Effects of conventional and problem-based learning on clinical and general competencies and career development

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OBJECTIVE To test hypotheses regarding the longitudinal effects of problem-based learning (PBL) and conventional learning relating to students' appreciation of the curriculum, self-assessment of general competencies, summative assessment of clinical competence and indicators of career development.

METHODS The study group included 2 complete cohorts of graduates who were admitted to the medical curriculum in 1992 (conventional curriculum, n = 175) and 1993 (PBL curriculum, n = 169) at the Faculty of Medicine, University of Groningen, the Netherlands. Data were obtained from student records, graduates' self-ratings and a literature search. Gender and secondary school grade point average (GPA) scores were included as moderator variables. Data were analysed by a stepwise multiple and logistic regression analysis.

RESULTS Graduates of the PBL curriculum scored higher on self-rated competencies. Contrary to expectations, graduates of the PBL curriculum did not show more appreciation of their curriculum than graduates of the conventional curriculum and no differences were found on clinical competence. Graduates of the conventional curriculum needed less time to find a postgraduate training place. No differences were found for scientific activities such as reading scientific articles and publishing in peer-reviewed journals. Women performed better on clinical competence than did men. Grade point average did not affect any of the variables.

CONCLUSIONS The results suggest that PBL affects self-rated competencies. These outcomes confirm earlier findings. However, clinical competence measures did not support this finding.

KEYWORDS *problem based learning; *career choice; clinical competence/*standards; education, medical, graduate/*methods; curriculum; self concept; personal satisfaction; students, medical/*psychology; humans.

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INTRODUCTION

Reviews of the effects of problem-based learning (PBL) curricula versus conventional curricula have revealed: high levels of student satisfaction with PBL; no differences in knowledge levels, and some evidence that PBL stimulates constructive, collaborative and self-directed learning.[1–5] For medical educators these outcomes may seem somewhat disappointing. Consequently, it is not surprising that these reviews have fuelled ongoing debate on PBL.[6–9] Some researchers have argued that most reviews are too strict and educational interventions are too complex to be evaluated by randomised controlled trials.[4,6] It has been suggested that a variety of different outcome measures would be more appropriate to establish effectiveness of PBL. These outcome measures should include measures beyond the standardised knowledge examinations. There is, for instance, some evidence that PBL students have better interpersonal competencies, which positively affect the quality of their interactions with patients.[10–12]

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Overview

What is already known on this subject

Effects of problem-based learning (PBL) curricula on student performance have been discussed extensively, but there is little support from empirical evidence. Recent findings have shown that PBL students score better on self-rated interpersonal competencies.

What this study adds

Self-ratings of general competencies, formal clinical competence measurements and aspects of career development of graduates from PBL and conventional curricula were analysed in a longitudinal study. The results add further validity with respect to self-rated competencies in favour of PBL. No differences were found on clinical competence and career development.

Suggestions for further research

Cross-validation of self-ratings with work-based assessment scores and direct measurements of practice performance is recommended.

In a recent study, Schmidt *et al.* analysed the longterm effects of PBL by comparing the competencies acquired by graduates of PBL and conventional curricula.[13] The findings suggested that PBL not only affects the typical PBL-related competencies in the interpersonal and cognitive domains, but also affects more work-related skills. However, this study was based on graduates of 2 different schools, the response rate was rather low (39% of PBL graduates and 19% of conventional graduates), and the outcomes were based only on graduates' self-ratings. The authors called for cross-validation using different methods to address these shortcomings.[13]

We conducted a study that may add to that by Schmidt *et al.* in several ways. Firstly, we examined 2 complete cohorts from the same school, comprising graduates of a PBL and a conventional curriculum. Secondly, in order to cross-validate earlier findings, we analysed not only self-assessments of general competencies, but also summative assessment grades on clinical competence. Thirdly, we collected data on graduates' career development.

Based on the existing literature on PBL, we formulated several hypotheses. We expected the PBL graduates to:

1. be more satisfied with their curriculum;[4,14,15]
2. rate themselves more highly on general competencies;[11,13,16]
3. achieve higher scores on clinical competence measures,[11,17] and
4. read more peer-reviewed journals.[18]

The rationale for the last hypothesis is that in a PBL curriculum students are supposed to be better prepared for self-directed learning. As this was a longitudinal study, we were also able to collect data on graduates' career development. Because, to our knowledge, this has not been done before, this part of the study is explorative.

