

The replacement of ‘paper’ cases by interactive online virtual patients in problem-based learning

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Abstract

St George’s University of London (SGUL) has a Problem-Based Learning (PBL) curriculum for its undergraduate medicine course, using traditional paper-based patient cases. To counter the limitation that paper cases are linear and do not allow students to explore the consequences of decisions, interactive online virtual patients (VPs) were developed which allowed students to consider options as the cases unfold, and allow students to explore the consequences of their actions. A PBL module was converted to VPs, and delivered to 72 students in 10 tutorial groups, with 5 groups each week receiving VPs with options and consequences, and 5 groups receiving online VPs but without options. A comprehensive evaluation was carried out, using questionnaires, and interviews. Both tutors and students believed that the ability to explore options and consequences created a more engaging experience and encouraged students to explore their learning. They regretted the loss of paper and neither group could see any value in putting cases online without the options. SGUL is now adapting its transitional year between the early campus years and the clinical attachment years. This will include the integration of all technology-based resources with face-to-face learning and create a more adaptive, personalised, competency-based style of learning.

Introduction

Increasingly, curricula in medicine are being built around enquiry-based collaborative approaches to learning, predominantly problem-based learning (PBL; Sanson-Fisher & Lynagh 2005). In this approach, students work in teams to explore, manage or solve a problem. Guided by a tutor they share their existing knowledge, agreeing on what they need to learn and how to carry it out. Typically, students discuss the emerging patient scenario at the beginning of the week. Throughout the week, they have access to many forms of face-to-face and online learning resources including sessional teaching, all related to the problem of the week. Such activities may include lectures, practical classes, tutorials and patient-based activities. Evaluations of PBL have shown that learners prefer this method of learning to traditional lecture-based teaching methods (Norman & Schmidt 1992; Albanese & Mitchell 1993; Vernon & Blake 1993) although demonstrating its efficacy has always been more challenging (Finucane et al. 1998; Colliver 2000; Smits et al. 2002). At least one recent study (Tiwari et al. 2006) suggests that PBL provides medical students with a specific advantage in that they have a statistically higher probability of developing critical thinking over students who learn in a more didactic environment.

When investigating problems, practitioners need to synthesise a range of relevant information, identify solutions, and test those solutions. Competence in this crucial process is necessary for all practitioners and requires an approach that differs from traditional teaching methods, where students

Practice points

- PBL has proved to be a useful tool to explore learning needs through the structured exploration of a patient case.
- One of the limitations of the conventional paper-based delivery of PBL is that it is linear and inflexible, and can only proceed in a single direction.
- With interactive (branched) VPs, students could take decisions in acute management situations and explore the consequences of their actions.
- Students and tutors found the interactive cases more engaging, and believed it helped students learn.

are relatively passive recipients of information. Despite this, the last 30–40 years has seen a move to a more structured hybrid model (Espey et al. 2007) combining didactic sessions with more structured PBL. As a result the PBL model has generally become more detailed, structured and in many ways more restrictive in comparison with, say, cases pioneered at McMaster University in the 1960s.

Although PBL has proved effective and popular, there are constraints in its paper-based nature. The paper cases used in tutorials can only proceed in a single direction, i.e. no matter what decision the learner may wish to take, particularly at points of acute management, learners can only follow one path. Such cases may have limited use in developing clinical

