ORIGINAL CONTRIBUTIONS

ARTICLES

Resolving Inconsistencies in Tutor Expertise Research: Does Lack of Structure Cause Students to Seek Tutor Guidance?

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Purpose. To investigate under what conditions tutors' subject-matter expertise influences student achievement. **Method.** Data were analyzed from 1,800 University of Limburg Faculty of Health Sciences students who in 1989–90 participated in tutorial groups led by content-expert staff tutors, non-expert staff tutors, or student tutors. Each student participated in an average of 4.1 tutorial groups. Overall, 4,111 data records were available for analysis. The basic analyses were of (1) students' achievement scores as a function of tutors' levels of subject-matter expertise and students' prior knowledge; (2) students' achievement scores as a function of tutors' levels of subject-matter expertise and educational units' levels of structure; and (3) differences in achievement between students guided by tutors of different levels of expertise in either high- or low-structure units. Statistical methods included analyses of variance. **Results.** The level of subject-matter expertise of tutors had a positive influence on student achievement. Similar results were found for the students' prior knowledge and the levels of structure of the units; the more prior knowledge students had, the better were their performances on the end-of-unit test; and the higher the level of structure of the unit, the better the achievement. More important, interactions were found between tutor expertise on the one hand and prior knowledge and unit structure on the other, tutor expertise being mainly important if the unit was poorly structured or students reported lack of prior knowledge. **Conclusion.** The results suggest that students need a minimum level of structure in order to profit from problem-based instruction. This structure can be internally provided through prior knowledge available for understanding the new subjects, or offered by the environment in the form of cues of what is relevant and what should be the focus of the activities. If prior knowledge falls short, or if the environment lacks structure, students will turn to their tutors for help and direction. Under those conditions, students who are guided by a subject-matter expert tutor may benefit more than students guided by a non-expert staff tutor or by a student tutor. These findings may explain the widely divergent results of tutor-expertise research. *Acad. Med.* 69(1994): 656–662.

Does a tutor's subject-matter expertise have a facilitative effect on student learning? This question has recently raised considerable discussion in the problem-based learning literature.[1–4] There is difference of opinion regarding the beneficialness or, alternatively, the disruptiveness of tutors' attempts to guide their students by using their own subject-matter knowledge. Silver and Wilkerson,[3] for instance, showed that content-expert tutors tended to take a more directive role in the tutorials, provided more direct answers to students' questions, and suggested more items for discussion. My colleagues and I,[4] on the other hand, found that content-expert tutors not only displayed more content-related behaviors than did non-expert tutors, such as conveying relevant information about the problem at hand, but also had a higher level of process-facilitative behaviors, such as asking open-ended questions and monitoring the group's progress.

In addition, findings from studies comparing the effects of tutors' subject-matter expertise on student effort and achievement seem contradictory. Eagle and colleagues,[1] for instance, demonstrated that students guided by content-expert tutors produced more than twice as many learning issues for self-directed learning and spent almost twice the amount of time on self-study. Davis and colleagues[2] found that performance on an achievement test was enhanced when students were guided by a content expert. A similar finding, based on a large-scale study involving more than 300 tutorial groups, was reported by my colleagues and myself.[4] We also found that students guided by subject-matter specialists performed better on a end-of-unit achievement test, although the effect was largely confined to the first curriculum year. By contrast, large-scale studies conducted by Swanson and colleagues[5] and Des Marchais and Black[6] failed to demonstrate measurable effects of tutor expertise. For a review see Schmidt and colleagues.[4]

Several possible explanations for these contradictory findings have been proposed.[4] One is that different studies employed different definitions

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An article and a commentary on related topics are on pages 663 and 646.

of what constitutes subject-matter expertise in tutoring.[2,7] In addition, in some studies the subject-matter experts behaved differently from the non-experts, whereas in others, expert and non-expert tutors could not be distinguished from each other in terms of the ways in which they approached their students.[2,4,6] However, even studies that resemble each other closely in design and measurement, such as the Sherbrooke[6] and Limburg studies,[4,5] report widely different findings. How can these inconsistencies in tutor expertise research be explained?

