Med Educ **45**(3): 273-279.

CONTEXT: Academic activity during internship is essentially practical and ward rounds are traditionally considered the cornerstone of clinical education. However, the efficacy and effectiveness of ward rounds for learning purposes have been under-investigated and it is necessary to assess alternative educational paradigms for this activity. OBJECTIVES: This study aimed to compare the educational effectiveness of ward rounds conducted with two different learning methodologies. METHODS: Student subjects were first tested on 30 true/false questions to assess their initial degree of knowledge on pneumonia and diarrhoea. Afterwards, they attended ward rounds conducted using an active and a traditional learning methodology. The participants were submitted to a second test 48hours later in order to assess knowledge acquisition and were asked to answer two questions about self-directed learning and their opinions on the two learning methodologies used. RESULTS: Seventy-two medical students taking part in a

paediatric clinic rotation were enrolled. The active methodology proved to be more effective than the traditional methodology for the three outcomes considered: knowledge acquisition (33 students [45.8%] versus 21 students [29.2%]; p=0.03); self-directed learning (38 students [52.8%] versus 11 students [15.3%]; p<0.001), and student opinion on the methods (61 students [84.7%] versus 38 students [52.8%]; p<0.001). CONCLUSIONS: The active methodology produced better results than the traditional methodology in a ward-based context. This study seems to be valuable in terms of the new evidence it demonstrates on learning methodologies in the context of the ward round.

Paulson, D. and J. Faust (2011) Active learning for the college classroom.

The past decade has seen an explosion of interest among college faculty in the teaching methods variously grouped under the terms 'active learning' and 'cooperative learning'. However, even with this interest, there remains much misunderstanding of and mistrust of the pedagogical "movement" behind the words. The majority of all college faculty still teach their classes in the traditional lecture mode. Some of the criticism and hesitation seems to originate in the idea that techniques of active and cooperative learning are genuine alternatives to, rather than enhancements of, professors' lectures. We provide below a survey of a wide variety of active learning techniques which can be used to supplement rather than replace lectures. We are not advocating complete abandonment of lecturing, as both of us still lecture about half of the class period. The lecture is a very efficient way to present information but use of the lecture as the only mode of instruction presents problems for both the instructor and the students. There is a large amount of research attesting to the benefits of active learning.

Turner, D. A., et al. (2011). "Do pediatric residents prefer interactive learning? Educational challenges in the duty hours era." Med Teach **33**(6): 494-496.

Background: The volume of information that physicians must learn is increasing; yet, trainee educational time is limited. Many experts propose using trainees' learning preferences to guide teaching. However, data regarding predominant learning preferences within pediatrics are limited.

Aim: Identify predominant learning preferences among pediatric residents in a Residency Training Program.

Methods: The Visual–Aural–Read/Write–Kinesthetic (VARK) questionnaire and Kolb Learning Style Inventory (LSI) were administered anonymously to 50 pediatric residents.

Results: Learning style assessments were completed by 50 pediatric residents. Residents were significantly more likely to be accommodating on the Kolb LSI, which is consistent with

an interactive learning preference ($p < 0.01$); 30% demonstrated a multimodal preference on the Kolb LSI (Figure 1). VARK assessments demonstrated that 45 (90%) respondents were kinesthetic, which is also consistent with a significant preference for interactive learning ($p < 0.01$). Forty (80%) were found to be multimodal on the VARK (Figure 1). There was no association between learning preference and the residents' anticipated career choice or level of training.

Conclusions: The predominant learning preferences among a cohort of pediatric residents from a single training program were consistent with a preference for interactive learning, suggesting that some trainees may benefit from supplementation of educational curricula with additional interactive experiences. Continued investigation is needed in this area to assess the effectiveness of adapting teaching techniques to individual learning preferences.

Wijnia, L., et al. (2011). "Investigating effects of problem-based versus lecture-based learning environments on student motivation." Contemp Educ Psychol **36**(2): 101-113.

This study examines the effects of two learning environments (i.e., problem-based learning [PBL] versus lecture-based [LB] environments) on undergraduates' study motivation. Survey results demonstrated that PBL students scored higher on competence but did not differ from LB students on autonomous motivation. Analyses of focus groups further indicated that active learning aspects, such as collaboration are perceived as motivating. However, controlling elements (i.e., mandatory presence) and uncertainty (i.e., in selecting the correct and sufficient literature) were described as detrimental for students' motivation. In conclusion, PBL does not always seem to lead to higher intrinsic motivation. It is therefore crucial to build in the right amount of structure in learning environments and balance controlling elements versus autonomy, even in learning environments that are intended to be motivating for students.

Bloodgood, R. A. (2012). "Active learning: A small group histology laboratory exercise in a whole class setting utilizing virtual slides and peer education." Anat Sci Educ **5**(6): 367-373.

