The Impact of Dental Curriculum Format on Student Performance on the National Board Dental Examination

Sireen Yang, D.D.S.; Paul C. Edwards, D.D.S., M.S.; David Zahl, M.A.; Vanchit John, D.D.S., M.S.; Surya S. Bhamidipalli, M.P.H.; George J. Eckert, M.A.S.; Kelton T. Stewart, D.D.S., M.S

Affiliations:

Dr. Yang is a M.S. Resident in the Department of Orthodontics and Oral Facial Genetics, Indiana University School of Dentistry, Indianapolis, Indiana, USA. Dr. Edwards is Senior Associate Dean of the Office of Academic Affairs, and Professor of the Department of Oral Pathology, Medicine and Radiology, Indiana University School of Dentistry, Indianapolis, IN, USA. Mr. Zahl is the Assistant Dean of Curriculum Development and Assessment of the Office of Academic Affairs, Indiana University School of Dentistry, Indianapolis, IN, USA. Dr. John is Chair and Associate Professor of the Department of Periodontology, Indiana University School of Dentistry, Indianapolis, Indiana, USA. Ms. Bhamidipalli is a biostatistician in the Department of Biostatistics and Health Data Science, Indiana University School of Medicine, Indianapolis, Indiana, USA. Mr. Eckert is Biostatistician Supervisor in the Department of Biostatistics and Health Data Science, Indiana University School of Medicine, Indianapolis, Indiana, USA. Dr. Stewart is Chair and Program Director of the Department of Orthodontics and Oral Facial Genetics, Indiana University School of Dentistry, Indianapolis, Indiana, USA.

Correspondence:

Kelton T. Stewart, DDS, MS, Associate Professor, Chair & Program Director, Department of Orthodontics and Oral Facial Genetics, Indiana University School of Dentistry, W. Michigan St, Room, Indianapolis, IN, USA. Email: keltstew@iu.edu

---

This is the author's manuscript of the article published in final edited form as:

Yang, S., Edwards, P. C., Zahl, D., John, V., Bhamidipalli, S. S., Eckert, G. J., & Stewart, K. T. (2022). The impact of dental curriculum format on student performance on the national board dental examination. Journal of Dental Education, 86(6), 661–669. https://doi.org/10.1002/jdd.12863

ABSTRACT

Purpose/Objective: The effectiveness of different curriculum types has long been debated by dental educators aiming to provide the best education possible to their students. This study aimed to evaluate the effect of curriculum type (hybrid problem-based learning (PBL) versus traditional) on National Board Dental Examination (NBDE) Part I and II pass rates. **Methods:** A retrospective cohort study was conducted with a hybrid PBL cohort and traditional cohort. NBDE Part I and II pass rates for the two cohorts were acquired, along with demographic and scholastic variables. Pass rates, scholastic variables, and demographic variables were compared using two-sample t-tests and chi-square tests. Associations of the variables with pass rates were analyzed using logistic regression. Significance was set at 5%. **Results:** No significant differences in pass rates for NBDE Part I and II were observed between the cohorts. Cumulative dental school GPA was found to be an independent predictor of success for NBDE Part I (OR: 1.40, 1.24-1.59 for 0.1 point intervals) and II (OR: 1.34, 1.18-1.52 for 0.1 point intervals), ($p<0.01$). DAT biology sub-score was found to be predictive of success for NBDE Part I (OR: 1.58, 1.14-2.19), ($p=0.01$). **Conclusions:** No significant difference in NBDE Part I and II pass rates between the cohorts was found. Dental school GPA was the most predictive variable for success on NBDE Part I and II. These findings may be helpful considerations as institutions assess the structure of their school curricula.

Keywords: Curriculum, Assessment, PBL, Problem-Based Learning, Outcomes

INTRODUCTION

As educational institutions have sought for the most effective teaching methods, different philosophies have emerged over time. Most traditional educational curricula have consisted of lecture-based courses organized by disciplinary boundaries, where instructors primarily impart their knowledge through presentations with supplemental discussions and cases.[1] In this type of curriculum, students benefit from specific and targeted delivery of facts and technical skills, and instructors can directly communicate the information that they would like students to learn in a timely fashion.[2] A later curricular development was problem-based learning (PBL); first introduced into dental education in the 1990's.[2] PBL uses a case-based, problem-driven, and student-led approach to the acquisition of knowledge and development of critical thinking skills.[2] In a PBL case, the clinical problem is presented first, rather than the information that will be required to solve the clinical problem. Students are placed in small groups and take the initiative to identify and seek out the knowledge they need to address the problem.[3] Faculty facilitators function to guide students when needed and ensure completion of learning objectives, but the goal is for students to take responsibility for their learning rather than relying on faculty to present the information.[4] Supporters of PBL argue that because students must critically evaluate the problem and identify information themselves prior to applying it to the problem, student learning shifts from a memorization-based culture to an analytical one.[4] This method also arguably allows easier integration of multiple disciplines and courses due to the comprehensive nature of the problem, while working in small groups fosters interpersonal development and simulates the teamwork needed to succeed in a healthcare setting after graduation.[3] One of the original proponents of the PBL curriculum, Howard Barrows, anticipated that students would

