

The relationship between student-generated learning issues and self-study in problem-based learning

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Abstract. A major assumption of problem-based learning (PBL) is that learning issues, generated by students while discussing a problem, are used as guides for self-directed learning activities. This assumption, though basic to PBL, has never been tested. At the University of Limburg, the Netherlands, two procedures have been developed that reflect the extent to which students are able to identify important learning issues given a particular problem, and whether subsequent, independent, learning corresponds with these learning issues. The focus of the present article will be on the relationship between the two. We have explored to what extent student-generated learning issues are a major factor influencing the nature of students' self-study, or whether other factors may be involved in decisions on what to study and how much time to spend on topics selected. First, the production of learning issues was studied and represented as the percentage of overlap between learning issues raised by students and pre-set faculty objectives for each problem. The second procedure consisted of the administration of a 'Topic Checklist' (TOC) which purports to measure students' actual self-directed learning activities. The TOC consists of a list of topics specifying the intended course content. Students were asked to indicate on a five-point Likert scale how much time they had spent studying each topic and to what degree they had mastered that topic. Third, learning issues and TOC topics were compared directly in a qualitative sense. Comparisons between the procedures revealed that a low proportion of variance of TOC scores could be predicted from the percentage of faculty objectives identified for each problem and the direct match between learning issues and TOC scores. It is concluded that scrutinizing student-generated learning issues and topics covered during self-study may provide information about what content is covered by students in tutorial groups. The discrepancy between the results of the measurements suggests, however, that learning issues produced during group discussion are not the sole source on which students base self-study decisions. Several other factors may be involved, such as tutor guidance, content already covered in previous units, issues raised during sessions with resource persons, and the nature of the learning resources available. Therefore, the relationship between learning issues and content covered during self-study is not as straightforward as is suggested.

Key words: problem-based learning, student learning

Introduction

Recommendations in the report of the panel on the General Professional Education of the Physician (GPEP), entitled Physicians for the Twenty-First

Century (Association of American Medical Colleges, 1984), have put in motion curricular changes in many medical schools. 'Conventional' approaches to education characterized by 'spoon-feeding' would not sufficiently prepare students for lifelong learning, since students in such curricula are assumed to be more or less passive recipients of information. According to the report, innovative approaches to education are required, that encourage students to become active, independent, self-directed learners and problem-solvers in order to prepare them for lifelong learning. An innovative approach to medical education that appears to accommodate the recommendations as listed in the GPEP report is problem-based learning (PBL). Whereas a conventional approach to education tends to emphasize teacher control over the learning activities of students, mainly through lectures, PBL puts students in charge of their own learning, making them responsible for decisions on what to study and to what extent. Whereas conventional training generally can be considered 'teacher-centered', PBL is generally seen as more 'student-centered' (Barrows & Tamblyn, 1980; Norman & Schmidt, 1992). Problem-based learning encourages students to eventually take full responsibility for their own learning. These ideas are in accordance with work on the application of psychological science to education that have brought into reach the aim of fostering students' ability to become architects of their own knowledge (Glaser, 1991).

That PBL is indeed successful in inducing these expected behaviors in students is indirectly evidenced in a study by Blumberg & Michael (1992). Data from library circulation statistics showed that PBL students during pre-clinical years, as well as during clerkship years, borrowed more resource materials than students from a conventional track. It is generally assumed that this information-seeking behavior results from prior problem discussion and encouraging students to generate their own learning issues in need of further exploration (Barrows, 1985; Walton & Matthews, 1989). However, Blumberg & Michael (1992) suggest that group-generated learning issues may not be the sole determinant of content to be learned, but that self-directed learning activities are also influenced by factors such as reinforcement and encouragement by peers and faculty facilitators, and congruity between the various elements that make up the curriculum, such as books and articles referred to and subject-matter covered in resource sessions. They do not, however, provide empirical evidence that what students actually *do* may not only be determined by what they *intend to do*, i.e., the learning issues generated through small-group discussion. This discrepancy between what students intend to do and what they actually do will be illustrated below.

In PBL, problems are the starting-point for students' self-directed learning activities. Problems can be considered the most important instructional

materials presented to students during a course; they embody the objectives of the teachers who produced them. Teachers do write problems with certain objectives in mind: The problem should introduce the student to a particular domain and help him/her acquire an understanding of that domain. Unlike conventional education, however, the control over student learning is indirect; objectives are usually not shared with students. The reason for this is that providing students with the objectives underlying each problem would take away the process of discovery of what is important to learn, and, hence, would deprive students of the opportunity to acquire self-directed learning skills (Bruner, 1971). A group of 8 to 10 students guided by a tutor discusses problems such as these and tries to explain the phenomena in terms of their underlying processes, principles, or mechanisms (Schmidt, 1983). During these discussions issues emerge that require further exploration. These student-generated learning issues are used as guides for self-directed learning activities and define what students intend to study.

