Effectiveness of postgraduate education in occupational medicine
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CHAPTER 5

Is problem-based learning more effective than lecture-based learning in postgraduate medical education?

A randomized controlled trial

(submitted)
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Abstract

Context
Problem-based learning is an alluring and widely used educational approach in medical education, which usually leads to satisfied course participants. However, there is hardly any rigorous evaluation research on the effectiveness of this approach in postgraduate specialist training programmes.

Objective
To study the effectiveness of problem-based learning compared with lecture-based learning in a postgraduate medical training programme for occupational physicians concerning management of mental health problems.

Design
Randomized controlled trial in 1999 with a mean follow up of fourteen months after the educational intervention.
**CHAPTER 5**

**Setting**
Postgraduate medical education and training for occupational physicians

**Subjects/participants**
118 physicians in training for occupational physician

**Intervention**
The intervention programme was based on the principals of problem-based learning, the control programme used the traditional lecture-based approach. Both programmes were aimed at improving knowledge of and performance in occupational management of work-related mental health problems.

**Main outcome measures**
Knowledge tests consisting of true/false and open answer questions. Performance in practice based on self-report and performance indicators. Satisfaction rating with the course on offer was measured by questionnaires.

**Results**
Knowledge increased equally in both groups directly after the programmes and decreased equally at follow up (p<.001). The gain in knowledge remained positive. Performance indicator scores also increased in both groups, but significantly more in the problem-based group (p<.05). The problem-based group was less satisfied with the course (p<.001).

**Conclusions**
Both forms of postgraduate medical training are effective. In spite of less favorable evaluations, the problem-based programme appeared to be more effective than the lecture-based programme in improving performance.

**Keywords**
Postgraduate medical education, occupational physicians, problem-based learning, lecture-based learning, work-related mental health problems, continuing medical education, continuing professional development.
**Introduction**

Postgraduate medical education and continuing medical education are a means of improving the knowledge and skills of practicing physicians. In most countries, certification as a medical specialist requires postgraduate education. Continuing certification requires life-long medical education. It involves a lot of personal effort to go through a postgraduate training programme and also makes quite a large demand on the health care budget. It is surprising that so little evaluation research on the effectiveness of postgraduate specialist training programmes is being carried out.

Problem-based learning (PBL) is one of the best described interactive learning methods and is advocated by many as more effective in terms of life-long learning skills and also as being more fun.\(^1\) At the beginning of the 1990s, four systematic reviews on problem-based learning in undergraduate medical education cautiously supported the notion of positive outcomes of problem-based learning compared with traditional learning methods. They found that the results in clinical performance and the student satisfaction rating of the programme were better for problem-based learning and that in the long term knowledge is better retained.\(^2\)\(^3\)\(^4\)\(^5\) Since then, many medical curricula have changed, wholly or partially, to problem-based learning. However, recently a new review questioned the extra value of problem-based learning in undergraduate medical education.\(^6\)

Participants in postgraduate medical education and continuing medical education (CME) differ from undergraduate medical students in that they are supposed to look beyond increasing knowledge and skills and aim at improving their competence and performance in practice. Ideally, these courses should lead to better health outcome among patients.\(^7\) Interactive, problem-based learning may also be effective in postgraduate teaching and CME.\(^8\)\(^9\) Available evidence on CME, shows that interactive sessions can change professional practice. However, there have been few well-conducted trials on this subject.\(^10\)\(^11\) For these reasons we studied problem-based learning to try to establish if it is more effective in increasing knowledge and performance than a traditional, lecture-based programme in postgraduate training of occupational physicians. Our hypothesis is that the inter-
active problem-based programme is more effective in increasing knowledge and performance and that it shows higher satisfaction rates.

Methods

**Design and participants**

An experimental study was set up with pre-test and post-test measurement and a follow-up measurement after 12 - 17 months. (see table 5.1). The experimental group participated in a problem-based training programme and the control group received traditional training on a lecture-based learning approach. We determined a sample size of 38 participants as sufficient to detect a difference of 1 point out of a total score of ten for the knowledge test with a power of 0.80 and a two-sided alpha of 0.05 and based on a standard deviation of 1.1 point. However, we were able to enroll participants (n=118) of 10 complete year groups of physicians of all four schools of occupational medicine in the Netherlands. These physicians work in occupational health practice during their four years of specialist training and attend the school of occupational medicine one day each week.

