

A Comparison of Problem-Based Learning and Traditional Curricula in Baccalaureate Respiratory Therapy Education

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BACKGROUND: Problem-based learning (PBL) is a constructivist model of education that uses ill-structured, authentic problems to stimulate and organize all learning. The major goal of PBL is to help learners construct knowledge in contexts similar to the real-world environments in which the knowledge will be used. Although PBL is a widely accepted educational method, controversy persists about its effectiveness, how appropriately to measure its outcomes, and, more generally, whether grand education experiments can explain a curriculum intervention's effects. The present study was undertaken to compare PBL and traditional curricula in baccalaureate-level respiratory-therapy education, in terms of (1) graduate and employer ratings of cognitive, psychomotor, and affective competencies on standardized follow-up surveys mandated by the Committee on Accreditation for Respiratory Care, and (2) scores on the National Board for Respiratory Care (NBRC) examinations. **METHODS:** The survey and examination data were collected for the 1999–2002 graduates of 4 baccalaureate degree respiratory-therapy programs in the southeastern and south-central United States: two that used PBL and two that used conventional curricula. Multivariate analyses of variance and 2-tailed *t* tests for independent samples were used to analyze the data. **RESULTS:** Although some significant differences were present between the groups in the graduates' program-entry characteristics, when considered as covariates, none of the differences were significant with regard to the survey ratings. Sex did not affect the results of statistical analyses, nor did the school that the graduates attended. The 2 most important findings were that (1) PBL graduates rated their programs' overall quality in preparing them as respiratory therapists significantly higher than did the traditional program graduates ($p = 0.012$), and (2) there were no significant differences in mean scores overall between PBL graduates and traditional graduates on either the NBRC entry-level examination ($p = 0.866$) or the NBRC written Registered Respiratory Therapist examination ($p = 0.971$). **CONCLUSIONS:** Respiratory-therapy graduates from the 2 PBL programs were more satisfied with their program's overall quality than were the graduates of the 2 traditional-curricula programs. Moreover, the PBL teaching and learning method did not place graduates at a disadvantage on standardized, objective tests of knowledge (the licensing and credentialing examinations). These findings are consistent with similar published studies on PBL approaches in medical and health care professional education. *Key words:* problem-based learning, problem-based curriculum, experiential learning, active learning. [Respir Care 2007;52(11):1497–1506. © 2007 Daedalus Enterprises]

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Introduction

Problem-based learning (PBL) is a constructivist model of education in which learning is viewed as a process of

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active knowledge building rather than passive knowledge reception.¹ Constructivist theory holds that learners cannot passively absorb new information, but must incorporate it with pre-existing knowledge to build new ideas and concepts—a process profoundly affected by the context in which new information is encountered. These ideas are consistent with a philosophy of learning espoused by individuals such as John Dewey, Ernst von Glasersfeld, Jerome Brunner, and Howard Gardner. PBL first appeared as a distinct curricular method over 3 decades ago at McMaster University's medical school in Hamilton, Ontario.^{2,3} Today, most medical schools in the United States and the world incorporate PBL into their curricula to greater or lesser degrees.^{4,5} PBL has been widely adopted in allied health and nursing education as well.

The Problem-Based-Learning Philosophy

Problem-based learning's most universal feature is the use of authentic, ill-structured, real-world problems to stimulate and organize all learning. It may be more appropriate to think of PBL as a philosophy than a specific teaching method. As a philosophy, PBL transforms the entire curriculum into a student-centered approach, emphasizing knowledge *construction* rather than knowledge *transmission*. Traditional teaching strategies emphasize the broad coverage of content areas through lecture, whereas the PBL method relies on the *problem* as a vehicle to guide learners to relevant content information. As Boud⁶ succinctly stated, "The principal idea behind problem-based learning is. . . that the starting point for learning should be a problem, query, or puzzle that the learner wishes to solve." This philosophy of learning fundamentally challenges the traditional assumption that information should be acquired before problem-solving can begin, and that learning should be sequential, progressing from basic scientific concepts to clinical application. Traditional lecture-based courses tend to emphasize teaching rather than learning, passive rather than active learning, and *having* rather than *creating* knowledge.^{7,8} Barrows⁹ has been credited with developing the classic model of PBL in medical education.

