Problem-Based Learning: Effects on Standard Outcomes


Abstract: Dental students at the Harvard School of Dental Medicine (HSDM) participate fully in the first two years of the curriculum with the Harvard Medical School (HMS) while also taking parallel dental classes. HSDM students were first exposed to problem-based learning (PBL) in 1987 when the “New Pathway” curriculum was introduced at HMS in the first two years of the medical school curriculum (the HSDM courses remained traditional lecture-based classes). In 1994, HSDM incorporated PBL into the first, second, and third (clinical year) year dental courses, and the curriculum shifted from a five-year curriculum to a four-year curriculum. The purpose of this study was to evaluate the effect of PBL and program length on measurable outcomes for dental education: NBDE Part I scores, attrition and graduation rates, and percentage of graduates entering postdoctoral training programs. This study was designed as a retrospective analysis of outcomes data from 1980 to 2002. Univariate linear regressions were computed for each measure against each outcome. Subsequent bivariate regression analyses revealed that the implementation of PBL has markedly affected NBDE Part I scores, graduation rates, attrition rates, entrance into postdoctoral plans, and percentage of graduates entering GPR/AEGD programs, while program length has had an effect on graduation rates, attrition rates, entrance into postdoctoral programs, and percentage of graduates entering GPR/AEGD programs. The findings of this report suggest that the implementation of PBL combined with a change in program length has been successful for all outcomes measured and that PBL alone has contributed to the rise in NBDE Part I scores among HSDM graduates.

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Key words: problem-based learning, curriculum change, standard outcomes

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Over the past twenty years, the predoctoral curriculum at the Harvard School of Dental Medicine (HSDM) has transitioned from a traditional, discipline-specific program to the current hybrid problem-based learning (PBL) curriculum. The “traditional” program, which was based on department-organized lecture, lab, and clinical sessions, was in place from 1980 to 1987. The transition to the hybrid PBL curriculum—which combines didactic training with group-based problem-solving sessions in preclinical years and focuses on comprehensive patient care provided in multidisciplinary clinics during the clinical years—was accomplished in two stages. The first stage involved the introduction of the hybrid PBL methodology into the preclinical curriculum at Harvard Medical School (HMS), where dental students take the same courses, participate in the same clinical experiences, and are held to the same academic standards as their medical colleagues. The introduction of PBL into the HMS curriculum occurred in 1987, and the first graduating HSDM class to experience this “New Pathway” of learning, as HMS administration dubbed it, was the HSDM class of 1992.1

The second stage of the transition was the introduction of the PBL methodology to the preclinical and clinical courses at HSDM. In addition to the preclinical courses taken at the medical school, HSDM students take a core curriculum of preclinical courses in the dental basic sciences. In 1991, HSDM began an intensive review of the predoctoral program. It had become apparent that students were enjoying learning in the PBL environment at HMS and were flourishing in an atmosphere of student-driven tutorials and self-directed inquiry. The result of the HSDM review was the development and 1994 implementation of a new four-year PBL curriculum for preclinical and clinical dental education.2 It was the first program to introduce hybrid PBL methodology across all areas of basic and clinical dental education.

Concurrent with the introduction of PBL for the teaching of clinical dentistry was the decision to return to a four-year D.M.D. curriculum. Beginning
with the class of 1980 and continuing through the class of 1998, the D.M.D. curriculum at HSDM included an additional year of study, making Harvard the only school in the United States to offer a mandatory five-year dental curriculum. The intent of the five-year program was to enable students to enhance their critical thinking skills and enrich their educational experience through intensive exposure to an area of personal interest (biomedical research, a GPR intern year, health care administration, public policy, etc.). In the five-year program, the first four years remained essentially unchanged from the traditional four-year D.M.D. curriculum, and the fifth “enrichment” year occurred at the end of the program, after all didactic and clinical requirements for Years 1-4 had been met. In 1993, in concert with the implementation of the hybrid PBL curriculum, the decision was made to change the curriculum back to a four-year program, resulting in two graduating classes in 1998. One group of graduates, labeled herein as 1998a, was the last class to complete the five-year curriculum and entered in the fall of 1993. The second group, labeled herein as 1998b, was the first class to complete the four-year hybrid PBL curriculum and entered in the fall of 1994.

The implementation of PBL at HSDM has been described in detail elsewhere. The purpose of this investigation is to begin to examine some of the measurable outcomes of this curriculum change and to determine if the current program is meeting the school’s goals in a number of areas.