Histology laboratory instruction is moving away from the sole use of the traditional combination of light microscopes and glass slides in favor of virtual microscopy and virtual slides. At the same time, medical curricula are changing so as to reduce scheduled time for basic science instruction as well as focusing on student-centered learning approaches such as small group active learning and peer-instruction. It is important that medical schools resist the temptation to respond to this conjunction of events by turning histology into a self-study activity. This article describes a lymphoid histology laboratory exercise, occurring in a specially equipped Learning Studio housing an entire medical class that utilizes virtual slides in the context of small group active

learning and peer instruction.

Carnegie, J. A. (2012). "The use of limericks to engage student interest and promote active learning in an undergraduate course in functional anatomy." Anat Sci Educ **5**(2): 90-97.

The study of anatomy is a content-dense discipline with a challenging vocabulary. A mnemonic is a series of letters, a word, a phrase, or a rhyme that students can use when studying to facilitate recall. This project was designed to promote active learning in undergraduate students studying anatomy and physiology by asking them to create limericks based on course content and then to evaluate the limericks written by their peers for learning value, accuracy, style, and adherence to limerick characteristics. Students (278 and 288, respectively, in the 2009 and 2010 sections of ANP1107) worked in groups of three to create a total of 242 limericks. Peer evaluation was accomplished in two stages using a 20-point marking rubric. In Stage 1, students were randomly divided into 10 groups (n = 23 +/- 2 students) with each group member evaluating the same 12 +/- 1 limericks. In Stage 2, the top 19% of limericks were reevaluated by all students so that the best three could be chosen. In each of the two years, 60% of students completed all parts of the assignment. Higher percentages (75-80%) participated in limerick writing and one of the two assessment stages. A positive association was noted between level of student participation in the limerick assignment and final course marks. Limerick creation and evaluation can be used to promote active learning by encouraging students to review functional-anatomy-based content to create limericks with good learning value and to provide valid assessments of limericks written by their peers.

Desselle, B. C., et al. (2012). "Evaluation of a faculty development program aimed at increasing residents' active learning in lectures." J Grad Med Educ **4**(4): 516-520.

BACKGROUND: Active engagement in the learning process is important to enhance learners' knowledge acquisition and retention and the development of their thinking skills. This study evaluated whether a 1-hour faculty development workshop increased the use of active teaching strategies and enhanced residents' active learning and thinking. METHODS: Faculty teaching in a pediatrics residency participated in a 1-hour workshop (intervention) approximately 1 month before a scheduled lecture. Participants' responses to a preworkshop/postworkshop questionnaire targeted self-efficacy (confidence) for facilitating active learning and thinking and providing feedback about workshop quality. Trained observers assessed each lecture (3-month baseline phase and 3-month intervention phase) using an 8-item scale for use of active learning strategies and a 7-item scale for residents' engagement in active learning. Observers also assessed lecturer-resident interactions and the extent to which residents

were asked to justify their answers. RESULTS: Responses to the workshop questionnaire (n = 32/34; 94%) demonstrated effectiveness and increased confidence. Faculty in the intervention phase demonstrated increased use of interactive teaching strategies for 6 items, with 5 reaching statistical significance (P </= .01). Residents' active learning behaviors in lectures were higher in the intervention arm for all 7 items, with 5 reaching statistical significance. Faculty in the intervention group demonstrated increased use of higher-order questioning (P = .02) and solicited justifications for answers (P = .01). CONCLUSION: A 1-hour faculty development program increased faculty use of active learning strategies and residents' engagement in active learning during resident core curriculum lectures.

Jacobs, J. C., et al. (2012). "Development of an instrument (the COLT) to measure conceptions on learning and teaching of teachers, in student-centered medical education." Med Teach **34**(7): e483-491.

BACKGROUND: Conceptions of medical teachers regarding learning and teaching affect their teaching practice. Therefore conceptions should be addressed in faculty development. AIM: To facilitate this, we constructed the Conceptions Of Learning and Teaching (COLT) instrument. METHOD: The COLT was adapted based on experts' comments during a meeting and interviews, followed by a Delphi procedure (Part I). It was administered to teachers from two Dutch medical schools with different traditions in student-centered education (Part II; N=646). The data were analyzed using confirmatory factor analysis and reliability analysis. RESULTS: 324 Teachers (50.2%) completed the questionnaire. Confirmatory factor analysis did not confirm the underlying theoretical model, but an alternative model demonstrated a good fit. This led to an instrument with eighteen items reflecting three underlying factors: 'teacher centeredness', 'appreciation of active learning', and 'orientation to professional practice'. We found significant differences in COLT scores between the faculty of the two medical schools. CONCLUSIONS: The COLT appears to be a construct valid tool resulting in reliable scores of teachers' conceptions of learning and teaching, in student-centered medical education. Two of the three factors are new and may be specific for student-centered medical education. The COLT may be a promising tool to improve faculty development.