Study Purpose and Rationale

The purpose of this study was to determine if there were differences between PBL and traditional baccalaureate respiratory therapy curricula in terms of graduate and employer satisfaction ratings on standardized surveys, and national board examination scores. There was no a priori assumption of superiority for either curriculum. The study design was retrospective. Traditional curricula were defined as those in which instructors provided the learning objectives and assignments, gave lectures to the entire

class, conducted structured laboratories, and used mostly multiple-choice or other objective examinations to assess student learning.

The following research questions were investigated. Were there significant differences between PBL graduates and traditional-program graduates in:

- Self-perceived cognitive, psychomotor, and affective competencies, as measured by the standardized Committee on Accreditation for Respiratory Care graduate satisfaction surveys?
- Employer-perceived graduate competencies in cognitive, psychomotor, and affective domains, as measured by the standardized Committee on Accreditation for Respiratory Care employer satisfaction surveys?
- Scores on the credentialing examinations administered by the National Board for Respiratory Care (NBRC)?

This study is the first published investigation across institutions of PBL's effectiveness, compared to traditional lecture-based strategies, in respiratory therapy education. To date, only one preliminary report has been published, in which NBRC examination scores were compared for consecutive graduating classes before and after conversion from a conventional to a PBL curriculum.¹⁰ No studies have been published that compare graduate and employer satisfaction with PBL and conventional respiratory therapy curricula in terms of the graduate's cognitive competencies (eg, ability to make sound clinical judgments and ability to recommend appropriate procedures) or affective competencies (eg, effective communication ability, self-directedness, ability to work effectively with supervisory personnel, professional-organization membership, and ethical/professional behavior). Improvement in these competencies and in graduate and employee satisfaction might justify PBL even if it does not improve board examination scores. This study also examined whether any of the measured variables (such as teaching-learning strategy or survey ratings in cognitive, psychomotor, and affective domains) are associated with performance on the national board examinations. The identification of such variables would provide insight into the measures program faculty might employ to maximize the probability of graduate success.

Methods

Baccalaureate-level respiratory-therapy programs at 4 universities in the southeastern and south-central United States participated in this study; two were PBL programs and two were traditional programs. Each program prepared students to function at the Registered Respiratory Therapist (RRT) level. In all the programs, the freshman and sophomore years comprised a pre-respiratory-therapy

curriculum of general education and prerequisite science courses. Students entered the professional phases of these respiratory-therapy programs at the beginning of their junior years. The participating programs' professional-phase curricula generally consisted of pre-clinical classroom and laboratory courses, with a gradually increasing integration of clinical courses throughout the course of the program. Comparison of PBL and traditional curricula in this study pertained to only the professional phases of the participating respiratory-therapy programs.

Instruments

Graduate and Employer Satisfaction Surveys. Since 1999, the Committee on Accreditation for Respiratory Care has mandated the use of standardized graduate and employer satisfaction surveys for all respiratory-therapy programs in the United States.¹¹ These surveys ask respondents to rate the graduate's achievement of competencies in cognitive, psychomotor, and affective domains; in addition, graduate respondents are asked to rate the overall quality of the program, and employers are asked to rate the overall quality of the graduate. All ratings are based on a 5-point Likert scale. The surveys are typically administered no sooner than 6 months after graduation.

National Credentialing Examinations. The NBRC credentialing examination content matrices and test eligibility requirements for the certified respiratory therapist (CRT) and RRT credentials can be found at <http://www.nbrc.org>. In the present study, only the CRT and written RRT examination scores were used as graduate performance measures, because the NBRC reports results of the clinical simulation portion of the RRT examination only in aggregate form, on a pass-fail basis. In contrast, the NBRC reports numerical CRT and written RRT examination scores separately for each individual. In addition, individual scores are broken down into test subsection scores.

Subjects

The directors of baccalaureate-degree respiratory-therapy programs in 4 southeastern and south-central universities in the United States agreed to collect and provide, insofar as possible, copies of graduate surveys, employer surveys, and NBRC CRT and written RRT examination test scores for their 1999–2002 graduates. Names were removed from the surveys to protect confidentiality, and coding allowed subjects to be matched to their graduate and employer survey ratings. NBRC examination scores were anonymous and could not be matched to surveys. In addition, program directors provided the following information, insofar as possible, for each graduate: age, college credits earned upon entering the professional program,

grade point average (GPA) upon entering the professional program, and GPA at the end of the professional program.

