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ABSTRACT

This study tested a causal model of the influence of tutor behavior on student achievement and interest in the context of problem-based learning. Data were gathered from 524 tutorial groups involving students in the health sciences curriculum at the University of Limburg in the Netherlands during 1992-93. Correlations among the 261 tutors' social congruence, expertise use and cognitive congruence behaviors, and small-group functioning and students' self-study time, intrinsic interest in the subject matter, and level of achievement were analyzed using structural equations modelling. The study found that the tutors' level of expertise use and social congruence not only directly affected their level of cognitive congruence but also affected other elements of the model. The level of cognitive congruence influenced tutorial group functioning, which in turn affected student self-study time and intrinsic interest. The results suggest that subject-matter expertise, a commitment to the students' learning and their lives in a personal, authtentic way, and the ability to express oneself in the language used by the students are all determinants of learning in problem-based curricula. (Contains 14 references.) (MDM)

What makes a tutor effective? A structural equations modelling approach to learning in problem-based curricula

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Abstract

Purpose. To test and further develop a causal model of the influence of tutor behaviors on student achievement and interest in the context of problem-based learning. **Method.** Data were analyzed from 524 tutorial groups involving students participating in the four-year undergraduate Health Sciences curriculum at the University of Limburg in 1992-93. These tutorial groups were guided by 261 tutors. Overall, 3792 data records were studied, with each student participating in an average of 2.3 groups. Correlations among tutor's social congruence, expertise use and cognitive congruence behaviors, small-group functioning, students' self-study time, intrinsic interest in subject-matter and level of achievement were analyzed using structural equations modelling. This statistical technique allows the investigator to test causal hypotheses on correlational data by comparing the structure of these data with a theoretical model. **Results.** After minor adaptations, the hypothesized causal model of the effective tutor fitted the data extremely well. The tutor's level of expertise use and social congruence not only directly affected his or her level of cognitive congruence but also other elements of the model. Level of social congruence influenced group functioning in a direct fashion, while expertise use had a slightly negative impact on the students' level of self-study time and a slightly positive on level of achievement. As hypothesized, level of cognitive congruence influenced tutorial group functioning. Level of group functioning affected self-study time and intrinsic interest. Finally, time spent on self-study influenced level of achievement. **Conclusion.** The results suggest that subject-matter expertise, a commitment to the students' learning and their lives in a personal, authentic way, and the ability to express oneself in the language used by the students are all determinants of learning in problem-based curricula. The theory of the effective tutor, presented in this article, merges two different perspectives prevalent in the literature. One perspective emphasizes the personal qualities of the tutor; his or her ability to communicate with students in an informal way, coupled with an empathic attitude that enables them to encourage student learning by creating an atmosphere in which open exchange of ideas is facilitated. The other stresses the tutor's subject-matter knowledge as a determinant for learning. The data presented in this article suggests that what is needed, really, is much of both.

Recently, a number of studies have shed light on the role of the tutor in student learning in the context of problem-based curricula. In particular, subject-matter expertise of the tutor has been a focus of attention.[1,2,3,4] A number of studies have demonstrated effects of tutor expertise on their students' achievement and effort. Davis and colleagues[2] at the University of Michigan, for instance, showed that student performance on a test measuring knowledge of influenza was enhanced when their tutors entertained an active research interest in that field. Eagle, Harasym and Mandin[1] 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. Schmidt and colleagues[4] found effects of subject-matter expertise on achievement in a health sciences curriculum (although these effects were largely confined to the first curriculum year). Other studies, however, failed to demonstrate noticeable effects.[5,6] According to Schmidt,[7] this may be due to the fact that subject-matter expertise seems tc play a rolė predominantly when the learning environment does not contain sufficient cues as to what is important to study or when students lack prior knowledge. Under such unstructured circumstances, students seem to rely on their tutor for guidance and might profit if their tutor happens to be someone knowledgeable regarding the subject under study.