develop interpersonal and analytical skills, an ability to integrate knowledge across various disciplines, an enhanced recall ability, and a lasting desire to learn after graduation.[5, 6]

Over the years, schools have integrated PBL to different degrees. Some schools utilize PBL throughout the entire curriculum, others employ a hybrid approach with both PBL and a traditional instructional format. Moreover, some schools only use this instructional approach in a single course.[5] In general, medical schools have employed PBL more broadly and for a longer period of time than other professional schools.[2]

Relatively little research has been performed on the implementation of PBL curricula in dental schools compared to medical schools in the United States.[2] While it may be tempting to apply the research performed at medical schools to dental schools, the differing structure of dental education makes such an extrapolation of limited value.[2, 7, 8] Moreover, dental students have identified an excessive focus on factual memorization as a key weakness in current dental education, as well as lack of applied instruction and course integration.[9] A survey conducted by the American Dental Education Association identified educational best practices in the literature and internal curriculum review as the two most important factors driving curricular change, suggesting further research on the outcomes of each curricular structure can be a valuable guide for dental schools as they contemplate modifying their curricula and address student concerns.[1]

The existing literature comparing PBL and traditional curricula at dental schools have typically measured the comparative effectiveness of each curriculum using subjective measures, such as student and faculty questionnaires, and/or non-standardized measures like individual course examinations. Some of these studies have indicated that PBL students report less stress[10] and higher confidence upon graduation in their knowledge and their clinical skills.[11-14] While others

report no significant difference[15, 16] or even report a decreased perception of preparedness in certain clinical areas[12, 17, 18]. Studies on individual course examination scores have found that PBL students generally perform better, but sample groups are typically small, bias is difficult to control, and the cohorts are sometimes from different schools and taught by different faculty.[2, 19] Very few studies have utilized objective standardized outcome measures such as standardized test scores.[2] Those that have done so have found increased NBDE Part I scores after transitioning from a traditional to a PBL curriculum.[20-22] A meta-analysis performed by Bassir et al. in 2013 concluded that PBL increases students' perception of readiness to practice and does not negatively affect acquisition of knowledge. However, it stops short of claiming a positive effect on knowledge acquisition as the quality of the articles included in the meta-analysis were weak to moderate.[2]

Other concerns about the PBL approach include the high financial cost, increased space requirements, faculty training requirements, and time intensiveness of both the development and implementation of the cases.[19, 23] As a result, and with only limited data on the effectiveness of PBL, many PBL-based schools have shifted back to traditional lecture-based curricula.[19] While there is literature investigating the transition from a traditional to a PBL curriculum, no research could be identified that evaluated the differences in outcome factors after a transition back to a lecture-based (traditional) curriculum. Most research on standard outcome measures was also performed in full PBL programs, and minimal research has been performed on hybrid curricula. Shortcomings of these studies include small sample sizes, lack of true control groups, and an absence of external objective outcome measures.

Evaluating the effectiveness and merit of a particular pedagogical approach could help dental faculty decide which educational approach best prepares their students to effectively manage the needs of their future patients.

The aim of this study is to examine the relationship between NBDE Part I and II board pass rates and the implementation of a hybrid PBL curriculum versus a traditional curriculum at Indiana University School of Dentistry (IUSD). The results of this study may also provide insight into possible independent predictors of NBDE Part I and II performance.

MATERIALS AND METHODS

This retrospective cohort study was approved by the Indiana Institutional Review Board (#10334). The sample population consisted of dental students who attended Indiana University School of Dentistry for their predoctoral education. The hybrid PBL curriculum cohort included students from the Classes of 2009-2016 and the traditional curriculum cohort included students from the Classes of 2018-2020. Exclusion criteria for the study included transfer students, international dental program students, students dismissed from the program prior to taking either the NBDE Part I or II examination, and students with incomplete records. The Class of 2017 was excluded because they experienced a hybrid PBL curriculum their first year and a traditional curriculum their second year as the school transitioned curriculum types. The hybrid curriculum consisted of PBL structured instruction for the anatomical and biomedical sciences and traditional lecture-based instruction for clinical courses.