Maskiewicz, A. C., et al. (2012). "Using targeted active-learning exercises and diagnostic question clusters to improve students' understanding of carbon cycling in ecosystems." CBE Life Sci Educ **11**(1): 58-67.

In this study, we used targeted active-learning activities to help students improve their ways of reasoning about carbon flow in ecosystems. The results of a validated ecology

conceptual inventory (diagnostic question clusters [DQCs]) provided us with information about students' understanding of and reasoning about transformation of inorganic and organic carbon-containing compounds in biological systems. These results helped us identify specific active-learning exercises that would be responsive to students' existing knowledge. The effects of the active-learning interventions were then examined through analysis of students' pre- and postinstruction responses on the DQCs. The biology and non-biology majors participating in this study attended a range of institutions and the instructors varied in their use of active learning; one lecture-only comparison class was included. Changes in pre- to postinstruction scores on the DQCs showed that an instructor's teaching method had a highly significant effect on student reasoning following course instruction, especially for questions pertaining to cellular-level, carbon-transforming processes. We conclude that using targeted in-class activities had a beneficial effect on student learning regardless of major or class size, and argue that using diagnostic questions to identify effective learning activities is a valuable strategy for promoting learning, as gains from lecture-only classes were minimal.

Mayberry, J., et al. (2012). "Exploring teaching and learning using an iTouch mobile device." Active Learn High Educ **13**(3): 203-217.

Appropriate use of instructional technology can be an elusive quest for many faculty members. The iTouch is one of the latest technologies available to us, yet there is little literature on its use and effectiveness to support learners in their learning. Six new faculty members from various disciplines elected to integrate the device in their own classes, collect quantitative and qualitative data, and report their findings. The results show several innovative active learning strategies for incorporating the iTouch inside and outside of the classroom, along with perspectives on the strengths and weaknesses of these approaches, and recommendations for future use. The study serves as an exemplary model for other universities that wish to foster experiential learning among faculty.

Minhas, P. S., et al. (2012). "The effects of passive and active learning on student preference and performance in an undergraduate basic science course." Anat Sci Educ **5**(4): 200-207.

Active learning is based on self-directed and autonomous teaching methods, whereas passive learning is grounded in instructor taught lectures. An animal physiology course was studied over a two-year period (Year 1, n = 42 students; Year 2, n = 30 students) to determine the effects of student-led seminar (andragogical) and lecture (pedagogical) teaching methods on students' retention of information and performance. For each year of the study, the course was divided into two time periods. The first half was dedicated

to instructor-led lectures, followed by a control survey in which the students rated the efficiency of pedagogical learning on a five-point Likert scale from one (strongly disagree) to five (strongly agree). During the second period, students engaged in andragogical learning via peer-led seminars. An experimental survey was then administered to students using the same scale as above to determine students' preferred teaching method. Raw examination scores and survey results from both halves of the course were statistically analyzed by ANOVA with Newman-Keuls multiple comparison test. By the end of the study, student preference for peer-led seminars increased [mean +/- SD: (2.47 +/- 0.94)/(4.03 +/- 1.36), P < 0.04], and examination scores significantly increased [mean +/- SD: (73.91% +/- 13.18)/(85.77 +/- 5.22), P < 0.001]. A majority of students (68.8%) preferred a method that contained peer-led seminars and instructor-led lectures. These results may indicate that integration of active and passive learning into undergraduate courses may have greater benefit in terms of student preference and performance than either method alone.

Prober, C. G. and C. Heath (2012). "Lecture halls without lectures--a proposal for medical education." N Engl J Med **366**(18): 1657-1659.

Annotation:

The authors argue that the present way in which doctors are trained has not kept pace with major changes in the field (i.e., increased medical knowledge, complexity of the health care system, evolved pedagogical methods, technological support for learners). They argue we need to “make lessons ‘stickier’ (more comprehensible and memorable) and embrace a learning strategy that is self-paced and mastery-based and boosts engagement”. Teaching by describing cases that capture curiosity as well as involve an emotional response in the listener help make an idea ‘sticky’. The authors think a “more radical and important strategy” is to embrace the use of the flipped classroom where students watch video lectures at their own pace as homework and come to class ready for active learning (emotion-provoking simulation exercises, problem-based and team-based exercises). Advantages of applying the Khan Academy model (used with elementary and high schools) to medical schools are discussed. Stanford Medical School’s core biochemistry, as well as other Stanford University courses have used the model and found student class attendance improved and student course reviews rose substantially. The flipped classroom makes sense as a strategy to maximize the time needed to educate medical students.

Ruiter, D. J., et al. (2012). "How to achieve synergy between medical education and cognitive neuroscience? An exercise on prior knowledge in understanding." Adv Health Sci Educ Theory Pract **17**(2): 225-240.

