Student Lecture Attendance and Its Relation to Exam Performance in the Era of Lecture Capture Technology.

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Research article

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Abstract

Background: Students can now review on-line lecture recordings rather than attend lectures. However, there is little data on the fraction of students attending lectures, the patterns of attendance, or the ultimate learning outcomes. To study this issue, attendance data was used to compare learning outcomes of students with different patterns of attendance.

M**ethods:** A retrospective observational analysis was performed using data collected in the Medical Pharmacology course in Fall 2013 (197 students) and Fall 2014 (207 students). Attendance was monitored at 13 of 40 lectures with an audience response system in each semester. All lectures were recorded using lecture-capture, and students could attend lectures or review online recordings and PowerPoint files as desired. Exam averages of students in different attendance categories were compared, along with the frequency distribution of exam scores in the different attendance categories.

Results: In the years studied, 12-14% of the students had a consistent pattern of high attendance at monitored lectures; 35-46% of the students had an erratic pattern of low to intermediate attendance, and 41-52% of the students did not attend any monitored lectures. Aggregate exam averages of students with >80% attendance were over 5 percentage points higher than those of students in other attendance categories ($P<0.05$ using t-tests or ANOVA). Students with >80% attendance also displayed a significant shift in aggregate exam averages to higher ranks in frequency distribution analyses ($P<0.05$ using Chi-Square tests). Exam averages of students with low to intermediate attendance did not differ from students with no attendance. The scoring advantage associated with >80% lecture attendance remained evident 20 weeks after the Fall semester when students took a comprehensive pharmacology examination ($P<0.05$).

Conclusions: On average, students with a consistent pattern of high lecture attendance had higher exam scores than students with low to intermediate or no attendance who had access to the identical course material on-line. This may reflect factors related to the method of content acquisition (live vs. on-line) or differences in the learning readiness of students choosing one approach vs. another. The data suggest that curricular changes that encourage consistent lecture attendance might improve learning outcomes for some students.

Background

Faculty lectures in a classroom with students has been a traditional teaching format in medical education for generations. Faculty convey essential knowledge in a structured dialog involving words/speech, body language and visual aids (PowerPoint slides with text, charts, diagrams, photos, etc. in modern times). However, in modern times student lecture attendance is often no longer required due to lecture capture technology that records lectures and uploads the video files to online learning management systems where students can study the material whenever desired (1-3). The lack of a mandatory attendance requirement at lectures that are recorded, and approaches like the ‘flipped classroom' give the impression that review of online lecture recordings enables learning as effectively as live lecture attendance. However, data comparing the learning outcomes of live lecture attendance and review of on-line lecture recordings is sparse and variable in its findings (4-9). Some studies found lower exam performance in students using online recordings to replace lecture attendance (4-6); while others reported similar efficacy (7-9). A 2010 meta-analysis comparing traditional in-person lectures and on-line teaching approaches (10) concluded that blended approaches with online offerings were as effective as traditional instruction. However, that report also noted that blended approaches typically benefited from greater learning time, more instructional materials, differing pedagogies and greater collaborative opportunities than traditional lectures (10). Similar conclusions were reached in a 2013 survey of flipped classroom research (11); the flipped classroom produces an expansion of the curriculum as well as a re-arrangement of curricular activities. This imbalance in learning time, educational resources and instructional approaches remains evident in virtually all studies comparing flipped classrooms to traditional lectures (12-20). Given such curricular advantages, it is surprising that improved academic performance is not a consistent finding in studies comparing flipped classrooms to traditional lectures (13,15,17-20). This suggests that the learning efficacy of live lecture attendance may be underestimated.

Our understanding of the learning efficacy of live lectures is greatly clouded by a lack of detailed information on student attendance. In particular, what proportion of the class attends any lectures, what is the average attendance level among those present, how variable is attendance over time, and how do these factors relate to exam performance? Most modern data on lecture attendance is largely based on student surveys with limitations in participation, accuracy, and detailed attendance data (2,8,21-28). Moreover, studies have shown that attendance decreases over the course of a semester and from year to year (21,23,24,27,28). This complicates efforts to assess the value of live lectures relative to online offerings since students may initially attend and later switch to on-line viewing. Such attendance decreases might reflect recognition that online viewing enables learning as well as live attendance (2). However, surveys assessing student attitudes indicate that diverse factors influence attendance decisions (2,8,21-26). Thus, time of day, subject matter, other commitments, lecturer quality, lifestyle choices, distance from school, time-savings from accelerated replays and other convenience factors all prominently figure in student attendance decisions (2,8,21-26). Overall, the learning efficacy of live lecture attendance versus review of on-line recordings remains unresolved but is an important issue since material covered in lectures typically provides foundational knowledge that other teaching formats build upon.