NBDE Part I and II pass rates (Pass/Fail) for the two cohorts were acquired, along with the following demographic data and scholastic data for each cohort:

Demographic data

- Sex
    - Categorized into: (Male, Female, Not disclosed)
- Race
    - Categorized into: (African American, Asian Pacific Islander, Latinx/Hispanic, Caucasian, Other, Not disclosed)
- Undergraduate major
    - Categorized into: (Biological Sciences, Chemistry and Physics, Humanities, Business, Dual/Multiple, Other, Not disclosed)

Scholastic data

- Undergraduate GPA
    - Numerical scores for each subcategory: science GPA, non-science GPA, cumulative undergraduate GPA
- Dental Admissions Test (DAT) scores
    - Numerical scores for each subcategory: biology, organic chemistry, inorganic chemistry, perceptual ability, quantitative reasoning, reading comprehension, total science, academic average, overall average
- Cumulative dental school GPA
    - One numerical value

De-identified data was obtained from the Indiana University School of Dentistry Office of Academic Programs and ADEA AADSAS. Due to the transition from a scored NBDE test to a pass-fail exam format in 2012, pass rates rather than raw score data were analyzed as the standardized external outcome measure. This transition was made because the Joint Commission on National Dental Examinations felt the test is incapable of differentiating students based on raw scores.[24-26] For each student, only data from NBDE Part I and II first attempts was included. Results from subsequent attempts were excluded, since second time attempt results could have been influenced by the students' exposure to the actual examination. Additionally, incorporating subsequent exam attempts could have resulted in inflated exam pass rates. All data was compiled into a Microsoft Excel spreadsheet and stored in a dual authentication and password-protected online database. For statistical analysis, each demographic variable was assigned a numerical value.

Statistical Analysis

Data was summarized for NBDE Part I and Part II pass rates by hybrid PBL and traditional approaches. Scholastic and demographic variables were compared between the two cohorts using two sample t tests and chi-square tests for numerical and nominal data, respectively. Associations of the scholastic and demographic variables with pass rates were analyzed using logistic regression in bivariable and multivariable analyses. Curriculum types and pass rates were compared between the two groups using logistic regression. A 5% significance level was used for all tests. Analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA).

RESULTS

Data was compiled for 783 students in the hybrid PBL cohort and 297 students in the traditional cohort. Descriptive statistics are displayed in Table 1. In both cohorts, a majority of the students were male (57% and 53.4% for the hybrid PBL and traditional cohorts, respectively). The overall distribution of race differed between the cohorts ($p=0.02$), with a higher percentage of Asian/Pacific Islander students in the traditional cohort than the hybrid PBL cohort. The overall distribution of undergraduate majors also differed between the cohorts ($p<0.01$). In both cohorts, the majority of students had majors in the biological sciences, but the percentage of students with biological science majors increased from 49.7% to 60.9% from the hybrid PBL to traditional cohort. More students had dual/multiple majors in the hybrid PBL cohort (13.4% versus 8.8%). The distribution of other majors was similar across the cohorts.

Table 1 also displays the descriptive data for the scholastic variables that were examined. DAT scores were also higher in all subsets in the traditional cohort ($p<0.01$) compared to the hybrid PBL cohort. There was no significant difference between the cohorts in undergraduate science, non-science, and cumulative GPA. The hybrid PBL cohort displayed higher cumulative dental school GPAs ($p<0.01$). No statistically significant differences in pass rates for NBDE Part I and Part II were observed between the cohorts ($p=0.3$ and $p=0.87$, respectively).

Logistic regression analyses were performed to determine the presence of independent predictors of success. Univariate logistic regression results are displayed in Table 2. For numerical data, analysis was performed in 1.0 point intervals, except with dental school GPA, which was performed in both 1.0 and 0.1 point intervals due to the magnitude of a 1.0 point difference in grade point average. Curriculum type was not shown to be a predictor of success on NBDE Part I

or Part II (p=0.30, p=0.87). Among the other demographic and scholastic variables analyses, the univariate analysis model showed an increased likelihood of passing NBDE Part I with male gender, higher DAT scores in all subcategories, undergraduate GPA in all subcategories, and dental school GPA.