A major challenge in contemporary research is how to connect medical education and cognitive neuroscience and achieve synergy between these domains. Based on this starting point we discuss how this may result in a common language about learning, more educationally focused scientific inquiry, and multidisciplinary research projects. As the topic of prior knowledge in understanding plays a strategic role in both medical education and cognitive neuroscience it is used as a central element in our discussion. A critical condition for the acquisition of new knowledge is the existence of prior knowledge, which can be built in a mental model or schema. Formation of schemas is a central event in student-centered active learning, by which mental models are constructed and reconstructed. These theoretical considerations from cognitive psychology foster scientific discussions that may lead to salient issues and questions for research with cognitive neuroscience. Cognitive neuroscience attempts to understand how knowledge, insight and experience are established in the brain and to clarify their neural correlates. Recently, evidence has been obtained that new information processed by the hippocampus can be consolidated into a stable, neocortical network more rapidly if this new information fits readily into a schema. Opportunities for medical education and medical education research can be created in a fruitful dialogue within an educational multidisciplinary platform. In this synergetic setting many questions can be raised by educational scholars interested in evidence-based education that may be highly relevant for integrative research and the further development of medical education.

van den Bergh, L., et al. (2012). "Teacher feedback during active learning: Current practices in primary schools." British Journal of Educational Psychology: no-no.

Background. Feedback is one of the most powerful tools, which teachers can use to enhance student learning. It appears difficult for teachers to give qualitatively good feedback, especially during active learning. In this context, teachers should provide facilitative feedback that is focused on the development of meta-cognition and social learning. Aims. The purpose of the present study is to contribute to the existing knowledge about feedback and to give directions to improve teacher feedback in the context of active learning. Sample. The participants comprised 32 teachers who practiced active learning in the domain of environmental studies in the sixth, seventh, or eighth grade of 13 Dutch primary schools. A total of 1,465 teacher–student interactions were examined. Methods. Video observations were made of active learning lessons in the domain of environmental studies. A category system was developed based on the literature and empirical data. Teacher–student interactions were assessed using this system. Results. About half of the teacher–student interactions contained feedback. This feedback was usually focused on the tasks that were being performed by the

students and on the ways in which these tasks were processed. Only 5% of the feedback was explicitly related to a learning goal. In their feedback, the teachers were directing (rather than facilitating) the learning processes. Conclusions. During active learning, feedback on meta-cognition and social learning is important. Feedback should be explicitly related to learning goals. In practice, these kinds of feedback appear to be scarce. Therefore, giving feedback during active learning seems to be an important topic for teachers' professional development.

Chen, X., et al. (2013). "Training TAs in scientific teaching for the human physiology and anatomy laboratory." Adv Physiol Educ **37**(4): 436-439.

Annotation:

The authors trained graduate teaching assistants (TAs) to use scientific teaching (ST) methods in both inquiry-based and regular laboratory sections of an undergraduate physiology course. ST stresses active learning and an inquiry-based framework as compared to the traditional lecture-based course. Students of the physiology course, as well as those of a comparison course using the traditional approach were surveyed with the SALG (student assessment of their learning gains) regarding 1) their perceived laboratory learning experience and 2) their perceived integration of what is learned in the laboratory to their overall understanding of course content. The authors found that "students perceived more learning gains in a laboratory curriculum that is structured within the ST framework". The authors conclude that, although this was a pilot study with noted limitations, ST is "particularly well suited for laboratory teaching that is traditionally delivered by lecturing."

Everly, M. C. (2013). "Are students' impressions of improved learning through active learning methods reflected by improved test scores?" Nurse Educ Today **33**(2): 148-151.

PURPOSE: To report the transformation from lecture to more active learning methods in a maternity nursing course and to evaluate whether student perception of improved learning through active-learning methods is supported by improved test scores. METHODS: The process of transforming a course into an active-learning model of teaching is described. A voluntary mid-semester survey for student acceptance of the new teaching method was conducted. Course examination results, from both a standardized exam and a cumulative final exam, among students who received lecture in the classroom and students who had active learning activities in the classroom were compared. RESULTS: Active learning activities were very acceptable to students. The majority of students reported learning more from having active-learning activities in the classroom rather than lecture-only and this belief was supported by improved test scores. Students who had active learning activities in the classroom scored significantly

higher on a standardized assessment test than students who received lecture only. IMPLICATIONS: The findings support the use of student reflection to evaluate the effectiveness of active-learning methods and help validate the use of student reflection of improved learning in other research projects.

Harden, R. M. and J. M. Laidlaw (2013). "Be FAIR to students: Four principles that lead to more effective learning." Med Teach **35**(1): 27-31.

A teacher is a professional not a technician. An understanding of some basic principles about learning can inform the teacher or trainer in their day-to-day practice as a teacher or a trainer. The FAIR principles are: provide feedback to the student, engage the student in active learning, individualise the learning to the personal needs of the student and make the learning relevant. Application of the principles can lead to more effective learning - the poor teacher can become a good teacher and the good teacher an excellent teacher.