In conclusion, student learning in PBL is a process comprising several components which should occur in a specific sequence as the students work in small groups. This process can be briefly summarized as follows: teachers design problems with certain faculty objectives in mind, subsequently, students discuss these problems and generate learning issues. A major assumption of PBL is that these student-generated learning issues are used as guides for students' learning activities during self-study.

A problem usually consists of a description of a set of phenomena in need of some kind of explanation. An example of a problem is shown below. It is presented to the students at the Medical School of the University of Limburg, the Netherlands, during a second-year course on normal child development in the 1990–91 academic year.

Problem: 'Unknown feelings'

Susan feels her baby moving in her womb. Besides this new experience, a number of things have changed in the last six months. Her breasts have enlarged and have become more sensitive. Sometimes, she loses a few drops of milk. Furthermore, she has gained about six kilograms in weight and feels like a swollen balloon.

Her husband complains of Susan eating too many sweets. Because Susan has gained weight, her clothes do not fit any more. Furthermore, she experiences some physical troubles. She has felt clumsy for the last few weeks, as she breaks a lot of things. Needlework, one of her favorite hobbies, is very difficult for her. For a few weeks she has been unable to stand temperatures above 25 degrees Celsius. Her shoes do not fit anymore and her rings pinch. Because of heartburn behind her breastbone and tingling fingers, she sleeps poorly at night.

Despite all these inconveniences, she really enjoys her pregnancy, she feels a fulfilled woman, a feeling she has never had before.

As indicated already, during discussion students generate learning issues. Ideally, these student-generated learning issues should match faculty objectives. This statement is self-evident. If students produce issues for self-study that are entirely different from those intended, one could question why the particular problem was written in the first place, since it does not play any role in the decision process. In the second place, if students fail to generate the appropriate issues, the intended learning outcomes are not accomplished. An example of assessing the match between student-generated learning issues and faculty objectives is shown below. Faculty had five objectives in mind while designing the problem 'Unknown feelings', presented above. These objectives were: (1) adaptation of the mother's circulatory system and metabolism during pregnancy, (2) role of the placenta in the process of the adaptation of the mother's circulatory system and metabolism during pregnancy, (3) mother's organ changes (e.g. kidneys) during pregnancy, (4) consequences of changes in mother's body functions for mother and baby during early and late pregnancy, and (5) changes in mother's behavior and mood during pregnancy and factors influencing this behavior and mood. Given the particular problem one tutorial group generated the following six learning issues: (1) Which mechanisms explain enlargement and sensitiveness of breasts? (2) Which mechanisms explain gain in body weight, swollen feet and tingling fingers? (3) What explains clumsiness and poor sleeping during pregnancy? (4) Which hormonal changes take place during pregnancy? (5) What psychological changes take place during pregnancy? (6) Does the fetus have a sleep-wake rhythm? Comparing the learning issues of this tutorial group with the pre-set objectives stated above, reveals that the third objective, 'Addressing changes in the various organs (e.g. kidneys) during pregnancy,' was not identified by the tutorial group. Students may not have raised this issue because of several reasons, such as lack of cues in the problem itself pointing to the importance of organ changes. The fact that the organ-change issue was not raised, does not, however, automatically imply that these students did not study any relevant material. The literature might have revealed to them that this is an important element in understanding the changes occurring during pregnancy and, hence, the organ-change issue deserves attention. On the other hand, it might be possible that students, although they identify the pre-set faculty objectives, do not actually pursue the learning activities suggested by the learning issues they have raised. Students will not study certain learning issues when they have already studied the relevant material in previous courses. It is also possible that students pay a lot of attention to a learning issue during discussion in the tutorial group and eventually decide not to spend

time on this issue during self-study. From these examples, it may be clear that student-generated learning issues produced during group discussion may not be the sole source on which students base self-study decisions. In other words, student-generated learning issues may not solely determine students' learning activities, but several other factors might also have a significant influence.

