

Appendix A. Search Strategy

Medline 18Dec06

1. Students, Medical/
2. Schools, Medical/
3. Medical student\$.mp.
4. "students of medicine".mp.
5. Preclinical.mp.
6. Medical education.mp.
7. exp Education, Medical, Undergraduate/ or Education, Medical/
8. or/1-7
9. ((first or 1st) adj year).ti,ab.
10. ((2nd or second) adj year).ti,ab.
11. or/9-10
12. exp Teaching/mt, td [Methods, Trends]
13. curriculum/ or competency-based education/ or "mainstreaming (education)"/
14. Curricul\$.mp.
15. curricul\$.mp.
16. ed.fs.
17. models, educational/
18. Learning/ or (learning or teach\$ or instruct\$).mp.
19. or/12-18
20. active.mp.
21. team.mp.
22. (electronic or digital or medical or online or simulat\$ or web-based).mp.
23. "Computer-Assisted".mp.
24. exp Problem Solving/
25. problem-based.mp.
26. (mcmaster or harvard or pathway or illinois).ti,ab.
27. maastricht.ti,ab.
28. (experience adj based).mp.
29. "early experience".mp.
30. "early clinical".mp.
31. ((group or outcome) adj based).mp.
32. (case adj based).mp.
33. "step 1".mp.
34. "step one".mp.
35. small group\$.mp.
36. participation\$.mp.
37. (self adj direct\$).mp.
38. (independent or contextual).ti,ab.
39. experiential.mp.
40. fieldwork.mp.
41. cooperative.mp.
42. (role adj play\$).mp.
43. (interactive or integrated).mp.
44. (student adj (center\$ or centre\$)).mp.
45. shadow\$.mp.
46. longitudinal.mp.
47. blended.mp.
48. reflective.mp.
49. asynchronous.ti,ab.
50. (passive or didactic or traditional or conventional or standard).mp.
51. (rote or observational or memoriz\$).mp.
52. (lecture adj based).mp.
53. (teacher adj (center\$ or centre\$)).mp.
54. or/20-53
55. 19 and 54
56. (PBL or LBL or ILA).ti,ab.
57. Problem-Based Learning/
58. Integrated learning activity.mp.
59. "service learning".mp.

60. (peer\$ adj tutor\$).ti,ab.
61. or/56-60
62. or/55,61
63. Educational Measurement/
64. exp Professional Competence/
65. (clinic\$ adj3 (competen\$ or perform\$)).mp.
66. ((test\$ or exam\$) adj score\$).ti,ab.
67. Program Evaluation/
68. evaluation studies/
69. (st or mt or td).fs.
70. or/63-69
71. 8 and 19 and 62 and 70
72. 8 and 11 and (19 or 54 or 61)
73. or/71-72
74. *"Education, Medical, Continuing"/ or cme.ti,ab.
75. 73 not 74
76. limit 75 to (addresses or bibliography or biography or comment or editorial or letter)
77. 75 not 76
78. (veterinar\$ or nurse\$ or nursing or dental or dentist\$ or occupational or physiotherap\$ or allied health).mp.
79. medical.mp.
80. 78 not 79
81. 77 not 80
82. (german democratic republic or germany or germany east or "germany federal republic of" or germany west or great britain or greece or hungary or iceland or eng or england or "federal republic of germany" or ireland or fraance or israel or france or italy or canada or denmark or ilinois or illinois).cp.
83. (australia or czech republic or austria or czechoslovakia or belgium or bulgaria).cp.
84. (luxembourg or malta or monaco or netherlands or northern ireland or norway or sweden or switzerland or swtizerland or poland or portugal or turkey or united kingdom or united kingdom misc islands or united states or scotland or vatican city).cp.
85. or/82-84
86. 81 and 85
87. RANDOMIZED CONTROLLED TRIAL.pt.
88. CONTROLLED CLINICAL TRIAL.pt.
89. RANDOMIZED CONTROLLED TRIALS/
90. RANDOM ALLOCATION/
91. DOUBLE BLIND METHOD/
92. SINGLE-BLIND METHOD/
93. or/87-92
94. ANIMAL/ not HUMAN/
95. 93 not 94
96. CLINICAL TRIAL.pt.
97. exp CLINICAL TRIALS/
98. (clin\$ adj25 (trial\$ or study or studies or design)).ti,ab.
99. ((singl\$ or doubl\$ or trebl\$ or tripl\$) adj25 (blind\$ or mask\$)).ti,ab.
100. PLACEBOS/
101. placebo\$.ti,ab.
102. random\$.ti,ab.
103. RESEARCH DESIGN/
104. or/96-103
105. 104 not 94
106. 105 not 95
107. COMPARATIVE STUDY/
108. exp EVALUATION STUDIES/
109. FOLLOW UP STUDIES/
110. (Follow up adj5 (study or studies or design)).ti,ab.
111. PROSPECTIVE STUDIES/
112. exp COHORT STUDIES/
113. CROSS-SECTIONAL STUDIES/
114. exp CASE-CONTROL STUDIES/
115. Epidemiologic studies/
116. Epidemiological factors/
117. exp Causality/
118. Age factors/
119. Comorbidity/
120. Odds ratio/
121. exp Risk/