The objective of the present study was to collect detailed data on the features of student attendance at voluntary lecture sessions, and then use that data to perform an analysis of the relation of student attendance to exam performance. We accomplished this with attendance data collected over two years from the Medical Pharmacology course for second year medical students at New York Medical College (Valhalla, New York, USA). In particular, an audience-response system (ARS) was used in a subset of lecture sessions to pose questions that students answered using wireless response devices (29,30). In addition to answer choices, transmitted responses identified students in attendance. The attendance data provided primary information on the attendance habits of students and enabled secondary analyses of the relation of attendance to exam scores in the course.

Methods

Experimental design: A retrospective observational population-based study was conducted using student data that had previously been collected in the Medical Pharmacology 1 course at New York Medical College. This course was taken by all 2nd year medical students during the Fall semesters in 2013 (192 students) and 2014 (207 students). The course begins in early August and ends in late December and included 40 voluntary lecture sessions covering foundational material. Mandatory laboratory demonstrations, problem-solving exercises and clinical case conferences built upon the material covered in voluntary sessions. Thirteen of the voluntary lectures between mid-October to early December included an interactive component where an ARS (Turning Point 5, Turning Technologies, Youngstown, Ohio, USA) interfaced with PowerPoint to pose multiple-choice questions that students answered using wireless response devices (Turning Technologies ResponseCard RF). The sessions chosen to include an ARS component were those that the authors (C.A.P. and M.A.C.) taught in the Fall semester, and were on dates where the authors would have normally been lecturing. The original purpose of including the ARS in the selected sessions was to conduct a feasibility analysis on the use of such technology in all large-group sessions of the course. The ARS data collected was later repurposed for the present analyses.

Lectures involved PowerPoint presentations in a large auditorium with equipment and software that created synchronized audio and screen-capture recordings (Camtasia Recorder, TechSmith, Okemos, Michigan, USA). Lecture recordings (including the ARS questions) were promptly posted to an online learning management system for student use. All students also had on-line access to the PowerPoint files for each lecture before and after the session.

Students were provided with advance notice of which voluntary lectures would include interactive questions to encourage attendance and alert them to bring their wireless response devices. Wireless response devices were mandatory equipment for medical students since the ARS was already used to administer required formative quizzes in 2nd year courses. Each response device was registered to a specific student and transmits its identifying code along with the student responses. Turning Technologies software (Turning Pont 5) automatically generated an ARS session file that was converted to Excel spreadsheets for use in the data analysis. The ARS assigned attendance points to students who answered at least 50% of the questions presented in a session. Attendance points were only used to track and calculate student attendance during the voluntary lecture sessions that were monitored; they had no bearing on the formal assessment of student performance in the course. Attendance data from monitored sessions, and data from exam result spreadsheets were compiled and analyzed to examine the relation of student attendance to exam performance.

Statistical analysis: Compiled data were analyzed using NCSS Data Analysis software (version 11; Kaysville, Utah, USA). There was no set ‘a priori’ format for analyzing the data. The data was subjected to a sequential series of formal statistical analyses designed to provide insight on the relation of student attendance to exam performance (see Results).

Datasets of exam performance and student attendance were initially subjected to linear regression analysis. Datasets were subsequently stratified into groups based on different levels of attendance. Due to differences in the 2013 and 2014 course schedules, minor variations in attendance groups were used in different years (see Results). Attendance stratifications that yielded groups with equivalent exam averages were often re-stratified into a smaller number of groups to enhance statistical power. The datasets were analyzed using ANOVA followed by multiple comparison tests (Tukey HSD test) or by t-tests when only two means were analyzed. Frequency distribution analyses were performed using the Chi-squared statistic to verify that groups with significantly higher exam averages also displayed a significant shift in exam scores to higher scoring ranks. The criterion of significance for ANOVA, Tukey tests, t-tests, and Chi-square tests was $P<0.05$.