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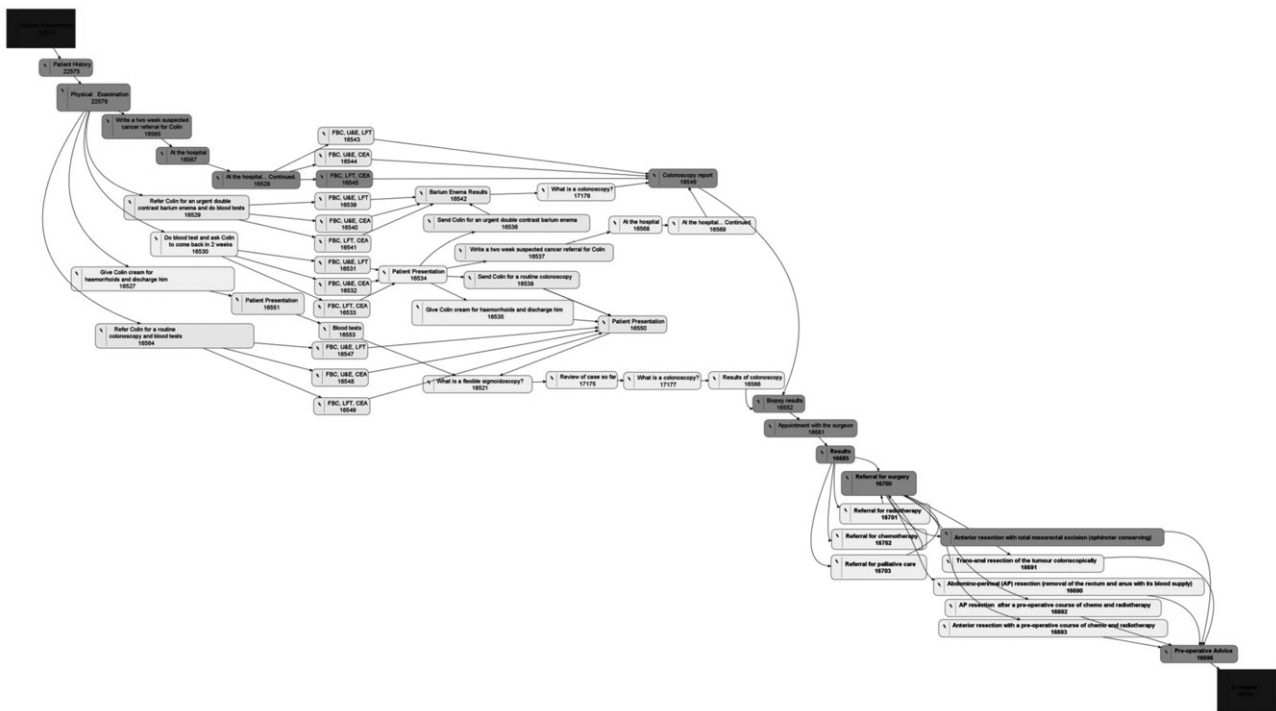


Figure 1. 'VUE map' of a VP case showing the original linear 'pages of the tutorial' (the grey boxes), and the additional choices and potential consequences (squares in light grey). The dark grey boxes represent the beginning and end of the tutorial.

reasoning, and are unrealistic for emulating real life, where there are frequently several ways to tackle a problem and mistakes made may not be immediately obvious. There is no evidence that PBL curricula result in improvements in general (content-free) problem-solving skills (Norman and Schmidt 1992). This approach may be less engaging for senior students than more complex, multi choice scenarios.

Furthermore, simply putting PBL online has proved to be a poor use of the technology. At a recent meeting of the 'Flinders collaboration' (a group of universities using a similar PBL model), five out of six universities reported that simply putting PBL online had proved deeply unpopular with students who had experienced paper cases before and saw no real advantage to the change.

VPs have demonstrated their use in teaching, learning and assessment (Issenberg et al. 1999), and throughout a wide range of designs for learning (Ellaway et al. 2006). However, the types of interactive VPs described above have not appeared in PBL to any great extent largely due to clinician time and cost (Huang et al. 2007).

In 2005 SGUL began to produce multi-route, engaging VPs at low cost (Round 2007). Only one VP player was suitable for the generation of this type of virtual patient (VP), 'Labyrinth' (Begg et al. 2007) and the open source version 'OpenLabyrinth', an application capable of producing the multi route paths allowing PBL students to make decisions, and explore the consequences. Cases constructed in this way could be more lifelike and provided excellent tools to practice reasoning and decision-making skills.

Each case required 8–10 hours of a specialist's time, and simple development support. This development made it possible to consider the replacement of linear PBL with similar

interactive VPs, which would allow students to take decisions and explore the consequences of those decisions.

In this study, undertaken in two phases, paper PBL cases were adapted for online delivery and repurposed by as branching rather than linear VPs with the addition of different options and consequences at key points in the case.

Methods

Construction of the cases

The original PBL cases were used as the templates upon which to construct the VPs. The 5-week module chosen for the trial was part of the 2nd year intake of the St. George's PBL Graduate Entry Programme.