Larsen, D. P., et al. (2013). "Comparative effects of test-enhanced learning and self-explanation on long-term retention." Med Educ **47**(7): 674-682.

CONTEXT: Educators often encourage students to engage in active learning by generating explanations for the material being learned, a method called self-explanation. Studies have also demonstrated that repeated testing improves retention. However, no studies have directly compared the two learning methods. METHODS: Forty-seven Year 1 medical students completed the study. All students participated in a teaching session that covered four clinical topics and was followed by four weekly learning sessions. In the learning sessions, students were randomised to perform one of four learning activities for each topic: testing with self-generated explanations (TE); testing without explanations (T); studying a review sheet with self-generated explanations (SE), and studying a review sheet without explanations (S). Students repeated the same activity for each topic in all four sessions. Six months later, they took a free-recall clinical application test on all four topics. RESULTS: Repeated testing led to better long-term retention and application than repeatedly studying the material ($p < 0.0001$, eta(2) = 0.33). Repeated generation of self-explanations also improved long-term retention and application, but the effect was smaller ($p < 0.0001$, eta(2) = 0.08). When data were collapsed across topics, both testing conditions produced better final test performance than studying with self-explanation (TE = 40% > SE = 29% [$p = 0.001$, $d = 0.70$]; T = 36% > SE = 29% [$p = 0.02$, $d = 0.48$]). Studying with self-explanation led to better retention and application than studying without self-explanation (SE = 29% > S = 20%; $p = 0.001$, $d = 0.68$). Our analyses showed significant interaction by topic ($p = 0.001$, eta(2) = 0.06), indicating some variation in the

effectiveness of the interventions among topics. CONCLUSIONS: Testing and generating self-explanations are both learning activities that can be used to produce superior long-term retention and application of knowledge, but testing is generally more effective than self-explanation alone.

Roopa, S., et al. (2013). "What type of lectures students want? - a reaction evaluation of dental students." J Clin Diagn Res **7**(10): 2244-2246.

INTRODUCTION: An one hour didactic lecture is the common method of teaching in dental colleges in India. Lengthy lectures are boring and students are passive recipients of the information. Interactive lectures are suggested as a means of overcoming the disadvantages of regular lectures. AIMS: The present study was conducted to pilot various methods of making lectures interactive and to find the students' reactions to interactive lectures as compared to regular lectures. MATERIAL AND METHODS: An entire batch of first year dental students (n = 78) was exposed to both interactive and regular lectures for the cardiovascular system in physiology. Among the total number of 12 lectures, alternate lectures were conducted in an interactive style. At the end of the 12 lecture series, students' opinions were obtained using a structured feedback evaluation questionnaire, consisting of five statements, on a five point Likert scale. Statistical Analysis was done using SPSS software, version 15. RESULTS: Interactive lectures were found to be more useful than regular lectures by 92% of the students. Significantly more number of students agreed or strongly agreed that interactive lectures kept them attentive, created interest, overcame monotony, motivated them for self learning and provided well defined learning than regular lectures. Among the different techniques which were used, the students preferred use of video clippings (58.1%), followed by each-one-teach-one. RESULTS of the present study support the use of interactive lectures for ensuring increased interest and attention of students during lectures. CONCLUSION: Interactive lectures were more accepted and considered to be more useful than regular lectures by the students.

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Tess, P. A. (2013). "The role of social media in higher education classes (real and virtual) – A literature review." Comput Hum Behav(0).

The ubiquity of social media (e.g., Facebook, Twitter) is no more apparent than at the university. Social media are increasingly visible in higher education settings as instructors look to technology to mediate and enhance their instruction as well as promote active learning for students. Many scholars argue for the purposeful integration of social media as an educational tool. Empirical evidence, however, has lagged in supporting the claim. Most of the existing research on the utility and effectiveness of social media in the higher education class is limited to self-reported data (e.g., surveys, questionnaires) and content analyses. This paper summarizes the scholarly writings as well as reviews the findings of empirical investigations. Some limitations are discussed, and future areas of research are proposed.

Freeman, S., et al. (2014). "Active learning increases student performance in science, engineering, and mathematics." Proc Natl Acad Sci U S A **111**(23): 8410-8415.

To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. The effect sizes indicate that on average, student performance on examinations and concept inventories increased by 0.47 SDs under active learning (n = 158 studies), and that the odds ratio for failing was 1.95 under traditional lecturing (n = 67 studies). These results indicate that average examination scores improved by about

6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. Heterogeneity analyses indicated that both results hold across the STEM disciplines, that active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes--although the greatest effects are in small (n </= 50) classes. Trim and fill analyses and fail-safe n calculations suggest that the results are not due to publication bias. The results also appear robust to variation in the methodological rigor of the included studies, based on the quality of controls over student quality and instructor identity. This is the largest and most comprehensive meta-analysis of undergraduate STEM education published to date. The results raise questions about the continued use of traditional lecturing as a control in research studies, and support active learning as the preferred, empirically validated teaching practice in regular classrooms.