Results

Student Attendance Levels: Student attendance during the voluntary lecture sessions was monitored in 13 of 40 sessions during the Fall semester by using an ARS to pose interactive questions. There were 192 students in the course in 2013, and 207 students in 2014. Fig. 1 (left panel) shows the percent of students within in different ranges of attend levels (attendance groups) in the monitored sessions in 2013 and 2014. High attendance (>80%) was exhibited by only 12-14% of the students; 34-47% of the students exhibited low to intermediate attendance, and 41-52% of the students did not attend any of the monitored voluntary sessions. Fig. 1 (right panel) shows the average composition of the students attending lectures. In both Fall 2013 and Fall 2014, less than 30% of the attending students had high attendance, and over 70% of students had low to intermediate attendance. The average attendance at monitored sessions for the high attendance group was 91.7% in 2013 and 96.0% in 2014. Average attendance for the 77-46% attendance group was 57.1% in 2013 and 58.7% in 2014. Average attendance for the 38-8% attendance group was 22.8% in 2013 and 23.4% in 2014.

The attendance data also enabled an analysis of the pattern of attendance in the different attendance groups. The high attendance group exhibited a consistent pattern of high attendance; averaging 12% variation in attendance levels in October monitored sessions compared to November and December monitored sessions. In contrast, the low to intermediate attendance groups exhibited an erratic attendance pattern; averaging 39% variation in attendance levels in the different course sections.

Relation of Student Lecture Attendance to Performance in Course Exams.

Student performance in Medical Pharmacology 1 is assessed using 4 in-house exams composed of multiple-choice questions prepared by the teaching faculty. Complete datasets of the attendance level and the average of all 4 exams for each student were initially subjected linear regression analysis. The results revealed weak positive correlations that provided little insight; 2013 $r=0.173$, $r^2=0.030$, $P=0.016$;

2014 r= 0.072, r^2=0.005, P=0.302. For a more discriminating analysis the datasets were segregated into groups based on attendance levels. Datasets were initially stratified into 6 groups based on different levels of attendance (100-80%, >80%<60%, >60%<40%,>40%<20%,>20%<0%, 0%) and the aggregate exams averages of the different attendance levels were calculated. This led to the identification of higher exam scores in the group with >80% attendance but not in any other groups (data not shown).

The large number of attendance groups and the small number of students in some groups weakened the statistical power of the dataset. Thus, we switched to an attendance stratification that gave fewer attendance groups to improve statistical power (100-83%, 67-17%, 0% in 2013 and 100-83%, 77-8% and 0% in 2014). Figure 2 (left panel) shows the average scores for students exhibiting high, intermediate to low, or no attendance during the monitored class sessions during each of the 4 exams held during the Fall 2013 semester. The group with high attendance had higher exam scores (+3 to 6 percentage points) compared to groups with intermediate to low or no attendance. This difference was significant for exams 1, 3 and 4, The 2013 data also indicated that students with intermediate to low attendance did not exhibit a significant scoring advantage relative to students with no attendance.

Fig 2 (right panel) shows the corresponding data for Fall 2014. Unlike Fall 2013, exam 1 scores were not related to attendance rates in Fall 2014; this may reflect higher attendance and higher exam scores that are typically seen in the first section of the course. However, on exams 2, 3 and 4 the group with high attendance had higher exam scores (+3 to 5 percentage points) compared to groups with intermediate to low or no attendance. This difference was significant for exams 3 and 4. Thus, the 2014 data for Exams 2, 3 and 4 generally matched the Fall 2013 data showing that high attendance was associated with a scoring advantage relative to students with intermediate to no attendance. The Fall 2014 data also confirmed the Fall 2013 data showing that students with intermediate to low attendance did not exhibit a scoring advantage relative to students with no attendance.

The relatively small numbers of students exhibiting high attendance weakened the statistical power of analyses focusing on a single exam. Thus, we analyzed the aggregate exam averages of the different attendance groups. Figure 3 (upper left panel) compares the aggregate exam averages of groups of students exhibiting high, intermediate to low, or no attendance in Fall 2013. The high attendance group had a significantly higher aggregate exam average than the groups with either intermediate to low or no attendance (+5.9 to 5.5 percentage points). This dataset was then subjected to frequency distribution analysis to assess the relation of student attendance to relative scoring rank (Fig. 3 upper right panel). The frequency distribution analysis revealed that high attendance was associated with a significant shift in aggregate exam averages towards the high rank coupled with a decrease in the intermediate and low ranks. Thus, students with high attendance were 71% more likely to have an upper rank, and 50% less likely to have a low rank, compared to students with intermediate to low or no attendance.