The study's methodology was approved by the University of North Dakota's institutional review board. Only one of the participating institutions required institutional review board approval for this study, which was obtained. Two of the professional programs had traditional curricula and two used PBL strategies. The 2 PBL programs differed somewhat in the extent to which PBL strategies were employed. One of these programs had a major PBL component in each semester of the junior and senior years, running concurrently with complementary, traditionally taught clinical (direct patient care) courses. Only a few traditional lecture-based courses supplemented the PBL courses. The other PBL program offered an introduction to PBL in the first semester of the junior year, followed by 2 major PBL courses, one in the second semester of the junior year and one in the first semester of the senior year. All remaining courses were traditionally taught.

Data Analysis Approach

The independent variable in this study was the teaching strategy (PBL or traditional), and the dependent variables were ratings on graduate and employer satisfaction surveys and scores (total score and subsection scores) on the NBRC CRT and written RRT examinations. To control for confounding variables, age, number of credit hours at program entry, GPA at program entry, and GPA at program

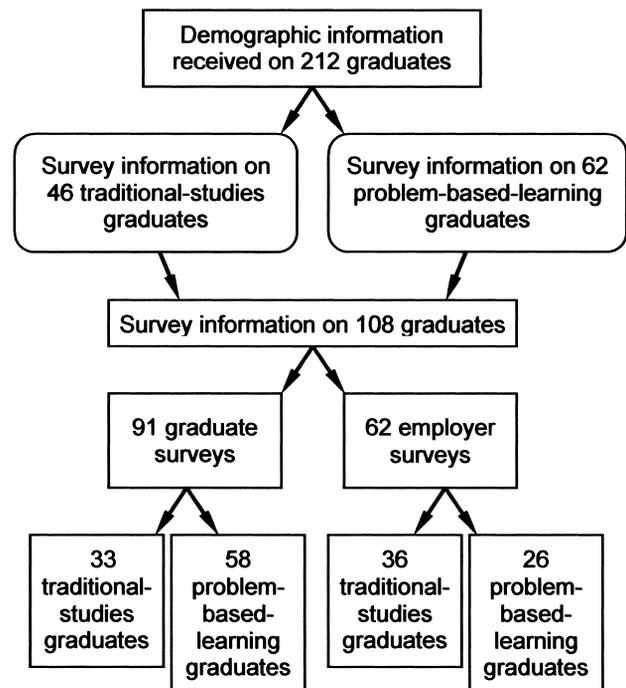


Fig. 1. Origin of survey information analyzed in the present study.

PROBLEM-BASED LEARNING VERSUS TRADITIONAL CURRICULA IN RT EDUCATION

Table 1. Age, Entering Credits, Entering GPA, and Ending GPA of Surveyed Respiratory Therapy Program Graduates

Variable	Problem-Based Learning		Traditional		P
	(n*)	(mean ± SD)	(n*)	(mean ± SD)	
Age (y)	61	22.9 ± 3.3	45	27.1 ± 5.9	< 0.01
Entering credits (n)	62	94.0 ± 27.8	28	117.6 ± 38.4	0.001
Entering GPA	62	3.06 ± 0.43	45	2.92 ± 0.41	0.085
Ending GPA	62	3.36 ± 0.43	45	3.19 ± 0.32	0.019

*Number of graduates
GPA = grade point average

end were treated as control variables. Graduate and employer survey Likert scale ratings were treated as interval data. The level of significance (α) was set at 0.05 for the data analyses.

Program directors of the participating institutions supplied information regarding age, college credits upon program entry, GPA upon program entry, and GPA upon graduation for a total of 212 graduates; 120 were from traditional programs and 92 were from PBL programs. Completed standard Committee on Accreditation for Respiratory Care graduate and employer surveys were supplied for 108 graduates, but both surveys were not supplied for all subjects. Of the 108 graduates, 46 (43%) were from traditional programs and 62 (57%) were from PBL programs (Fig. 1). Thirty-five (33%) graduates were males, and 72 (67%) were females (one did not identify sex).