In this article, the major assumption of PBL that learning issues, generated by students while discussing a problem, are used as guides for self-directed learning activities, is tested. Since, ultimately, students in a problem-based curriculum select their own topics for self-study and decide for themselves how much time to spend on studying each of these topics, it is not an easy task to acquire an insight into the nature of the learning issues raised and the learning going on when students individually pursue these learning goals. In this article, three procedures are described that are helpful in recording these activities. The first is based on the use of tutors as informants. They are asked to record the learning issues generated by their tutorial group for each problem. These learning issues are listed for each problem. Subsequently, pairs of expert raters are asked to judge the match between faculty objectives and student-generated learning issues. The amount of content covered for each problem is computed as the average percentage of faculty objectives identified by the tutorial groups participating in a particular course. The second procedure questions students about their actual learning activities. This procedure consists of a list of topics, identified by the teachers who developed the problems, representing the subject-matter expected to be studied by the students. Students are asked to indicate on a five-point Likert scale how much time they spent studying each topic and to what degree they assume they have mastered the specific topics. The third procedure consists of a qualitative comparison between learning issues and topics. One of the authors judged whether each topic was covered by the learning issues generated by each tutorial group for that problem. All procedures are based on a comparison with the original instructional intentions of the teachers who designed the problem that gave rise to the various learning activities. We will discuss these procedures in some detail below. The goal of the present article is to report on a comparison of the results of these procedures and to account for possible discrepancies. This comparison of indicators of learning in PBL might assist in answering the question whether student-generated learning issues are the major force in driving students' learning, as is generally assumed in PBL (Barrows, 1985; Walton & Matthews, 1989), or whether other factors may be involved.

Method

Subjects

This study was conducted in a second-year course of the medical curriculum of the University of Limburg, the Netherlands. In total, 70 students in the 1990–91 academic year participated in this study. In addition, 12 tutors were part of the experiment. Both students and tutors were randomly assigned to 12 tutorial groups. The number of participating students for each tutorial group varied between four and eight. All the students that participated in this study attended at least 80 percent of all tutorial group meetings.

Materials and procedure

The course under scope of study was a six-week second-year course. This course deals with subject-matter related to childbirth, psychomotor development, and psychosexual development. The materials in this study consisted of 12 problems and a list of topics specifying the subject-matter that faculty expected students to cover for each problem. These materials are described below.

The 12 problems were based upon 51 faculty objectives covering the course as a whole, one to eight objectives for each problem, with an average of 4.3 objectives. The tutors participating in this course were asked to record for each problem all the learning issues generated by their tutorial group. Tutorial groups generated 1 to 10 learning issues for an individual problem, with an average of 3.6. Subsequently, 12 pairs of expert raters were asked to judge the match between faculty objectives and student-generated learning issues. They were instructed to judge individually the correspondence between student issues and faculty objectives (Dolmans, Gijselaers, Schmidt & Van der Meer, 1993; Eagle, Jennet & Mandin, 1992). For each comparison, raters had to judge whether a particular learning issue was (1) definitely similar to a particular faculty objective, or (2) definitely dissimilar. The cases in which raters could not give definite judgements were considered dissimilar. A faculty objective was assumed to be identified if both raters agreed about its similarity to the learning issue judged. If both raters agreed that there was no similarity, then an objective was considered as being not identified by the students. If the raters disagreed, i.e., if one rater observed similarity and the other failed to do so, then an objective was also assumed not to have been identified. The average inter-rater agreement for the pairs of raters, as estimated by the Kappa-coefficient, was 0.45, which demonstrates a moderate level of agreement between raters (Dolmans, Gijselaers, Schmidt & Van der

Meer, 1993). The amount of content covered for each problem was measured as the average percentage of faculty objectives identified by the 12 tutorial groups. These data were collected at the level of problem by tutorial group. Consequently, the data consisted of 12 (problems) by 12 (tutorial groups), or 144 data-points.

