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ABSTRACT

The aim of this study was to identify the relationship between elements that are important for the tutorial group process and the individual learning process in a problem-based curriculum. The variables under investigation were: (1) student-generated learning issues; (2) individual learning process; (3) reporting in the tutorial group; and (4) achievement. A questionnaire containing 21 items was developed. Data were collected in the first year from 195 students at the Medical School of Maastricht University (the Netherlands) in the 1997-98 school year. Data were analyzed with a structural modeling approach. Results indicate that the model fitted the data well. The path coefficients were moderately high, particularly between the explanation-oriented approach and the depth of the reporting in the tutorial group. High path coefficients were also found between the depth of the reporting and achievement. In sum, the model gives insight into how important variables are related. It is recommended that data be collected to test the model repeatedly. (Contains 2 tables, 2 figures, and 14 references.) (Author/SLD)

Testing a Causal Model for Learning in a Problem-based Curriculum

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Introduction

One of the most striking characteristics of problem-based learning (PBL) is that an important part of the learning process takes place in a small tutorial group. This small group learning as an educational format has certain advantages. For example, Webb, Troper and Fall (1995) have shown that students, who learn in small groups, are stimulated to clarify or explain their ideas. They are more conscious of deficiencies in their knowledge and they develop more elaborate explanations for the problem at hand (Coles, 1985). Furthermore, students who discuss topics or try to solve a problem in a small group, establish actively new relations between concepts that they already know. In other words, as a result of the small-group discussion, students create a structure of deep and rich connections in their knowledge base. Gabbert, Johnson & Johnson (1986) have shown that learning in small groups results in positive effects on student achievement and retention of information. They found that, on tasks which require the use of high-level reasoning strategies, individuals who learned in a cooperative setting showed a better achievement. Webb (1985) has also demonstrated the relationship between the interactions within small groups, and achievement. In particular, this author found that giving and receiving highly elaborated explanations had a positive influence on achievement.
As has been mentioned above, one of the environments that enable students to work in small groups is established within PBL. In PBL active learning is stimulated by discussing problems in so-called tutorial groups under guidance of a tutor (Barrows & Tamblyn, 1980).
The tutorial group process and the individual learning process play an important role in students learning in a PBL setting. During the tutorial group process, students discuss problems that are to a large extent new to them. In order to understand what this problem is about, they have to activate their prior knowledge. Because students discuss the problem in a group, they are confronted with different explanations. Discussing these differences in opionion, students almost automatically elaborate on the problem. As a result of this small group discussion student become clear what they already know and what they do not know yet. Those topics that need further study become the tutorial group's learning issues. Blumberg and Michael (1992) describe learning issues as factual or conceptual topics that each group decides must be better understood in order to analyze the problem under discussion. These learning issues guide students' individual study

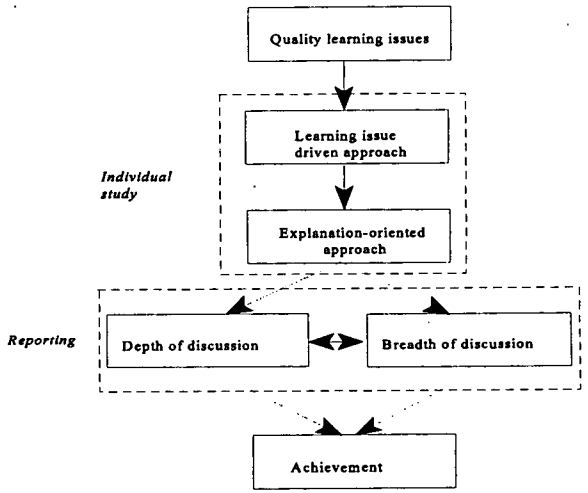
activities. In other words, the processes that take place in the tutorial group are assumed to structure the students' learning.