After listwise deletion for missing survey item responses, a total of 91 valid graduate surveys and 62 employer surveys were analyzed. Of the 91 graduate surveys, 58 (64%) were from PBL programs and 33 (36%) were from traditional programs. Of the 62 employer surveys, 26 (42%) were on PBL graduates, and 36 (58%) were on traditional graduates (see Fig. 1). In order to determine if the institution attended had an independent effect on survey ratings, multivariate analyses of variance were conducted, which revealed no significant differences among the institutions across graduate (Wilks' lambda = 0.614, $p = 0.439$) and employer survey items (Wilks' lambda = 0.370, $p = 0.371$). None of the associated univariate analysis-of-variance (ANOVA) values were significant for any of the survey items. Therefore, the data on the 2 PBL programs were combined, and the data on the 2 traditional programs were combined to determine if differences existed between the education methods.

A 2-tailed t test for independent samples was computed on the variables of age, college credits upon program entry, GPA upon program entry, and GPA at the program's end (Table 1). There were significant differences ($p < 0.05$) in age (traditional > PBL), college credits upon program entry (traditional > PBL), and GPA at the program's end (PBL > tra-

ditional). A multivariate analysis of covariance was then computed on the graduate and employer survey items to determine if controlling for the possible covariates of age, entering credits, and ending GPA was necessary. None of the covariates had significant independent effects; therefore, no covariates were considered in further analyses.

To compare PBL and traditional graduates, survey item ratings in cognitive, psychomotor, and affective domains were analyzed using multivariate ANOVA for both graduate and employer surveys. A 2-tailed t test for independent samples was computed on the single survey item regarding the quality of the program (graduate survey), or the quality of the graduate (employer survey). A multivariate ANOVA was performed across graduate survey items between males and females to determine if there were sex differences. Chi-square analyses were computed for dichotomous survey data that required yes-or-no responses.

2-tailed t tests for independent samples were computed on the mean NBRC examination scores (CRT and written RRT examination) to compare PBL and traditional graduates. Multivariate ANOVA was used to compare content subsection scores for both the CRT and written RRT examinations. Scores for the 140-item CRT and the 100-item written RRT examinations were provided anonymously and were not linked to the graduate or employer surveys. The number of graduates for whom NBRC examination scores were obtained exceeded the number of graduates for whom surveys were collected. A total of 128 CRT test scores (52 from PBL graduates and 76 from traditional-program graduates) and 91 written RRT examination test scores (27 from PBL programs and 64 from traditional-program graduates) were included in the data analysis.

Results

Graduate Survey Results

No significant multivariate differences were found in the survey ratings between the PBL graduates and the traditional-

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Table 2. Respiratory Therapy Program Graduates' Satisfaction With the Various Aspects of Their Respiratory Therapy Programs*

Variable†	Graduates' Satisfaction Score 1–5 Likert Scale (mean ± SD)		Mean Difference	95% CI‡	F Statistic	P
	Problem-Based Learning (n = 58)	Traditional (n = 33)				
Cognitive						
1a	4.72 ± 0.586	4.52 ± 0.712	0.209	–0.066 to 0.484	2.28	0.134
1b	4.64 ± 0.667	4.39 ± 0.747	0.244	–0.058 to 0.546	2.58	0.112
1c	4.78 ± 0.65	4.48 ± 0.667	0.291	0.007 to 0.575	4.14	0.045
1d	4.69 ± 0.627	4.52 ± 0.667	0.175	–0.104 to 0.453	1.56	0.216
1e	4.55 ± 0.68	4.48 ± 0.712	0.067	–0.233 to 0.367	0.20	0.659
1f	4.57 ± 0.704	4.45 ± 0.666	0.114	–0.185 to 0.413	0.58	0.449
Psychomotor						
2a	4.5 ± 0.778	4.24 ± 0.751	0.258	–0.075 to 0.591	2.36	0.128
2b	4.62 ± 0.745	4.42 ± 0.751	0.196	–0.127 to 0.520	1.45	0.231
2c	4.4 ± 0.674	4.3 ± 0.77	0.094	–0.214 to 0.401	0.37	0.547
2d	4.43 ± 0.678	4.45 ± 0.754	–0.024	–0.330 to 0.283	0.02	0.879
Affective						
3a	4.71 ± 0.593	4.42 ± 0.867	0.283	–0.022 to 0.588	3.39	0.069
3b	4.74 ± 0.609	4.64 ± 0.549	0.105	–0.150 to 0.360	0.67	0.415
3c	4.4 ± 0.897	4.39 ± 0.788	0.003	–0.370 to 0.375	0.00	0.989