Topics reflecting the content faculty expect students to cover during self-study for each problem, were listed in the so-called 'Topic Checklist' (TOC). The process of generating topics consisted of two stages. First, the researcher specified for each problem a list of topics reflecting the intended course content. Second, this list of topics was presented to three teachers responsible for the development of the course. They first individually assessed whether these topics were intended when constructing the course. Topics which were not intended according to all three teachers were removed and topics missing from this list were added. In the few cases in which the teachers disagreed, i.e., one teacher considered that it was important to list the topic and the others did not, then the topic was discussed by the teachers until they reached consensus. Since these teachers were responsible for the development of the course, they were assumed to be experts in examining which topics were to be studied by students. The resulting list of 126 topics reflected the course content assumed to be studied by students during self-study, and as such these topics can be seen as a blueprint of the course. Topics related to the problem presented above were, for instance: (1) metabolism during the last four months of pregnancy, (2) changes in hormonal activity during pregnancy, (3) changes in water-balance during pregnancy, (4) accumulation of fat and water, (5) changes that take place in breasts, (6) physiological changes in blood circulation, (7) the influence of placenta hormones on feelings of mothers-to-be towards pregnancy, (8) manifest phenomena during pregnancy, (9) changes in behavior and mood of mothers-to-be, (10) metabolism during the first months of pregnancy, and (11) psychological aspects of pregnancy. In addition, eight topics not related to the course content were included to estimate response set effects. Thus, the total number of topics included in the TOC was 134. For each topic two Likert-type questions were formulated. First, students were asked to indicate whether they mastered each topic: not at all (1), insufficiently (2), reasonably well (3), sufficiently (4) or very well (5). Second, they had to indicate whether they had spent: no time at all (1), little time (2), a fair amount of time (3), much time (4) or very much time (5) on studying each particular topic. The first question measures students' perceptions about the degree to which they mastered the subject-matter as mentioned. The second question measures students' estimate of time spent on studying a particular topic.

At the end of the course, students were asked to fill out the TOC. Since the topics of the TOC were initially derived from the 12 problems, the topics could be categorized across problems. Subsequently, average time and mastery scores were computed for each problem. TOC scores were computed as the average score per problem. In addition, TOC data were aggregated at the level of tutorial groups, to enable comparisons among learning issues raised (expressed as a match percentage) and tutorial groups' average time and mastery scores for each problem. Thus, due to the level of aggregation, the TOC data also consisted of 12 (problems) by 12 (tutorial groups), or 144 data-points.

A number of studies have been conducted to assess the TOC's reliability and validity. The results of these studies are reported in Dolmans, Gijsselaers & Schmidt (1993) and can be summarized as follows. Generalizability studies indicated that the TOC is a fairly reliable procedure. Furthermore, the TOC's content validity was assured, since the topics were selected on the basis of explicit rational considerations. Moreover, the criterion validity, measured as the correlation between the total average TOC scores for each individual student and corresponding achievement test score, was modest.

In addition, in a qualitative sense the learning issues generated in each tutorial group were compared with TOC topics. For this qualitative comparison, one of the authors judged whether each topic that teachers had in mind while developing the problem was covered by the learning issues generated by each tutorial group for that particular problem. The degree of correspondence was judged on a five-point Likert-scale: not at all (1), insufficiently (2), reasonably well (3), sufficiently (4) or well (5).

Finally, two subsequent sessions of one tutorial group while working on the 'Unknown feelings' problem were observed by one of the authors. This was done to collect further qualitative data on how students produce, and subsequently deal with, learning issues.

Results and discussion

First, the amount of overlap between student-generated learning issues and faculty objectives will be presented. Second, the results of the TOC will be discussed. Third, TOC time and mastery scores will be compared. Fourth, the percentage of faculty objectives identified and TOC scores will be compared. Finally, the results of the qualitative comparisons between learning issues generated and TOC topics will be presented.

The average amount of overlap between learning issues and faculty objectives for the set of 12 problems was 64.1 percent ($SD = 26.7$). The amount

Table 1. Percentages of overlap between faculty objectives and student-generated learning issues (column 2), average time scores (column 3), average mastery scores (column 4) and direct match scores between learning issues and topics (column 5) for 12 problems in a second-year course on normal pregnancy, delivery, and child development, 1990–1991.

Problem	Overlap		Time spent		Mastery		Direct match	
	mean		mean	SD	mean	SD	mean	SD
1	76.3		2.69	0.29	3.21	0.23	3.52	0.31
2	71.7		2.91	0.27	3.45	0.27	3.04	0.44
3	70.8		2.56	0.21	3.28	0.29	3.31	0.57
4	56.7		3.19	0.34	3.70	0.34	3.03	0.58
5	63.3		2.43	0.23	2.99	0.29	2.70	0.26
6	61.1		2.94	0.38	3.49	0.35	3.38	0.64
7	60.4		2.80	0.33	3.29	0.38	3.92	0.60
8	68.8		2.85	0.26	3.29	0.24	3.07	0.45
9	56.3		2.55	0.29	3.10	0.30	3.52	0.85
10	56.7		2.62	0.28	3.31	0.30	3.18	0.61
11	27.7		2.97	0.29	3.68	0.18	2.96	0.42
12	100.0		2.05	0.30	2.43	0.29	2.57	0.57
Total	64.1		2.71	0.40	3.27	0.43	3.18	0.64

of overlap for each of the 12 problems varied between 27.7 and 100 percent and differed significantly ($F(11,143) = 6.84, p < 0.000$). The percentage of overlap for each problem is shown in column 2 of Table 1. The amount of overlap between objectives and learning issues for each of the 12 tutorial groups varied between 45.7 and 77.5 percent, but did not differ significantly ($F(11,143) = 1.24, p = 0.266$).