Multivariate logistic regression was then performed to account for overlap between variables and decrease noise in the results (Table 3). Multivariate logistic regression revealed that curriculum type was still not predictive of success on NBDE Part I or II (p=0.06, p=0.28). The only variables that were still found to be independent predictors of success were cumulative dental school GPA for both NBDE Part I (OR: 29.53, 8.55-101.97 for 1.0 point intervals; OR: 1.40, 1.24-1.59 for 0.1 point intervals) and Part II (OR: 18.53, 5.19-66.19 for 1.0 point intervals; OR: 1.34, 1.18-1.52 for 0.1 point intervals), ($p<0.01$) and DAT biology sub-score for NBDE Part I (OR: 1.58, 1.14-2.19), (p=0.01).

Race was also statistically shown to be an independent predictor of success in both univariate and multivariate analyses (Tables 2 & 3), but the sample size of the subgroups was so small that no meaningful conclusion can be drawn from these results regarding the effect of race.

The number of students in the PBL and traditional cohorts were 783 and 297, respectively. Observed failure rates in the PBL cohort were 8.7% for NBDE Part I and 7.0% for NBDE Part II. With these sample sizes and failure rates, the study had 80% power to detect a 3.9% difference in failure rates for NBDE Part I and a 2.8% difference in failure rates for NBDE Part II, based on a chi-square test and a 5% significance level.

DISCUSSION

No significant differences were found between pass rates for NBDE Part I and II between the hybrid PBL cohort and traditional cohort. This finding is incongruent with previous studies that have examined NBDE boards scores. Susarla et al. reported significant increases in NBDE Part I scores after transitioning to a PBL curriculum, as well as reduced attrition rates, increased on time graduation, and increased percentages entering postgraduate programs.[22] Likewise, both Shuler et al. and Navazesh et al. also found increased NBDE Part I scores for PBL students compared to traditional students.[20, 21] It is notable that these studies were performed in schools with a full PBL program rather than hybrid programs, and there is no current literature directly comparing a hybrid PBL and full PBL program across schools. The authors believe this is an area that could use further research to elucidate the differences between different types of PBL programs. Other studies that have looked at non-standardized objective outcome measures in school-specific exams have found conflicting results, with some studies finding higher PBL scores[14] and others finding no significant difference[16, 19], as the current study did.

Conflicting results in research on PBL versus traditional curricula is nothing new, as shown in medical school literature. Medical schools that have undergone PBL/traditional curriculum transitions have shown increased USMLE scores[27], decreased USMLE scores[28], and no significance difference[29] between USMLE scores in their cohorts. This wide array of results suggests that multiple factors, which may differ between schools, may play a role in how effective a curriculum type is at a specific institution, and there is no clear data that shows one curriculum is better than another.

There was no strong correlation observed between demographic data and odds of success on the NBDE exam. The univariate analyses showed sex and race to be predictive of success on the NBDE exams, but sex was no longer significant after the multivariate analysis was performed, and the correlation with race decreased as well. Even though race was still numerically significant in predicting success for NBDE Part II, according to the p-value for the "Other/Not Disclosed" category, the number of students in that category was extremely small (less than 1% in the traditional cohort), and the authors do not believe this result to be meaningful. There is also no good way to ascertain what races were included in the category in question since many of those students did not disclose their race. Other studies in the past have not found race to be predictive of success on NBDE Part II or on other comprehensive exams.[30, 31]

Scholastic data, in contrast, showed a stronger correlation with NBDE pass rates. The DAT biology score was found to have increased odds of success on NBDE Part I. This is in agreement with De Ball et al., Behar-Horenstein et al., and Kinsgley at al., who all found that DAT biology scores were predictive of success on NBDE Part I.[32-34] It is worth noting, however, that these studies also found other subscores to have predictive value (such as reading comprehension, quantitative analysis, and organic chemistry), while this study only found significance in the biology subscore.

The most significant predictor of success was dental school cumulative GPA, which was found to be predictive of success on both Part I and II of the NBDE. An odds ratio of 29.53 and 18.53, for Part I and II respectively, for every 1.0 point interval and 1.40 and 1.34 for every 0.1 point interval was observed. This means that the odds of passing Part I & II of the NBDE is 29.53 and 18.53 times greater respectively, with every 1.0 increase in dental school GPA. Likewise, the odds of passing Part I and Part II are 1.40 and 1.34 times greater with each 0.1 point increase in

dental school GPA. Both sets of odds ratios indicate that students are more likely to perform successfully on the NBDE exams as their dental school GPAs increase. The high correlation of dental school GPA with boards performance suggests that it may be prudent for institutions to implement a system to monitor student progress throughout the curriculum and identify early those who may need additional academic help or intervention.