**Table 5.1. Study design.**

<table>
<thead>
<tr>
<th>Baseline: three months before training</th>
<th>Start of the training</th>
<th>Intervention</th>
<th>End of the training</th>
<th>Follow-up 12 – 17 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0 Randomisation</td>
<td>T1</td>
<td>X1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>Intention to treat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=118</td>
<td>N=59</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X1 experimental problem-based programme of 4 days
X2 'traditional' lecture-based programme of 4 days

Effect variables and time of measurement:

Knowledge tests: at T0, T1, T2 and T3
Performance indicator scores: between T0 / T1 and in six months after T2
Satisfaction measurement: at T2 and T3
Randomized controlled trial

They were in their first or second year of training and all still had to learn the Dutch guidelines on occupational management of workers with mental health problems.

**Randomization and assignment**

The participants of each group were allocated at random by one of us (CdB) to the problem-based group or the lecture-based group by means of a random number table and block randomization to account for equal allocation of participants over the groups.

**Intervention**

The educational programmes were designed with the aim of teaching the Guidelines of the Dutch Association of Occupational Physicians on 'Occupational management of workers with work-related mental health problems'.\textsuperscript{12,13} Both educational intervention courses had the same objectives and content and were of equal size. The only difference was the educational strategy: problem-based versus traditional, lecture-based. Both programmes lasted four days and were delivered one day a week over a four-week period in 1999. The lecture-based programme was given to three groups of about 20 participants each. The problem-based programme was given to seven groups of about 9 participants each. Box 5.1 details the objectives, content and design of the interventions. The educational programmes incorporated the advice of occupational physicians, who had participated in the drawing up of the guidelines. The three course leaders and seven facilitators of the 10 groups were all occupational physicians with experience in education. The authors were not directly involved in delivering the training. The four week programmes started three months after baseline testing.

**Outcomes**

Knowledge tests, performance indicators and satisfaction ratings were used to measure the outcomes of the educational programmes. Learning styles of the participants were measured at baseline.\textsuperscript{14,15} Knowledge was assessed four times, at baseline three months before the start of the educational programmes, at the beginning of the programme, on completion of the programmes and after a follow up of 12 - 17 months. Each knowledge test consisted of 70 true/false and 10 open
In this study the programmes were based on the Dutch guidelines on occupational management of mental health problems. These guidelines are based on evidence from literature and on consensus from the practice of occupational health. The content of the programmes focused on diagnosis, cognitive behavioural interventions for occupational physicians and other interventions (in work- and medical-curative environments). Both programmes were spread over four days in a four week period.

**Educational strategies**

The experimental 4 day-programme was based on the principles of problem-based learning. In small groups of about 9 participants, with a facilitator and an own chairperson. The content was divided into three parts; diagnosis, cognitive interventions and other interventions. The educational process comprised four steps:

1. Case description from individual practice; including exchanging and elaborating on existing knowledge, practical experience and questions (brain-storming).
2. Consensus on answerable questions and learning objectives
3. Private study, experimentation and search for evidence
4. Reporting to the group on newly learned information and experiences.

On the third day there was an opportunity to practice some intervention strategies which were chosen by consensus from within the group, with the help of an experienced occupational physician. The facilitator was an occupational physician with experience in teaching and knowledge of the guidelines.

The control programme was a traditional lecture-based programme for a group of about 20 participants. During the four day programme six external teachers (occupational physicians and psychologists) introduced the guidelines and other basic material, to the group and discussed it with them. The three topics and learning goals were similar to these of the problem-based programme. On the third day there was an opportunity to practice some intervention strategies. To this end the group was split into two smaller groups. The topics were chosen by the trainers who were experienced occupational physicians. An occupational physician from the school of occupational medicine with experience in teaching and using the guidelines was available to guide the group and the external teachers.

**Course book**

Both programmes were provided with a course book containing course requirements, a specified programme, objectives and learning goals, literature preparation and further reading suggestions, data on the external teachers and course leaders and on the lecture-based or problem-based setting in this post graduate programme.

In both programmes, knowledge tests and the collection of cases from individual practices, (both pre and post programme), formed part of the curriculum. The collection of cases from individual practices following the programme can be seen as a particularly important method of reinforcing the educational content in the context of practice.
answer questions, randomly selected from a question-bank of items reflecting the topics of the guidelines. The test was developed according to the rules described by Van der Vleuten. The open answer questions were scored independently by two of the authors (PS, JV). A correct answer to a true/false question scored one point and to an open answer question, three points. Answers left open or false answers got zero points. Performance in practice was measured by means of twelve performance indicators. These were derived from the guidelines for management of workers with mental health problems by two of the authors (PS, JV) as described by Van der Weide et al. Box 5.2 details the contents of the performance indicators. The guideline development team agreed that they give a valid and representative picture of the quality of care as outlined in the guidelines. The indicators were made operational by criteria that demarcate good from poor care. These criteria can be met, not be met or be inapplicable. In a previous experiment we experienced the use of performance indicators very positively. The participants were asked to randomly collect and register from their own practice, five people with mental health problems in the three months before and five cases in the six months following the educational programmes. Structured forms were used. The data from these forms were used to calculate the performance score. This score (for correct care) was calculated in each case by dividing the number of performance indicators for which the criteria were met by the number of all indicators that were applicable and expressed as a percentage. We calculated the average percentage of correct care of the cases before and of the cases after the training for every physician.