My colleagues and I[4] noticed that the influence of tutor expertise on student achievement, if any, tended to be confined to the first curriculum year or was demonstrated in experiments in which the students were exposed only to a limited extent to problem-based learning. In more advanced groups, the effect of tutor expertise was less clear or even entirely absent. We concluded that

> . . . students who have been exposed to problem-based learning only to a limited extent tend to lean more heavily on their tutors. If the subject-matter expertise of a tutor is to play a role in the learning of students, its influence will be more pervasive in those cases where students rely most extensively on their tutor for guidance. This may be particularly the case in the first year when students still have to adapt to the requirements set by the problem-based approach. When, through experience, students become more self-directed and independent of their tutor, his or her influence on student learning may become smaller.

The question, of course, is what does experience, or lack of it, mean in this context? No doubt, students have to adapt to the requirements of the problem-based approach. They have to acquire skills necessary for small-group learning, such as the ability to defend one's point of view, to accept and understand other perspectives, and to chair sessions. In addition, students must master self-directed learning skills, such as competence in literature search and literature review and other library-related skills. There is evidence, however, that mastering these skills and accommodating the new educational philosophy takes between two and three months for most students.[8] Therefore, lack of experience with problem-based learning as a method of acquiring new knowledge can account only to some extent for the fact that first-year students seem to turn to their tutor for guidance more often than do advanced students. There is, however, another kind of "lack of experience" that may plague first-year students when entering the university. Especially in the first year of study, students are exposed to new domains of knowledge largely unfamiliar to them. In the case of medicine, subjects such as physiology, biochemistry, and anatomy, let alone the clinical disciplines, are largely unfamiliar at first. Each of these domains has its own set of concepts and its own internal organization to which students are generally unaccustomed. Of course, before entering the school, most have been exposed to some biology and chemistry, but medicine confronts them with many new concepts that need to be digested and integrated into their already existing knowledge bases. It is well known that prior knowledge facilitates the processing, comprehension, and retrieval of new knowledge by providing a cognitive structure by which new concepts can be assimilated.[9,10] But if prior knowledge is limited, students may have serious difficulty in interpreting the new information to be acquired and, hence, their learning may suffer. In this case, the presence of a subject-matter expert tutor may be helpful. He or she may provide the structure that the students cannot yet provide themselves through their prior knowledge. The implication of this analysis is that tutors' content expertise would be predominantly effective in those units for which students lack the necessary prior knowledge.

There is still another issue that seems to be relevant when one is interested in resolving the inconsistencies in tutor expertise research. An informal analysis of the data reported by my colleagues and myself[4] showed that effects of tutor expertise showed up in only some of the first-year units, whereas in other units the effect could not be found (a unit is a period of six weeks in which students study a particular theme). This observation suggests that the effect of tutor expertise on learning must be mediated through an unknown, unit-related factor. One possibility may be that, in some units, the learning environment provided—problems, learning resources, lectures, and skills training—is structured such that it can compensate for the relative lack of structure provided by a non-expert tutor. Davis and his associates, who previously published data indicating that tutor expertise has a considerable influence on student achievement,[2] failed to replicate this finding when they structured the learning environment of their students more extensively.[11] These observations suggest that, if one provides more structure to the learning of students, the effects of tutor expertise may become less pervasive.

Thus, the present study was done to investigate the conjecture that students in a problem-based curriculum need a minimum level of structure if any useful learning is to take place. This structure can be provided either internally, through the prior knowledge that students already have with regard to the topic at hand, or externally, through the structure provided by the learning materials. If these kinds of structures are missing for some reason, students will seek for structure provided by their tutor. Only under these conditions, may a content-expert tutor have a positive impact on his students' learning. Or to put it negatively: Only under these circumstances are students with a non-expert tutor handicapped as compared with their peers.

This theory of the way in which learning takes place in a problem-based curriculum has a number of testable consequences. First, effects of tutor expertise are mainly to be found in those units for which students lack relevant prior knowledge. In units for which students have a sufficient level of prior knowledge, no significant effect of subject-matter expertise of the tutor is to be expected. Second, expert tutors have their greatest impact on their students' learning in units where relatively unstructured learning materials are offered or where otherwise cues as to what to do are lacking. Third, effects of tutor expertise on achievement must be largest in those units that are unstructured and for which students lack prior knowledge. These hypotheses, predicting interactions between tutor expertise and students' prior knowledge and the "structuredness" of course materials, were tested using data acquired from the University of Limburg's health sciences curriculum.

