

The teaching of pathology has changed over the years. For example, in most US medical schools, students are not required to perform an autopsy (7). Autopsies have been the staple of pathology instruction for more than one hundred years, from the times of Virchow and Rokitsky. Histopathology is rarely taught at the microscope and it seems as though computer-based "virtual slides" will replace standard microscopic glass slides in the near future (8). Pathology examinations have also changed over the years, not only in content, but also in form. New modalities for testing medical students' knowledge have been introduced (9).

Curricular changes taking place in US medical schools are advocated as a panacea by enthusiastic proponents and are criticized by the usual skeptics, who typically account for most of the faculty. Some curricular changes are made for the wrong reasons (e.g., introducing problem-based teaching because everybody is doing it), strengthening the arguments of the luddites. On the other hand, many changes introduced into medical education have been favorably received by medical students and have improved their education.

Traditionally, the goals of medical education have been to gather information provided through lectures, with an emphasis on passive memorization. Revisionists, cognizant of the fact that theory should not be dissociated from practice, insisted that learning should occur in context. It should be based on the active acquisition of knowledge in a student-centered curriculum. Problem-based learning (PBL), patterned on the case study approach practiced in laws schools and business schools, has been one of the most popular innovations. However, as several surveys have shown, most US medical schools have chosen to retain some aspects of the old system and only partially implement this revised mode of learning (1-6). Three general trends are recognized: 1) adherence to the traditional curriculum with minor or minimal reform, 2) complete restructuring of the curriculum, and 3) a half-way approach in which certain aspects of the traditional curriculum are retained, some are modified, and some novelties are introduced (3).

Curricular changes in US medical schools have been coordinated loosely with changes in the assessment by the National Boards of Medical

Examiners (NBME). The national licensing examinations have changed (Part I → Step I) and the format of reporting educational outcomes has been revised. Medical schools no longer receive discipline-based subscores for their students. These changes make it almost impossible to use the current NBME reports for comparing educational outcomes over time, or for comparing the educational outcomes of one school with those of another. This paper provides an example of a medical education study that could be performed previously, but is no longer possible today.

In this paper, we relate our experiences reforming the sophomore Pathology Course at Jefferson Medical College (JMC) in Philadelphia, Pennsylvania more than 20 years ago. We tested our hypothesis that changes in the format of teaching pathology, moving from a lecture based to a participatory curriculum, forcing students to change from passive to active learning, can influence students' academic achievement. Our findings indicate that curricular reform can improve student's performance on externally administered, comprehensive examinations. This analysis would not be possible under current conditions of testing by the NBME.

Subjects and Methods

During the period of this study (JMC entering classes 1982-1988), the sophomore Pathology Course was taught either as a lecture-based course (1982-1984) or as an active learning, participatory course (1985-1988). The new pathology curriculum was based on independent study, small group seminars, and case study discussion sessions. Each week was typically devoted to one chapter of the first edition of *Rubin's pathology: clinicopathologic foundations of medicine* (10).

The entire class was divided into 10 groups of approximately 20 students per group. Students met with an instructor who was assigned to that group for the entire semester. Students and faculty met twice per week. One small group session was devoted to the discussion of five typical cases, illustrated with appropriate color slides of gross and microscopic pathology and relevant clinical findings (e.g., X-rays, serum electrophoresis, and urinary findings). The second small group session centered on key concepts identified by students in their reading of the assigned textbook. The instructor's role was to stimulate discussion

rather than to provide answers. Instruction based on questions and answers is often referred to as "Socratic teaching." Take home messages and "final answers" were supposed to represent consensus statements and "prevailing opinions" rather than dogmatic transcripts from the textbook or unexamined professorial proclamations. Academic achievement was evaluated using weekly quizzes, interim examinations, and a final comprehensive examination.