The authors acknowledge that this study contained some limitations. Many factors contribute to the effectiveness of a curriculum type, including but not limited to student and faculty engagement, execution of the curriculum as intended, space availability, thorough training of instructors, and administrator transitions. As a retrospective study, many of these confounding factors could not be controlled. Additionally, other data such as the number of hours students studied for the board exams and whether they used outside resources in their studying in addition to the school's curriculum could not be gathered or analyzed. The structure of course examinations and evaluation methods (larger case-based triple jump exams versus smaller individual exams) were also different between cohorts. However, these areas could provide material for future studies, during which these confounding factors could be controlled or quantified using a prospective study design, so that statistical analyses could be performed to determine the extent of influence these factors might have on student/curriculum success. There were also challenges with data collection, as data was stored in different databases across the years, some of which were no longer active or available. This led to more students being excluded than anticipated. This study was also limited to one school, but it would be valuable for future studies to compare student performance and curriculum implementation across schools. It would also be interesting to examine the effect of resource-heavy curricula such as PBL on other areas at an institution, such as capacity and support for research.

As dental schools continue to evaluate their educational methodologies and consider changes to address the introduction of the new INBDE, this study may help guide institutions as they make decisions and consider their curricular structure. These findings suggest that there is no significant difference in student performance based on dental curriculum format, which supports the viability of different curriculum types. The most appropriate and effective curriculum type for a certain institution may depend on that institution's unique preferences and/or available resources.

CONCLUSION

The study did not find a statistically significant difference in NBDE Part I and Part II pass rates between the hybrid PBL and traditional cohorts. Dental school GPA was the most predictive variable for success on both the NBDE Part I and II exam. The study findings may be helpful considerations for institutions as they assess the structure of their school curricula in the future.

ACKNOWLEDGEMENTS

The authors acknowledge Sheree Koester for her invaluable help in obtaining access to historical student records and data. Funding was provided by the Indiana University School of Dentistry Graduate Student Research Committee Fund.

DISCLOSURE

The authors disclose that they have no financial, economic, or professional interest that may have influenced the design, execution or presentation of this scholarly work.

REFERENCES

1. Haden NK, Hendricson WD, Kassebaum DK, et al. Curriculum change in dental education, 2003-09. J Dent Educ 2010;74(5):539-57.
2. Bassir SH, Sadr-Eshkevari P, Amirikhorheh S, Karimbux NY. Problem-based learning in dental education: a systematic review of the literature. J Dent Educ 2014;78(1):98-109.
3. Fincham AG, Shuler CF. The changing face of dental education: the impact of PBL. J Dent Educ 2001;65(5):406-21.
4. Neville AJ, Norman GR. PBL in the Undergraduate MD Program at McMaster University: Three Iterations in Three Decades. Academic Medicine 2007;82(4).
5. Barrows HS. The essentials of problem-based learning. J Dent Educ 1998;62(9):630-3.
6. Pourshanazari AA, Roohbakhsh A, Khazaei M, Tajadini H. Comparing the long-term retention of a physiology course for medical students with the traditional and problem-based learning. Adv Health Sci Educ Theory Pract 2013;18(1):91-7.
7. Hendricson W, Cohen P. Future Directions in Dental School Curriculum, Teaching and Learning; 1999. p. 37-62.
8. Abdelkarim A, Schween D, Ford T. Attitudes Towards Problem-Based Learning of Faculty Members at 12 U.S. Medical and Dental Schools: A Comparative Study. J Dent Educ 2018;82(2):144-51.
9. Henzi D, Davis E, Jasinevicius R, Hendricson W. In the students' own words: what are the strengths and weaknesses of the dental school curriculum? J Dent Educ 2007;71(5):632-45.
10. Polychronopoulou A, Divaris K. Dental students' perceived sources of stress: a multi-country study. J Dent Educ 2009;73(5):631-9.