*Scores on the Graduate Satisfaction Survey of the Committee on Accreditation for Respiratory Care

†See Reference 11 for description of the various evaluation subcategories (1a, 1b, etc).

‡95% confidence interval of the difference between means

Table 3. Graduates' Overall Satisfaction With Their Respiratory Therapy Training*

	Respiratory Therapy Education Style		Mean Difference	95% CI†	P
	Problem-Based Learning (n = 52)	Traditional (n = 36)			
Graduates' overall satisfaction score (mean ± SD)	4.58 ± 0.637	4.19 ± 0.749	0.382	0.087 to 0.678	0.012

*1–5 Likert score on the Graduate Satisfaction Survey of the Committee on Accreditation for Respiratory Care

†95% confidence interval of the difference between means

program graduates (Wilks's lambda = 0.815, p = 0.207). Table 2 shows the means, standard deviations, and univariate results. The mean rating of program quality was significantly higher among the PBL graduates than the traditional graduates (p = 0.012) (Table 3).

No significant multivariate differences were found (Wilks's lambda = 0.716, p = 0.222) in the survey ratings between males and females. A *t* test for independent samples revealed that there was no significant difference between male and female mean ratings of overall program quality (p = 0.750).

Chi-square tests computed for dichotomous survey data regarding yes-or-no responses revealed no significant differences between the PBL graduates and the traditional graduates for any of the statements:

1. I have actively pursued attaining my NBRC credentials (p = 0.142)
2. I am a member of the state respiratory therapy professional association (p = 0.129)
3. I am a member of the national respiratory therapy professional association (p = 0.284)
4. I actively participate in continuing education activities (p = 0.604)

Employer Survey Results

Significant multivariate differences were found in employer survey ratings between the PBL and the traditional graduates (Wilks's lambda = 0.557, p = 0.028). Table 4

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Table 4. Employers' Satisfaction With the Various Aspects of the Respiratory Therapy Training of Respiratory Therapists in Their Employ*

Variable†	Employers' Satisfaction Score 1-5 Likert Scale (mean ± SD)		Mean Difference	95% CI‡	F Statistic	P
	Problem-Based Learning (n = 26)	Traditional (n = 36)				
Cognitive						
1a	4.69 ± 0.471	4.5 ± 0.561	0.192	-0.078 to 0.463	2.03	0.160
1b	4.54 ± 0.508	4.44 ± 0.607	0.094	-0.198 to 0.386	0.41	0.523
1c	4.50 ± 0.583	4.61 ± 0.549	-0.111	-0.401 to 0.179	0.59	0.447
1d	4.38 ± 0.571	4.50 ± 0.561	-0.115	-0.406 to 0.175	0.63	0.431
1e	4.08 ± 0.484	4.42 ± 0.604	-0.340	-0.626 to 0.053	5.62	0.021
1f	4.27 ± 0.604	4.56 ± 0.607	-0.286	-0.598 to 0.025	3.38	0.071
Psychomotor						
2a	4.31 ± 0.549	4.47 ± 0.560	-0.165	-0.450 to 0.121	1.33	0.254
2b	4.35 ± 0.562	4.53 ± 0.609	-0.182	-0.485 to 0.122	1.43	0.236
2c	4.35 ± 0.689	4.47 ± 0.609	-0.126	-0.457 to 0.205	0.58	0.450
2d	4.04 ± 0.528	4.33 ± 0.586	-0.295	-0.584 to 0.005	4.15	0.046
Affective						
3a	4.35 ± 0.689	4.69 ± 0.525	-0.348	-0.657 to 0.040	5.11	0.028
3b	4.50 ± 0.648	4.86 ± 0.424	-0.361	-0.634 to 0.089	7.03	0.010
3c	4.58 ± 0.578	4.69 ± 0.749	-0.118	-0.469 to 0.234	0.45	0.506
3d	4.69 ± 0.549	4.72 ± 0.513	-0.030	-0.302 to 0.242	0.05	0.827
3e	4.46 ± 0.811	4.56 ± 0.909	-0.094	-0.542 to 0.354	0.18	0.676
3f	4.38 ± 0.804	4.64 ± 0.833	-0.254	-0.677 to 0.168	1.45	0.234
3g	4.65 ± 0.562	4.64 ± 0.899	0.015	-0.385 to 0.415	0.01	0.941