Several variables might be considered to influence the outcomes of this study. In a systematic review, women were consistently found to outperform men in medical training and clinical assessments.[19] Furthermore, secondary school grade point average (GPA) scores have been shown to be related to study progress and career development.[20] Therefore, gender and GPA were included as moderator variables.

METHODS

Participants and context

Participants were graduates of the Medical Faculty of the University of Groningen who had enrolled in the medical training programme in 1992 and 1993 and graduated between 1998 and 2001. Starting in the academic year 1993–1994, the curriculum of the first 4 years of the 6-year undergraduate programme was changed from a traditional discipline-based curriculum to a PBL curriculum. Therefore, the cohort that entered in 1992 (101 women, 74 men) was offered a conventional (discipline-based) curriculum with lectures and training in anatomy and physiology laboratories, and the cohort that entered in 1993 (91 women, 78 men) followed the new PBL curriculum. A typical week in the PBL curriculum started with a clinician presenting a patient. On the same day, the students attended their first tutorial, in which one of the students presented a short report on the patient's problem in order to provide medical context for the learning cycle. The cycle started with students brainstorming on 4 study tasks related to the presented patient's problem. The cycle continued with (self) study, followed by the second tutorial in the same

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week in which students reported on the work they had done on the tasks. During the tutorials, the students assumed several roles in the communication process which were similar to roles seen in health care settings. The clinical phase of the curriculum (Years 5 and 6) was the same for both groups and involved obligatory clerkship rotations in most of the clinical disciplines.

Procedure

Both cohorts were involved in a longitudinal study. Telephone interviews were conducted once a year.

The respondents consented to our use of their performance and survey data. Researchers guaranteed anonymity and confidentiality.

Summative assessment grades on clinical performance were retrieved from the faculty's database (100% for both cohorts). Information on papers published as first author or co-author was gathered by literature searches (100% both cohorts). Self-ratings of general competencies and data on career development were based on interviews carried out in 2004 with 148 graduates of the conventional curriculum (85%) and 146 graduates of the PBL curriculum (86%).

Variables

The variables used in the analysis and the corresponding scales are presented in Table 1.

The following dependent variables were included in the study.

Appreciation

Graduates expressed their appreciation of the curriculum on a 10-point scale, where 1 = very poor and 10 = excellent. The cut-off score between unsatisfactory and satisfactory was 5.5. The graduates gave 2 ratings: an overall rating for the curriculum as a whole and a rating for the scientific quality of the curriculum.

Self-assessment scores

The graduates rated, on the same 10-point scale, their competence at the time of graduation in respect of 8 competencies assumed to be important to medical practice (Table 1). We used graduation as point of reference for the self-assessments because the graduates had finished undergraduate medical training at different times and varied in amount of clinical experience at the time of interview. In this way we hoped to ensure that the self-ratings would represent the same situation for all graduates.

Clinical competence

Both cohorts had followed an identical programme of clinical clerkship rotations. At the end of each rotation, students' clinical competence was assessed. Students performed a long case and presented their findings to a clinical specialist of the discipline in question, who rated global clinical performance on a scale of 1 (poor) to 10 (excellent). This type of marking is commonly used at all levels of education in the Netherlands. A score below 5.5 is considered 'unsatisfactory'. For this study, we used grades for the clerkships in internal medicine, neurology, psychiatry, paediatrics, obstetrics and gynaecology, and surgery.

Career development

We used several indicators of postgraduate career development. Firstly, we determined whether the graduates had managed to secure a placement in a postgraduate training programme in their preferred disciplines. Secondly, we determined the time (in months) lapsed between graduation and commencement of postgraduate training. In the Netherlands graduates have to compete for a limited number of training posts. We assumed that 'placement in the preferred specialty within a certain amount of time' would be an indicator of clinical competence.

Another indicator of clinical competence we used was scientific performance,[20] which we defined as reading and publishing articles in peer-reviewed journals. During the interviews, the graduates were asked to estimate the average number of peer-reviewed articles they read in a month. Publication of articles in peer-reviewed journals was ascertained by a systematic MEDLINE search of author names for graduate names. These searches were performed in June 2005 and June 2006 for all graduates of the conventional curriculum (enrolment in September 1992) and all graduates of the PBL curriculum (enrolment in September 1993), respectively. A search of other databases for a subsample of the graduates yielded no additional publications. The following variables were defined: the graduate as first author of an article published in a peer-reviewed, English-language journal, and the graduate as co-author of an article published in a peer-reviewed, English-language journal.