Since the TOC topics were derived from the 12 problems, for each problem average time scores and mastery scores could be computed. These results are shown in Table 1. An estimate of the average time spent on the 12 TOC problems, expressed on a five-point scale, ranging from (1) no time at all to (5) very much time, was 2.71 ($SD = 0.40$). The average time spent for each problem varied between 2.05 ($SD = 0.30$) and 3.19 ($SD = 0.34$), as shown in Table 1. One-way analysis of variance indicated that time spent on TOC topics differed across problems ($F(11,143) = 12.52, p < 0.000$). The average time spent studying the eight topics not intended by faculty, but included for checking response set effects, was 1.95 ($SD = 0.25$). This finding suggests that the students did indeed fill out the questionnaire seriously. The average time spent varied across tutorial groups between 2.36 ($SD = 0.30$) and 3.18

($SD = 0.54$). One-way analysis indicated that these scores differed significantly ($F(11,143) = 6.06, p < 0.000$).

The average mastery score, measured on a five-point scale, ranging from (1) not at all to (5) very well, was 3.27 ($SD = 0.43$). The average mastery score for each problem varied between 2.43 ($SD = 0.29$) and 3.70 ($SD = 0.34$), also shown in Table 1. The average mastery scores differed across problems ($F(11,143) = 16.35, p < 0.000$). The average mastery of topics included for checking response set effects was 2.60 ($SD = 0.25$), which is low, but not as low as would be expected, since the average TOC mastery score for problem 12 is lower, 2.43 ($SD = 0.29$). An explanation for this finding is that some of the eight 'filler' items were related to a previous unit about the development of the embryo, which implies that, although students did not spend time on these topics during the unit at hand, they had already mastered some of these topics. The average mastery scores varied across tutorial groups between 2.78 ($SD = 0.40$) and 3.52 ($SD = 0.34$). One-way analysis indicated that these scores differed significantly ($F(11,143) = 3.83, p < 0.000$).

The results of the qualitative comparisons between TOC topics and learning issues are shown in the last column of Table 1. The average score, measured on a five-point scale, ranging from (1) not at all to (5) well, was 3.18 ($SD = 0.64$). The average score for each problem varied between 2.57 ($SD = 0.57$) and 3.92 ($SD = 0.60$), as shown in Table 1. One-way analysis of variance indicated that this score differed across problems ($F(11,143) = 5.63, p < 0.000$). This score did not differ across tutorial groups.

Comparing the results between average TOC time scores and mastery scores for each topic reveals that both procedures correlate highly, i.e., a large amount of time spent corresponds with a high mastery score and vice versa. The correlation coefficients between TOC time scores and mastery scores for each topic at the level of the individual student varied between 0.46 ($p < 0.001, N = 126$) and 0.89 ($p < 0.001, N = 126$). The median value was a correlation coefficient of 0.69 and the mode was a correlation coefficient of 0.76.

When the results are compared, i.e., the percentage of faculty objectives identified and the TOC scores for each problem, it is somewhat surprising to find that the results of both procedures reveal a moderate negative correlation. The Spearman rank correlation coefficient between the average problem overlap scores and the TOC time scores and mastery scores are both -0.36 ($p < 0.001, N = 144$). Both measures correlate negatively, i.e., a problem showing a high percentage of overlap displays relatively low averages on the relevant TOC topics and vice versa.