*Scores on the Employer Satisfaction Survey of the Committee on Accreditation for Respiratory Care

†See Reference 11 for description of the various evaluation subcategories (1a, 1b, etc).

‡95% confidence interval of the difference between means

Table 5. Employers' Overall Satisfaction With the Respiratory Therapy Training of Respiratory Therapists in Their Employ*

	Respiratory Therapy Education Style		Mean Difference	95% CI†	p
	Problem-Based Learning (n = 29)	Traditional (n = 36)			
Employers' overall satisfaction score (mean ± SD)	4.28 ± 0.702	4.22 ± 0.989	0.054	-0.382 to 0.489	0.806

*1-5 Likert score scores on the Employer Satisfaction Survey of the Committee on Accreditation for Respiratory Care

†95% confidence interval of the difference between means

shows the means, standard deviations, and univariate results. The mean employer rating of the traditional graduates was significantly higher than of the PBL graduates ($p < 0.05$) on 4 survey items:¹¹

1e: Ability to recommend appropriate diagnostic and therapeutic procedures using laboratory data and physical examination findings ($p = 0.021$)

2d: Ability to perform and interpret diagnostic procedures ($p = 0.046$)

3a: Communicates effectively in the health care setting ($p = 0.028$)

3b: Conducts self in an ethical and professional manner ($p = 0.010$)

A 2-tailed *t* test for independent samples revealed that mean employer ratings of the overall quality of the graduates were not significantly different between the PBL and the traditional graduates ($p = 0.806$) (Table 5).

NBRC Examination Results

There were no significant differences in mean overall scores between the PBL and the traditional graduates on

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Table 6. NBRC Examinations Scores of Respiratory Therapy Program Graduates

Examination	Problem-Based Learning		Traditional		Mean Difference	95% CI†	p
	(n*)	Score (mean ± SD)	(n*)	Score (mean ± SD)			
CRT	52	111.88 ± 8.722	76	111.62 ± 8.801	0.266	-2.857 to 3.389	0.866
Written RRT	27	77.67 ± 6.978	64	77.61 ± 6.687	0.057	-3.031 to 3.146	0.971

*Number of graduates

†95% confidence interval of the difference between means

NBRC = National Board for Respiratory Care

CRT = Certified Respiratory Therapist

RRT = Registered Respiratory Therapist

either the CRT ($p = 0.866$) or the written RRT examination ($p = 0.971$) (Table 6). No significant multivariate differences were found in mean scores across test content subcategories in either the CRT (Wilks's lambda = 0.953, $p = 0.722$) or the written RRT examination (Wilks's lambda = 0.955, $p = 0.709$). None of the univariate results reached significance in any subcategory.

Results Summary

Although some significant differences were present between the groups at program entry, when considered as covariates, none of the differences were significant with regard to the survey ratings. Neither were there any significant differences in the survey ratings between males and females, nor among graduates of different schools. No significant differences were found between traditional and PBL graduates' self-ratings in the cognitive, psychomotor, or affective components of the survey, but PBL graduates were significantly more satisfied with their programs' overall quality. This perception was not shared by employers; the employers' ratings of the graduate's overall quality were not significantly different between the groups. There were some significant differences between groups in the employer ratings of the graduates' competencies; these differences are further considered in the next section. Finally, there were no significant differences between groups in any of the NBRC examination scores.