METHOD

Students

The students were exactly 1,800 students attending the University of Limburg's Faculty of Health Sciences during the academic year 1989–90. Each student participated in an average of 4.1 tutorial groups. One hundred fifty-two staff tutors participating in the experiment ran 336 tutorials in 113 units. Each staff tutor ran an average of 2.2 tutorials. One hundred sixty-eight student tutors also participated in the experiment and ran 411 tutorials, for an average of 2.4 per tutor. The average response per tutorial group was 5.7 of ten members. Tutorial groups with less than four respondents were removed from the sample. The total number of data records—the number of students included in the study times the number of tutorials in which they participated—was 4,111. This was more than 55% of the total reservoir of records. The remaining records were excluded because they were incomplete.

Instruments

Student achievement was measured after each six-week unit by 100–150 true-false items (for first-year students) or by short-essay questions (for advanced students). The results were transformed to a scale ranging from 0 to 10, 6 being the passing score.

Routinely, students responded to a program evaluation questionnaire at the end of each unit, about two days before the achievement test was taken. This program evaluation questionnaire contained items inquiring about the quality of the various elements that comprised a unit, such as the problems used, the learning resources, the tutor, the lectures, skills training, and so forth. Students were asked to respond to these items on a five-point Likert scale ranging from 1, "strongly disagree," to 5, "strongly agree." Two items were relevant to the hypotheses tested in the present study. The first was "The unit's subject matter was adapted to my prior knowledge level." This item was considered an indicator of the amount of prior knowledge that the student brought to the learning situation. The second was "The unit has been well structured." This item was a measure of the amount of structure provided by the unit materials and other measures taken to ensure a structured environment, as perceived by the student. The data produced by the two measures were dichotomized to facilitate interpretation of the findings. A score of 1, 2, or 3 was considered low, whereas a score of 4 or 5 was considered high.

Procedure

For each unit, students and tutors were randomly assigned to the groups. The groups met twice a week for two hours to discuss the problems presented and to exchange information gathered through self-directed learning.

Two independent judges rated each of the staff tutors in each of the units as either a non-expert, a semi-expert, or an expert with respect to the subject matter of the unit. Non-experts were tutors whose previous training was unrelated to the topic at hand, e.g., a psychologist in a unit on metabolism. Tutors who had general background knowledge regarding the unit but not specific expertise, e.g., an epidemiologist tutoring a unit on health care management, were also considered non-experts. Experts were tutors with fairly specific background knowledge relevant to the unit, e.g., a biochemist in a unit on nutrition. Consequently, the same tutor could have been labelled a content expert in one unit and a non-expert in another unit. Interrater agreement was over 80%. Differences of opinion were resolved through discussion. Hence, three groups of tutors were defined, differing in levels of subject matter expertise: student tutors, non-expert staff tutors, and expert staff tutors.

Tutor characteristics, responses to the items of interest, and achievement data were analyzed using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Table 1 contains the average achievement scores under different levels of tutor expertise and students' prior knowledge. The first ANOVA conducted included tutors' expertise level and students' prior knowledge as independent variables and achievement as the dependent variable.

The main effect of expertise level on achievement was statistically significant, $F_{4110,2} = 12.30$, $p < .0001$, $MS_e = 1.04$. Thus, the higher the level of subject-matter expertise of the tutor, the better the students' achievement. The effect of prior knowledge was also statistically significant, $F_{4110,1} = 14.98$, $p < .0001$, $MS_e = 1.04$. This implies that students who indicated they had relatively limited prior knowledge performed less well on the achievement test than did those who indicated they had a fair amount of prior knowledge with regard to the unit's contents.

More important, the two-way interaction between tutors' expertise level and students' prior knowledge turned out to be statistically significant as well, $F_{4110,2} = 5.79$, $p < .003$, $MS_e = 1.04$. This finding is in agreement with the prediction that the level of expertise of the tutor interacts with the prior knowledge of the students: tutor expertise particularly influenced student achievement when the students had limited prior knowledge. When the level of prior knowledge was high, it was less important whether the tutor was a content expert. This can most clearly be seen in the relatively large difference between low- and high-knowledge students under the non-expert condition and the relatively small difference among the high-knowledge students under non-expert versus expert tutor conditions: .30 versus .11 respectively.

Table 2 lists the achievement scores with the three levels of tutor expertise and the amounts of structure provided by the various units. The influence of tutor expertise on achievement was, of course, statistically significant, $F_{4099,2} = 10.87$, $p < .0001$, $MS_e = 1.05$. So was the influence of low versus high structure, $F_{4099,1} = 6.49$, $p < .001$, $MS_e = 1.05$. The two-way interaction between expertise level and structure was also statistically significant, $F_{4099,2} = 3.25$, $p < .05$, $MS_e = 1.05$. When structure was low, the impact of tutor expertise was greater than when structure was high, suggesting that tutor expertise indeed compensated for lack of structure in the curriculum.