Although different studies have demonstrated that student-generated learning issues play indeed an important role in the development of self-directed learning skills (Blumberg & Michael, 1992; Walton & Matthews, 1989), it is still unclear how these learning issues influence students' individual study. For example, it is not known whether well-defined learning issues are used more frequently by students when searching literature as compared to poorly defined learning issues. In addition, there is a lack of information on what actually happens during individual study. For example, do students make summaries and notes, do they try to formulate the things that they have read in their own words and what is the influence of these activities on the quality of the discussion in the tutorial group afterwards? Do these activities contribute towards a better structure and deeper level of the discussion and ultimately lead to better achievement? Although the studies described above investigate several of the processes in learning in small groups and in PBL, most of these studies only take into account a limited number of variables.

In order to find out what actually takes place in the PBL groups it is interesting to investigate the relations among several variables that seem important for learning in PBL. For instance, Gijselaers & Schmidt (1990) describe a complex set of relations among relevant variables of the process of learning in a problem-based curriculum. They formulated a causal model in which the process of learning in a problem-based curriculum is described. It consists of input (prior knowledge, problems and tutor behaviour), process (study time and group functioning), and outcome variables (achievement and interest in subject matter). Their study showed that well constructed problems strongly determine the process in the tutorial group, and that the tutors' functioning has a positive influence on the functioning of the tutorial group. Furthermore, group functioning has a strong influence on time spent on individual study (see for a detailed discussion Gijselaers & Schmidt, 1990). Although the study of Gijselaers and Schmidt gives insight in how elements in the process of learning in a problem-based curriculum are interrelated, to obtain a more detailed understanding of what actually happens to learners in a PBL-context (e.g., during the process of individual study and the reporting in the group) certain parts of the model should be refined.

The present study, therefore, attempts to clarify the relation between generated learning issues, process of individual learning, discussion in the tutorial group and achievement. This process can be described in terms of a causal model shown in Figure 1.

Figure 1. Theoretical model representing a partof the learning process in problem-based learning.



Based on this model, the present study investigates the following research questions. First, does the quality of the generated learning issues influence the extent to which students search literature based on the learning issues formulated? Second, does the extent to which student search for relevant literature by making use of these learning issues, affect the extent to which they will prepare the literature (by defining what is relevant in the text, making summaries and notes, translating the literature in their own words, and by making selections in the text)? Third, does an explanation-oriented approach during individual study positively influence the depth and breadth of the reporting in the group? Finally, does a deep and broad reporting in the group lead to a higher achievement?

Method

Participants

Participants were all first-year students (N=195) at the Medical School of the Maastricht University in the Netherlands during the academic year 1997-1998. Students were involved in a problem-based course called 'Attack and defence.' This course deals with infection and the workings of the immune system. During the third week students completed a questionnaire in which they were asked to answer questions about their activities related to the problem discussed during that specific week. This procedure was repeated for the fourth week (in which a different problem was discussed). During the first measurement 175 students (90 %) and during the second measurement 171 students (88 %) responded, spread over 23 tutorial groups. On average in each tutorial group on average nine students participated and at least six students per tutorial group filled in the questionnaire.

Materials

A questionnaire was developed that contained 21 items reflecting the quality of the learning issues (one factor), process of individual study (two factors), and reporting phase (two factors). The number of items and an example of an item of each factor is shown in Table 1.

The first factor, referred to as 'learning issue driven approach', indicates the use of learning issues when searching learning resources. The second factor was called 'explanation-oriented approach,' indicating whether students studied the literature in order to explain the content to another student by means of making summaries and notes during studying. Two factors referred to the reporting phase: 'depth of discussion,' indicating the extent to which the newly learned information was integrated, and 'breadth of discussion', illustrating the extent to which a variety of topics related to the problem were discussed. Students were asked to give their opinion on each item using a 5-point Likert scale ranging from (1) totally disagree to (5) totally agree.