A questionnaire was used to evaluate the satisfaction rating immediately after the educational programme as well as at follow up. The questionnaire consisted of items concerning content, group size, organization and an overall satisfaction rating between 0 and 10.

Masking
The scoring of the knowledge tests was done blind of the group to which the physician was assigned. The scoring of the performance indicators from the forms was done blind of the experimental group by an automatic SPSS programme procedure.
## Box 5.2. Performance Indicators

<table>
<thead>
<tr>
<th>Performance indicator</th>
<th>A brief description of the performance indicators derived from the professional guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 History taking</td>
<td>The history taking of the occupational physician in the consulting room should be adequate and complete</td>
</tr>
<tr>
<td>2 Primary care diagnosis</td>
<td>The primary care diagnosis should be clear and correctly classified as a stress related disorder, depression disorder, anxiety disorder or other psychiatric diagnosis</td>
</tr>
<tr>
<td>3 Evaluation of medical treatment</td>
<td>The patient is asked about and assessed on whether medical treatment is adequate and / or any impediment to returning to work</td>
</tr>
<tr>
<td>4 Diagnosis of work relatedness</td>
<td>The patient is asked about and assessed on whether work or work environment is a causal factor for the disorder; and if there are colleagues with similar disorders</td>
</tr>
<tr>
<td>5 Evaluation of work disabilities</td>
<td>The patient is asked about and assessed on disabilities related to current work and necessary work adjustments</td>
</tr>
<tr>
<td>6 Intervention role of the occupational physician</td>
<td>The role of the occupational physician depends on his diagnosis. In all cases he chooses the role of case manager; if the diagnosis is stress related disorder he chooses a more active role in treatment</td>
</tr>
<tr>
<td>7 Cognitive behavioural interventions</td>
<td>Several cognitive behavioural interventions are chosen if the diagnosis is stress related disorder</td>
</tr>
<tr>
<td>8 Intervention in work</td>
<td>Interventions to achieve (temporary) work adjustments or to remove organisational impediments if necessary</td>
</tr>
<tr>
<td>9 Intervention in medical care</td>
<td>Interventions or consultation of medical colleagues if necessary</td>
</tr>
<tr>
<td>10 Advice on return to work</td>
<td>Advice on how to return to work is given</td>
</tr>
<tr>
<td>11 First contact</td>
<td>The first contact with the patient is planned according to the timetable offered by the guidelines</td>
</tr>
<tr>
<td>12 Revision appointment</td>
<td>A revision appointment is planned with intervals following the timetable offered by the guidelines</td>
</tr>
</tbody>
</table>
**Statistical analysis**

Analysis of results was performed on the basis of intention to treat. Missing values in knowledge tests were accounted for by substituting mean values. Statistical analysis was performed using SPSS. The internal consistency of the knowledge tests was estimated by using Cronbach's alpha. The scores from knowledge tests and performance indicators were analyzed using repeated measurement analysis of variance, with time as within-subjects factor and education as between-subjects factor. Analysis of differences of continuous variables was performed using independent t-tests.

**Costs**

Costs were calculated for both programmes and included development of the programmes, course material, teacher fees, education rooms and catering.

**Results**

**Subjects and data**

A hundred and eighteen physicians training to be occupational physicians participated in the experiment. Of these 59 were randomized to the experimental problem-based groups and 59 to the lecture-based groups. Table 5.2 shows the characteristics of the study population. There were no significant differences between the two groups.

**Compliance**

Of the 118 doctors 73 (62%) attended all four days training, 35 (30%) missed one day (21 in the intervention group and 14 in the control group), and 9 (8%) missed two or more days (6 intervention group and 3 control group). One case was unknown.