**Methods and Data Collection**

Standard outcome data, including graduation and attrition percentages, National Board Dental Examination (NBDE) Part I scores, and postdoctoral itineraries for graduates, were obtained from the Office of the Registrar at HSDM for classes from 1980 to 2002. These data are summarized in Table 1.

The variables included in the data set were categorized as either factors or outcomes. The primary factors were program length and program philosophy. Program length was either four or five years: five years for the classes of 1980 to 1998a and four years for the classes from 1998b to 2002. Program philosophy was a measure of the degree of PBL exposure within the program. Throughout this text and in the tables, the following definitions will be used: *No PBL*—equivalent to a traditional, lecture-based curriculum; *HMS PBL*—dental students participated in the medical school PBL curriculum in years one and two, but dental classes were still taught in the traditional lecture-based format; *HMS/HSDM PBL*—dental students participated in a PBL curriculum in years one and two of the medical and dental school curriculum, and in a PBL curriculum in the year three dental school curriculum. No PBL was the program philosophy for all classes graduating from 1980 to 1991. For classes that graduated from 1992 through 1998a, the program philosophy was HMS PBL only. Starting with the class that graduated in 1998b and extending to the class of 2002, the program format was HMS/HSDM PBL. In order to examine synergy between our primary factors, a secondary factor—program format—was created; it was the composite product of program length and program philosophy measures.

Outcome variables were the percentage of students graduating on time, the attrition rate, National Board Dental Examination Part I averages, and the percentage of graduates entering postgraduate programs immediately after obtaining a D.M.D. degree. Percentage of students graduating on time was calculated as the percentage of students graduating within the specified curriculum length (five years if before 1994, four years if after 1993) out of those matriculating in the appropriate entry year. Attrition percentage was calculated as the percentage of students graduating within the specified curriculum length (five years if before 1994, four years if after 1993) out of those matriculating in the appropriate entry year. Thus, graduation and attrition percentages in this case measure different outcomes, as a student taking an additional year to do research or pursue an additional degree would not be counted in the attrition rate or the graduation rate for their entering year class. Only students leaving HSDM without a D.M.D. degree were counted in the attrition percentage. NBDE Part I averages were calculated as the mean of the section scores (Anatomical Sciences, Biochemistry and Physiology, Microbiology and Immunology, and Dental Anatomy/Occlusion) for each class. Percentage of graduates pursuing postgraduate training was calculated as the number of graduates entering an advanced training program immediately after completion of the D.M.D. degree. These data were analyzed overall and by specialty.
Table 1. Primary outcome measures by graduation year