To measure the quality of the generated learning issues, students had to fill in the generated learning issues. Furthermore, they scored on a scale from 1 to 10, 1 insufficient, 10 being excellent, each learning issue on three characteristics (useful keyword, conciseness and clearness), which appeared in an earlier study to be important characteristics (Van den Hurk et al., 1998).

Table 1. Examples of items of each of the phases of the model

Individual study
Learning issue driven searching (5 items)
* When I start studying, I use the learning issues as a starting point to determine what literature I will search
Preparing-oriented approach (5 items)
* To prepare the reporting phase I make summaries of the literature
Reporting phase
Breadth of discussion (4 items)
* When someone found something that was not directly related to the learning issues, it was explained to one another.
Depth of discussion (4 items)
* During the discussion the new facts in the tutorial group were integrated and elaborated

Five educational researchers with expertise in the field of problem-based learning and twelve first-year students were asked to judge a draft version of the questionnaire. They were asked whether each item reflected one of the factors. Achievement was measured by using the mean score of the group on the block test. In general, the block test, administered after each block, reflects the content of the foregoing course of six weeks. The major goal is to assess students' knowledge about the course contents and to provide the students with information on their achievement in relation to the course objectives. Each test is composed of 160 to 190 questions in the true/false format. Students are required to complete the block-test immediately after the end of each six-week course.

Analyses

The data were aggregated at the tutorial group level by computing mean average scores across students for each tutorial group, and for each factor. This procedure was repeated for the second data set. To assess the quality of the learning issues in each tutorial group, the mean scores of the three characteristics for all learning issues per tutorial group were computed.

To test the reliability of the factors, Cronbach's alpha was calculated. The results showed that the alpha coefficient for the factors varied between .64 and .74, except for one factor: the coefficient for the breadth of discussion was .53. The correlation between the factors in the reporting phase ($r=.66$; $p \leq 0.01$) was significant which suggests that these two factors provide limited unique information.

The data were analysed using a structural modelling approach. The computer program AMOS 3.6 was used to test the hypothetical interrelationships between the factors in the model (Arbuckle, 1997).

Results

In Table 2 the mean score on each factor is shown. The quality of the learning issues has a mean of 7.1 on a scale of 1 to 10. There are no large differences in mean scores between the other factors, the lowest score is on the factor 'breadth of discussion' (M=3.0) and the highest score is on the factor 'depth of the discussion' (M=3.4).

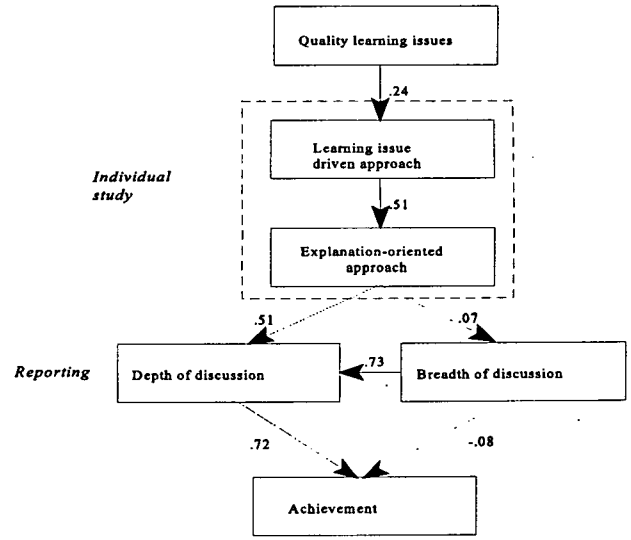
Table 2. Measurement scale (Scale), Number of items (Items), mean scores on factors (Mean), standard deviation (SD), number of groups (N)

	Scale	Items	Mean	SD	N
Quality of generated learning issues	1-10	3	7.1	.5	23
Learning issue driven approach	1-5	5	3.1	.3	23
Explanation-oriented approach	1-5	5	3.2	.3	23
Breadth of discussion	1-5	4	3.0	.4	23
Depth of discussion	1-5	4	3.4	.5	23

To facilitate the interpretation of the model, standardised path values are reported. As a consequence, all the path coefficients in the model can be compared with each other, although different scales were used.