The basic PBL paper case was transferred into the visual understanding environment (VUE –developed by Tufts University), allowing a case to be quickly drawn out to emulate the VP map using simple boxes and links. At this stage the case is still linear darker and additional boxes are added as required, expanding to incorporate the other decisions and pathways the user might consider taking, along with potential consequences (Figure 1).

Options and consequences

At this stage option and consequences were added to the VUE file. The decision points were always at points of action, usually acute management, and as much as possible these choices were designed to be realistic and based on evidence. Many of the choices were made based on situations that practitioners and institutions had experienced, including

OpenLabyrinth HOME CREATE USERS MY ACCOUNT HELP LOGOFF

Patient Presentation



Mrs Pat Hurst enters the consulting room of her General Practitioner's surgery. Below is a transcript of the initial conversation between her and her GP:

GP: How old are you Pat?
 Pat: I am 65.
 GP: What's the problem?
 Pat: Terrible backache! Really, really bad.
 GP: How long have you had this for?
 Pat: I've had it for quite a while. I keep thinking that it's because I've done too much work. It's so persistent now, getting out of bed is a bit difficult.
 GP: You've had it for a while. Can you put some kind of estimate on that? Months? Weeks?
 Pat: I've had it for months and months. It's just one of those things.
 GP: As much as a year?
 Pat: Could be over a year.
 GP: You say it's persistent?
 Pat: Yes.
 GP: Day and night?
 Pat: Yes.
 GP: Is it enough to keep you awake at night?
 Pat: Yes, very often.
 GP: Is it worse when you're walking or carrying shopping?
 Pat: Yes, definitely, yes.

Patient Presentation and History

Case Information
 Case: Pat Hurst Tutorial 1 (enriched) (501)
 ID: 13478
[Restart Case](#)

Case Pathway
 Review your pathway

Case Score

Figure 2. The VP case delivered in Labyrinth. Options would appear at the bottom.

some of the very poor choices, with possibly disastrous consequences. For example, in a first tutorial, the first choice may occur part way through a history, diverting the patient presentation into different paths, the second choice may occur during investigation; the third during choices of treatment. There were typically three major choices in each tutorial, based upon an early trial of how many options could be fitted for discussion by students in the time available.

From VUE to Labyrinth

VUE files were then transferred into OpenLabyrinth, with each 'box' in VUE generating a page in the case, and each arrow becoming a hyperlink between the pages. At this stage the VP case can be enriched with learning resources and other media to support the case. Finished cases can then be played within Open_Labyrinth, displaying the VP as a series of web pages that can be accessed online (Figure 2).

An important feature of the delivery was to give students the opportunity to discuss the relevant information, before the options appeared, otherwise the discussion would be limited by the options.

A typical setup within tutorial room shows the relative positioning between the students around the table and the online VP (Figure 3).

Tutor and student paper notes

It was accepted that both tutors and students also wanted paper versions of the case. Tutors needed the usual guidelines to facilitate the case and to steer them through the unusual complications of the students being able to take different paths through the cases. The tutor notes remained focussed on the text of the main path, 'the yellow brick road' as it became known, and additional notes in red at each option point guided the tutors through the different options and consequences available, and the impact these had on the patient or in the case. The students received a compiled text version of the 'yellow brick road' version of the case after each tutorial, and retained access to the online case after the tutorial.

Evaluation

In a preliminary trial, first year students had one paper-based tutorial replaced by an online tutorial PBL case presented in the branched format. After this successful test of the concept,



Figure 3. A typical PBL tutorial room layout showing the VP case delivered online.

Table 1. Controlled trial of the replacement of paper based PBL cases with either linear or branched VPs: Second year PBL students.

Groups	Type of VP				
	Case 1	Case 2	Case 3	Case 4	Case 5
1-5	Linear	Branched	Linear	Branched	Branched
6-10	Branched	Linear	Branched	Linear	Branched

permission was given to trial the approach in a full module, Life Protection, at the end of the second year of the MBBS. Each week five student groups would receive a linear version of the case and five others would receive the branched (non-linear) version of the case (Table 1). This ran for four consecutive weeks, and then the fifth case was delivered in the branched version for all 10 PBL rooms. Evaluation was by online questionnaire for both students and tutors, and by interviews of the tutors (Figure 4).