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage Graduating on Time</th>
<th>Percent Attrition</th>
<th>NBDE I Average</th>
<th>NBDE II Average or Comprehensive Score</th>
<th>Percentage of Graduates Entering Postgraduate Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>81.0</td>
<td>9.5</td>
<td>91.3</td>
<td>88.2</td>
<td>n/a</td>
</tr>
<tr>
<td>1981</td>
<td>75.0</td>
<td>20.0</td>
<td>90.2</td>
<td>87.7</td>
<td>n/a</td>
</tr>
<tr>
<td>1982</td>
<td>79.0</td>
<td>21.1</td>
<td>90.4</td>
<td>89.7</td>
<td>n/a</td>
</tr>
<tr>
<td>1984a</td>
<td>85.0</td>
<td>15.0</td>
<td>90.9</td>
<td>90.6</td>
<td>n/a</td>
</tr>
<tr>
<td>1985</td>
<td>47.6</td>
<td>33.3</td>
<td>89.9</td>
<td>87.9</td>
<td>n/a</td>
</tr>
<tr>
<td>1986</td>
<td>63.2</td>
<td>31.6</td>
<td>89.5</td>
<td>89.7</td>
<td>n/a</td>
</tr>
<tr>
<td>1987</td>
<td>75.0</td>
<td>20.8</td>
<td>91.8</td>
<td>89.6</td>
<td>n/a</td>
</tr>
<tr>
<td>1988</td>
<td>66.7</td>
<td>27.8</td>
<td>90.4</td>
<td>88.4</td>
<td>n/a</td>
</tr>
<tr>
<td>1989</td>
<td>47.6</td>
<td>33.3</td>
<td>92.4</td>
<td>91.1</td>
<td>n/a</td>
</tr>
<tr>
<td>1990</td>
<td>36.8</td>
<td>57.9</td>
<td>92.2</td>
<td>90.0</td>
<td>n/a</td>
</tr>
<tr>
<td>1991</td>
<td>69.6</td>
<td>26.1</td>
<td>92.3</td>
<td>89.1</td>
<td>n/a</td>
</tr>
<tr>
<td>1992</td>
<td>66.7</td>
<td>29.2</td>
<td>86.7</td>
<td>86.8</td>
<td>81.3</td>
</tr>
<tr>
<td>1993</td>
<td>82.1</td>
<td>17.9</td>
<td>91</td>
<td>86.2</td>
<td>71.4</td>
</tr>
<tr>
<td>1994</td>
<td>76.9</td>
<td>23.1</td>
<td>92.1</td>
<td>83.9</td>
<td>85</td>
</tr>
<tr>
<td>1995</td>
<td>73.1</td>
<td>19.2</td>
<td>92.7</td>
<td>88.4</td>
<td>100</td>
</tr>
<tr>
<td>1996</td>
<td>85.2</td>
<td>11.1</td>
<td>93.9</td>
<td>85.8</td>
<td>75</td>
</tr>
<tr>
<td>1997</td>
<td>84.0</td>
<td>16.0</td>
<td>94.5</td>
<td>86.3</td>
<td>95.2</td>
</tr>
<tr>
<td>1998a</td>
<td>93.6</td>
<td>3.2</td>
<td>94.4</td>
<td>85.1</td>
<td>70</td>
</tr>
<tr>
<td>1998b</td>
<td>81.8</td>
<td>6.1</td>
<td>93.8</td>
<td>86.2</td>
<td>100</td>
</tr>
<tr>
<td>1999</td>
<td>81.8</td>
<td>9.1</td>
<td>92.1</td>
<td>80.6</td>
<td>93.5</td>
</tr>
<tr>
<td>2000</td>
<td>83.3</td>
<td>6.7</td>
<td>92.3</td>
<td>85.1</td>
<td>92.9</td>
</tr>
<tr>
<td>2001</td>
<td>87.9</td>
<td>9.1</td>
<td>93.3</td>
<td>84.5</td>
<td>93.5</td>
</tr>
<tr>
<td>2002</td>
<td>91.4</td>
<td>8.6</td>
<td>94.2</td>
<td>86.5</td>
<td>90.9</td>
</tr>
<tr>
<td>2003</td>
<td>n/a</td>
<td>n/a</td>
<td>94.6</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

1 Graduation rates were calculated as the percentage of students graduating within the specified program length divided by the original class size, controlling for factors such as students granted advanced placement and students who took time off to do research, pursue other degrees, etc.

2 In the fall of 1979, the program length changed from a four-year curriculum to a five-year curriculum, so there is no class of 1983.

3 For classes entering in the fall of 1994, the program length changed from a five-year curriculum to a four-year curriculum, so both the class entering in 1993 and that entering in 1994 graduated in 1998 (a and b, respectively).

4 The format of score reports for NBDE Part II changed in 1994 with the report of a comprehensive score rather than individual section scores. The scores reported here are total scores from 1994 onward and arithmetic means for years prior to 1994. Since the comprehensive score reported by the testing services does not reflect a true arithmetic mean of section scores, there is no statistically valid way to compare scores prior to 1994 with those from 1994 onward.

n/a = Data not available.

- **No PBL**: dental students participated in a traditional, lecture-based curriculum in all classes at HMS and HSDM.
- **HMS PBL**: dental students participated in the medical school PBL curriculum in years one and two; dental classes were still taught in the traditional lecture-based format.
- **HMS/HSDM PBL**: dental students participated in a PBL curriculum in years one and two of the medical and dental school curriculum, and in a PBL curriculum in the year three dental school curriculum.
Statistical Analysis

The statistical analysis assumes that any differences between classes with regard to average GPAs, DAT scores, and other standards for admission were comparable to the rise in the national averages over the same period and that the constitution of the class (by gender, ethnicity, undergraduate college/major, etc.) is not an independent predictor of performance. The first assumption is supported by the idea that the Office of Admissions at HSDM has always strived to attract academically strong and highly motivated candidates from the national pool, and that while increases in GPA and DAT scores have been apparent over the past twenty years, the quality of candidates selected by HSDM, relative to the national pool of applicants, and the recruiting measures used to attract applicants have not changed significantly. With regard to both assumptions, there is contradictory evidence in the literature regarding the performance of males versus females in dental education and the correlations between GPA/DAT scores and NBDE Part I scores. Ethnicity, undergraduate majors, and a number of additional factors have not been thoroughly examined in this context.

