

Tutorial group discussion in problem-based learning : studies on the measurement and nature of learning-oriented student interactions

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Tutorial group discussion in problem-based learning

Studies on the measurement and nature of
learning-oriented student interactions

Universiteit Maastricht
Maastricht, 2006



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Tutorial group discussion in problem-based learning

Studies on the measurement and nature of
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PROEFSCHRIFT

Ter verkrijging van de graad van doctor aan
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Prof. mr. G.P.M.F. Mols,
volgens het besluit van het College van Decanen,
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Voor pap

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Introduction

The subject of this thesis is the tutorial group discussion in problem-based learning. The aim of the presented studies was to gain insight into the depth of the discussion in the tutorial group and in order to do so the prime focus was on learning-oriented interactions in the reporting phase of the problem-based learning process. We investigated the nature of the interactions and developed and applied different methods for analysing learning-oriented interactions in authentic contexts. This chapter presents the theoretical background and the context of the study (problem-based learning) as well as the problem definition and a brief outline of the thesis.

Background to the study

Theories of learning: active learning and (socio-)constructivism

In education today there is a great deal of interest in active learning. Active learning occurs when learners are challenged to exert their mental abilities while learning (Van Hout-Wolters, Simons & Volet, 2000). Learners are actively seeking meaning (Kirschner, Martens & Strijbos, 2004) and are expected to be the architects of their own knowledge (Glaser, 1991). Active learning plays a pivotal role in constructivist theories of learning.

Many of today's curriculums in higher education are grounded in constructivist theories of learning. Constructivism is a philosophy of how people come to understand or know. The construct of constructivism is not unambiguous. A multitude of approaches to constructivism have been described and there is ongoing debate about how constructivism should be operationalised (Driscoll, 1994; Harris & Alexander, 1998). Nevertheless, there are some general learning principles that are considered characteristic of constructivist approaches (Harris & Alexander, 1998; Brown, Collins & Duguid, 1989; Fetsco & McClure, 2005). The first principle is that learning is more powerful if learners are active participants in the construction of their own knowledge instead of passive recipients of others' teachings. This implies that students should form and test their own hypotheses, interact with the environment and reflect on their learning processes and outcomes. The second principle is that knowledge construction is

stimulated by the nature of students' interactions with persons and objects in their environment. This implies that students should be given the opportunity to discuss issues from differing points of view and engage in collaborative problem solving activities (Fetsco & McClure, 2005).

Apart from general characteristics of constructivist theories of learning, there are different constructivist approaches that merit our attention within the context of this thesis. One theoretical perspective is that of socio-constructivist theory, described by Dillenbourg and colleagues (1995) and by Van der Linden (2000). Socio-constructivists take the view that a person's knowledge is internalised as a result of their interacting with the social environment (Fetsco & McClure, 2005). The socio-constructivist approach focuses on individual cognitive development within the context of social interactions. This theory is an extension of Piaget's (1928; 1932) theory about the reasons for cognitive development in individuals. In the studies that established this research tradition, researchers investigated how social interaction affects individual cognitive development (cf. Doise & Mugny, 1984). Evidence showed that, under certain conditions, interaction among children led to performance on an individual post test that was superior to that after individual training. The catalyst of these superior results was assumed to be "socio-cognitive conflict", i.e. a conflict between different ideas generated by different perspectives, which may arise when children are interacting with each other (Dillenbourg et al., 1995).

Dillenbourg et al. (1995) and Van der Linden (2000) described another constructivist approach, i.e. socio-cultural theory (or shared cognition theory). This approach has its roots in Vygotsky's (1978) theory about the zone of proximal development. In this theory, learning is seen not as a process occurring solely in the learner's mind, but as a social and situated process of joint knowledge construction (Wertsch, 1991; Rogoff, 1995). This process is mediated by cultural tools, such as spoken and written language, images and gestures, and textbooks, calculators and computers. While socio-constructivists focus on individual development within the context of social interaction, socio-cultural researchers investigate the causal relationships between social interaction and individuals' cognitive development. Within the socio-cultural approach methods are continuously being developed, generally with social activity as the basic unit of analysis. Rogoff (1995) suggested that in studies of social activities, individual, interpersonal and institutional (e.g. the educational system, the culture of a certain university) processes cannot be studied in isolation, but that it is possible to focus on one of these processes without losing sight of the other ones. The studies presented in this thesis are performed from two different constructivist perspectives. They focus on students' individual perceptions of the interactions in problem-based tutorials, i.e. they adopt a socio-constructivist perspective, and they examine the interactions between the students, i.e. they use the socio-cultural perspective. We assume that the socio-constructivist and the socio-cultural approach are complementary and that learning can be described in terms of both individual and social processes (Philips, 1995; Cobb, 1994, see also Van Boxtel, 2000).