I assumed that the impact of tutor expertise would be greatest when a unit was both poorly structured *and* introduced topics unfamiliar to most students. To test this assumption, I combined the two variables, prior knowledge and unit structure, into one index, Prior Knowledge and Structure (PKS). Subsequently, an ANOVA was conducted on the achievement data with tutor expertise and the PKS as independent variables. Table 3 shows the results. Both main effects were found to be highly significant: expertise level, $F_{4095,2} = 10.42$, $p < .0001$, $MS_e = 1.04$, and PKS, $F_{4095,2} = 8.66$, $p < .0001$, $MS_e = 1.04$, as was the interaction between expertise level and PKS: $F_{4095,4} = 4.02$, $p < .005$, $MS_e = 1.04$. The interaction is graphically displayed in Figure 1.

Differences between different levels of PKS were larger under the non-expert than under the expert condition, again suggesting that expert tutors compensated for weaknesses in the curriculum. (The difference between the different levels of PKS was smallest for the students who had been guided by the student tutors. I discuss this finding in the General Discussion section.)

A problem with the method of analysis used here is that one cannot exclude the possibility of spurious correlations. For instance, students may know that their tutor is a non-expert, and therefore judge the unit in which he or she is the tutor as unstructured. Or they may have received so little guidance from this particular non-expert tutor that it seems to them that their prior knowledge was insufficient to deal with the contents of this particular unit. Alternatively, students

Table 1

Average Achievement Scores for Students with Low and High Levels of Prior Knowledge and with Tutors of Differing Content Expertise, University of Limburg Faculty of Health Sciences, 1989–90*

	Low Prior Knowledge		High Prior Knowledge			
Tutor Expertise	Avg. Score	No. of Student Data Records	Avg. Score	No. of Student Data Records	Total Avg. Score	Total No.
Student tutors	6.64	1,172	6.66	1,018	6.65	2,190
Non-expert staff tutors	6.51	366	6.81	363	6.66	729
Expert staff tutors	6.73	555	6.92	637	6.83	1,192
TOTAL	6.64	2,093	6.77	2,018	6.70	4,111

*Student achievement for the 1,800 students in the health sciences curriculum was measured after each six-week unit by 100–150 true–false questions (for first-year students) and short-essay questions (for advanced students). The results were transformed to a scale ranging from 0 to 10 (with 6 being the passing score). The students' levels of prior knowledge were self-assessed. The numbers of student data records indicate the numbers of students included in the study categories times the numbers of tutorials in which the students participated.

Table 2

Average Achievement Scores for Students in Units with Low and High Levels of Structure and with Tutors of Differing Content Expertise, University of Limburg Faculty of Health Sciences, 1989–90*

	Low-structure Units		High-structure Units			
Tutor Expertise	Avg. Score	No. of Student Data Records	Avg. Score	No. of Student Data Records	Total Avg. Score	Total No.
Student tutors	6.64	996	6.66	1,186	6.65	2,182
Non-expert staff tutors	6.54	317	6.76	409	6.66	726
Expert staff tutors	6.74	336	6.87	856	6.83	1,192
TOTAL	6.64	1,649	6.75	2,451	6.71	4,100

*Student achievement for the 1,800 students in the health sciences curriculum was measured after each six-week unit by 100–150 true–false questions (for first-year students) and short-essay questions (for advanced students). The results were transformed to a scale ranging from 0 to 10 (with 6 being the passing score). The units' levels of structure were assessed by the students. The numbers of student data records indicate the numbers of students included in the study categories times the numbers of tutorials in which the students participated.