Univariate linear regression analyses were performed between each independent variable (program length and program philosophy) and each dependent variable (graduation percentage, attrition percentage, NBDE Part I average, postgraduate plans, and percentage of graduates entering GPR/AEGD programs). For univariate linear regression analyses, p ≤ 0.05 was considered statistically significant. All statistical analyses were conducted using a standard statistical software package (SPSS v11.0; © SPSS Inc.). In instances where both independent variables satisfied the criterion for statistical significance, a bivariate linear regression model was computed to assess whether the use of the composite variable in a multivariate analysis was necessary. For variables in the bivariate linear regression, p ≤ 0.05 was considered statistically significant.

Results

The results of uni- and bivariate linear regressions for each independent variable and dependent outcome are shown in Tables 1-6. For the sample consisting of graduating classes from 1980 to 2002 (Table 1), the average percentage of students graduating on time (four or five years, depending on program length) was 74.5 ± 13.3 percent; the average attrition rate was 19.8 ± 12.4 percent; the mean GPA was 3.7 ± 0.5; the average DAT score was 650 ± 20; and the average NBDE Part I score was 850 ± 30. The average percentage of students entering graduate programs was 84 ± 13 percent.

Table 2. Univariate linear regressions of study variables with graduation rate (classes of 1980 to 2002)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intercept</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Philosophy (No PBL, HMS PBL, HMS/HSDM PBL)</td>
<td>59.201 (p &lt;0.001)</td>
<td>9.529</td>
<td>0.003</td>
</tr>
<tr>
<td>Program Length (4 year, 5 year)</td>
<td>93.823 (p &lt;0.001)</td>
<td>-11.176</td>
<td>0.053</td>
</tr>
</tbody>
</table>

Table 3a. Univariate linear regressions of study variables with attrition rate (classes of 1980 to 2002)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intercept</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Philosophy (No PBL, HMS PBL, HMS/HSDM PBL)</td>
<td>36.619 (p &lt;0.001)</td>
<td>-9.915</td>
<td>0.001</td>
</tr>
<tr>
<td>Program Length (4 year, 5 year)</td>
<td>-1.850 (p = 0.853)</td>
<td>13.108</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Table 3b. Bivariate linear regression of study variables with attrition rate (classes of 1980 to 2002)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>23.091</td>
<td>0.053</td>
</tr>
<tr>
<td>Program Philosophy</td>
<td>-8.046</td>
<td>0.010</td>
</tr>
<tr>
<td>Program Length</td>
<td>6.269</td>
<td>0.202</td>
</tr>
</tbody>
</table>
Table 4. Univariate linear regressions of study variables with NBDE Part I average (classes of 1980 to 2004)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Constant (p &lt; 0.001)</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Philosophy</td>
<td>89.423</td>
<td>1.436</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>(No PBL, HMS PBL, HMS/HSDM PBL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program Length (4 year, 5 year)</td>
<td>93.484</td>
<td>-0.923</td>
<td>0.237</td>
</tr>
</tbody>
</table>

Table 5a. Univariate linear regressions of study variables with postgraduate plans (classes of 1992 to 2002)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intercept (p &lt; 0.001)</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Philosophy</td>
<td>56.650</td>
<td>12.100</td>
<td>0.026</td>
</tr>
<tr>
<td>(No PBL, HMS PBL, HMS/HSDM PBL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program Length (4 year, 5 year)</td>
<td>110.117</td>
<td>-15.937</td>
<td>0.019</td>
</tr>
</tbody>
</table>

Table 5b. Bivariate linear regression of study variables with postgraduate plans (classes of 1992 to 2002)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>93.960</td>
<td>0.075</td>
</tr>
<tr>
<td>Program Philosophy</td>
<td>3.900</td>
<td>0.731</td>
</tr>
<tr>
<td>Program Length</td>
<td>-11.480</td>
<td>0.431</td>
</tr>
</tbody>
</table>