Discussion

Education researchers disagree about whether grand education experiments can elucidate a curriculum-level intervention's effects. Many education researchers maintain that interventions at the curriculum level can never be uniform, are impossible to blind, and can never produce a pure outcome attributable to only the intervention.¹²⁻²² Nevertheless, researchers, predominantly in medical education, have conducted numerous studies to compare PBL's

outcomes to those of conventional lecture-based instruction.

Three often-cited major meta-analyses of the medical education literature in the early 1990s, conducted by Albanese and Mitchell,²³ Vernon and Blake,²⁴ and Berkson,²⁵ explored PBL's effectiveness as a curriculum intervention. Colliver²⁶ conducted another meta-analysis in 2000, in which he took issue with the generally positive findings of the 3 earlier studies. In 2003, Newman²⁷ conducted yet another meta-analysis of PBL's effectiveness, and also took issue with earlier positive findings. A major point of contention among researchers is the appropriateness of objectivist scientific methods (which focus on generalizable results) in assessing the effects of a curriculum-level intervention.

The scientific method places randomized controlled trials at the top of the evidence hierarchy in judging the quality of research, but many education researchers believe that randomized controlled trials are inappropriate for assessing a curriculum-level intervention's effects, because one cannot be certain that students actually receive the "treatment." These researchers advocate a more qualitative approach that focuses on individual detailed descriptions of cases and their outcomes; the goal of such an approach is to develop theory rather than generalizable results. In any event, the general findings of many studies confirm that PBL graduates perform as well as their traditionally educated counterparts on standardized knowledge tests,²⁸⁻³³ that they are generally more satisfied with their education experiences,^{23-26,34,35} and that they engage in more self-directed learning in the course of their studies.^{36,37}

The findings of the present study are consistent with the medical education literature, which indicates that graduates of PBL programs are generally more satisfied with their preparation than are their traditionally educated counterparts. The finding of no difference between PBL and traditional graduates regarding membership in state and national professional organizations, pursuit of professional

credentialing, or involvement in continuing education activities is not surprising; credentialing is required for state licensure and practice, and most continuing education is delivered through state and national professional meetings, at a discount to members.

The employers rated the traditional graduates significantly higher than the PBL graduates in the ability to (1) recommend therapy and procedures based on diagnostic data, (2) perform diagnostic procedures and interpret diagnostic data, (3) communicate effectively, and (4) act in an ethical, professional manner. These findings are generally inconsistent with the literature on PBL in medical education. On the other hand, the employers' rating of overall graduate quality was not significantly different between the PBL and the traditional graduates, which mitigates the aforementioned rating differences.

The findings of no difference on mean NBRC examination scores provides further evidence that PBL instruction apparently addresses content adequately in terms of scope and depth—a concern raised in the major meta-analyses by Albanese and Mitchell,²³ Vernon and Blake,²⁴ and Colliver.²⁶ The findings of the present study are consistent with most of the recent medical literature, which reported no disadvantage for PBL graduates on traditional, objective tests of knowledge.

Conclusions

Before drawing conclusions from this study, one must take into account the considerable controversy in the education community over the measurement of a curriculum-level intervention's effects. Factors that potentially confound the effects of a change at the curriculum-level are so numerous and complicated that outcomes may not be amenable to objective scientific quantification. Human behavior is subject to environmental, psychological, and emotional nuance. Prideaux²¹ suggested that the ascendancy of evidence-based medicine in the medical community has perhaps inappropriately influenced efforts to evaluate the effectiveness of education interventions.

Traditional objective student assessment methods, such as multiple-choice examinations, may not be sensitive to PBL's effectiveness. Major and Palmer¹⁷ noted that PBL elicits student creation of knowledge, which fosters student ownership of knowledge; moreover, PBL fosters leadership that moves from student to student, depending on the kind of leadership the situation requires. These kinds of outcomes cannot be assessed with multiple-choice tests. Suggested *authentic* assessment techniques for PBL include (1) outside evaluation by experts, (2) content analysis of projects, (3) focus groups, (4) peer evaluations, (5) journals or activity logs, and (6) personal reflections.¹⁷

Lechner¹⁶ believes that education evaluation should focus on students' perceptions of their learning experienc-

es—an approach that focuses more on *understanding* than *measurement*. Student enjoyment of and success in an education experience produces a “winning cycle,” which validates this kind of measurement, in Lechner's view. Makoul et al³⁸ share Lechner's philosophy that graduate perceptions are valid criteria in curriculum evaluation.