Table 3

Average Achievement Scores for Students at High, Medium, and Low Prior Knowledge and Structure (PKS) Levels and with Tutors of Differing Content Expertise, University of Limburg Faculty of Health Sciences, 1989–90*

Tutor Expertise	Low PKS Avg. Score	Low PKS No. of Student Data Records	Medium PKS Avg. Score	Medium PKS No. of Student Data Records	High PKS Avg. Score	High PKS No. of Student Data Records	Total Avg. Score	Total No.
Student tutors	6.64	619	6.65	922	6.67	639	6.65	2,180
Non-expert staff tutors	6.43	188	6.64	305	6.88	233	6.66	726
Expert staff tutors	6.65	183	6.80	523	6.95	484	6.84	1,190
TOTAL	6.60	990	6.69	1,750	6.80	1,356	6.71	4,100

*Student achievement for the 1,800 students in the health sciences curriculum was measured after each six-week unit by 100–150 true–false questions (for first-year students) and short-essay questions (for advanced students). The results were transformed to a scale ranging from 0 to 10 (with 6 being the passing score). In addition, the students assessed the units' levels of structure and their own levels of knowledge prior to the units. These assessments were combined into a prior-knowledge-and-structure (PKS) index. The numbers of student data records indicate the numbers of students included in the study categories times the numbers of tutorials in which the students participated.

who worked with a subject-matter expert may have perceived the learning environment as sufficiently structured and their prior knowledge as adequate, simply because this tutor created the circumstances that led them to that judgement. The interactions disclosed between expertise and the two other variables may have been caused by these spurious processes, rather than by a genuine causal chain in which the structure in the curriculum or in the students' minds interacted with the level of expertise of the tutor to produce the findings reported.

To deal with this possible criticism, which would reduce the significance of the findings, I devised a second test of the theory. To that end, the 20 least structured and 20 most structured units were selected. The theory predicts that significant differences in achievement as a result of level of expertise of the tutor will emerge in the least structured units, but not in the most structured ones. The same applied to the 20 units that I selected for which students had the least prior knowledge and the 20 units for which they had the most prior knowledge. Again, differences in achievement would be expected in units for which prior knowledge was minimal, and no (or only marginal) differences would be expected when much knowledge was available.

The results generally supported the predictions. In units for which only limited prior knowledge was available, an effect of tutor expertise was found, $F_{731,2} = 3.91$, $p < .05$, $MS_e = 1.10$. This effect was absent in the high-prior-knowledge units, $F_{322,2} = 1.31$, $p < .28$, $MS_e = 1.44$. Similar results were produced by the analyses of the data gathered in the structured versus the unstructured units, with the exception that the difference was marginally significant ($p < .10$) in the high-structure units. These findings again support the idea that subject-matter expertise of tutors compensates for lack of structure in the curriculum or lack of prior knowledge among students, or both. If units are sufficiently structured and sufficient prior knowledge is available, effects of tutor expertise are ignorable.

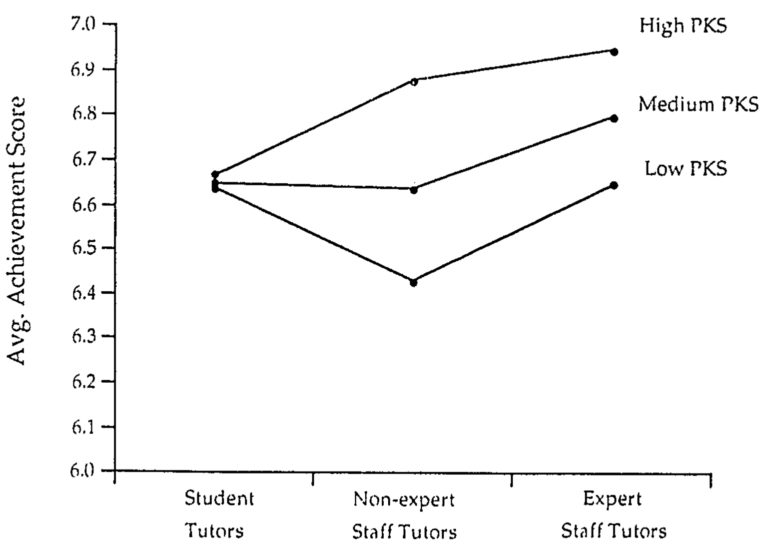

Figure 1. **Average achievement scores for students at low, medium, and high levels for the combined index of prior knowledge and unit structure (PKS) and with tutors of differing content expertise, University of Limburg Faculty of Health Sciences, 1989–90. A total of 1,800 students in the health sciences curriculum participated in the study, taking an achievement test after each six-week unit (with a score of 6.0 as the passing score). Both the students' levels of knowledge prior to the units and the units' levels of structure were assessed by the students.**

GENERAL DISCUSSION

Previous research led to the conclusion that students seek guidance from their tutor particularly in the first year, presumably because they are relatively unaccustomed to the practice of problem-based learning.[4] The tutor represents the person who may provide certainty, who can lead the way in an unstable learning environment. If the tutor is a content expert, leading the way can result in better achievement by his or her students.