Table 1 Variables and scales

Variable	Scale
Independent variable	
Cohort (C)	– 1: cohort 1992
	1: cohort 1993
Moderator variables	
Gender (G)	– 1: male
	1: female
GPA	GPA minus average GPA (mean = 0)
Dependent variables – appreciation curriculum	
Quality curriculum	10-point (1–10)
Quality scientific aspects	10-point (1–10)
Dependent variables – self-assessments	
Communication	10-point (1–10)
Clinical skills	10-point (1–10)
Research skills	10-point (1–10)
Clinical problem solving	10-point (1–10)
Social context patient	10-point (1–10)
Knowing of own limitations	10-point (1–10)
Basic science knowledge	10-point (1–10)
Clinical science knowledge	10-point (1–10)
Dependent variables – clinical competencies	
Internal medicine	10-point (1–10)
Paediatrics	10-point (1–10)
Neurology	10-point (1–10)
Psychiatry	10-point (1–10)
Obstetrics and gynaecology	10-point (1–10)
Surgery	10-point (1–10)
Average score on clinical competencies	10-point (1–10)
Dependent variables – career development	
Time between graduation and start of postgraduate specialist training	Months
Consulting peer-reviewed articles	Log-value: log (1 + number of articles)*
Publications as first author	Dichotomous 1 publications, 0 no publications
Publications as co-author	Dichotomous 1 publications, 0 no publications
Start postgraduate specialist training	Dichotomous 1 no placement, 2 placement

*Transformed variable is analysed because the distribution of the original variable was very skewed
GPA = grade point average

In this study, 'cohort' was the independent variable of interest. Moderator variables were 'gender' and 'GPA' of secondary school final examinations (i.e. the mean score on 7 examination subjects). The mark for each subject was based on school examinations (50%) and a national certification test (50%). Marks were given on a 10-point scale, with 5.5 as the cut-off score. Because it represented the average of 7 scores on a 10-point scale, the GPA was considered a continuous 1–10 variable.

Analysis

Stepwise multiple linear regression was used to analyse the continuous data. The main focus of this study was the effect of 'cohort' on the dependent

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variables. The moderator variables 'gender' and 'GPA' (and their interaction) were included in the model, as were their interactions with 'cohort', in order to examine their contribution to the variation. Only variables that significantly contributed to the explanation of the dependent variables were included in the final model in a stepwise procedure.

To interpret the magnitude of a standard regression coefficient (β), the effect size indication for correlations was used, with 0.10, 0.30 and 0.50 considered to represent small, moderate and large effect sizes, respectively.[21]

In order to investigate the influence of 'cohort' on the dependent variables 'postgraduate specialist training', 'scientific publications as first author', and 'scientific publications as co-author', stepwise logistic regression analyses were performed. Again, only variables that significantly contributed to the explanation of the dependent variable were included in the final model.

RESULTS

The results of the multiple linear regressions for the continuous dependent variables are shown in Table 2.

Appreciation

The hypothesis concerning satisfaction was not supported: the PBL graduates showed no greater appreciation for overall curriculum quality than the graduates of the conventional curriculum. In both curricula, appreciation scores for the scientific aspects of the curriculum were lower than general appreciation scores.

Self-rated competencies

The hypothesis that PBL graduates would rate their own general competencies more highly was supported by the results. Graduates of the PBL curriculum showed higher self-ratings on communication skills ($\beta = 0.507$), scientific skills ($\beta = 0.133$), clinical problem solving ($\beta = 0.332$), dealing with the social context of patients ($\beta = 0.250$), knowing one's limitations ($\beta = 0.136$), and clinical knowledge ($\beta = 0.142$). Their average score was also significantly higher ($\beta = 0.314$). Graduates of the conventional cohort rated themselves higher on basic science knowledge ($\beta = -0.285$).