122. Probability/
123. (effect\$ or outcome\$ or Allocat\$ or control\$ or assign\$ or treatment or compar\$ or interven\$ or experiment\$ or analys\$ or analyz\$).mp.
124. (group or groups).ti,ab.
125. (control\$ or prospectiv\$ or retrospectiv\$ or volunteer\$ or participant\$ or compar\$).mp. and (trial\$ or study or studies or design).ti,ab,sh.
126. cohort\$.ti,ab.
127. case-control\$.ti,ab.
128. Cross sectional.ti,ab.
129. (observational adj5 (study or studies or design)).ti,ab.
130. Longitudinal.mp.
131. Retrospective.ti,ab.
132. Relative risk.ti,ab.
133. Odds ratio.ti,ab.
134. (case adj (comparison or referent)).ti,ab.
135. (Causation or causal\$).ti,ab.
136. (Analytic adj (study or studies)).ti,ab.
137. single subject.mp. or SSRD.ti,ab. [mp=title, original title, abstract, name of substance word, subject heading word]
138. "n-of-1".ti,ab.
139. or/107-138
140. 139 not 94
141. 140 not (95 or 106)
142. 95 or 106 or 140
143. 86 and 142
144. limit 143 to (english language and yr="1995 - 2007")

[mp=title, original title, abstract, name of substance word, subject heading word]

APPENDIX B. METHODOLOGICAL QUALITY OF INCLUDED STUDIES

Table B1. Methodological quality of randomized and non-randomized trials based on The Cochrane Collaboration’s Risk of Bias Tool

	Allocation sequence adequately generated	Allocation adequately concealed	Blinding (knowledge of allocated intervention prevented)	Incomplete outcome data adequately addressed	Reports free of suggestion of selective outcome reporting	Study free of other sources of bias (i.e., baseline imbalances, inappropriate influence of study sponsors)	Overall risk of bias
<i>Randomized</i>							
Dyke 2001	Unclear	unclear	no	yes	yes	yes	high
Mennin 1993	Unclear	unclear	no	yes	yes	yes	high
Moore 1994	Unclear	unclear	no	yes	yes	yes	high
<i>Non-Randomized</i>							
Eisenstaedt	Unclear	unclear	no	no	yes	no	high

Table B2. Methodological quality of cohort studies based on Newcastle-Ottawa Quality Assessment Scale*
 (http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm)

	Timing	Representativeness of PBL cohort	Selection of non-PBL cohort	Comparability of cohorts	Assessment of outcome	Consistent definition of outcomes	Adequacy of follow-up
Casassus 1999	prospective	truly representative	same source as exposed cohort	analysis controlled for expertise of tutor	blind	standard exam	unclear
Distlehorst 2005	retrospective	self-selected	same source as exposed cohort	analysis controlled for age, gender, MCAT scores	unclear	common medical school performance outcomes	all subjects accounted for
Enarson 2001	retrospective	selected group of students	same source as exposed cohort	no control for confounding	blind (medical licensing exam)	standard exam	unclear
Farquar 1986	retrospective	self-selected	same source as exposed cohort	matched on scores for subtest of MCAT	blind (medical licensing exam)	standard exam	all subjects accounted for
Hinduja 2005	prospective	self-selected (volunteered for study)	source different from exposed cohort	no control for confounding	blind	standard test	unclear
Hmelo 1998	prospective	self-selected (volunteered for study)	same source as exposed cohort	no control for confounding; assessed BL comparability [†]	blind	problem-solving defined	Unclear [‡]
Lycke 2006	prospective	truly representative	same source as exposed cohort	no control for confounding	self-report for learning strategies and mental models of learning; no description for knowledge exam	questionnaire developed for two outcomes; knowledge assessed using standard exam	completion of tests ranged from 67% to 100%
Patel 2001	prospective	selected group of students	source different from exposed cohort	results reported by area of specialization	blinding unclear	inter-rater reliability assessed; third party for consensus	all subjects accounted for
Richards 1996	retrospective	self-selected	same source as exposed cohort	analysis controlled for age, gender, race, MCAT, year of graduation, medicine rotation and psychological inventory	blind (medical licensing exam); blinding unclear for clinical ratings	common medical school performance outcomes	data missing for greater proportion of non-PBL group (91 vs 97%)