Figure 3 (lower left panel) shows the aggregate averages of Exams 2-4 for the high attendance group and the groups exhibiting intermediate to low or no attendance in Fall 2014. High attendance was again associated with significantly higher aggregate exam averages (+5.4 percentage points) relative to intermediate to no attendance. Frequency distribution analysis revealed that high attendance was again associated with a shift in the number of students with averages in the higher rank coupled with a decrease in the number of students scoring in the lower rank (Fig. 3, lower right panel). Thus, students with high attendance were 60% more likely to have an upper rank, and 37% less likely to have a lower rank compared to students with intermediate to low or no attendance.

The Medical Pharmacology 1 course in the Fall semester is followed by a Medical Pharmacology 2 course in the Spring semester that concludes with a comprehensive exam in pharmacology covering material taught in both semesters. The comprehensive pharmacology subject exam is prepared by the National Board of Medical Examiners (NBME)(Philadelphia, Pennsylvania, USA) and uses questions prepared by a national committee of content experts assembled by the NBME. The NBME exams were given 20 weeks after the end of the Fall semester when the attendance data was collected, In both years the group with high lecture attendance had a higher NBME exam average than groups with intermediate to low or no attendance (+4.5 points in Spring 2014 and + 3.1 points in Spring 2015); this difference was significant for the Fall 2013 class (t-test $P < 0.02$), and approached significance in the Fall 2014 class (t-test $P < 0.13$). To increase the statistical power of the NBME exam data analysis, we transformed the NBME scores to give a mean of 55.6 for both classes, with no change in the variance of either class. The data were then pooled and analyzed. The pooled data showed that the high attendance group had a significantly higher NBME average (+3.8 pts.) than the intermediate to low and no attendance groups (Fig. 4, left panel). Frequency distribution analysis of NBME scores showed that high attendance was associated with a significant shift in scores towards the higher rank coupled with a decrease in scores in the lower rank (Fig. 4, right panel). Students with high attendance were 50% more likely to have an upper rank and were 48% less likely to have a lower rank. Thus, on average, high lecture attendance in the Fall semester was associated with increased NBME exam scores almost 5 months later.

Discussion

After the introduction of lecture capture technology, it became apparent that attendance at voluntary lecture sessions progressively declined during the semester, particularly after exam 1. This declining attendance has been widely reported (24-28). It was anticipated that most students attending lectures in the late October to early December would have high attendance. However, this was not true; only a small fraction of those attending had a consistent pattern of high attendance. The other attending students had an erratic pattern low to intermediate attendance.

Attendance variability has prompted others to use linear regression analysis to correlate attendance level to course outcomes such as exam performance (9,31-34). Such analyses have generally found low correlations with coefficients of determination (r^2) below 0.1. Although the correlations were positive, such data suggested that attendance was not a major determinant in exam performance for most students. Similar low correlations were found in the present data. However, linear regression analyses assume there is a linear relationship between two variables, and further analysis of the present datasets showed that this was not true.

When students were stratified into groups based on attendance levels it was evident that, on average, students with high attendance consistently achieved higher exam scores than students with intermediate to low or no attendance. This was true in 7 out of the 8 in-house exams administered in Fall 2013 and 2014 and confirmed in the aggregate exam averages of Fall 2013 and Fall 2014. The scoring advantage associated with high attendance also appeared long-lasting. On average, students with high attendance displayed higher scores in a comprehensive pharmacology NBME exam given 20 weeks after the end of the Fall semester. Frequency distribution analyses demonstrated that students in the high attendance groups had a significant shift towards higher exam scores coupled with a decrease in lower scores. This was true for both the in-house exams and for the NBME exam.

The reasons why some students adopted a high attendance approach was not addressed but presumably reflects their preferred learning style and desire for live interactions with classmates and faculty. In this regard, it is notable that surveys of student attitudes regarding attendance indicate that many students prefer live attendance to study of recorded lectures, but factors related to lifestyle, other commitments and convenience can over-ride such preferences (7,22,24). Interestingly, students who did not attend any monitored sessions had the most consistent attendance pattern and the most specialized study approach: attendance had been abandoned in favor of online or other resources. Nonetheless, on average, this approach did not yield an exam scoring advantage. The reasons why so many students chose not to attend lectures was not addressed but surveys of student attitudes indicate that a multitude of factors play a role in such decisions, many of which relate to convenience rather than perceived learning outcome (2,7,21-28).