Gender effects were found for communication skills: women rated themselves higher ($\beta = 0.113$). Gender–GPA interaction effects were found for communication skills ($\beta = -0.103$), clinical problem solving ($\beta = -0.151$), dealing with the social context of patients ($\beta = -0.114$), and average self-assessment score ($\beta = -0.127$). These effects indicated that men with higher GPA scores tended to give higher self-ratings, whereas women with higher GPA scores tended to give lower self-ratings. The highest self-assessment score was for clinical science knowledge (7.20) and the lowest was for scientific skills (6.05).

Clinical competence

The hypothesis that PBL graduates would receive higher ratings on clinical competencies was not confirmed. Except for obstetrics and gynaecology ($\beta = 0.109$), no differences were found between the cohorts in clinical competence assessments during clerkships. Women's ratings were higher for paediatrics ($\beta = 0.141$), neurology ($\beta = 0.146$), psychiatry ($\beta = 0.113$), obstetrics and gynaecology ($\beta = 0.117$) and average clerkship scores on clinical competence ($\beta = 0.192$).

Career development

The cohorts differed significantly in the amount of time between graduation and start of postgraduate training ($\beta = -0.248$), with graduates of the conventional curriculum taking 3 months less to find placements of their choice.

Graduates on average read 6–7 peer-reviewed articles per month. Contrary to our expectation, no significant differences were found between the cohorts. Men read more than women ($\beta = -0.116$). No differences were found with regard to publication in peer-reviewed journals (Table 3). For scientific output as first author, a 3-way interaction among Cohort, Gender and GPA was found. For the men in cohort 93 and the women in cohort 92, higher GPAs were associated with more publications: the odds of having published 2 or more articles as first author increased by a factor of 1.75 for a 1-point increase in GPA. The opposite was found for the men in cohort 92 and the women in cohort 93: for a 1-point increase in GPA the odds decreased by a factor of 0.57, so the corresponding odds ratio was 3 : 1.

Furthermore, no effect was found for the moderator variable GPA except for appreciation of the curriculum: the higher the GPA, the greater the appreciation.

Table 2 Results of the multiple linear regression analysis

Dependent variable (continuous)		**Constant**	**Gender (G)**	**GPA (X)**	**GX**	**Cohort (C)**	**CG**	**CX**	**CGX**
		Independent variables							
Appreciation									
Quality curriculum	*P*	**0.000**	NS	**0.003**	NS				
	B	**7.13**	− 0.026	**0.165**	− 0.078				
	β		− 0.040	**0.176**	− 0.083				
Quality scientific aspects	*P*	**0.000**	NS	NS	NS				
	B	**6.16**	0.023	0.015	− 0.016				
	β		0.019	0.008	− 0.009				
Self-ratings									
Communication skills	*P*	**0.000**	**0.029**	NS	**0.046**	**0.000**			
	B	**7.16**	**0.131**	− 0.097	**− 0.175**	**0.588**			
	β		**0.113**	− 0.057	**− 0.103**	**0.507**			
Clinical skills	*P*	**0.000**	NS	NS	NS				
	B	**7.10**	0.095	− 0.044	− 0.025				
	β		0.095	− 0.030	− 0.017				
Scientific skills	*P*	**0.000**	NS	NS	NS	**0.027**			
	B	**6.05**	0.040	0.105	− 0.019	**0.153**			
	β		0.034	0.063	− 0.012	**0.133**			
Clinical problem solving	*P*	**0.000**	NS	NS	**0.007**	**0.000**		**0.043**	
	B	**6.97**	− 0.009	0.000	− **0.206**	**0.310**		**0.155**	
	β		− 0.010	0.000	− **0.151**	**0.332**		**0.114**	
Social context patient	*P*	**0.000**	NS	NS	NS	**0.000**			
	B	**6.59**	0.082	0.004	− 0.195	**0.292**			
	β		0.070	0.003	− 0.114	**0.250**			
Knowing one's own limitations	*P*	**0.000**	NS	NS	NS	**0.023**			
	B	**6.93**	− 0.024	0.084	− 0.188	**0.159**			
	β		− 0.020	0.049	− 0.111	**0.136**			
Basic science knowledge	*P*	**0.000**	NS	NS	NS	**0.000**			
	B	**7.06**	− 0.012	0.072	− **0.034**	− 0.241			
	β		− 0.014	0.058	− **0.027**	− 0.285			
Clinical science knowledge	*P*	**0.000**	NS	NS	NS	**0.019**			
	B	**7.20**	0.028	− 0.010	− 0.030	**0.121**			
	β		0.033	− 0.008	− 0.024	**0.142**			
Average score	*B*	**0.000**	NS	NS	**0.025**	**0.000**			
	β	**6.89**	0.042	0.012	**− 0.108**	**0.184**			
			0.071	0.015	**− 0.127**	**0.314**			
Clinical competence									
Internal medicine	*P*	**0.000**	NS	NS	NS				
	B	**7.38**	0.062	0.044	− 0.015				
	β		0.085	0.043	− 0.014				