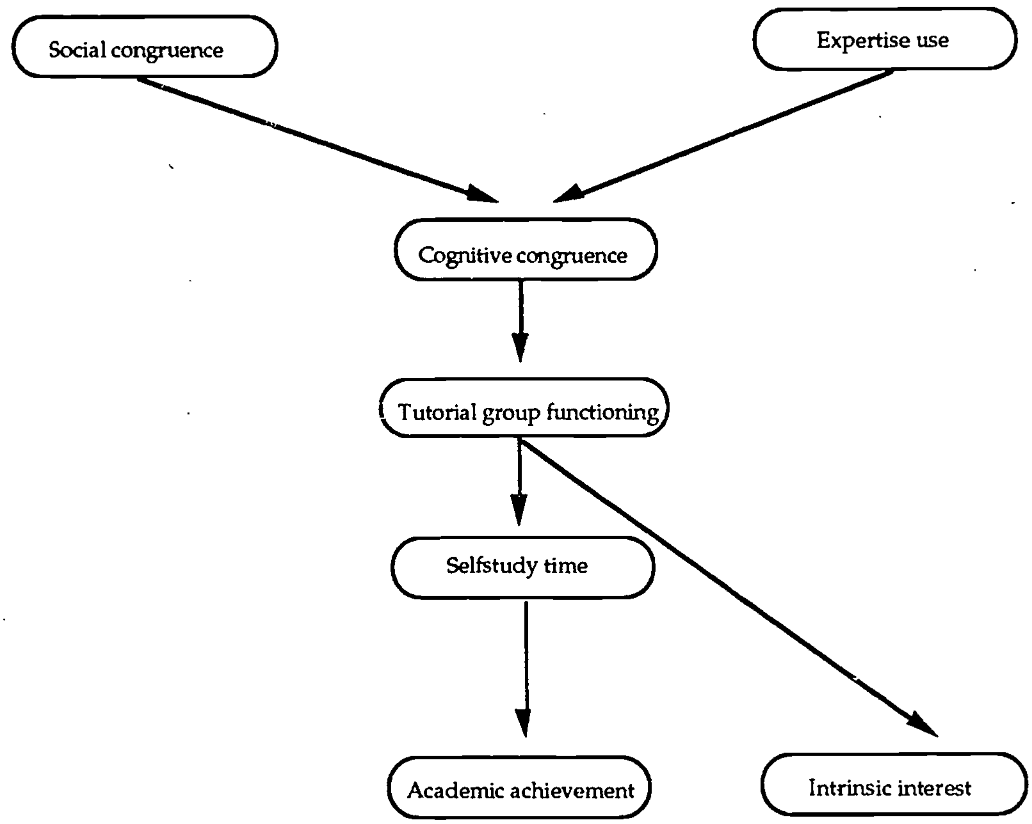
Less is, however, known about the actual *behaviors* of tutors that may produce these effects on student achievement. Schmidt and colleagues[4] found that subject-matter related tutor behaviors, such as guiding students using one's own knowledge, were positively correlated with process-facilitative behaviors, such as asking stimulating questions, while both were related to achievement. These findings seem to suggest that both categories of behaviors make a difference with regard to student achievement. Silver and Wilkerson,[3] on the other hand, showed that expert tutors tended to take a more directive role in the tutorials, spoke more often and for longer periods, provided more direct answers to students' questions, and suggested more items for discussion. Tutor-to-student exchanges predominated, with less student-to-student discussion. These findings suggest that expert tutors influence achievement at the expense of involving students in their own learning (Silver and Wilkerson, however, did not report achievement data). Davis et al.,[2] finally, were unable to demonstrate any differences in behavior between their expert and less-expert tutors.

In a careful analysis of behaviors displayed by staff and peer tutors involving extensive direct observation and interviewing, Moust[8] distinguished between six sets of behaviors that can be found among those guiding tutorial groups: Use of subject-matter knowledge, use of authority, achievement orientation, an orientation towards co-operation in the tutorial group, "role congruence," and "cognitive congruence." He defined role congruence as the willingness of the tutor to be "student among the students," that is: to seek an informal relationship with the students and display an attitude of personal interest and caring. Cognitive congruence was defined as the ability to express oneself in the language of the students, using the concepts they use and explaining things in ways easily grasped by students. Studying student learning in a problem-based law curriculum, he found that staff tutors, as compared with student tutors, were rated as making more extensive use of their subject-matter knowledge, more authoritarian, less cognitively congruent, less role congruent, and less achievement oriented. He found no differences in co-operation orientation.