11. Thammasitboon K, Sukotjo C, Howell H, Karimbux N. Problem-based learning at the Harvard School of Dental Medicine: self-assessment of performance in postdoctoral training. J Dent Educ 2007;71(8):1080-9.
12. Greenwood LF, Townsend GC, Wetherell JD, Mullins GA. Self-perceived competency at graduation: a comparison of dental graduates from the Adelaide PBL curriculum and the Toronto traditional curriculum. Eur J Dent Educ 1999;3(4):153-8.
13. Last KS, Appleton J, Stevenson H. Basic science knowledge of dental students on conventional and problem-based learning (PBL) courses at Liverpool. Eur J Dent Educ 2001;5(4):148-54.
14. Rich SK, Keim RG, Shuler CF. Problem-based learning versus a traditional educational methodology: a comparison of preclinical and clinical periodontics performance. J Dent Educ 2005;69(6):649-62.
15. Polyzois I, Claffey N, Attstrom R, Kelly A, Mattheos N. The role of the curriculum and other factors in determining the medium- to long-term attitude of the practicing dentist towards life-long learning. Eur J Dent Educ 2010;14(2):84-91.
16. Login GR, Ransil BJ, Meyer M, et al. Assessment of preclinical problem-based learning versus lecture-based learning. J Dent Educ 1997;61(6):473-9.
17. Yiu CK, McGrath C, Bridges S, et al. Graduates' perceived preparedness for dental practice from PBL and traditional curricula. J Dent Educ 2011;75(9):1270-9.
18. Montero J, Dib A, Guadilla Y, et al. Dental Students' Perceived Clinical Competence in Prosthodontics: Comparison of Traditional and Problem-Based Learning Methodologies. J Dent Educ 2018;82(2):152-62.

19. Callis AN, McCann AL, Schneiderman ED, et al. Application of basic science to clinical problems: traditional vs. hybrid problem-based learning. J Dent Educ 2010;74(10):1113-24.

20. Navazesh M, Rich SK, Tiber A. The rationale for and implementation of learner-centered education: experiences at the Ostrow School of Dentistry of the University of Southern California. J Dent Educ 2014;78(2):165-80.

21. Shuler CF, Fincham AG. Comparative achievement on National Dental Board Examination Part I between dental students in problem-based learning and traditional educational tracks. J Dent Educ 1998;62(9):666-70.

22. Susarla SM, Medina-Martinez N, Howell TH, Karimbux NY. Problem-based learning: effects on standard outcomes. J Dent Educ 2003;67(9):1003-10.

23. Servant-Miklos VFC. Fifty Years on: A Retrospective on the World's First Problem-based Learning Programme at McMaster University Medical School. Health Professions Education 2019;5(1):3-12.

24. Fagin AP, Howell TH, Park SE. Impact of the NBDE grading change on postgraduate admissions processes. J Dent Educ 2015;79(4):362-8.

25. Neumann LM, Macneil RL. Revisiting the National Board Dental Examination. J Dent Educ 2007;71(10):1281-92.

26. Brodie AJ, Crow HC, Eber RM, et al. Evaluating postdoctoral dental candidates: assessing the need and recommendations for a national qualifying examination. J Dent Educ 2011;75(6):719-25.

27. Blake RL, Hosokawa MC, Riley SL. Student performances on Step 1 and Step 2 of the United States Medical Licensing Examination following implementation of a problem-based learning curriculum. Acad Med 2000;75(1):66-70.

28. Vernon DT, Blake RL. Does problem-based learning work? A meta-analysis of evaluative research. Acad Med 1993;68(7):550-63.

29. Enarson C, Cariaga-Lo L. Influence of curriculum type on student performance in the United States Medical Licensing Examination Step 1 and Step 2 exams: problem-based learning vs. lecture-based curriculum. Med Educ 2001;35(11):1050-5.

30. Lee MK, Allareddy V, Howell TH, Karimbux NY. Association Between National Board Dental Examination Part II Scores and Comprehensive Examinations at Harvard School of Dental Medicine. J Dent Educ 2011;75(1):90-7.

31. Allareddy V, Howell TH, Karimbux NY. Association between students' dental admission test scores and performance on comprehensive clinical exams. J Dent Educ 2012;76(2):168-73.

32. De Ball S, Sullivan K, Horine J, Duncan WK, Replogle W. The relationship of performance on the dental admission test and performance on Part I of the National Board Dental Examinations. J Dent Educ 2002;66(4):478-84.

33. Behar-Horenstein LS, Garvan CW, Bowman BJ, et al. Cognitive and learning styles as predictors of success on the National Board Dental Examination. J Dent Educ 2011;75(4):534-43.

34. Kingsley K, Sewell J, Ditmyer M, O'Malley S, Galbraith GM. Creating an evidence-based admissions formula for a new dental school: University of Nevada, Las Vegas, School of Dental Medicine. J Dent Educ 2007;71(4):492-500.