Table 6a. Univariate linear regressions of study variables with percentage of graduates entering GPR/AEGD programs (classes of 1992 to 2002)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intercept (p = 0.229)</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Philosophy</td>
<td>-14.700</td>
<td>12.171</td>
<td>0.028</td>
</tr>
<tr>
<td>(No PBL, HMS PBL, HMS/HSDM PBL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program Length (4 year, 5 year)</td>
<td>40.517</td>
<td>-16.937</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Table 6b. Bivariate linear regression of study variables with percentage of graduates entering GPR/AEGD programs (classes of 1992 to 2002)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>38.860</td>
<td>0.419</td>
</tr>
<tr>
<td>Program Philosophy</td>
<td>0.400</td>
<td>0.971</td>
</tr>
<tr>
<td>Program Length</td>
<td>-16.480</td>
<td>0.260</td>
</tr>
</tbody>
</table>

NBDE I score was 91.8 ± 1.9; and the mean NBDE II score was 85.2 ± 2.0 percent. Data regarding postgraduate plans were limited to classes from 1992 onward. For this sample, the mean number of graduates entering postgraduate programs was 84.9 ± 12.4 percent. The mean percentage of graduates entering specialty programs was determined: GPR/AEGD (13.7 ± 12.6 percent), Orthodontics (18.9 ± 6.7 percent), Endodontics (8.8 ± 6.0 percent), Periodontics (9.9 ± 3.8 percent), OMFS (17.6 ± 11 percent), Prosthodontics (5.3 ± 5.5 percent), and Pedodontics (7.3 ± 4.5 percent).

Univariate linear regression analyses revealed that program philosophy and program length are each associated with some, if not all, of the primary outcome variables. Upon examining graduation rates (Table 2), program philosophy was statistically significantly associated with graduation rates (coefficient...
cient = 9.5; p = 0.003) and program length was near-statistically significantly associated (coefficient = -11.2; p = 0.053).

Univariate linear regression analyses for attrition rate revealed that both program philosophy and program length were associated with attrition rates (Table 3a). In bivariate linear regression analyses (Table 3b), when controlling for program length, program philosophy was still statistically significant; controlling for program philosophy rendered program length insignificant as a predictor. For NBDE Part I scores (Table 4), univariate analyses demonstrated that program philosophy was statistically significant (coefficient = 1.4; p < 0.001), but program length was not (coefficient = -0.9; p = 0.237).

Univariate analyses of postgraduate plans (Table 5a), namely percentage of graduates pursuing postdoctoral education, indicated that both program length (coefficient = -15.9; p = 0.019) and program philosophy (coefficient = 12.1; p = 0.019) were associated with the percentage of graduates entering postdoctoral programs. Bivariate analyses (Table 5b) revealed that neither factor is statistically associated with this outcome when controlling for the other (this is very likely an effect of our sample size, as this variable was limited to classes from 1992 onward).

These data indicate that as the curriculum at HSDM has evolved to the present-day four-year HMS/HSDM PBL curriculum, the percentage of students graduating on time increases, attrition rate decreases, NBDE I scores increase, and the percentage of students entering postdoctoral programs increases. An increase in program length is independently associated with lower graduation rates, higher attrition rates, and a lower percentage of graduates entering postdoctoral programs immediately after completion of the D.M.D. degree.

The implementation of PBL is independently associated with higher graduation rates, lower attrition rates, higher NBDE I scores, and a greater percentage of graduates pursuing postgraduate studies.

Analysis of the relationships between the primary factors and percentage of graduates entering a particular type of specialty program indicated that there were no significant relationships, with the exception of those graduates entering GPR/AEGD programs. As shown in Table 6a, both program length (coefficient = -16.4; p = 0.012) and program philosophy (coefficient = 12.2; p = 0.028) were statistically associated with the percentage of graduates entering GPR/AEGD programs. However, neither was significant in the bivariate analysis (Table 6b).

These data indicate that, as the program evolves from a five-year to a four-year program and as PBL is more deeply integrated into the curriculum, the number of graduates choosing to enter GPR/AEGD programs increases, but these variables are not synergistic.

Discussion

Various studies have examined the outcomes of problem-based learning (PBL) in medical school curricula.7-10 These investigations have come to a wide variety of contradictory conclusions regarding the effectiveness of PBL, fueling the controversy over whether the additional resources required for the implementation of PBL over traditional curricula are yielding significant dividends. Albanese and Mitchell presented a review of PBL literature from 1972 to 1992 that indicated that while students enjoyed interacting in a PBL format more than a conventional format and performed as well on clinical and faculty evaluations as their traditional counterparts, they did not perform as well on basic science examinations and cognitive assessments of aggregate medical knowledge.7 These conclusions were supported by the meta-analysis of Vernon and Blake, who reported that there was no significant difference in student performance on miscellaneous tests of factual and clinical knowledge, but that PBL students performed significantly worse than their traditional counterparts on Part I of the United States Medical Licensing Examination (USMLE).8 This conclusion was in contrast to that of Blake et al. who concluded that PBL did not compromise performance on standard licensing examinations and that PBL may actually enhance performance.9 In another literature review, Colliver concluded that there was no significant evidence indicating the superiority of PBL over traditional curricula, especially not in proportion to the resources devoted to implementing such curricula.10