Based on these findings, Moust[8] has proposed a theory of tutor performance and how it relates to student achievement. A key concept in his theory is cognitive congruence. Cognitive congruence is a necessary condition for tutors to be effective. If a tutor is not able to frame his or her contributions in a language that is adapted to the level of the students' understanding of the subject-matter studied, these contributions will go unnoticed. In addition, cognitive congruence assumes sensitivity of the tutor concerning the difficulties that students may come across while dealing with a problem or with the content relevant to that problem. He or she should know when to intervene and what to offer: asking for clarification, suggesting a counterexample, or providing some brief explanation. A tutor can only be effective in this respect, according to Moust, if he or she has relevant subject-matter knowledge and, in addition, has an authentic interest in his or her students' lives and their learning. Without appropriate subject-matter knowledge it will be difficult to follow the students' line of reasoning, let alone actively contribute to it. And without a genuine and personal interest in the students and their learning there would not be a tempting reason to help them carrying out their task, nor would there be a particular urge to understand the nature of the difficulties students meet with while learning based on problems. Therefore, both subject-matter expertise and interpersonal qualities are necessary conditions for cognitive congruence to occur.

Moust framed his ideas in the context of a theory of problem-based learning proposed by Schmidt and Gijselaers[9]. These authors assume that the tutor's behavior is one of three factors affecting the way in which small-group tutorials function (the other two being the students' prior knowledge and the quality of the problems handled). In turn, the small group's functioning would influence time spent on self-directed learning activities and intrinsic interest in the topic studied. Time spent, finally, would influence achievement on appropriate tests. Figure 1 summarizes Moust's position on tutor behavior and its effects on students.

Figure 1. Theoretical model of tutor behaviors and their relationship with other elements of problem-based learning.[a]



The figure can be read as follows: The more socially congruent the tutor is, and the more he uses his subject-matter knowledge, the more cognitively congruent he will be. Higher levels of cognitive congruence cause the tutorial group to function better, which expresses itself in more intrinsic interest in subject-matter displayed by the students, extended self-study time and higher achievement. The diagram can be considered a causal model within the "models-of-school-learning" tradition, exemplified by authors such as Bloom[10] and Carroll[11].

The purpose of the present paper is to report on the results of a study in which this theory of the effective tutor was tested against data gathered in the University of Limburg's health sciences curriculum. To that end, data from 524 tutorial groups and their tutors were studied. These data were analyzed using a structural equations modelling

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[a] Based on a post-hoc analysis of Moust's data, I decided to merge role congruence and authority into "social congruence," because they were highly negatively correlated in Moust's study and appeared to refer to the same underlying construct; authority implying an aloof attitude and, therefore, being the reverse of role congruence.

approach.[12] Structural equations modelling is a statistical technique that allows the investigator to test causal hypotheses on correlational data by comparing the structure of these data with a theoretical model. The data may, or may not "fit" the model.

Method

Subjects

Subjects were 1452 students attending the University of Limburg's Health Sciences curriculum during the academic year 1992-1993. Each student participated in on average 2.3 tutorial groups. From the pool of 618 tutorial groups from which data were available, 524 were selected. The selection criterion was that, for these groups, at least five student ratings of their tutors were available. This was considered necessary to obtain a reliable judgement of the tutors' behavior. In the final sample, 261 tutors were assessed who ran, on average, two groups. A total of 3792 data records was included, averaging 7.24 per tutorial group.

Instruments

Routinely, students responded to a program evaluation questionnaire at the end of each course, about two days before the achievement test was taken. This program evaluation questionnaire contains items inquiring about the quality of the various elements that comprise a course, such as the problems used, the learning resources, the tutor, the lectures, the practicals, and so forth.[13] Students are asked to respond to these items on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." For the present study, tutor behavior was rated on a three-point scale ranging from "not present," via "somewhat present," to "present."