Comparing the average TOC time and mastery scores with the results of the qualitative analysis in which learning issues and TOC topics were compared

directly, reveals correlation coefficients of 0.08 (n.s., $N = 144$) and 0.21 ($p < 0.01$, $N = 144$) respectively. A case in point is problem 11. Problem 11 displays a relatively low overlap between learning issues and faculty objectives and a relatively low score on the direct match between learning issues and topics, whereas the TOC scores for this problem are relatively high. The same holds for problem 4. Problem 12, on the other hand, shows relatively low TOC averages and a low score on the direct match of learning issues and topics, whereas all tutorial groups succeeded in identifying the pre-set faculty objective (that is: the correspondence between student-generated learning issues and faculty objectives was 100 percent).¹ Problem 9 shows low values for all measures, except the direct match between learning issues and TOC topics. In summary, the order in which the problems are ranked across the procedures, overlap between issues and objectives or the direct match between learning issues and TOC scores is not highly related. Since the number of problems is necessarily limited, one cannot exclude the possibility that this finding is influenced by one or two extreme datapoints. One example may be problem 12, which can be considered atypical since it was based on only one faculty objective, which none of the groups had difficulty in identifying. Therefore, the Spearman rank correlation coefficients were also computed excluding problem 12. In the latter case, coefficients between the average problem overlap scores and the TOC time and mastery scores are -0.21 ($p < 0.01$, $n = 132$) and -0.17 (n.s., $n = 132$) respectively; coefficients between the direct match between learning issues and TOC topics on the one hand and the TOC time and mastery scores on the other are -0.10 (n.s., $n = 132$) respectively. Taking these values as descriptive rather than inferential statistics, the proportion of the variance of TOC scores that can be predicted from overlap between student-generated learning issues and faculty objectives is not larger than 0.13 for time and mastery scores. Data from the same course in the previous year, in the academic year 1989–90, produced Spearman rank correlation coefficients of 0.01 and 0.03, (both n.s., $n = 142$) respectively.

General discussion and conclusions

The aim of this article was to test a major assumption of PBL, i.e., that student-generated learning issues are used as guides for self-directed learning activities. Therefore, the relation between student-generated learning issues and students' independent learning during self-study was investigated. Based on the assumption of PBL that student-generated learning issues are the major source driving students during self-study, a high correlation would be

expected between the percentage of faculty objectives identified and students' independent learning corresponding with these learning issues.

The high correlation coefficient between TOC time scores and TOC mastery scores indicates that students' perception of their own mastery and time spent are closely related. This suggests that there is a positive relationship between the amount of time students invest in a particular topic and their sense of mastery of this topic. This finding is in agreement with most theories of school learning that assume that amount of time spent on learning is causally related to mastery (Gettinger, 1984). Of course, there is the alternative possibility of the high correlation simply being the result of response set. However, the average time spent and mastery for the eight 'filler' items was fairly low as compared to the other TOC items. This indicates that a response set effect is a less likely explanation for the present finding.

The low proportion of the variance of TOC scores that can be predicted from overlap between student-generated learning issues and faculty objectives or a direct match between learning issues generated and TOC scores indicates that the relationship between student-generated issues and TOC-scores at the problem level essentially can be considered negligible. This means that students may have identified most issues considered important by the teachers, and at the same time may not report that they have spent time on topics related to these issues (and have mastered them) and vice versa. In other words, what students actually do may not only be determined by what they intend to do, as expressed in the list of learning issues produced after problem discussion.

There may be several explanations for these somewhat counterintuitive findings. Three possibilities for why students did identify the intended learning issues, but report that they did not spend time on topics related to these issues during self-study will be mentioned. The first possibility is that the issue has already been covered in a previous unit. Second, the nature of the subject-matter dealt with in these learning issues is perceived as less interesting. Third, the issue is defined too broadly and so does not provide guidance for students about what to study. Each possibility will be outlined below.

The first possibility is that content covered in previous units may influence the nature of students' self-study. Students may assign lower priority to these issues as compared to issues which are totally new to them. This explanation arose while analyzing problem 2 in detail. Problem 2 deals with physiological and psychological changes in mothers-to-be occurring during the last four months of pregnancy. Scrutinizing the learning issues generated by all twelve tutorial groups showed that most tutorial groups generated learning issues regarding changes in respiration, blood circulation, metabolism and the central nervous system and learning issues related to hormonal changes. Studying the average topic scores related to this problem showed on the con-

trary that the average time spent on changes in hormonal activity as well as the average mastery score on this topic were relatively low, 2.29 ($SD = 0.96$) and 2.55 ($SD = 1.09$) respectively, whereas average time spent and mastery scores for all eleven topics related to problem 2 are 2.91 ($SD = 0.27$) and 3.45 ($SD = 0.27$) respectively. A possible explanation for the low time spent is that hormonal changes had already been covered in the previous unit focusing on the embryonic development. The low level of mastery, however, is not in line with this explanation; a recurrence of the topic hormonal changes would indeed reduce the amount of time spent but not necessarily the level of mastery. Hormonal changes is, however, a difficult topic for students to master which may cause mastery scores to be low.