During the period of this study, JMC students were required to take the NBME Part I Examination at the end of their second year of medical school. This objective, comprehensive examination was designed to assess students' understanding of and ability to apply concepts and principles important in health and disease. Comparisons between the group of students taking pathology before curricular reform ($n=655$) and those taking pathology after curricular reform ($n=846$) were made on the basis of selected measures of academic achievement and psychosocial information retrieved from the database of the Jefferson Longitudinal Study of Medical Education (11). The Longitudinal Study has been collecting data on Jefferson graduates continuously since 1968 and is widely used in medical education research (12).

Measures of academic achievement included students' undergraduate grade point averages, scores on the preadmission Medical College Admissions Test (MCAT), JMC second-year grade point average, final grades in the Pathology Course, and performance on Part I and Part II of the NBME medical licensing examination (total scores and pathology subscores). In addition to reporting mean scores, we normalized the data to control for year-to-year variation in the performance of the national cohort. Normalized data were calculated as a percent difference: $(\text{JMC Mean} - \text{National Mean}) / \text{National Mean} \times 100$.

In order to test the effects of curricular reform on the development of clinical skills, we compared JMC students in the two groups on the basis of their postgraduate ratings of clinical competency (13). The rating form consists of 33 statements, dealing with three major aspects of clinical competence: "knowledge and data gathering skills," "clinical judgment and professional attitudes," and "socioeconomic aspects of patient care." This form is distributed to all residency program directors for Jefferson graduates, and the re-

sponse rate is approximately 80%. Exit polls of student satisfaction at Jefferson were also analyzed. Student satisfaction with the curriculum was measured on a 4-point Likert scale. A two-tailed *t* test was used to evaluate the statistical significance of our findings. During the period of this study, curricular reform at JMC was limited to the changes in the sophomore Pathology Course.

Results

Based on data stored in the Jefferson Longitudinal Study Database, students who completed pathology prior to curricular reform (entering classes 1982-84) and those who completed pathology following curricular reform (entering classes 1985-88) showed no significant differences in either academic or social characteristics. Thus, there were no significant differences between the two comparison groups in the female/male ratio, average age at matriculation, undergraduate grade point averages, and mean scores on the preadmission MCAT examination (data not shown).

Curricular reform at JMC was not associated with a significant change in the second year grade point average, which hovered around 82% for the entire seven years of this study (data not shown). During the period of this study, JMC students performed at or above the national mean on the NBME Part I Examination, and there were no significant differences in total Part I scores between the two comparison groups (data not shown).

A different result was obtained when we examined pathology subscore data provided by the NBME. JMC students who were taught using the reformed pathology curriculum scored significantly higher on the pathology component of the Part I Examination (Table 1, $P < 0.001$). To control for year-to-year variation in the performance of the national cohort on this medical licensing examination, we calculated percent differences from the national mean. Normalized data for Part I total scores and pathology subscores are shown in Figure 1. Pathology curricular reform at JMC was associated with a dramatic increase in students' performance on the pathology component of the NBME Part I licensing examination. A modest increase in the students' overall test performance (total score) was also noted.

Table 1. Student Performance on the National Board of Medical Examiners (NBME) Part I Examination

Entering class	NBME Part I-Pathology Subscore*		P
	Jefferson	National	
Traditional curriculum 1982	505	502	NS
1983	510	486	<0.01
1984	486	488	NS
Reformed curriculum 1985	551	487	<0.001
1986	527	471	<0.001
1987	547	491	<0.001
1988	552	491	<0.001

*Data represent pathology subscores for the "first-time taker group" who took the NBME Part I Examination in June following the second year of medical school (1984-1990). Pathology subscores for classes in the revised curriculum are more than half a standard deviation above the national mean. Statistical significance of the data was determined using a two-tailed Student t test (NS, not significant).