Galway, L. P., et al. (2014). "A novel integration of online and flipped classroom instructional models in public health higher education." BMC Med Educ **14**: 181.

BACKGROUND: In 2013, a cohort of public health students participated in a 'flipped' Environmental and Occupational Health course. Content for the course was delivered through NextGenU.org and active learning activities were carried out during in-class time. This paper reports on the design, implementation, and evaluation of this novel approach. METHODS: Using mixed-methods, we examined learning experiences and perceptions of the flipped classroom model and assessed changes in students' self-perceived knowledge after participation in the course. We used pre- and post-course surveys to measure changes in self-perceived knowledge. The post-course survey also included items regarding learning experiences and perceptions of the flipped classroom model. We also compared standard course review and examination scores for the 2013 NextGenU/Flipped Classroom students to previous years when the course was taught with a lecture-based model. We conducted a focus group session to gain more in-depth understanding of student learning experiences and perceptions. RESULTS: Students reported an increase in knowledge and survey and focus group data revealed positive learning experiences and perceptions of the flipped classroom model. Mean examination scores for the 2013 NextGenU/Flipped classroom students were 88.8% compared to 86.4% for traditional students (2011). On a scale of 1-5 (1 = lowest rank, 5 = highest rank), the mean overall rating for the 2013 NextGenU/Flipped classroom students was 4.7/5 compared to prior years' overall ratings of 3.7 (2012), 4.3 (2011), 4.1 (2010), and 3.9 (2009). Two key themes emerged from the focus group data: 1) factors influencing positive learning experience (e.g., interactions with students and instructor); and 2) changes in attitudes towards environmental and occupation health (e.g.,

deepened interest in the field). CONCLUSION: Our results show that integration of the flipped classroom model with online NextGenU courses can be an effective innovation in public health higher education: students achieved similar examination scores, but NextGenU/Flipped classroom students rated their course experience more highly and reported positive learning experiences and an increase in self-perceived knowledge. These results are promising and suggest that this approach warrants further consideration and research.

McLaughlin, J. E., et al. (2014). "The flipped classroom: a course redesign to foster learning and engagement in a health professions school." Acad Med **89**(2): 236-243.

Recent calls for educational reform highlight ongoing concerns about the ability of current curricula to equip aspiring health care professionals with the skills for success. Whereas a wide range of proposed solutions attempt to address apparent deficiencies in current educational models, a growing body of literature consistently points to the need to rethink the traditional in-class, lecture-based course model. One such proposal is the flipped classroom, in which content is offloaded for students to learn on their own, and class time is dedicated to engaging students in student-centered learning activities, like problem-based learning and inquiry-oriented strategies.In 2012, the authors flipped a required first-year pharmaceutics course at the University of North Carolina Eshelman School of Pharmacy. They offloaded all lectures to self-paced online videos and used class time to engage students in active learning exercises. In this article, the authors describe the philosophy and methodology used to redesign the Basic Pharmaceutics II course and outline the research they conducted to investigate the resulting outcomes. This article is intended to serve as a guide to instructors and educational programs seeking to develop, implement, and evaluate innovative and practical strategies to transform students' learning experience.As class attendance, students' learning, and the perceived value of this model all increased following participation in the flipped classroom, the authors conclude that this approach warrants careful consideration as educators aim to enhance learning, improve outcomes, and fully equip students to address 21st-century health care needs.

Mi, M. and D. Gould (2014). "Wiki technology enhanced group project to promote active learning in a neuroscience course for first-year medical students: an exploratory study." Med Ref Serv Q **33**(2): 125-135.

A wiki group project was integrated into a neuroscience course for first-year medical students. The project was developed as a self-directed, collaborative learning task to help medical students review course content and make clinically important connections. The goals of the project were to enhance students' understanding of key concepts in

neuroscience, promote active learning, and reinforce their information literacy skills. The objective of the exploratory study was to provide a formative evaluation of the wiki group project and to examine how wiki technology was utilized to enhance active and collaborative learning of first-year medical students in the course and to reinforce information literacy skills.

Miller, C. J. and M. J. Metz (2014). "A comparison of professional-level faculty and student perceptions of active learning: its current use, effectiveness, and barriers." Adv Physiol Educ **38**(3): 246-252.