Social congruence was measured by a five-item rating scale: To what extent the tutor took a personal interest in the students' learning activities and the group's well-being? To what extent was he or she open to the students' points of view? *Use of subject-matter expertise* was measured by five items, such as: The tutor was sufficiently knowledgeable regarding the course's subject-matter. And: The tutor used his subject-matter knowledge to guide the group. *Cognitive congruence* was measured by three items, among them: The tutor displayed an understanding of our problems with the subject-matter. And: The tutor succeeded in explaining things in a comprehensible way. *Tutorial-group functioning* was measured by two items inquiring whether students considered the group productive and whether they thought the meetings were agreeable. *Time spent on learning* was measured by asking students to give an estimate of the number of hours per week spent on self-directed learning activities. *Student achievement* was measured after each six-week course by 100-150 true-false items (in the first year) and short-essay questions (in subsequent years). The results were transformed to a scale ranging from 1 to 4, 3 being the pass score. Finally, *intrinsic interest* in subject-matter was measured by inquiring how interesting they thought the course's subject-matter was. Intraclass coefficients as indicators of the generalizability of the ratings varied between .75 and .90 (for use of expertise) under the assumption that five raters were involved. This finding indicates that the measures were sufficiently reliable for use in further analyses.

Procedure

For each course, 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. Ratings and achievement data were collected at the end of each six-week course. The resulting data were aggregated for each tutorial group. This was done to ascertain independent measurement.

Statistical analysis

The data were analyzed using a structural equations modelling approach.[12] Structural equations modelling allows one to test causal hypotheses among multivariate data. These theoretical, causal, hypotheses are expressed as a set of structural equations, akin to multiple regression functions. EQS, the program used,[12] provides a number of relevant statistics, among them a χ^2 statistic that can be used to test whether the empirical data sufficiently fit the theoretical model. In addition, other statistics have been developed for the evaluation of a particular model. Since educational theories are not yet sufficiently developed to allow for all-or-none decisions regarding the acceptability of a certain model, often a number of reasonable alternative models are tested, each less stringent than its precursor.

Results and Discussion

Table 1 displays the correlation matrix for the variables of interest.

Although the structural equations modelling program analyzes covariances among variables rather than correlations, the correlation matrix is given for readability purposes.

Table 1. Correlations among variables of interest. Means and standard deviations are also given.