At this point it should be noted that there were many students in the top ranks of the class who had intermediate to low or no lecture attendance. Thus, other learning approaches worked well for some students. Conversely, high lecture attendance did not guarantee high exam scores since some students with high attendance had scores that placed them in the middle or lower ranks of the class. Nonetheless, a learning strategy that increases the chance of earning a score in the middle ranks may be highly valued by some students given the varying academic strengths and weaknesses of individuals within a class.

Although our data show that the high attendance group had increased exam performance relative to those with lower attendance, the behavioral characteristics of students with high lecture attendance might also contribute. Thus, personal attributes such as organization, discipline and motivation that may foster high attendance may also improve the learning readiness of the students. However, such attributes should not be viewed as innate character traits; they are more likely to reflect the influence of years of learning experiences that rewarded class attendance and shaped behavior accordingly.

Conclusions

The objective of the present study was to collect detailed data on student lecture attendance and use that data to assess the relation of lecture attendance to exam performance. It was found that most students either did not attend voluntary lecture sessions or had an erratic pattern of intermediate to low attendance. On average, students with a consistent pattern of high lecture attendance achieved significantly higher exam scores than other students who had access to the identical material in lecture recordings and other course materials posted on-line. The benefits of high lecture attendance also appeared long-lasting (>20 weeks). The data suggest that curricular changes that encourage consistent lecture attendance might improve learning outcomes for some students.

A limitation of this study is that it is observational and does not address causation. Thus, it is unclear if the differing learning outcomes are related to different methods of content acquisition (live vs. on-line) or differences in the learning readiness of students using different learning approaches. In addition, attendance was measured at only 13 of 40 voluntary lecture sessions. Thus, it was not possible assess how attendance before each exam was related to subsequent exam performance. Acquisition of such data would be a useful direction for further research.

Abbreviations

ARS – audience response system

NBME – National Board of Medical Examiners

Declarations

Ethics Approval and Consent to Participate: The protocol used was reviewed by the Committee for Protection of Human Subjects of New York Medical College (approval L-12,058, January 27, 2017). The protocol was given a waiver of informed consent /HIPPA waiver based on the minimal risk exemption for research in educational settings involving normal educational practices [45 CFR 46.104(d)(1) Exemption 1]

Consent for publication: Not applicable.

Availability of data and materials: The course datasets used in the study are not publicly available as they are based on exam scores and attendance data of identifiable students. Datasets are available from the corresponding author on reasonable request after modification to remove identifiers.

Competing Interests: The authors declare they have no competing interests.

Funding/Support: The authors declare there was no external body involved in the design of the study, the collection, analysis and interpretation of the data, or in writing the manuscript.

Author’s Contributions: C.A.P. was responsible for all phases of the research (conception, design, data collection, data analysis and interpretation, manuscript preparation). M.A.C. contributed to the design, data collection, and editing of the manuscript. All authors have read and approved the manuscript.

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Author's Information:

C.A.P. has been the course director of the Medical Pharmacology courses at New York Medical College for over 20 years. He is also the course director of two advanced graduate courses and is a teaching faculty member in many other courses. He has actively encouraged, supported, and implemented diverse innovations in medical education in the courses he directs or teaches in. This includes the use of lecture-capture technology - which provides on-line lecture recordings that are a valuable learning resource for students. The medical education research of C.A.P. seeks to better understand the diverse learning approaches used by students and explore how such diversity can be more effectively assisted by versatile methods of curriculum delivery. Lecture attendance is one of many methods students use to achieve their educational goals and should neither be ignored nor over-emphasized.