Active learning is an instructional method in which students become engaged participants in the classroom through the use of in-class written exercises, games, problem sets, audience-response systems, debates, class discussions, etc. Despite evidence supporting the effectiveness of active learning strategies, minimal adoption of the technique has occurred in many professional programs. The goal of this study was to compare the perceptions of active learning between students who were exposed to active learning in the classroom (n = 116) and professional-level physiology faculty members (n = 9). Faculty members reported a heavy reliance on lectures and minimal use of educational games and activities, whereas students indicated that they learned best via the activities. A majority of faculty members (89%) had observed active learning in the classroom and predicted favorable effects of the method on student performance and motivation. The main reported barriers by faculty members to the adoption of active learning were a lack of necessary class time, a high comfort level with traditional lectures, and insufficient time to develop materials. Students hypothesized similar obstacles for faculty members but also associated many negative qualities with the traditional lecturers. Despite these barriers, a majority of faculty members (78%) were interested in learning more about the alternative teaching strategy. Both faculty members and students indicated that active learning should occupy portions (29% vs. 40%) of face-to-face class time.

Miller, C. J. and M. J. Metz (2014). "Birds of a feather flock together: the importance of seating location with active learning in the professional classroom." Adv Physiol Educ **38**(2): 181-182.

Annotation:

Does seating location in a professional classroom using active learning make a difference?

The authors describe the exam and final grade results for students in a large dental physiology course. When active learning strategies are employed that make students more dependent on one another for learning the material, what happens if students who are struggling with the material are seated next to one another? Will they be prone to reinforce misunderstandings of the content with each other? The authors suggest

that it would be useful to follow this study of just one class with others in professional schools that are using engaged lectures. The authors plan to investigate what happens when the course director rearranges seating to ensure that students who have failed the first exam are not seated together. If higher performing students sit near and work with the lower performing students on the assigned tasks, their own knowledge and comprehension could be reinforced and all students could then succeed.

Moffett, J. and A. C. Mill (2014). "Evaluation of the flipped classroom approach in a veterinary professional skills course." Adv Med Educ Pract **5**: 415-425.

BACKGROUND: The flipped classroom is an educational approach that has had much recent coverage in the literature. Relatively few studies, however, use objective assessment of student performance to measure the impact of the flipped classroom on learning. The purpose of this study was to evaluate the use of a flipped classroom approach within a medical education setting to the first two levels of Kirkpatrick and Kirkpatrick's effectiveness of training framework. METHODS: This study examined the use of a flipped classroom approach within a professional skills course offered to postgraduate veterinary students. A questionnaire was administered to two cohorts of students: those who had completed a traditional, lecture-based version of the course (Introduction to Veterinary Medicine [IVM]) and those who had completed a flipped classroom version (Veterinary Professional Foundations I [VPF I]). The academic performance of students within both cohorts was assessed using a set of multiple-choice items (n=24) nested within a written examination. Data obtained from the questionnaire were analyzed using Cronbach's alpha, Kruskal-Wallis tests, and factor analysis. Data obtained from student performance in the written examination were analyzed using the nonparametric Wilcoxon rank sum test. RESULTS: A total of 133 IVM students and 64 VPF I students (n=197) agreed to take part in the study. Overall, study participants favored the flipped classroom approach over the traditional classroom approach. With respect to student academic performance, the traditional classroom students outperformed the flipped classroom students on a series of multiple-choice items (IVM mean =21.4+/-1.48 standard deviation; VPF I mean =20.25+/-2.20 standard deviation; Wilcoxon test, w=7,578; P<0.001). CONCLUSION: This study demonstrates that learners seem to prefer a flipped classroom approach. The flipped classroom was rated more positively than the traditional classroom on many different characteristics. This preference, however, did not translate into improved student performance, as assessed by a series of multiple-choice items delivered during a written examination.

Mustafa, T., et al. (2014). "Lectures in medical educaton: what students think?" J Ayub Med Coll Abbottabad **26**(1): 21-25.

BACKGROUND: The volume of medical knowledge has increased exponentially and so has the need to improve the efficiency of current teaching practices. With increasing emphasis on interactive and problem based learning, the place of lectures in modern medical education has become a questionable issue. Objectives were to assess the perspective of undergraduate medical students regarding the role and effectiveness of lectures as a mode of instruction as well as the ways and means that can be employed to enhance the effectiveness of lectures. METHODS: A cross sectional study was carried out among 2nd to final year medical students from five medical colleges including both private and public sector institutions. A total of 347 students participated by completing a structured questionnaire. Data was analyzed using SPSS-17. RESULTS: Sixty seven percent students considered lectures as a useful mode of instruction (47% males and 77% females), whereas 83% of the students reported that clinical sessions were superior to lectures because of small number of students in clinical sessions, active student participation, enhanced clinical orientation, and interaction with patients. About 64% responded that lectures should be replaced by clinical sessions. Majority of the students (92%) reported not being able to concentrate during a lecture beyond 30 minutes, whereas 70% skipped lectures as they were boring. A significantly greater proportion of male respondents, students from clinical years, and those who skipped lectures, considered lectures to be boring, a poor utilization of time and resources, and could not concentrate for the full duration of a lecture compared to females, students from preclinical years, and those who do not skip lectures, respectively. CONCLUSION: Lecturing techniques need to be improvised. The traditional passive mode of instruction has to be replaced with active learning and inquiry based approach to adequately utilize the time and resources spent on lectures.