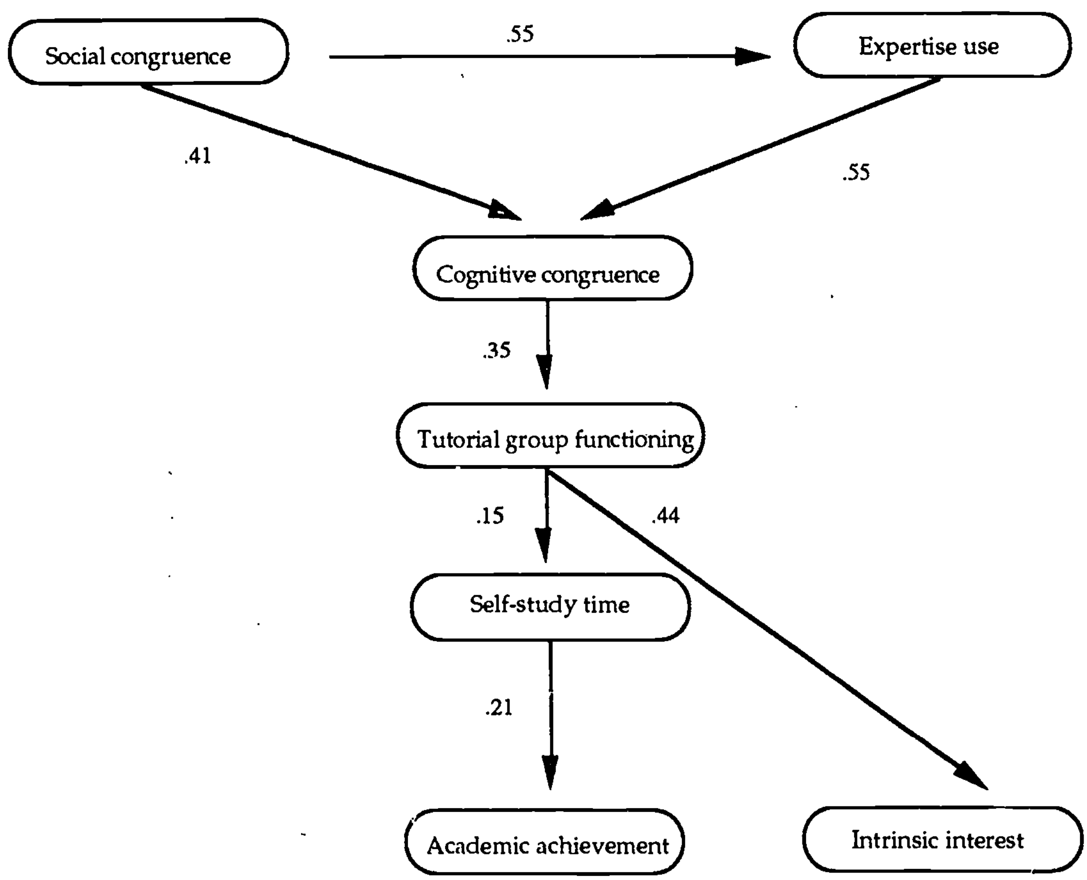
	Expertise use	Social congruence	Cognitive congruence	Group functioning	Time spent	Achievement	Intrinsic interest
Expertise use	1.00						
Social congruence	.55**	1.00					
Cognitive congruence	.77**	.71**	1.00				
Group functioning	.26**	.37**	.35**	1.00			
Time spent	- .07	- .08	- .09	.15**	1.00		
Achievement	.10*	.08	.06	.06	.21**	1.00	
Intrinsic interest	.16**	.15**	.16**	.44**	.11*	.10*	.00
Means	2.60	2.74	2.69	3.86	16.62	3.01	3.90
Standard deviations	.32	.26	.32	.57	5.90	.41	.61

* $p < .05$. **$p < .01$.

The model of problem-based learning, outlined in the introduction section, was tested against these data. The resulting χ^2 was equal to 46.89, based on df = 14, $p<.001$. These findings indicate that the Moust model of the effective tutor does not adequately represent the data. A problem, however, with analyses using χ^2 for the evaluation of model adequacy is, that this statistic is quite sensitive to violations of its distribution, in particular in relatively small samples. Therefore, other statistics of fit have been developed that are less sensitive to violation of assumptions underlying the $\chi 2$ distribution. These statistics include the Bentler-Bonnett Normed and Nonnormed Fit Indices and the