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Figures

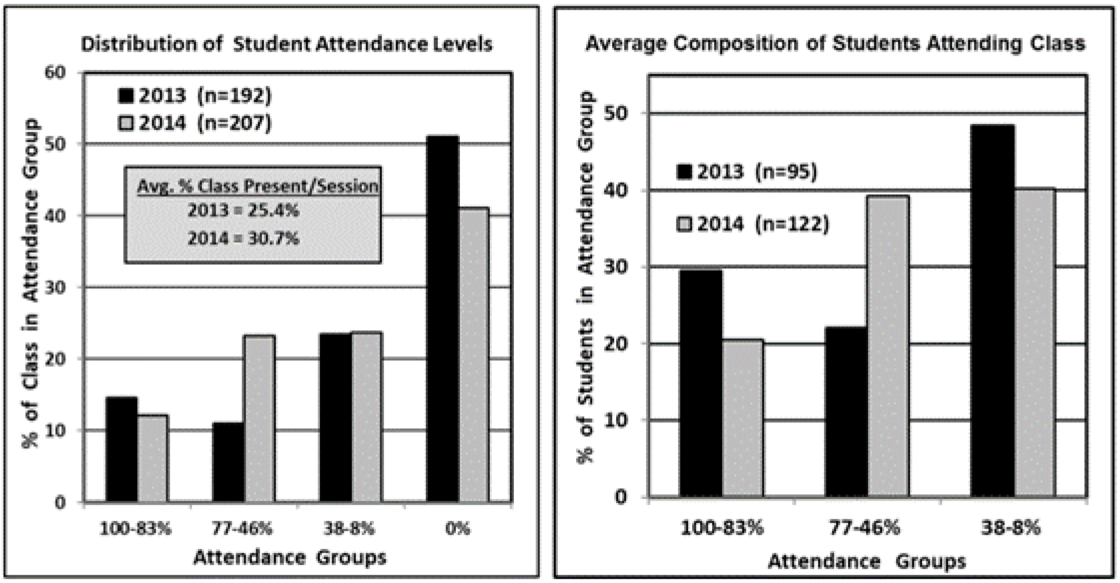

Figure 1

Characterization of student attendance at voluntary lecture sessions where interactive questions were posed using an ARS during Fall 2013 and 2014. Left panel: Distribution of student attendance levels. Data show the percentage of class in the different attendance groups. Right panel: Average composition of students attending class. Data show the percent of attending students in the different attendance groups.

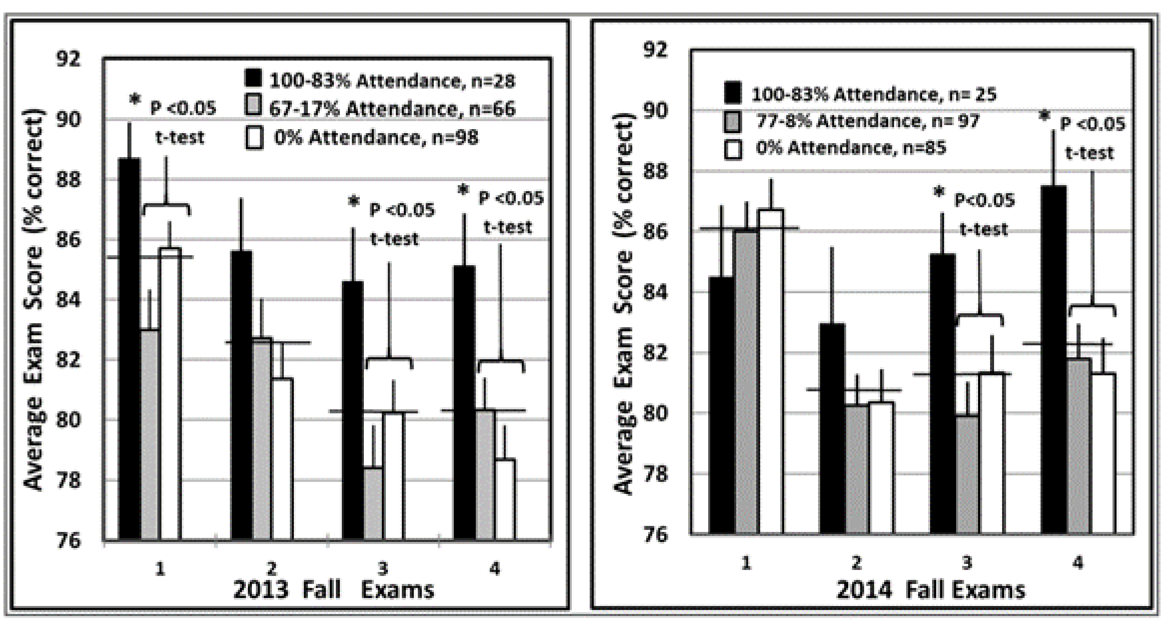

Figure 2

Relation of lecture attendance to exam performance in Fall 2013 and 2014. Exam averages for each attendance group in each of the 4 in-house exams are shown for 2013 (left panel) and 2014 (right panel). Data show mean + SEM. Horizontal line through each exam set shows class average for exam. * indicates P <0.05 for t-tests comparing the 100-83% attendance group to pooled group with all other attendance levels.