Sadofsky, M., et al. (2014). "National standards in pathology education: developing competencies for integrated medical school curricula." Arch Pathol Lab Med **138**(3): 328-332.

CONTEXT: Medical school education has evolved from department-specific memorization of facts to an integrated curriculum presenting knowledge in a contextual manner across traditional disciplines, integrating information, improving retention, and facilitating application to clinical practice. Integration occurs throughout medical school using live data-sharing technologies, thereby providing the student with a framework for lifelong active learning. Incorporation of educational teams during medical school prepares students for team-based patient care, which is also required for pay-for-performance models used in accountable care organizations. OBJECTIVE: To develop learning objectives for teaching pathology to medical students. Given the rapid expansion of basic science knowledge of human development, normal function, and pathobiology, it is neither possible nor desirable for faculty to teach, and students to

retain, this vast amount of information. Courses teaching the essentials in context and engaging students in the learning process enable them to become lifelong learners. An appreciation of pathobiology and the role of laboratory medicine underlies the modern practice of medicine. As such, all medical students need to acquire 3 basic competencies in pathology: an understanding of disease mechanisms, integration of mechanisms into organ system pathology, and application of pathobiology to diagnostic medicine. DESIGN: We propose the development of 3 specific competencies in pathology to be implemented nationwide, aimed at disease mechanisms/processes, organ system pathology, and application to diagnostic medicine. Each competency will include learning objectives and a means to assess acquisition, integration, and application of knowledge. The learning objectives are designed to be a living document managed (curated) by a group of pathologists representing Liaison Committee on Medical Education-accredited medical schools nationally. CONCLUSIONS: Development of a coherent set of learning objectives will assist medical students nationally to gain the basic competencies in pathology necessary for clinical practice. Having national standards for competencies preserves schools' independence in specific curriculum design while assuring all students meet the evolving needs of medical practice.

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White, C., et al. (2014). "Why are medical students 'checking out' of active learning in a new curriculum?" Med Educ **48**(3): 315-324.

OBJECTIVES: The University of Virginia School of Medicine recently transformed its pre-clerkship medical education programme to emphasize student engagement and active learning in the classroom. As in other medical schools, many students are opting out of attending class and others are inattentive while in class. We sought to understand why, especially with a new student-centered curriculum, so many students were still opting to learn on their own outside of class or to disengage from educational activities while in class. METHODS: Focus groups were conducted with students from two classes who had participated in the new curriculum, which is designed to foster small-group and collaborative learning. The sessions were audio-recorded and then transcribed. The authors read through all of the transcripts and then reviewed them for themes. Quotes were analyzed and organized by theme. RESULTS: Interview transcripts revealed candid responses to questions about learning and the learning environment. The semi-structured nature of the interviews enabled the interviewers to probe unanticipated issues (e.g. reasons for choosing to sit with friends although that diminishes learning and attention). A content analysis of these transcripts ultimately identified three major themes embracing multiple sub-themes: (i) learning studio physical space; (ii) interaction patterns among learners, and (iii) the quality of and engagement in learning in the space. CONCLUSIONS: Students' reluctance to engage in class activities is not surprising if classroom exercises are passive and not consistently well designed or executed as active learning exercises that students perceive as enhancing their learning through collaboration. Students' comments also suggest that their reluctance to participate regularly in class may be because they have not yet achieved the developmental level compatible with adult and active learning, on which the curriculum is based. Challenges include helping students better understand the nature of deep learning and their own developmental progress as learners, and

providing robust faculty development to ensure the consistent deployment of higher-order learning activities linked with higher-order assessments.

Gilboy, M. B., et al. (2015). "Enhancing student engagement using the flipped classroom." J Nutr Educ Behav **47**(1): 109-114.

The flipped classroom is an innovative pedagogical approach that focuses on learner-centered instruction. The purposes of this report were to illustrate how to implement the flipped classroom and to describe students' perceptions of this approach within 2 undergraduate nutrition courses. The template provided enables faculty to design before, during, and after class activities and assessments based on objectives using all levels of Bloom's taxonomy. The majority of the 142 students completing the evaluation preferred the flipped method compared with traditional pedagogical strategies. The process described in the report was successful for both faculty and students.

Ratta, C. B. (2015). "Flipping the classroom with team-based learning in undergraduate nursing education." Nurse Educ **40**(2): 71-74.

This article describes the use of team-based learning (TBL) within a flipped classroom setting in an undergraduate nursing course. TBL facilitates active learning through the use of small group, classroom activities. Students used classroom time to solve problems while developing important professional competencies. A preclass PowerPoint lecture with narration, a component of the flipped classroom, was added to address student feedback. Despite mediocre course evaluations, improved student performance on the final course examination was noted.