The theoretical model was tested to assess whether it fits the data. The results showed a chi-square = 8.53; df = 8; p =.39, CFI = .98. These indices suggest that the model tested, represents the structure underlying the data (Saris & Stronkhorst, 1984; Bentler, 1990). To determine whether the model fitted on the second data set, the procedure was repeated. Results showed a chi-square =13.00; df = 8; p =.09, and CFI = .86. These findings suggest that the model less adequately represents the second data set, but still fits the data reasonably well.

Figure 2. Linear structural model representing the learning process in problem-based learning. The values represent standardized regression weights



The results of the relationships of the first data-sets among the elements is shown in Figure 2. The model shows that the impact of the quality of the learning issues on students' learning issue driven approach is equal to .24. Thus, when students

use learning issues in an extensive way during individual study, they will prepare themselves in a more explanation-oriented way (.51). The depth of the discussion in the tutorial group is strongly influenced by an explanation-oriented approach. Thus, the more students prepare themselves in an explanation-oriented way, the deeper the discussion in the tutorial group will be (.51). However, more explanation-oriented preparation has no influence on the breadth of the discussion (.07). Finally, a deeper discussion in the tutorial group leads to a higher score on the block-test (.72), in contrast to the breadth of the discussion which has no influence on the score on the block-test (-.08).

Conclusion and discussion

The aim of this study was to identify and measure the relationship between variables which are important for the learning process in a problem-based curriculum. The variables under investigation were student-generated learning issues, individual study, the reporting in the tutorial group and achievement.
The process of selecting and using learning issues is important for the development of the students' self-directed learning skills. The results of this study show that the extent to which students select the literature on the basis of the learning issues does not only depend on how well the learning issues are defined. The quality of the preceding discussion in the tutorial group will probably also be of substantial importance. When a discussion is very productive, students will be better motivated to search for answers for the problems discussed, even if the learning issues might not be formulated clear, concise or contains a useful keyword. This illustrates that the learning issues generated are always a result, a final product, of the preceding discussion. Our model should be expanded to assess this effect.
One of the advantages of learning in small groups, is that students can exchange information, learn to clarify and relate new concepts and learn to defend their points of view. However, the extent to which this takes place seems to depend on the way students prepare themselves during individual study. In order to prepare the reporting in the tutorial meeting, students summarize the literature, make notes and are aware of how they explain new concepts to other students. The results of this study seem to support the idea that when students make summaries and notes of what they have learned and prepare to explain concepts in the group to other students in their own words, the reporting will lead to a deeper understanding. This indicates that new relations between concepts are made, establishing a structure of deep and rich connections in their knowledge base. The results show that a deep reporting will lead to higher achievement. Therefore, especially students in a problem-based curriculum should be trained in how to prepare themselves during individual study for reporting in the tutorial group. For example, summaries made by students can be analysed on their usefulness in the reporting phase and subsequently, students can be given instructions or suggestions for making useful summaries.
Although the explanation-oriented approach is positively related to the depth of reporting, this relation is not found for the breadth of the discussion. Furthermore, the extent to which a variety of topics related to the problem were discussed does not positively influence students' test scores. This can be explained by the fact that students in the first year only discuss topics closely related to the learning issues and that the test only covers the core contents of the course.
However, the study presented here has some limitations. The most important limitation is that students were used as raters of the quality of the reporting phase. Although they are in an good position to evaluate the investigated factors, because they can observe the depth and breadth of the reporting phase, their role is to learn and not to observe. Therefore, further studies should make use other ways of observations of the depth and breadth of the reporting phase in the tutorial group. Another limitation is that the model only includes first year students. It is assumable that the learning process is different in later years. Therefore, the study should be replicated in all years of the curriculum.

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