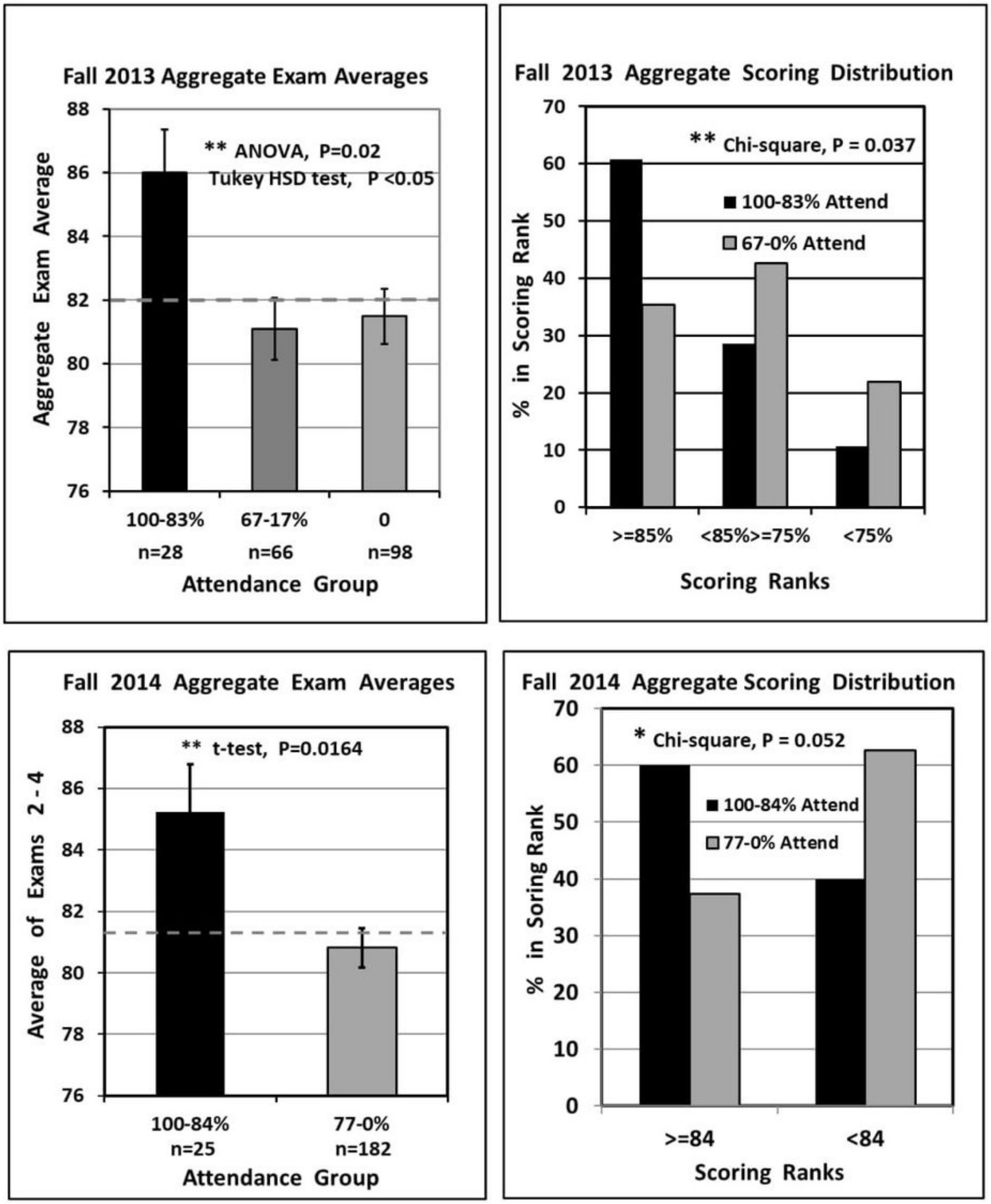

Figure 3

Relation of Student Attendance to Aggregate Exam Averages and Scoring Distribution in Fall 2013 and 2014. Upper left panel: Fall 2013 aggregate exam averages. Data shows the average of exams 1-4 for students in the different attendance groups. Mean + SEM are indicated for each attendance group. Dashed line shows the aggregate exam average for the entire class. Upper right panel: Fall 2013 aggregate scoring distribution for the indicated attendance groups. Lower left panel: Fall 2014 aggregate exam averages for the indicated attendance groups. Data shows the average of exams 2-4 for students in the indicated attendance groups. Mean + SEM are indicated for each attendance group. The dashed line shows the aggregate exam average for the entire class. For the 2014 analysis, 77-8% and 0% attendance groups were pooled to increase the statistical power. Lower right panel: Fall 2014 aggregate scoring distribution for the indicated attendance groups. For 2014, only two scoring ranks were used to increase statistical power.