**Participant flow and follow up**

Most participants completed the knowledge tests: at T0 baseline 112 (95%), T1 start of training 109 (92%), T2 end of training 102 (86%) and T3 at follow up 96 (81%). Before the educational programmes 103 participants (87%) provided 513 cases from their own practice. Following the programmes 81 participants (69%) provided 399 prac-
Table 5.2. Characteristics of the study population

<table>
<thead>
<tr>
<th></th>
<th>Problem-based groups</th>
<th>Lecture-based groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 59</td>
<td>N = 59</td>
</tr>
<tr>
<td>% men</td>
<td>63</td>
<td>61</td>
</tr>
<tr>
<td>Age in years</td>
<td>35.9 ± 5.35</td>
<td>34.9 ± 5.21</td>
</tr>
<tr>
<td>Years since graduation as a medical doctor:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean and SD</td>
<td>7.5 ± 4.69</td>
<td>6.8 ± 4.70</td>
</tr>
<tr>
<td>Learning style (Kolb):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract / active</td>
<td>7 (12%)</td>
<td>11 (19%)</td>
</tr>
<tr>
<td>Active / concrete</td>
<td>13 (22%)</td>
<td>10 (17%)</td>
</tr>
<tr>
<td>Concrete / reflective</td>
<td>10 (17%)</td>
<td>11 (19%)</td>
</tr>
<tr>
<td>Reflective / abstract</td>
<td>18 (30%)</td>
<td>20 (34%)</td>
</tr>
<tr>
<td>Other / unknown</td>
<td>11 (19%)</td>
<td>7 (12%)</td>
</tr>
<tr>
<td>University of graduation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maastricht (PBL curriculum)</td>
<td>3 (5%)</td>
<td>4 (7%)</td>
</tr>
<tr>
<td>Other Dutch Universities</td>
<td>54 (92%)</td>
<td>54 (92%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>2 (3%)</td>
<td>1 (2%)</td>
</tr>
</tbody>
</table>

There are no significant differences between the two groups.

Practice cases. A comparison of performance indicators before and after the educational programmes was possible in 78 participants; 34 (58%) in the problem-based group (335 cases) and 44 (75%) in the control group (437 cases).

Knowledge
Over all the knowledge tests showed a satisfactory internal consistency for evaluation purposes: T1 alpha is .60, T2 .66 and T3 .64. On T0 base line however the internal consistency was low with alpha is .33.20 The knowledge tests scores were similar for the two groups at baseline (T0) with a mean score of 55% ± 4,9 correct for the problem-based (PBL) group and 55% ± 5,4 for the lecture based (LB) group. Knowledge scores increased significantly in both groups between base line and end of training (PBL group T1 59% ± 6,7, T2 71% ± 6,9; LB group T1 61% ± 7,1, T2 70% ± 7,8). The scores decreased significantly at follow up T3 (PBL group 63% ± 7,0 and LB
Knowledge tests

Figure 5.1. Repeated measurement analysis of variance of knowledge test results at T0, T1, T2 and T3. Mean percentage correct answers for problem-based and lecture-based groups. Within-subjects factor significant: $F(3,116) = 189.4, p < .001$. No significant interaction effect for educational intervention: $F(3,116) = 1.9, p = .126$. For both groups the follow-up score at T3 is significantly higher than at T1: paired samples t-test $p < .01$.

Performance

Before the training there was no significant difference between the two groups. The PBL group had a score of $74\% \pm 8.4$ correct and the LB group $76\% \pm 6.7$. The scores increased significantly in both groups (PBL after training $81\% \pm 8.5$, LB group $79\% \pm 8.0$). Figure 5.2 shows the results of the repeated measurement analysis of variance. Participants in the problem-based group improved their performance indicator score more than participants in the lecture-based group.
CHAPTER 5

Performance indicators

Figure 5.2. Repeated measurement analysis of variance of performance indicator scores before and after the training programme. Mean percentage correct for problem-based and lecture-based groups. Within-subjects factor is significant: F(1,76) = 30.6 p < .001. There is also a significant interaction effect for the educational intervention F(1,76) = 4.4 p < .05.

Table 5.3. Satisfaction rating

<table>
<thead>
<tr>
<th></th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>End of training</td>
<td>Follow up</td>
</tr>
<tr>
<td>Problem-based groups (n=51/46)</td>
<td>6.0 SD 1.36</td>
<td>5.4 SD 1.64</td>
</tr>
<tr>
<td>Lecture-based groups (n=49/45)</td>
<td>6.9 SD 0.99</td>
<td>6.7 SD 1.30</td>
</tr>
</tbody>
</table>

Possible scores 1 (very bad) –10 (very good)

Satisfaction rating: means and SD, at T2 (end of the training) and T3 (follow up). Differences between problem-based groups and lecture-based groups are significant; t-test p<.001.
Non-response analysis revealed that age, experience as physician, knowledge, learning style and occupational health service were not related to performance increase. Gender showed a slight relationship in favor of women (p=.055). The PBL group showed more female non-responders (20%) than the LB group (13%) (n.s.). We conclude that our findings are not biased by a selective non response.