Fraser and Greenhalgh¹⁵ suggested that the evaluation of learning outcomes of PBL should focus more on *capability* (evaluating one's ability to work effectively in an unfamiliar context) than on *competency* (evaluating one's skills and knowledge). Evaluating capability, defined in this way, is difficult to accomplish with standardized tests of knowledge.

In light of the foregoing observations, the results of the present study must be guardedly interpreted. One must be cautious about attributing any differences in the results of surveys and tests (given 6 months or longer after graduation) to the type of curriculum from which the students graduated. The 2 most important conclusions that can be drawn from the present study are that (1) PBL graduates were more satisfied than traditional program graduates with the quality of their education, and (2) PBL did not place graduates at a disadvantage on standardized, objective tests of knowledge, such as licensing and credentialing examinations. The medical literature strongly corroborates these conclusions.

The medical literature does not corroborate the present study's peculiar finding that the employers rated PBL graduates lower than traditional graduates in their ability to recommend therapy based on physiological data, to interpret diagnostic data, to communicate effectively, and to conduct themselves in an ethical, professional manner. It is especially difficult to explain why employers would rate PBL graduates lower as effective communicators, considering the predominant role of communication skills in small-group PBL methods. One can speculate that employers might rate the employee lower on communication skills if the employee frequently questioned the status quo and insisted on a rationale for therapy and diagnostic procedures. Those who question what others deem unquestionable might be seen as contentious and not “team players.”

Another factor to consider is that the employer survey results represented a much smaller proportion of the PBL graduate pool than they did of the traditional graduate pool. Surveys were collected for a total of 108 graduates; both graduate and employer surveys were collected for some of these graduates, but only one of the surveys was available for other graduates. Of the 108 graduates, 62 (57%) were from PBL programs and 46 (43%) were from traditional programs. Of the pool of 62 PBL graduates, only 26 valid employer surveys were collected, which represented 42% of the PBL graduate pool. Of the pool of 46 traditional graduates, 36 valid employer surveys were collected, which represented 78% of the traditional graduate

pool. Thus, the employer survey results do not represent the PBL graduate pool as validly as they represent the traditional graduate pool; that is, the employer survey results cannot be generalized to the pool of PBL graduates with as much confidence as they can be generalized to the traditional graduate pool.

The finding that PBL graduates did not rate themselves higher than traditional graduates in the cognitive domain is consistent with the literature; a possible reason for the similarity in self-ratings could be that the clinical patient care components of both PBL and traditional curricula were conducted in similar traditional ways, and were predominant during the latter parts of the programs. To some extent, clinical education has an inherent PBL-like component. Thus, the similarity of clinical experiences in the latter portions of the curriculum might have masked some of the differences that would have otherwise appeared between PBL and traditional curricula. These same reasons may help explain the finding of no difference between PBL and traditional graduates in *employer* satisfaction with the overall quality of the program's graduate.

Limitations

This study was retrospective in design and did not employ random sampling; association between variables does not indicate causation. A major limitation to the validity of this study is the amount of time that elapsed between graduation and completion of the surveys and the NBRC examinations, which tended to dissociate the statistical results from the effects of the curriculum. It is possible, as Colliver²⁶ speculated, that differences between PBL and traditional graduates in clinical performance are merely a matter of timing—that once traditional graduates enter the clinical phases of their programs, they quickly catch up to PBL graduates in clinical competence. If this is true, it would help explain why graduates of PBL and traditional respiratory-therapy programs looked alike to employers in terms of satisfaction with overall quality of preparation.

The 4 universities from which data were collected represented different physical learning resources, and operated under different administrative policies and in different socioeconomic and political environments. Student cultural and socioeconomic backgrounds and attitudes toward learning were undoubtedly different, as were faculty experience, competence, and attitudes. It is thus reasonable to speculate that the school attended may have had an independent effect on survey ratings and examination scores; however, multivariate analyses of variance across all graduate and employer survey items and all NBRC examination subcategories revealed no significant differences among the 4 participating institutions.

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