Results

First year students

In a preliminary trial, first year students had been exposed to one tutorial of a case established in the branched format, and then asked to fill in an online questionnaire.

Of the 29 questionnaires completed 75% stated they would prefer to use branched (non-linear) cases in future, 21% preferred paper and only 4% chose linear online cases. Five of the eight tutors believed students were more engaged with the online interactive case, with two uncommitted, and one disagreeing. It should be noted that four PBL groups each answered the questionnaire as a single group so the response rate was actually higher than it seemed, and involved more than 50 of the students.

Second year students

At the very end of the second year, a module consisting of five cases was delivered in both linear and branched online formats as previously described. In the choice of which method of PBL they would prefer to undertake in the future the pattern was similar to the first year students with 59% preferring online with decisions. However more second year students chose paper PBL (44% compared with 21% in the first year) as their first choice.

Second year students clearly believed decision pathways (VPs) were more engaging than linear PBL (Table 2, Q1; 70% strongly agree or agree). They believed they went through the case at a reasonable pace, and did not find having to make decisions frustrating (Table 2; Q5, 6) and agreed that they still met the learning objectives (Table 2; Q8). Students clearly made every effort to get the 'right answer' but then frequently chose to explore other, often poorer options.

Students clearly disliked the absence of paper (Table 2; Q7), and of the 22 comments in response to the open text question 'did you encounter any problems working with the online cases' 13 said they disliked the absence of paper handouts, mostly because they couldn't jot 'notes onto the case as they

go along'. A few students also recognised that they were just 'more 'used to paper'.

Ninety-five per cent of students believed they had enough support for online cases, but complained of the number of typographic errors, a result of the speed with which cases had to be modified and delivered. A few students commented that the case on screen, to one side of the table, distorted the dynamics of group discussion.

Students preferred method of PBL for the future.

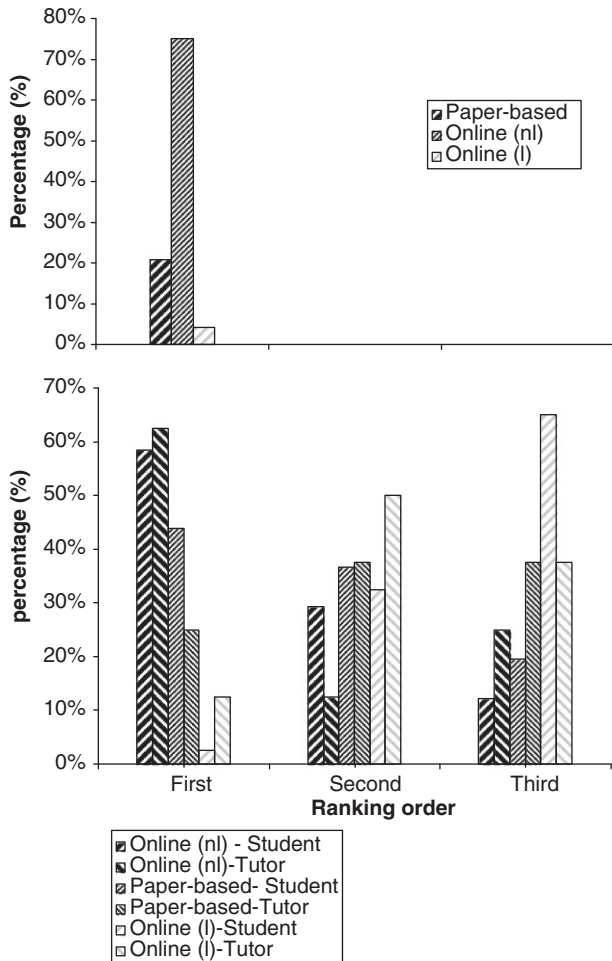


Figure 4. Students and tutors were asked to rank their choice of PBL for the future, and, in the second year, to give their second and third order choices. Most students and tutors preferred online VPs with decisions (right-hand columns).

Second year tutors

Tutor responses were very similar to student responses. Five out of eight preferred online cases with decisions for the future. In general they believed that (i) students were more engaged with the online cases (Table 3: Q3 and 4), (ii) students went through the cases at reasonable pace (which had been a concern before the trial) and (iii) they had enough support. Tutors believed that it was 'early days' and some more attention was needed to address the level of difficulty of decisions – some students had found some of them 'too easy'. This point was also raised by students.