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Table 2 Continued

Dependent variable (continuous)		Independent variables Constant	Gender (G)	GPA (X)	GX	Cohort (C)	CG	CX	CGX
Paediatrics	*P*	**0.000**	**0.011**	NS	NS				
	B	**7.57**	**0.101**	0.043	− 0.093				
	β		**0.141**	0.043	− 0.092				
Neurology	*P*	**0.000**	**0.008**	NS	NS				
	B	**7.23**	**0.113**	0.051	− 0.001				
	β		**0.146**	0.046	− 0.001				
Psychiatry	*P*	**0.000**	**0.041**	NS	NS				
	B	**7.50**	**0.091**	0.029	− 0.042				
	β		**0.113**	0.025	− 0.037				
Obstetrics and gynaecology	*P*	**0.000**	**0.035**	NS	NS	**0.049**			
	B	**7.59**	**0.087**	0.011	0.032	**0.080**			
	β		**0.117**	0.010	0.030	**0.109**			
Surgery	*P*	**0.000**	NS	NS	NS				
	B	**7.78**	**0.058**	− 0.009	− 0.051				
	β		**0.076**	− 0.009	− 0.045				
Average score clerkship	*P*	**0.000**	**0.001**	NS	NS				
	B	**7.51**	**0.080**	0.027	0.032				
	β		**0.192**	0.045	0.030				
Career development									
Time between graduation and postgraduate specialist training (months)	*P*	**0.000**	NS	NS	**0.04**	**0.001**			
	B	**25.458**	− 0.100	1.050	**− 3.129**	**− 3.453**			
	β		− 0.007	0.051	**− 0.151**	**− 0.248**			
Consulting peer-reviewed articles per month (log-value)	*P*	**0.000**	**0.051**	NS	NS				
	B	**0.879**	**− 0.044**	0.031	0.007				
	β		**− 0.116**	0.057	0.013				

GPA = grade point average; NS = not significant
The statistical significance (*P*), regression coefficients (*B*) and standardised coefficients β are shown (top down). Empty cells represent variables with non-significant contributions
The bold values represent statistical significance ($P < 0.05$)

DISCUSSION

We were able to confirm only our hypothesis that PBL graduates' self-ratings on competencies would be higher than those of graduates of a conventional curriculum. The other results were contrary to our expectations: PBL graduates showed no greater satisfaction with their curriculum; did not read more peer-reviewed journals, and did not receive higher ratings on clinical competencies. Although doubts have been raised with regard to the validity of self-ratings,[22,23] it may be assumed that over- or under-estimation occurred in both groups to a similar extent. Thus the validity of self-ratings at group level, as those used in this study, may be better than for individuals. The fact that the results of our study are comparable with those of earlier studies appears to support the validity of the conclusion that PBL affects general work-related skills, which are important for success in professional practice.[10,13,16]

Table 3 Results of the logistic regression analysis

Dependent variable (dichotomous)	Independent variables							
	Constant	**Gender (G)**	**GPA (X)**	**GX**	**Cohort (C)**	**CG**	**CX**	**CGX**
Scientific output co-author	**0.000**	NS	NS	NS				
	0.190	0.821	0.869	1.097				
Scientific output first author	**0.000**	NS	NS	NS				**0.038**
	0.107	1.192	1.1016	0.843				**0.570**
Start postgraduate specialist training	**0.006**	NS	NS	NS				
	1.37	0.918	1.014	1.014				

GPA = grade point average; NS = not significant
The statistical significance (*P*) and regression coefficients (*B*) are shown (top down). Empty cells represent variables with non-significant contributions
The bold values represent statistical significance ($P < 0.05$)