We sorted the Part I pathology subscore data to track the percentage of students who scored in the top 10% nationally (scores >600) and the percentage of students who scored in the bottom 10% nationally (scores <380). Curricular reform at Jefferson was associated with a significant decline in the percentage of students who scored in the bottom tenth percentile nationally (down from an average of 12% to 3%, $P < 0.001$ by z test) and a reciprocal increase in the percentage of JMC students who scored in the top tenth percentile nationally

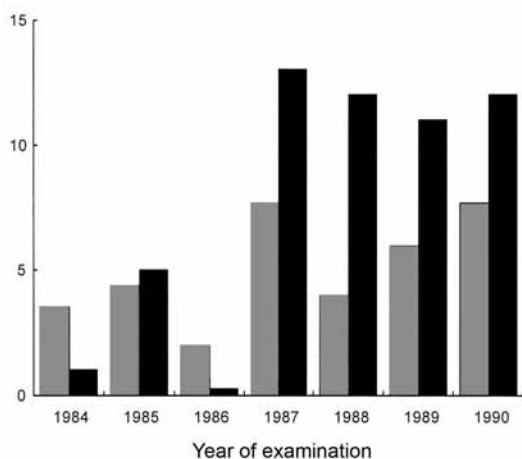


Figure 1. Relationship between curricular reform and the performance of Jefferson students on the National Board of Medical Examiners (NBME) Part I Examination. Data represent Part I total scores (gray bars) and pathology subscores (black bars) normalized as percent differences from the national mean. The results are plotted by year of examination. Students who studied pathology following the introduction of curricular change took this medical licensing examination in the years 1987 to 1990. Students' performance on the pathology subsection of the NBME Part I Examination increased dramatically following the introduction of our new pathology curriculum, based on small group teaching and principles of active learning.

(up from an average of 16% to 25%, $P = 0.01$). These data are shown in Figure 2.

Surveys given to JMC students at graduation showed that our efforts at curricular reform were associated with a significant increase in students' satisfaction with the entire second- and third-year medical curriculum (data not shown). On the other hand, curricular reform in pathology, based on active learning and close student-faculty interaction, did not translate into higher scores on the more clinical NBME Part II Examination, nor did it lead to significant changes in postgraduate ratings of clinical competencies by residency program directors (data not shown). The success of our educational reform was apparently limited to mastery of basic and systemic pathology and

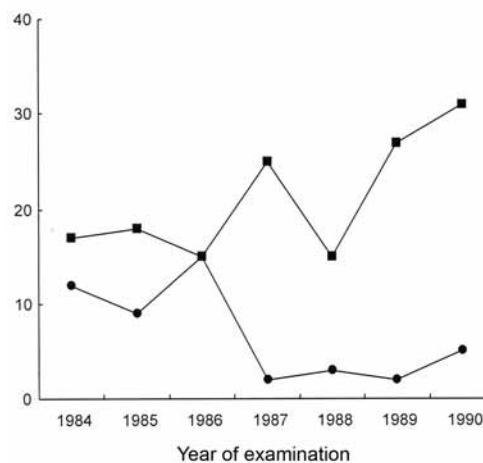


Figure 2. Effect of pathology curricular reform on students' performance on the pathology subsection of the National Board of Medical Examiners (NBME) Part I Examination. Jefferson students in the top tenth percentile nationally (scores >600) and bottom tenth percentile nationally (scores <380) were identified, based on information provided by the NBME. The results are plotted by year of examination. Students who studied pathology following the introduction of curricular change took this medical licensing examination in the years 1987 to 1990. Curricular reform was associated with a significant decline in the percentage of students with failing scores in the bottom tenth percentile nationally (circles, $P = 0.001$), and a reciprocal increase in the percentage of students scoring in the top tenth percentile nationally (squares, $P = 0.1$).

student satisfaction with the curriculum.

Discussion

The data presented here confirm our hypothesis that curricular changes that include an emphasis on active learning can improve the per-

formance of medical students on externally administered, objective examinations. We have shown that the means of the medical school class can be improved, the number of failing students reduced, and the number of high-scoring students increased. Improvement of the students' test scores was not limited to the first class after curricular reform, but persisted throughout the entire observation period of four years. The combination of independent study, assigned reading, and close student-faculty interaction clearly provided a rich medium for fostering academic excellence.