Our analyses have indicated that PBL has been effective at increasing NBDE Part I scores at HSDM, independent of program length. While this conclusion indicates that PBL may yield better performance on basic science assessments, it is not a conclusive result, as no comparison has been made between HSDM and other dental schools where PBL is utilized. In addition, the implementation of PBL at HSDM has accompanied significant advances in the use of technology in undergraduate as well as dental and medical education. The increased availability of
Internet resources (online journals, medical websites, etc.) and the use of computers in the classroom, while not readily quantifiable, are far from negligible. However, advancement of educational technologies is a supplement for hybrid PBL, more so than for traditional curricula, because it will serve to enhance the process of self-discovery fostered by PBL.

Additional factors, including changes in faculty, class size, and male/female class ratios, may also play a role in shaping the outcomes observed here. The faculty at HMS and HSDM has experienced minor changes since the implementation of PBL. However, these changes are not necessarily as important in the hybrid PBL curriculum as in a traditional curriculum, since a majority of class time is spent in tutorials with “expert” instructors whose roles, consistent with the student team-based learning approach that is the core of PBL philosophy, are to moderate the discussion and pose guiding questions, not to lecture or teach concepts. We hypothesize that the minimal involvement of faculty tutors in teaching concepts will negate any effects of faculty changes on PBL outcomes.

Over the past twenty years, male/female ratios and class sizes have fluctuated at HSDM. While these fluctuations may play a role in the outcomes measured here, further studies are required to isolate the roles these factors have on measurable outcomes.

From this preliminary analysis, it is clear that the introduction and implementation of PBL at HSDM has, in concert with program length changes, been more effective at generating “positive academic outcomes” (increased graduation rates and decreased attrition rates) and has led to an increase in the percentage of graduates pursuing training beyond their D.M.D. degree. At first glance the decline in attrition rates is remarkable, but this decline is partly due to policy changes involving transferring from HSDM to HMS or other medical schools (transferring to HMS was prohibited following the implementation of the hybrid-PBL program at HSDM). It is also possible, however, that this drop in attrition is due to the effect of PBL on reinforcing and enhancing students’ interests in clinical dentistry, thereby preventing the academic frustration that often is a catalyst for transferring from dental school to medical school in programs where the preclinical educations overlap.

While the increase in percentage of graduates entering postdoctoral programs overall and GPR/AEGD programs specifically has been associated with PBL and program length in our analyses, the reasons for this relationship are not immediately apparent. It is possible that PBL has led to an increase in graduates pursuing postgraduate education, specifically GPR/AEGD programs, because they feel less well prepared clinically. However, it is also possible that the implementation of PBL has introduced students to various clinically based aspects of dentistry that have enhanced their interest in pursuing specialty programs. While these conclusions cannot be definitively addressed in this analysis, they provide interesting insights for future studies.

The implementation of the hybrid-PBL program at HSDM has been an arduous task, but the analyses presented here are a preliminary indication that the benefits of the PBL curriculum are tangible and that the successes of classes in the PBL era of HSDM are partly attributable to the curriculum change. Future studies will focus on the effects of PBL on extracurricular interests, student perceptions of knowledge acquisition, career choices, and research pursuits. Additional long-term studies will be conducted in order to assess the ongoing effects of PBL on measurable outcomes of success.

Conclusion

The implementation of PBL at the Harvard School of Dental Medicine has been effective at increasing NDBE Part I scores, graduation rates, and percentage of graduates entering postgraduate education programs, as well as decreasing attrition rates. Because of the small size of HSDM as an institution, it is difficult to make a completely quantitative comparison, as there is no “true-control” equivalent for students currently in the PBL curriculum. Nevertheless, those comparisons that can be made between students in the pre-PBL curriculum to those in the PBL curriculum show that PBL has a statistically significant influence on academic outcomes. The aim of future studies will be to more concretely assess the impact of PBL on postdoctoral plans and extracurricular activities, particularly research.

REFERENCES