In the study reported in this article, I pursued a generalized version of this hypothesis. I assumed that students in a problem-based curriculum seek structure: cues that help them decide what to pay attention to and what not. This structure can be self-produced or provided by the environment. I argued that in order to master new knowledge, students need to mobilize prior knowledge that helps them make sense out of the new information. Prior knowledge facilitates the comprehension of new material because it provides scaffolding and a context in which the new is to be understood. If prior knowledge is largely unavailable, student learning may be cumbersome and without direction. Under these conditions, students may be particularly in need of guidance. A content-expert tutor may fill that gap.

I have mentioned a second source of potential intellectual discomfort to students who enter a problem-based school. Basic to the problem-based educational philosophy is that students should "do it on their own." Learning should be self-directed. Students are thought to become independent learners who make their own decisions about what to study and how to study, depending on current needs. Some teachers understand this philosophy such that they provide students with only minimal cues as to what is expected from them. Problems presented are often overly complex, overburdened with information, and containing few guidelines as to where they should lead. References to the literature are scarce, too general, or even lacking, and tutors do not receive suggestions as to where students could be heading. Lectures are discouraged because students should learn to consult resource persons based on current learning needs. That students may have difficulty formulating what exactly their needs are, and therefore tend not to make use of resource persons, is often overlooked. Such a learning environment can hardly be expected to "involve students in their own learning." On the contrary, it may lead students to rather frantically look for help, or force them into fruitless attempts to "master everything," a study pattern observed in more than one of the problem-based schools.

In conclusion, I suggest that students need a minimum level of structure in order to profit from instruction, problem-based or otherwise. This structure can be internally provided through prior knowledge available for understanding the new subjects, or offered by the environment in the form of cues about what is relevant and what should be the focus of the students' activities. My assumption is that when prior knowledge falls short, or when the environment lacks structure, students will turn to their tutor for help and direction. Under those conditions, students who are guided by a subject-matter expert tutor may benefit more from the learning than students guided by a non-expert or those guided by a student tutor.

The findings presented in this article generally support this analysis. Interaction effects of level of expertise and the structure variables on achievement were found. In addition, an analysis of student achievement in relation to tutor expertise in extreme units also showed that the effect of subject-matter expertise of the tutor is largely confined to conditions in which students lack adequate prior knowledge or in which the instruction is poorly structured.

The student-tutor data seem to be an exception to the rule. Although students guided by a student tutor generally achieve less well than did students guided by staff, no difference related to the structure variables was found. In particular, under low-structure conditions, student tutors did a somewhat better job than did non-expert staff tutors. So, although student tutors are of limited help to their younger peers, they are better in dealing with unstructured learning situations than their non-expert staff counterparts. It is not clear why this is so. A possible explanation is that student tutors compensate for some of their lack of deep knowledge of the domain with the ability to be "cognitively congruent" with their students to a larger extent than do staff tutors. According to Moust,[12] student tutors are in a better position to express themselves in a language understood by their younger peers and can better identify with the particular difficulties encountered by these students. So, although their knowledge may be limited, they can make an optimal use of it to help their students.

What are the implications of the present findings for the areas of tutor expertise research?

First, they provide a possible explanation for why in some studies effects of tutor expertise have been found and in others investigators have failed to demonstrate these effects. For instance, the Swanson and colleagues[5] and Sherbrooke[6] studies were conducted in fairly well-structured curricula. In such curricula, the influence of the content expert will be small. On the other hand, the health sciences curriculum in the present study shows considerable variability in the amounts of structure provided and in the knowledgeability of the students. The same may apply to the small-scale experiments conducted by Eagle and colleagues[1] and Davis and colleagues.[2] Under these circumstances, tutor expertise is bound to make a difference.

The findings presented here also have implications for curriculum design in problem-based learning. If one considers the dependence of students upon their tutor's expertise undesirable, then it becomes important to prepare educational materials that are adapted to the levels of the students who use these materials. Simply presenting a set of patient problems in a medical curriculum might not any longer do the trick. Issues of complexity of these problems, the sequence of presentation, and the supporting literature will become the focus of attention of curriculum developers. In this respect, problem-based learning is not so different from conventional education after all.

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