The second possibility is that students' actual learning activities are also dependent on the nature of the problem at hand. Students' motivation and interest with regard to studying psychology-related learning issues as compared to physiology-related learning issues may vary. For example, problem 5 related to the psychological well-being of the mother during childbirth, scored relatively low with respect to average time spent and average mastery scores, as shown in Table 1. However, most groups had no difficulty identifying the pre-set faculty objectives for this problem. The percentage of faculty objectives identified for problem 5 was 63.3, whereas the total average percentage of faculty objectives identified for all twelve problems was 64.1. Hence, it may be possible that the nature of the subject-matter dealt with in this problem is less interesting, giving rise to relatively low TOC scores. This finding is in accordance with faculty observations suggesting that medical students seem to prefer biology and physiology issues at the expense of psychological and social ones. Problem 4, dealing with physiological processes of delivery provides a pre-eminent example of this observation, since this problem scored relatively high on the TOC. Further illustrative evidence for these observations comes from direct observation in a tutorial group session by the author of this thesis. During the discussion preceding the generation of the learning issue about psychological changes taking place during pregnancy, one of the students noticed that they should not only focus on physical changes during pregnancy but, since they are working in a PBL curriculum, students were also expected to focus on psychological aspects of pregnancy. These remarks led students to the generation of a learning issue on psychological aspects of pregnancy. However, it is not only students' interest or motivation that may influence students' learning activities during self-study, but also their perceptions of the nature of the knowledge to be acquired. Faculty observations suggest that students experience more difficulties than usual when confronted with psychologically, socially, ethically, legally or economically oriented learning issues. Students complain that this literature is not as fact-oriented

as the literature on biology issues. This perception of having to master 'vague subject-matter without success' might be reflected by low TOC scores for topics related to social and psychological aspects.

The third alternative possibility for why students may decide not to spend time on the learning issues generated in the tutorial group emerged while analyzing problem 12. All groups succeeded in identifying the intended faculty objective for this problem, i.e., the percentage of overlap was 100%. Most tutorial groups generated the issue 'normal psychosexual development'. This issue, however, is not an easy one: it is broadly defined and requires extensive study of the literature. Students may feel insecure about the results of these study activities. Thus, although a broadly defined issue may cover the intended faculty objectives sufficiently, it may hardly provide guidance for students and, hence, lead to relatively low TOC scores.

Four possibilities may be mentioned as to why students report that they did spend time on topics during self-study, although they did not identify the learning issues related to these topics. The first possibility is that the issue appeared to be relevant while reading the literature. Second, the issue was covered during resource sessions. Third, the issue was covered in a self-assessment test. Fourth, the tutor stressed the importance of the issue. Each possibility will be outlined below.

The first possibility is that learning resources might reveal to students that a particular issue, although not raised during the discussion, still is an important element in understanding the problem at hand and, therefore, deserves attention. In other words, the particular contents of the available learning resources may influence students' learning activities during self-study.

Second, particular issues addressed during resource sessions or other additional curricular activities might influence students' decisions on what to study. For example, problem 4 deals with childbirth. During a training program in physical examination skills in the skills laboratory², students learnt how to diagnose the second stage of delivery, how to give the right pushing instructions and how to manage the normal delivery in occiput presentation. Since normal child delivery was addressed during training in the laboratory, students' scores on the TOC for problem 4 were very high, 3.19 ($SD = 0.34$) and 3.70 ($SD = 0.34$) respectively, whereas the percentage of relevant faculty objectives identified for this problem was moderate, 56.7.

Another possibility is that incongruity between the subject-matter tested and the subject-matter addressed in the problems might influence students' learning activities during self-study. In some courses, questions are presented to students as self-assessment tools to provide them with feedback about their performance. Based on this self-assessment, students might decide to spend more time on a particular learning issue during self-study. In other words, the

incongruity between topics addressed in the problems and issues covered in self-assessment tests may also drive students' learning in a PBL curriculum.