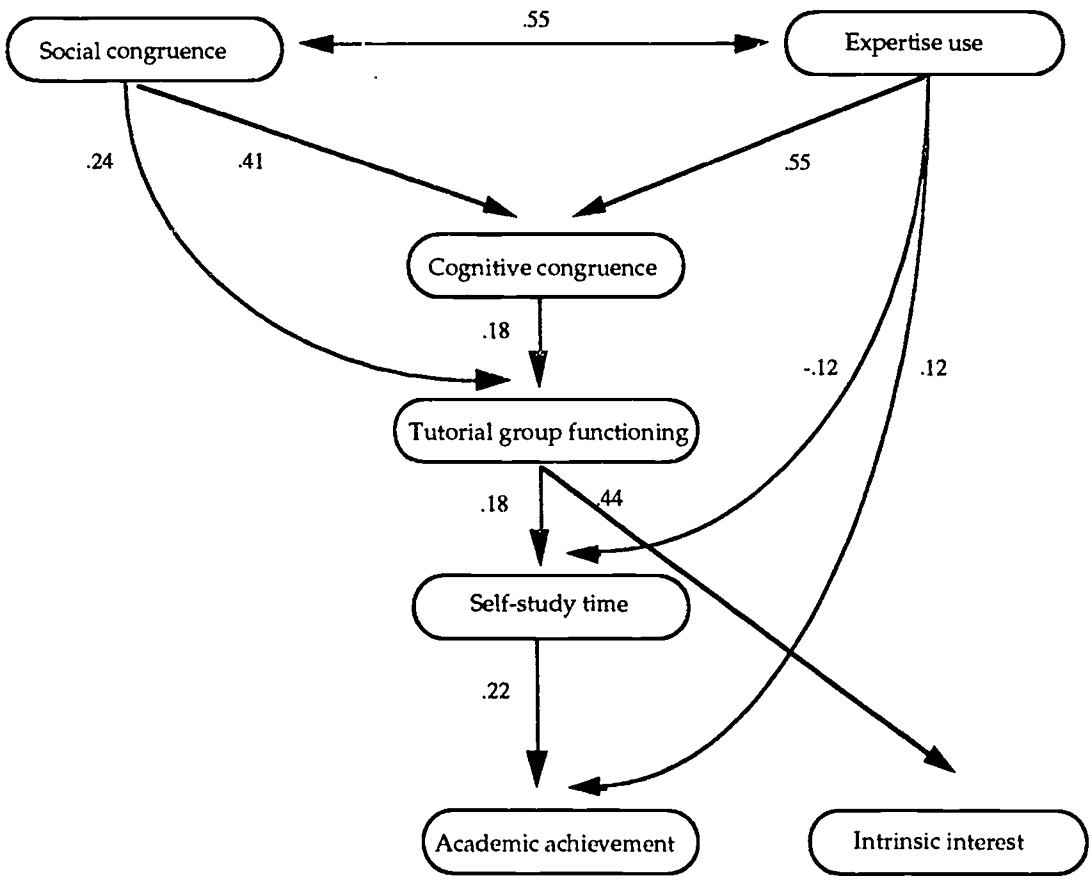
Comparative Fit Index (CFI). Since the CFI takes into account attributes of the unrestricted model relative to the model under test, it will be reported here. For the model tested, CFI = .97. In addition, the root mean square residual (RMSR) was smaller than .07.[14] The latter two indices suggest that the model tested represents a reasonable first approximation of the structure underlying the data. Figure 2 shows the relevant path coefficients. These path coefficients indicate the strength of the causal relationship between any two variables. Only statistically significant path coefficients are displayed.

Figure 2. Causal paths for the M<oust model of the effective tutor (error terms are omitted for readability).



In comparison to prototypical findings using this technique, the causal influences of social congruence and expertise use on cognitive congruence; of cognitive congruence on group functioning; and of group functioning on intrinsic interest are fairly large. The influence of tutorial group functioning on self-study time is somewhat more limited and so is the influence of time-on-task on achievement. Note that in this model only one-to-one relations are allowed. This may be an unnecessary restriction, because there is no compelling theoretical reason why, for instance, social congruence of the tutor could not influence the quality of tutorial group functioning directly, in addition to an indirect influence via cognitive congruence. Assuming that social congruence not only contributes to higher levels of cognitive congruence in the tutor, but also may have a direct positive impact on the way the group members interact with each other, a direct path would be appropriate. In addition, one could assume that the use of expertise by the tutor would not only indirectly, through cognitive congruence and group functioning, but also directly, affect the amount of time spent by students, or achievement. Etc. We tested some of these alternatives and found that with a number of adaptations of the original model an excellent fit of the data could be established. The less restrictive model is displayed as Figure 3. For this embellished model of the effective tutor, χ^2 was equal to 15.36, df = 11, and p = .17. In addition, CFI = .99 and RMSR < .07.

Figure 3. Less restrictive variant of the effective-tutor model.



These findings complicate, but do not contradict Moust's (1993) original assumptions. Both social congruence and expertise use appear to be important constructs because they do not only affect cognitive congruence --as was hypothesized by Moust-- but also influence other variables in the model. Social congruence does not only help the tutor being more cognitively congruent with his or her students, but also seems to facilitate group performance in a more direct way. Observations of small-group sessions have indeed documented immediate effects of tutoring style on the nature of student interactions, the more informal tutoring leading to higher levels of participation.[3] In addition, students almost invariably report that they feel more free to contribute if a tutor displays an interest in what they do.[8]