Table 1. Descriptive Statistics

VARIABLE (N = 1080)	HYBRID PBL (N = 783)	TRADITIONAL (N = 297)	P-VALUE
NBDE - 1			0.3
Pass	715 (91.3%)	277 (93.3%)	
Fail	68 (8.7%)	20 (6.7%)	
NBDE - 2			0.87
Pass	728 (93%)	277 (93.3%)	
Fail	55 (7%)	20 (6.7%)	
Sex			0.38
Male	446 (57%)	158 (53.4%)	
Female	335 (42.8%)	138 (46.6%)	
Not Disclosed	2 (0.2%)	0	
Race			**0.02**
African American	21 (2.7%)	8 (2.7%)	
Asian/Pacific Islander	112 (14.4%)	57 (19.2%)	
Latino/Hispanic	18 (2.3%)	7 (2.4%)	
Caucasian	588 (75.6%)	223 (75.1%)	
Other	16 (2.1%)	0	
Not Disclosed	23 (3%)	2 (0.7%)	
Undergraduate Major			**<0.01**
Biological Sciences	389 (49.7%)	181 (60.9%)	
Chemistry And Physics	73 (9.3%)	28 (9.4%)	
Humanities	33 (4.2%)	12 (4%)	
Business	22 (2.8%)	8 (2.7%)	
Dual/Multiple	105 (13.4%)	26 (8.8%)	
Other	105 (13.4%)	42 (14.1%)	
Not Disclosed	56 (7.2%)	0	
DAT Academic Average	18.8 (1.7)	19.6 (2.0)	**<0.01**
DAT Biology	18.6 (2.1)	19.1 (2.3)	**<0.01**
DAT Inorganic Chemistry	18.9 (2.4)	19.6 (2.8)	**<0.01**
DAT Organic Chemistry	18.7 (3.1)	19.6 (3.0)	**<0.01**
DAT Pat	19.0 (2.3)	19.7 (2.3)	**<0.01**
DAT Quantitative Reasoning	17.2 (2.9)	18.5 (2.7)	**<0.01**
DAT Reading Comprehension	20.3 (2.6)	21.0 (2.8)	**<0.01**
DAT Total Science	18.7 (1.8)	19.2 (2.0)	**<0.01**
DAT Average All	18.4 (3.0)	19.6 (1.9)	**<0.01**
Undergraduate Science GPA	3.5 (0.4)	3.5 (0.4)	0.95
Undergraduate Non-Science GPA	3.7 (0.3)	3.7 (0.3)	0.09
Undergraduate Cumulative GPA	3.5 (0.3)	3.6 (0.3)	0.50
Dental School GPA	3.6 (0.2)	3.4 (0.3)	**<0.01**

Table 2. Logistic Regression Bivariate Analysis

	NBDE PART-1			NBDE PART-2		
	Odds Ratio	**Confidence Interval**	**P-value**	**Odds Ratio**	**Confidence Interval**	**P-value**
Curriculum						
Hybrid PBL	Reference			Reference		
Traditional	1.32	0.79-2.21	0.30	1.05	0.62-1.78	0.87
Sex						
Female	0.54	0.35-0.84	**0.01**	0.84	0.52-1.34	0.46
Male	Reference			Reference		
Race						
Caucasian	Reference			Reference		
African American	0.13	0.06-0.30	**<0.01**	0.23	0.08-0.64	**0.01**
Other/Not Disclosed	0.64	0.39-1.08	0.09	0.29	0.18-0.48	**<0.01**
Undergraduate Major						
Biological Sciences	Reference			Reference		
Chemistry And Physics	0.81	0.38-1.73	0.59	2.08	0.73-5.91	0.17
Humanities	0.82	0.28-2.39	0.71	1.84	0.43-7.86	0.41
Business	0.72	0.21-2.46	0.60	—	—	—
Dual/Multiple	0.67	0.35-1.26	0.21	1.32	0.61-2.87	0.49
Other	0.90	0.46-1.75	0.75	1.06	0.53-2.10	0.87
Not Disclosed	1.03	0.36-3.00	0.95	0.87	0.33-2.30	0.79
DAT Academic Average	1.63	1.38-1.91	**<0.01**	1.35	1.16-1.58	**<0.01**
DAT Biology	1.48	1.29-1.70	**<0.01**	1.21	1.08-1.36	**0.01**
DAT Inorganic Chemistry	1.27	1.15-1.40	**<0.01**	1.17	1.06-1.29	**<0.01**
DAT Organic Chemistry	1.13	1.06-1.21	**<0.01**	1.07	0.99-1.15	0.07
DAT Pat	1.20	1.09-1.32	**<0.01**	1.13	1.02-1.24	**0.02**
DAT Quantitative Reasoning	1.12	1.04-1.20	**<0.01**	1.07	0.99-1.16	0.07
DAT Reading Comprehension	1.22	1.11-1.33	**<0.01**	1.26	1.14-1.38	**<0.01**
DAT Total Science	1.58	1.35-1.86	**<0.01**	1.24	1.09-1.42	**<0.01**
DAT Average All	1.09	1.04-1.16	**<0.01**	1.08	1.02-1.15	**0.01**
Undergrad Science GPA	3.20	1.67-6.13	**<0.01**	5.06	2.58-9.92	**<0.01**
Undergrad Non-Science GPA	2.03	1.07-3.83	**<0.01**	4.12	2.24-7.56	**<0.01**
Undergrad Cumulative GPA	3.62	1.93-6.79	**<0.01**	5.65	2.90-11.02	**<0.01**
Dental School GPA (1.0)	37.88	15.41-93.11	**<0.01**	23.42	9.31-58.91	**<0.01**
Dental School GPA (0.1)	1.44	1.31-1.57	**<0.01**	1.37	1.25-1.50	**<0.01**