Nine of the ten tutors attended training, and it was noticeable when the data was reviewed that the respective tutorial group of the tutor who had refused training had a greater number of negative comments.

To a large extent the tutor interviews confirmed the data and open comments in both student and tutor questionnaires, with one significant addition. The tutors described the difficulty of tutoring students at a stage of the course when they are becoming bored with PBL having already completed more than 50 cases up to that point. Tutors believed that the online cases with decisions 'woke students up', and 'recaptured their attention', and they slowed down to discuss the steps in the case more thoroughly; though opinions were mixed on this latter point and one tutor believed that, in the PBL room where the projection board was more difficult to see, discussion was less active.

Discussion

The initial test of online interactive VPs in PBL was carried out with first year students to establish whether the process was firstly, 'safe', i.e. it did not interfere with the problem-solving

Table 2. Student questionnaire (41 second year students).

Questions (Q1–Q8)	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Rating average
I found online PBL more engaging than paper PBL	12% (5)	20% (8)	29% (12)	32% (13)	7% (3)	3.02
I found PBL with decision pathways more engaging than a linear PBL case	5% (2)	5% (2)	20% (8)	46% (19)	24% (10)	3.80
We went through the cases with decision pathways at a reasonable pace	2% (1)	10% (4)	17% (7)	66% (27)	5% (2)	3.61
We went through the cases without decision pathways at a reasonable pace	0% (0)	7% (3)	17% (7)	71% (29)	5% (2)	3.73
I found having decisions to make frustrating	37% (15)	54% (22)	7% (3)	2% (1)	0% (0)	1.76
It was difficult not having a print-out of the PBL during tutorials	0% (0)	12% (5)	12% (5)	34% (14)	42% (17)	4.05
We met the learning objectives for the cases with decision pathways	0% (0)	2% (1)	37% (15)	59% (24)	2% (1)	3.61

Table 3. Tutor questionnaire.

Questions (Q1–Q7)	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Rating average	Response count
The students prefer paper-based case	0	3	3	2	0	2.88	8
It is easier to tutor paper-based cases	0	3	2	3	0	3.00	8
The students were more engaged with the online cases	0	1	2	5	0	3.50	8
Adding decision pathways did not make the students engage more	1	6	1	0	0	2.00	8
Online PBL makes it harder to meet the LOBs	1	2	4	0	0	2.43	7
My PBL group went through the cases with decision pathways at a reasonable pace	0	1	0	6	1	3.88	8
My PBL group went through the cases without decision pathways at a reasonable pace	0	0	0	7	1	4.13	8

process, and secondly, could be considered acceptable to the course team, which in practice meant that students and tutors would not find the process unacceptable. The outcome that both students and tutors found the process engaging, and also considered it helped student learning led to the full module trial described here.

The main advantages were seen by the students to be the ability to make decisions and explore the consequences and by the tutors as an approach which engaged students more fully, particularly at a stage in the course when students were starting to become bored by PBL.

The original intention with these VP/PBL cases was that the fifth case would also be delivered in the trial in the same way as for the previous four. It soon became apparent to students that half of them would therefore have three branched cases (non-linear), and the other half only two. Because of student unrest (linear cases were unpopular), for the final case of the module both sets of groups were given the branched PBL/VP case. Clearly the students found no value in the linear online cases compared to the branched versions.

Complaints fell into two main categories, firstly the lack of paper which was difficult to address, and secondly, the mechanical complaints concerning size of text, images, orientation of the screen, etc. Notwithstanding these concerns, most students and all tutors enjoyed the interactive VP/PBL process, and believed the students learnt more during the discussion. The opportunity to take decisions, appeared to outweigh the disadvantage of the lack of paper, and this was seen as a critical element in the sustainability of the new delivery system.

It is not clear from this study if students would have reacted strongly to the lack of a paper handout if they had not become used to it during the majority of their course, but it was clear that students near the beginning of the course were less likely to choose paper as their first option, than students near the end of the second year. To some extent student comments supported the idea that by that stage they were just 'used to paper'.