Intriguing is the slightly negative influence of expertise on time-on-time on task, suggesting that the more the tutor contributes to the discussion using his own subject-matter knowledge, the less time students spend on self-directed learning. A similar trade-off effect has been demonstrated between tutorial group functioning and time-on-task (though not in the present study), suggesting that students tend to compensate for more extensive forms of education -- be it through the quality of their tutorial sessions, be it through direct intervention of their tutors-- by decreasing the amount of time they spent on self-study.[9] Finally, the effect of the tutor's subject-matter expertise on achievement has been demonstrated in other studies as well.[2,4]

The study presented here has several shortcomings, the most notable being that students were used as raters of their tutor's behavior. Although students are in the best position to observe a tutor for prolonged periods of time, their role is not to observe their tutor but to learn. This may have narrowed their perspective on their tutor's functioning. A further difficulty with the use of student ratings is, that students may share an implicit theory of effective tutoring that not necessarily matches what really is going on in tutorial groups. In the latter case, the findings may reflect this implicit theory of tutoring rather than reality. However, the fairly high intraclass coefficients found suggest that whatever students may have observed, their agreement on what they have seen is considerable. In addition, the relationship of the student ratings with achievement found in this study and several others is an argument in favor of accurate observation by student raters and, hence, of the validity of the data.

A second, more serious, limitation of the study is the retrospective nature or the measurements. The variables of the model were measured at the end of a six-week learning cycle. Generally, it is to be preferred to measure behaviors when they occur rather than to ask subjects to report retrospectively on them. Retrospective observation is generally more sensitive to possible Halo effects than "on-line" observation because of the human tendency to restructure the past such that "everything makes sense."

A final and related limitation of the study is that most variables, with the exception of achievement were measured concurrently. This poses a problem for causal models that assume --at least theoretically-- some sort of temporal order in the occurrences of events and, therefore, in their measurement. It is, however, extremely difficult to measure variables in the predicted temporal order in an ongoing educational process in which some of the influences may be reciprocal, others circular. "True" temporally ordered measurement may only be possible in experimental designs.

These considerations, of course, limit the significance of the findings and, at the same time, show avenues for further research into the issue of effective tutoring. It would, for instance, be useful to study tutors and their effects on student learning using direct observation by independent raters. In addition, it would be important to develop measures other than retrospective ratings for some of the variables in the model. This would be particularly useful for time-on-task and tutorial group functioning, because of their central role, not only in the model of effective tutoring presented here, but also in the more general model of problem-based learning as developed by Schmidt and Gijselaers.[9]

Conclusion

Effective tutoring in the context of problem-based learning seems to imply three distinct, though interrelated, qualities; the possession of a suitable knowledge base with regard to the topic under study, a willingness to become involved with students in an authentic way, and the skill to express oneself in a language understood by students. The present study has demonstrated how these skills interact with each other and how they influence other elements of learning in a problem-based environment: Tutorial-group functioning, self-study time and academic achievement. The findings corroborate and extend those from an earlier study, using different measurements.[4] In the latter study, it was shown that use of subject-matter expertise and student-facilitation behaviors were both causally related to achievement and, in addition, were positively correlated. The present study demonstrates *why* this is so.

This theory of the effective tutor merges two different perspectives prevalent in the literature. One perspective emphasizes the personal qualities of the tutor; his or her ability to communicate with students in an informal way, coupled with an empathic attitude that enables them to encourage student learning by creating an atmosphere in which open exchange of ideas is facilitated.[3,8] The other stresses the tutor's subject-matter knowledge as a determinant for learning.[2] The data presented in this article suggests that what is needed, really, is a lot of both.

This theory has implications both for the selection and the training of tutors. Relevant subject-matter knowledge is an obvious selection criterion of tutors for a particular course. Previous research has shown that particularly in unstruc'ured learning environments and in situations in which the students lack relevant prior knowledge, content expertise of the tutor makes a difference.[7] Training should concentrate on methods by which tutors can create an informal learning environment in which students feel free to exchange ideas with their peers and their tutor. Particular attention should be given to cognitive congruence: How can tutors use their subject-matter expertise in helping student to come to grips with the topics studied?

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