The finding that PBL graduates did not show more appreciation of their curriculum seems rather unusual.[4,14,15] A possible explanation may be that both cohorts consisted of students of the same university who may be assumed to have been exposed to the same educational climate. In connection with the curriculum change, faculty at Groningen Medical School not only invested a great deal in the new PBL curriculum, but also paid much attention to the students of the last cohort of the conventional curriculum, who were provided with individual coaching, special information booklets, and speeches delivered by the dean. This may have affected students' opinions favourably. Furthermore, there was considerable resistance to the new PBL curriculum among some staff members, who freely expressed these opinions during lectures, telling the conventional students how lucky they were to have been taught to become 'good, old-fashioned' doctors and issuing warnings to PBL students of the type: 'I wonder who will be interested in a PBL doctor.' These social processes may have influenced appreciation of the curriculum in both groups. It might be argued that it would have been preferable to use a study design in which an earlier conventional cohort was compared with a later PBL cohort.[15] However, in such a design, time might have been an important source of error.

To cross-validate the self-ratings of competencies, we included summative assessments of clinical performance (clerkship grades) in the analysis.[13] We expected PBL students to achieve higher scores on clinical competence, because their curriculum focused strongly on learning in the medical context, training in problem solving, and collaborative learning.[11,17] Although other studies have revealed relationships between PBL and higher clerkship grades,[14,15] in our study this hypothesis was not supported. A possible explanation may be that formal clerkship grades tend to represent more than just clinical competence. In an extensive analysis, Wimmers *et al.* demonstrated that clerkship grades reflected not only general clinical competence, but also theoretical knowledge.[23] We found that the PBL students rated themselves more highly on competencies, whereas the conventional students showed significantly higher self-ratings on basic science knowledge. Assuming that these self-ratings are valid, these aspects may have neutralised each other in the clerkship grades. However, for future analyses we would recommend the inclusion of work-based assessment, more frequent and better measurements of generic skills, and direct assessments of practice performance.[24] Furthermore, our analysis focused on outcome measures such as self-ratings and clerkship grades. We suggest that further research should involve analysis of whether cohorts differ on process variables, such as reasoning, thinking and clinical decision making.

As far as scientific development is concerned, we found no significant differences between the 2 groups of graduates in reading and publishing in peer-reviewed journals. This is by contrast with the results of previous research, which showed that graduates of PBL curricula were more diligent readers of the scientific literature.[18]

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The explorative part of our study on career development showed that graduates of the conventional curriculum took significantly less time to secure a placement in a postgraduate training programme of their choice. A possible explanation may be that basic science knowledge, on which the conventional graduates rated themselves higher, played a more crucial role in finding a placement than did clinical competence, on which the PBL graduates rated themselves higher. Another speculation might concern possible prejudice against PBL graduates.

In respect of the 2 moderator variables (gender and GPA), the results showed that gender was only associated with differences in clinical competence, with women receiving higher grades than men. This result was consistent with those from previous studies.[19] A surprising outcome was the absence of relationships between GPA and the dependent variables, except for appreciation of the curriculum. Students with higher GPA scores appreciated their curriculum more, regardless of the didactic approach. Previous research showed that students with higher GPA scores perform better and publish more often.[20] A possible explanation for the absence of such relationships in our study may be that faculty paid considerable attention to the study skills of the students of both cohorts. In addition, the examination rules were geared towards encouraging students to keep up with the regular programme and not procrastinate with regard to their study activities.[25] Possibly these measures may have neutralised influences of GPA during the study.

One of the strengths of this study is that it involved 2 complete cohorts of students. This means that there was no response bias. Another strong point is that all graduates studied at the same medical school and graduated during the same period of time. This implies that differences in school culture and developments in the medical environment after graduation were reduced. A possible source of error may have been the time between graduation and the interviews in 2004. Although students were asked to look back to the moment of graduation and rate their competencies at that time, subsequent clinical experiences may have flawed the self-ratings.

In conclusion, we found a positive effect in favour of PBL for graduates' self-ratings on general competencies. However, the other measurements revealed no striking differences between graduates of PBL and conventional curricula. As we have argued, the absence of differences between the 2 curricula in the formal assessments of clinical competence may reflect the fact that formal assessments involved a broader range of competences than clinical competence alone. Therefore, we would suggest that further research should include work-based assessment scores, more frequent and better measurements of generic skills, and direct measurement of practice performance.

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