Medical educators have been trying to improve the education of future doctors, but the effects of the changes introduced in various schools are hard to measure (14). A more fundamental issue is that there is no consensus on what it means to be a good doctor and no consensus on how to evaluate physicians on the basis of their competency, such as their ability to work as members of a complex medical team, continue to learn throughout their entire professional life, and provide service and leadership (15-17).

Examination grades provide a means to evaluate students, but even such supposedly objective criteria are not constant and are known to fluctuate (12,18). Comparison of grades from different medical schools has its own inherent problems, and the NBME has discouraged the use of their data for comparing the educational outcomes in different student groups. The current practice of reporting summary students' grades by the NBME does not even allow one to perform such comparisons. Nevertheless, as US medical students are painfully aware, many directors of the most competitive residency programs still use United States Medical Licensing Examination (USMLE) data for stratifying applicants and choosing residents. Longitudinal studies have shown that undergraduate grades are a reasonable predictor of future achievements of medical students (12). Thus, motivating students to obtain good grades may be a reasonable approach to achieving excellence, although some educators dismiss this approach and recommend the promotion of problem solving skills and reflection over acquisition of factual knowledge (19).

The results presented here show that medical students' grades can be improved by changing how a course is taught. Because these findings cannot be tested experimentally, several

possible interpretations of the data must be considered. First, we considered the possibility that our students reacted to nothing but changes in the teaching method and the new teaching staff. However since the "novelty effect" did not wear off but persisted for at least three more years, this explanation can be discarded. In a previous paper (20), we showed that academic achievement cannot be ascribed to an improved teaching staff – the quality of professors and their popularity with students had no measurable effect on the outcome of teaching. Second, the Pathology Course offered before and after curricular reform had the same number of contact hours, so time alone can not explain our findings. Third, curricular reform at JMC was limited to changes in the format of pathology education during the period of this study. Accordingly, we believe that the most significant difference between the two comparison groups was the abrupt transition from a passive to a more active mode of learning.

Active learning was stimulated at JMC by several means. First, the students were told in no uncertain terms that they were responsible for their own education. They were told that the examinations would cover essentially the entire textbook, and that they would be tested on it cover-to-cover. Interim examinations were used to reinforce that message. The first two interim examinations gave students immediate feedback about their performance and also allowed us to identify medical students with academic problems. Students at risk were counseled and given additional tutorial assistance. During the academic year, the performance of almost all students improved and only an insignificant number of students failed the course (3 to 5 students on average in a class of over 200).

Active learning in our reformed curriculum was also stimulated through small group discussion sessions, which were held twice a week. Students studied the macroscopic and microscopic features of various diseases and learned in a Socratic manner how to correlate pathologic findings with clinical data. In these discussion groups, the students were asked to discuss the assigned readings. To make sure that our students were prepared for these discussions, they were given quizzes in the form of short essays or "fill-in-the-blank" questions. Quizzes were administered at the end of each class period.

Student satisfaction with the course was relatively high, as evidenced by data obtained from exit polls given at the end of the course and at the time of graduation. The course director received the annual teaching award from the students. At that time, we did not use the sophisticated evaluation techniques that are currently in use (21), but it was still surprising that the students reacted so positively. The course was considered to be difficult and it is known that courses that are considered to be difficult and require a lot of reading are not always popular (1). As time progressed the satisfaction of students actually rose, probably because of feedback from upper classmen, who assured them that the Pathology Course had a low failure rate and that their efforts in pathology would yield higher scores on the NBME Examination.

Since these data were obtained before the era of widespread computerization of medical education our paper could be construed as an apology for old fashioned classroom teaching, still widely practiced worldwide, except in the most advanced countries of North America and Western Europe. It could also be viewed as an argument in support of the recently published views of Bosman (22), who posited that an honest intellectual effort may give more valuable outcomes than expensive technology based initiatives.

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