An interesting feature of the PBL process was the extent to which students took the decisions seriously. A widespread concern before the trial was that students would just click quickly and possibly randomly on options, and quickly move from option to option. This did not happen. However, whilst students wished to make the right decision they apparently

paradoxically enjoyed the shock-horror of a very poor and even fatal choice. Even so, they described, in their open comments in the questionnaire, the value of such 'safe practice'. As a direct result of this trial, this interactive VP process is now being embedded at the heart of the undergraduate medicine at St George's University of London.

The trial was deemed to be so successful that I, In a programme termed Generation 4 (G4) funded by the Joint Information Systems Committee (JISC) of England, the online interactive VPs are replacing paper-based cases from September 2009, throughout the 'transitional year' (T year) of undergraduate medicine at St George's University of London. This is the year in which students entering medicine through different routes, i.e. graduates and school-leavers, are brought together for a combined year of clinical PBL and clinical experience. Perhaps surprisingly, this radical innovation and bold political step forward has been received with enthusiasm by both staff and students alike.

Conclusion

The replacement of paper cases by online interactive VPs was seen as a success by students and tutors, and both groups appreciated the improvements it brought to their PBL process. In many ways it had much in common with the first large-scale development in electronic competency training, the flight simulator; it allows choices to be made and consequences to be explored and mistakes to be made as safe practice. It therefore can share the myriad learning theories directed as such simulations. But enthusiasm for the change from students and staff has been unanimous, and as one tutor put it. 'it doesn't need a pile of educational theories to tell you when something is working!'

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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References

- Albanese MA, Mitchell S. 1993. Problem-based learning: A review of literature on its outcomes and implementation issues. *Acad Med* 68:52–81.
- Colliver JA. 2000. Effectiveness of problem-based learning curricula: Research and theory. *Acad Med* 75:259–266.
- Finucane PM, Johnson S, M.Prideaux DJ. 1998. Problem-based learning: Its rationale and efficacy. *Med J Aust* 168(9):445–448.
- Espey E, Ogburn T, Kalishman S, Zsemlye M, Cosgrove E. 2007. Revitalizing problem based learning: Student and tutor attitudes towards a structured tutorial. *Med Teach* 29:143–149.
- Begg M, Ellaway R, Dewhurst D, MacCleod H. 2007. Transforming professional healthcare narratives into structured game-informed-learning activities. *Innovate* 3(6). <http://www.innovateonline.info/index.php?view=article&id=419>.
- Ellaway R, Candler C, Greene D, Smothers V. 2006. An Architectural Model for MedBiquitous Virtual Patients. Baltimore, MD: MedBiquitous. http://www.medbiq.org/working_groups/virtual_patient/MVP_WhitePaper_115ep2006.pdf.
- Huang G, Reynolds R, Candler C. 2007. Virtual patient simulation at US and Canadian medical schools. *Acad Med* 82(9):446–451.
- Issenberg SB, McGaghie WC, Hart IR, Mayer JW, Felner JM, Petrusa ER, Waugh RA, Brown DD, Safford RR, Gessner IH, et al. 1999. Simulation technology for health care professional skills training and assessment. *JAMA* 282(9):861–866.
- Norman GR, Schmidt HG. 1992. The psychological basis of problem-based learning: A review of the evidence. *Acad Med* 67(9):557–565.
- Round J. 2007. Creating your own virtual patients. The Academy Subject Centre for Medicine, Dentistry and Veterinary Medicine Newsletter 01, no. 13, pp. 20–22. Available from: <http://www.medev.ac.uk/newsletter/01.13.html>
- Sanson-Fisher RW, Lynagh MC. 2005. Problem-based learning: A dissemination success story? *Med Educ* 183:258–260.
- Smits PBA, Verbeek JHAM, de Buissonj CD. 2002. Problem based learning in continuing medical education: A review of controlled evaluation studies. *BMJ* 324:153.
- Tiwari A, Lai P, So M, Yuen K. 2006. A comparison of the effects of problem-based learning and lecturing on the development of students' critical thinking. *Med Educ* 40:547–554.
- Vernon DT, Blake RL. 1993. Does problem-based learning work? A meta-analysis of evaluative research. *Acad Med* 68:550–563.