- Correlation of business major with NBDE Part II was left out from the respective analysis as the data point distribution was not sufficient to run regression analysis.

Table 3. Logistic Regression Multivariate Analysis

	NBDE PART-1			NBDE PART-2		
	Odds Ratio	**Confidence Interval**	**P-value**	**Odds Ratio**	**Confidence Interval**	**P-value**
Curriculum						
Hybrid PBL	Reference			Reference		
Traditional	1.89	0.97-3.71	0.06	1.45	0.74-2.87	0.28
Sex						
Female	0.63	0.35-1.12	0.12	__	__	__
Male	Reference			__	__	__
Race						
Caucasian	Reference			Reference		
African American	0.66	0.21-2.08	0.47	1.52	0.39-5.89	0.55
Other/Not Disclosed	0.98	0.50-1.93	0.96	0.37	0.20-0.69	**<0.01**
Undergrad Major						
Biological Sciences	Reference			Reference		
Chemistry and Physics	0.53	0.21-1.34	0.18	3.15	0.70-14.07	0.13
Humanities	0.85	0.23-3.15	0.80	4.79	0.60-38.12	0.14
Business	0.51	0.11-2.39	0.39	__	__	__
Dual/Multiple	0.48	0.21-1.08	0.08	1.21	0.49-2.94	0.68
Other	0.91	0.38-2.16	0.83	1.15	0.50-2.62	0.74
Not Disclosed	1.31	0.39-4.43	0.66	1.20	0.40-3.61	0.75
DAT Academic Average	0.77	0.41-1.45	0.42	1.10	0.52-2.29	0.81
DAT Biology	1.58	1.14-2.19	**0.01**	1.20	0.87-1.65	0.28
DAT Inorganic Chemistry	1.26	0.95-1.68	0.11	1.05	0.79-1.40	0.73
DAT Organic Chemistry	1.09	0.89-1.35	0.39	0.97	0.78-1.20	0.76
DAT Pat	1.03	0.88-1.19	0.74	1.04	0.90-1.20	0.62
DAT Quantitative Reasoning	1.06	0.88-1.27	0.52	0.97	0.80-1.17	0.72
DAT Reading Comprehension	1.19	0.99-1.44	0.07	1.15	0.95-1.39	0.16
DAT Total Science	0.87	0.45-1.69	0.68	0.95	0.49-1.85	0.88
DAT Average All	0.83	0.53-1.31	0.42	1.04	0.90-1.19	0.61
Undergrad Science GPA	0.94	0.13-6.96	0.95	0.85	0.09-7.69	0.88
Undergrad Non-Science GPA	0.65	0.14-3.17	0.60	2.02	0.44-0.30	0.37
Undergrad Cumulative GPA	1.75	0.09-32.75	0.71	1.92	0.07-49.78	0.69
Dental School GPA (1.0)	29.53	8.55-101.97	**<0.01**	18.53	5.19-66.19	**<0.01**
Dental School GPA (0.1)	1.40	1.24-1.59	**<0.01**	1.34	1.18-1.52	**<0.01**

- Correlation of sex and business with NBDE Part II was left out from the respective analysis as the data point distribution was not sufficient to run regression analysis.