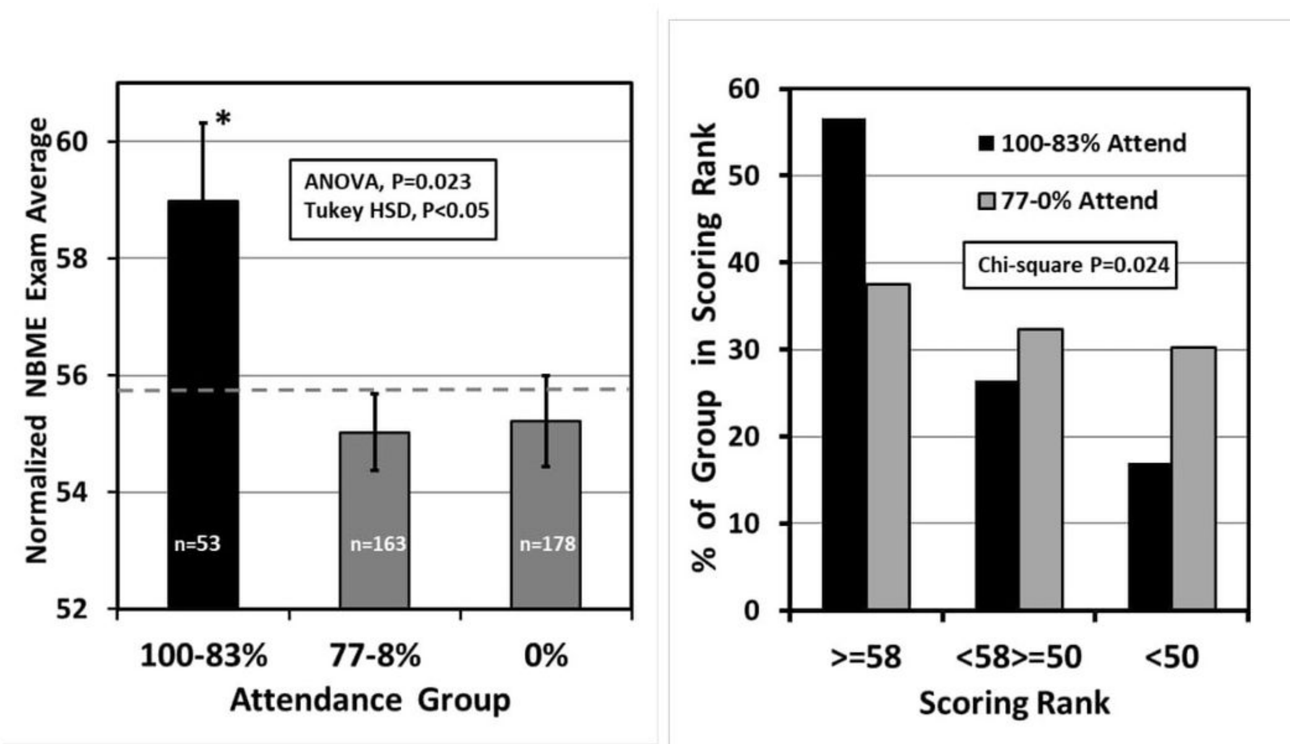

Figure 4

Relation of voluntary lecture attendance in Fall semester to scoring on the National Board of Medical Examiner’s (NBME) pharmacology exam given 20 weeks after the end of the Fall semester. Left panel: NBME exam scores from Spring 2014 and Spring 2015 were transformed to yield a mean of 55.6 for each year (no change in variance) and then pooled and average scores determined for the indicated attendance groups. The dashed line indicates the pooled NBME average for the two classes. Right panel:

The NBME exam scoring distribution for the indicated attendance groups. Note: the NBME did not use % correct scores in 2013 and 2014. Scaled scores were used with a national average of ~50, and a maximum possible score = 70.