Collaborative learning

Collaborative learning assigns learners an active and constructive role in their own learning (Van der Linden et al., 2000). As a result, collaborative learning fits with the constructivist views of learning described in the preceding paragraphs. Collaborative learning situations can stimulate students to develop a deep learning approach (Biggs, 2003). This means that students try to develop a critical understanding of the material and integrate new knowledge into their prior knowledge instead of just memorising facts for reproduction. Educational researchers generally agree that a distinction should be made between collaborative learning and the traditional ‘direct transfer’ model, with the teacher as the purveyor of knowledge and skills (Lehtinen et al., 2001). In this thesis, we adhere to the following broad definition of collaborative learning used by Lehtinen et al. (2001): “Collaborative learning refers to instructional methods whereby students are encouraged or required to work together on learning tasks”. Central characteristics of this definition are that:

- learning is an active process;
- students engage in small-group activities;
- the teacher is a facilitator rather than a ‘sage on the stage’;
- students must take responsibility for their own learning;
- students benefit from being part of a small and supportive academic community, et cetera (Matthews et al., 1995; Kirschner, Martens, & Strijbos, 2004).

Further to Lehtinen et al.’s (2001) definition of collaborative learning, we take the view that students collaborate in small groups to achieve *common* learning goals, instead of dividing the work among group members (Dillenbourg, 1999). This definition fits well with the collaborative learning environment investigated in this thesis, i.e. problem-based learning (PBL). PBL requires students to work towards a common goal by tackling one learning task together. PBL thus challenges students to interact and share ideas.

Elaboration and co-construction as learning-oriented interactions

This thesis focuses on the interactions between students collaborating in problem-based tutorial groups, with particular emphasis on interactions that are manifestations of elaboration and/or co-construction processes. These interactions are referred to as “learning-oriented interactions”, because they are assumed to stimulate deep learning. Elaboration and co-construction are two types of learning-oriented interactions described in the literature on collaborative learning. Together they make a substantial contribution to explaining the cognitive effects of collaborative learning (Van der Linden et al., 2000; Van Boxtel, 2000; 2004).

Elaboration evolved out of the socio-constructivist view on learning (Van der Linden, 2000). Interactions within a small group stimulate elaborative cognitive processing activities in students (Slavin, 1996; Van der Linden, 2000). Elaboration is initiated by collaborative verbalisation of learning content (Van Boxtel, 2000; 2004; Van der Linden, 2000). Students can elaborate in several ways. They can translate unusual or unfamiliar vocabulary into familiar terms, describe the relationships between

different concepts, provide detailed justifications of the reasoning used in explaining the problem (Webb & Sullivan Palincsar, 1996) et cetera.

Co-construction was developed within the context of a socio-cultural or shared cognition approach to learning (Van der Linden, 2000). It focuses on the social dynamics and co-constructed features of interaction in small groups. This concept is gaining increasing popularity in the literature and has been labelled in several ways, for instance as “shared (or mutual) understanding” (Van Boxtel, 2000). Co-construction refers to the emergence of a group’s shared understanding of the problem, the concepts and the procedures they are using. When students in a small group are tackling a problem collaboratively, a shared understanding must be created and sustained (Roschelle, 1992). Without shared understanding, effective communication would be impossible (Brown, Collins & Duguid, 1989; Van der Linden et al., 2000). Students thus construct knowledge through social interaction among group members (Hmelo-Silver, 2004). Co-construction is characterised by, for example, building on the contributions of different group members, asking questions to verify that one has understood correctly what was said by others, and jointly formulating answers to questions (Van der Linden, 2000; Van Boxtel, 2000).

Problem-based learning

Problem-based learning as an example of collaborative learning

Problem-based learning evolved out of the “learning-by-discovery” approach and the “case study method” (Schmidt, 1982) as a special way of acquiring knowledge about subject matter (Schmidt & Moust, 2000). It was first introduced at McMaster University in Hamilton, Canada. A uniform definition of PBL remains elusive. Institutions that have implemented PBL may use different PBL formats (Maudsley, 1999). Barrows (1996) distinguished six core characteristics of PBL: 1) learning is student-centred; 2) learning occurs in small groups of students; 3) a tutor is present as a facilitator; 4) authentic problems are the starting point for learning; 5) the problems are used as a tool for achieving knowledge and acquiring problem-solving skills; 6) new information is acquired through self-directed learning.