Satisfaction

Table 5.3 shows the results of the satisfaction rating at the end of the training (T2) and at follow-up (T3). At T2 the problem-based group was significantly less satisfied than the lecture-based group. This difference was maintained at follow-up.

Discussion

We studied the effect of two learning strategies in postgraduate medical education for occupational physicians: problem-based and lecture based. Both were effective in improving knowledge and performance, but performance increased more in the experimental problem-based group. At follow-up knowledge score of the groups did not differ. The problem-based group was less satisfied.

The strength of this study was the randomized controlled design. The knowledge tests showed an overall satisfactory internal consistency, though this was low at base line with an alpha of .33. This can be explained by the low level of prior knowledge which increases the involvement of coincidence in answering the questions. The measurement of performance was based on physician’s self-report. However, the participants did not know the criteria we used to assess deviation from the guidelines. These results are consistent with those from earlier experiments. It was shown in another study that performing well, as measured by performance indicators, predicted a better outcome and patient satisfaction. Therefore, we conclude that the performance scores do reflect the quality of performance in practice. The results of the performance indicators could be biased by selective drop-out of participants. However, a non-response analysis did not reveal selective drop-out.
The experimental programme was based on the principals of problem-based learning. (See box 1) However, the lecture-based programme was more of a 'mixed' type. Most of the teachers actively tried to involve the participants with questions. Discussion is always possible within in a group of about 20 doctors. So in fact the lecture-based programme contained didactic lectures and interactive sessions. In a recent review, Davis et al. calls this type of education 'mixed' (that means a mix of didactic and interactive education).\textsuperscript{10} Maybe therefore knowledge and performance also increased in the lecture-based group and outcomes would have been different if the lecture-based programme was purely lecture-based.

According to Davis et al. there is some evidence that mixed and interactive education in continuing medical education is effective in changing the performance of doctors and health outcome. However, there are few well conducted studies.\textsuperscript{10,11,22} Our study confirms this - if you may call the lecture-based programme 'mixed'. In a well-conducted RCT on the effects of small group education in CME for general practitioners, no effects were found on physician performance and health outcome.\textsuperscript{23} Recently an article has been published concerning the weak rationale and outcome of problem-based learning. However it was based on undergraduate medical education only.\textsuperscript{6} In most studies on problem-based learning, one of the main results is the enthusiasm of the participants. Therefore the result of our study that the postgraduate physicians are actually less satisfied is remarkable. This may be because these groups are used to listening to lectures and not to being quite so actively involved in their own education. Lack of effects in many educational outcome studies may be due to compensatory efforts by students. Students tend to adjust their studying to testing requirements.\textsuperscript{24} We have no information on the effects upon these individual doctors' efforts outside and subsequent to the course. Finding any outcome effect may therefore be viewed as remarkable. Since performance in practice was not a formal testing situation, it may perhaps have been a more valid measure than the end-of-course knowledge test. In this study we have found an effect of both the problem-based and the lecture based mixed programmes with a moderate but meaningful
extra effect of the problem-based setting. We translated the PBL principles into a postgraduate setting, which meant a 4-step approach with extensive attention to individual knowledge and practice experience and a clear insight into the type of question it is possible to answer correctly. In our opinion this could be the extra value of the interactive problem-based learning approach. In this aspect we also see parallels with evidence based medicine (EBM) methods. This also starts out with a critical appraisal of practice cases, asking appropriate questions and then finding their answers.25

Ours is one of the few randomized studies on the effectiveness of problem-based learning in continuing medical education or postgraduate training compared to other methods. Even though some authors claim that problem-based learning or small group learning is far superior to other educational methods this is not supported by evidence.26 Some studies find a positive effect and others do not. In our study we found some small effect on performance which makes problem-based learning a slightly more effective teaching method for medium sized groups than lectures. If this counterbalances the higher degree of dissatisfaction among participants and the 15% higher costs is arguable. More research is needed to demonstrate that problem-based learning is more effective in increasing knowledge and performance of physicians in postgraduate or continuing medical education. Health outcomes in particular should be studied in addition to knowledge and performance indicators.

Conclusion

Both postgraduate programmes, problem-based and lecture-based, appeared to be effective in increasing knowledge and performance. This study shows some evidence that the problem-based programme has some small extra value for the participants in improving their performance, but as a type of education they rate it less highly.
Acknowledgments and funding:

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