Sivam 1995	retrospective	unclear	same source as exposed cohort	no control for confounding	blind (medical licensing exam)	standard exam	Unclear
Tamblyn 2005	retrospective	truly representative	source different from exposed cohort	analysis controlled for practice characteristics, practice experience, and temporal trends	record linkage	information from health administrative databases	all subjects accounted for
Verhoeven 1998	prospective	truly representative	source different from exposed cohort (volunteers)	no control for confounding	unclear	standard exam	Unclear
Way 1999	retrospective	self-selected	same source as exposed cohort	analysis controlled for year of entry and ability	blind (medical licensing exam)	standard exam	Unclear
Whitfield 2002	prospective	self-selected	same source as exposed cohort	analysis controlled for age, gender, race, preadmission GPA, class year, MCAT scores	unclear	standard clerkship examinations	Unclear

* two variables of the Newcastle-Ottawa Scale are not presented here as they were consistent across all studies: ascertainment of exposure (PBL vs. non-PBL) was based on school records; demonstration that outcome of interest was not present at start of study was not applicable to this set of studies.

† no differences between PBL and non-PBL cohorts for age, prior health care experience, undergraduate GPA, undergraduate math and science GPA, MCAT (biology, physical science, and verbal)

‡ 3 of 79 participants dropped-out and over time authors noted substantial cross-over between PBL and non-PBL groups

Table B3. Methodological quality of interrupted time series based on the Cochrane Effective Practice and Organization of Care Group's quality criteria (<http://www.epoc.cochrane.org/Files/Website/Reviewer%20Resources/inttime.pdf>)

	Protection against secular changes			Protection against detection bias		Completeness of data set	Reliable primary outcome measure
	Intervention independent of other changes	Sufficient data points for reliable statistical inference	Formal test for trend	Intervention unlikely to affect data collection	Blinded assessment of primary outcome(s)		
Hoffman 2006	done	done	not done	done	done (exam scores); unclear (performance evaluation)	done	done (exam scores); unclear (performance evaluation)

Table B4. Methodological quality of cross-sectional studies based on Newcastle-Ottawa Quality Assessment Scale*
(http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm)

	Representativeness of PBL cohort	Selection of non-PBL cohort	Comparability of cohorts	Assessment of outcome	Valid and reliable outcome measure	Completeness of data set
Albano 1996	self-selected	source different from exposed cohort	no control for confounding	blind	standard exam	inadequate
Boshuizen 1993	unclear	source different from exposed cohort	no control for confounding	unclear	previously used test and methods	all subjects accounted for
Remmen 2001	self-selected (volunteered for study)	source different from exposed cohort (volunteers)	analysis accounted for year/stage of medical education	unclear	standard written test	participation rate ranged from 12-93% (44% overall)
Rolfe 1995	somewhat representative	source different from exposed cohort	analysis controlled for age and gender	unclear	supervisor rating scale	at least one form completed for 97.2% of sample; 73.2% of all forms returned
Santos-Gomez 1990	unclear	same source as exposed cohort	analysis accounted for gender and year of residency	blind for supervisor and nurse ratings; also used self-reports	performance rating by supervisor, nurses, and self	complete returns for 55%; partial returns for another 16%
Schmidt 1996	self-selected (volunteered for study)	source different from exposed cohort (volunteers)	analysis controlled for curriculum year	two independent judges with inter-rater agreement >90%	unclear	unclear
Shin 1993	self-selected	source different from exposed cohort	analysis controlled for many potential confounders†	self-report	self-administered questionnaire	87% response rate
Van Hessen 1990	Unclear	source different from exposed cohort (volunteers)	analysis controlled for year of medical school	unclear	standard test	12% response rate from unexposed group
Verwijnen 1990	Unclear	source different from exposed cohort (volunteers in 2 of 3 control schools)	design controlled for school-specific content	unclear	standard test	unclear
Woodward 1990a	self-selected	source different from exposed cohort	paired analysis matched for sex, urban/rural practice, year of graduation, billing	record linkage	practice patterns based on billing data	all subjects accounted for

			district			
Woodward 1990b	self-selected	source different from exposed cohort	groups were matched but matching variables not specified	unclear	supervisor rating	unclear‡

* Two variables of the Newcastle-Ottawa Scale were not presented here as they were consistent across all studies: ascertainment of exposure (PBL vs. non-PBL) was based on school records; demonstration that outcome of interest was not present at start of study was not applicable to this set of studies. Two variables were modified for the cross-sectional studies: 'adequacy of follow-up' was changed to 'completeness of data sets', and 'consistent definition of outcomes' was changed to 'outcomes assessed using valid and reliable measures, implemented consistently across all study participants'

† variables controlled for in analysis: years in practice, medical school, family physician certification, sex, hours per week spent in patient care, number of patients seen per working day, proportion of patients with hypertension (outcome of interest)

‡ authors discuss problems with response rates