Direct observation by the author of this thesis during a tutorial group session discussing the problem 'Unknown feelings' may illustrate that tutor guidance also influences content covered by students during self-study. The discussion preceding the learning issue about the sleep-wake rhythm of the fetus, as listed in the example in the introduction section about 'Unknown feelings', is illustrative, since this learning issue was not expected by faculty to be generated and was not listed as a faculty objective. The preceding discussion will be outlined briefly. The tutorial group discussed the mothers' diminished night's rest because of heartburn behind her breastbone and difficulties finding a suitable sleeping position. A minute later, the tutor asked the students: 'What comes to your mind when you think about a baby moving in his mother's womb late at night?' Immediately after this intervention from the tutor one student asked: 'Does the fetus have a sleep-wake rhythm?' This question was raised as a learning issue and was a response to a salient detail in the tutor's question and the preceding discussion about the mother's poor sleeping at night, rather than to the main focus of the problem. This example illustrates that student-generated learning issues and students' self-study are determined by factors other than those related to the content of the problem itself. Tutors' guidance also influences content covered during self-study and tutorial group sessions.

Finally, the discrepancy between the percentage of faculty objectives identified and time spent and mastery may arise from the methodology used, because of three reasons. First, the percentage of faculty objectives identified may provide only partial information about the effectiveness of problems, since teachers' priorities regarding specific objectives related to a particular problem are not taken into account. Second, TOC topics are formulated at a more specific level due to which issues considered as more important are represented by more topics than issues considered as less important. As a result, TOC topics might to some extent better reflect teachers' priorities than learning issues generated by students. Due to these differences, existing relationships between learning issues and learning activities may be blurred. Third, the discussion preceding the generation of learning issues provides students with cues as to what they actually will study. This might imply that, although the learning issues generated are not clearly formulated, resulting in a low percentage of faculty objectives identified, students know exactly what topics should be covered during self-study, due to which TOC scores are high.

From the arguments listed thus far, it may become apparent that subsequent stages of discussing problems, generating learning issues and studying cor-

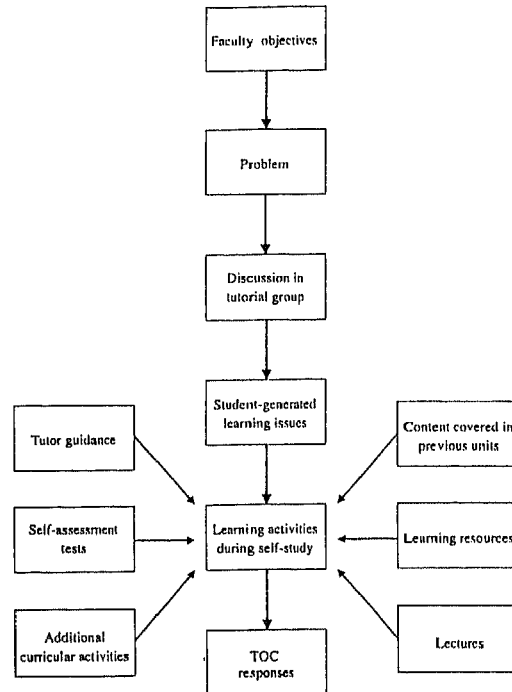


Figure 1. This figure illustrates that students' learning activities and, hence, corresponding TOC-responses are influenced by several other factors that may be involved in decisions on what students actually study.

responding topics during self-study, expressed as TOC-responses, are not so directly related to each other as assumed in PBL. Not only student-generated learning issues, but several other factors may play a part. These factors are summarized in Fig. 1.

In summary, the results of the comparison between learning issues and TOC topics suggest that student-generated learning issues are not necessarily a major factor influencing the nature of students' self-study. Hence, the assumption of PBL that learning issues are used as the major source for self-directed learning activities is not supported by the results of this study. Several explanations were raised that suggest why the relationship is not as straightforward as is often expected. Factors such as topics covered during discussion, the nature of the problems at hand, broadly defined learning issues, issues dealt with in the literature, content covered during resource sessions or additional curricular activities, incongruity between content covered in tests and content covered in problems, and tutor guidance may influence the

nature of students' self-study. Thus, what students actually do may not only be determined by what they intend to do.

Future research should focus on these other factors influencing students' learning activities in PBL. This research, however, may require more sophisticated analyses, for example interviewing students, keeping daily logs of students' learning activities or screening the literature or other sources that students are during self-study. Since procedures to do this in an appropriate way are not available yet, some work is still ahead before we really can answer the question of what happens to the learner in problem-based learning.

Notes

¹ The high level of overlap between issues and objectives for problem 12, however, might be the result of the fact that the designer of this problem had only one objective in mind, i.e., 'normal psychosexual development'. It might not have been too difficult for groups to identify this objective as a goal for learning.

² In the skills laboratory students can train their physical and social skills.

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