There is a large body of research on PBL. Much of it was carried out within the context of medical education, since PBL has its roots in Medicine and Health Sciences. Until recently, PBL research within medical education was a relatively separate research tradition, which made little use of research into collaborative learning settings in general. In recent years, PBL studies have come to present PBL more and more as an example of a collaborative learning environment (Dolmans et al., 2005; Arts et al., 2002; Koschmann et al., 1996; Hmelo-Silver et al., 2005).

A description of the problem-based learning process

In PBL, problems are the starting points for learning. The problems consist of descriptions of phenomena to be explained by the students as illustrated by the following example.

Falling, fractures and brittle bones

As a GP on call, you are called to Mrs Jones (76 years old). Mrs. Jones has had a fall in the bathroom and has a nasty cut on the forehead and bruises all down her left side where she hit the bathtub. Her left leg is lying in exorotation and seems shortened. It is extremely painful. She went to the toilet and probably slipped on the rug. She is fully aware of what happened this time, but she has fallen before without a clear cause. Clearly, Mrs Jones is in great pain and something has to be done.

You call the accident and emergency department of the local hospital to prepare them for the arrival of Mrs Jones.

(adapted from a course on ageing in the second year of the undergraduate medical curriculum, Maastricht University, 2004-2005)

Tutorial groups consist of 8-10 students and tutorials are facilitated by a tutor, who is generally a content expert on the relevant subjects. The group should first define the problem and try and also explain it in terms of underlying processes, mechanisms or principles (Schmidt, 1983).

The PBL group uses a systematic procedure. In seven steps they analyse the problem, collect additional information and try to arrive at a satisfactory explanation. The initial problem analysis culminates in the formulation of learning issues, i.e. issues on which the group needs additional information. The students gather this information during individual independent study activities, after which the group reconvenes for the reporting phase in which the findings are reported and synthesised. The aim of the final step is to determine whether a deeper understanding of the problem and its underlying processes has emerged. Steps one through five form the analysis phase, step six the individual study phase and step seven the reporting phase. The latter step is the focal point of this thesis. In this phase, interaction among the students is essential, because the students have to test hypotheses and share and construct knowledge from the information gathered during independent study activities. Detailed descriptions of the PBL process can be found in Schmidt (1983), Moust, Bouhuijs and Schmidt (1997), and Barrows (1988).

General problem definition

Many educational institutions use collaborative learning as an instructional approach. Problem-based learning is one of the collaborative learning environments. Effect studies on collaborative learning have yielded ambiguous or even conflicting results, with some studies reporting positive, some negative and others reporting no cognitive learning effects at all compared to individual learning settings (Van der Linden et al., 2000). Positive results dominate (Dillenbourg et al, 1995), however, and it has been shown that collaborative learning enhances student achievement (Cohen, 1994; Slavin, 1996;

Dillenbourg, 1999) and higher-order thinking skills, such as applying, evaluating and synthesising knowledge (Johnson, Johnson & Smith, 1991). PBL research has so far yielded no conclusive evidence that it is more effective than conventional methods in terms of cognitive outcomes (Norman & Schmidt, 2000). In multi-faceted collaborative learning environments like PBL the effects are diffused by a myriad of unexplained variables. This makes it difficult to draw conclusions about the effectiveness of collaborative learning on the basis of effect studies only (Webb & Sullivan Palincsar, 1996; Norman & Schmidt, 2000). Nevertheless it is important to shed more light on why and how collaborative learning in PBL might have a positive effect on student learning. There is a need for process-oriented studies that examine what actually happens in the “black box” of authentic tutorial groups (Van der Linden et al., 2000; Mifflin, 2004; Hak & Maguire, 2000). This has led to an increased interest in process-oriented studies focusing on group interactions (Van der Linden et al., 2000; Dillenbourg et al., 1995).

Studies of the interactions in tutorial groups require instruments for measuring, observing and analysing these interactions. Although such instruments are scarce (Van der Linden et al., 2000; Dillenbourg et al., 1995), some were recently developed in (computer-supported) collaborative learning studies (e.g. Van Boxtel, 2000; Kumpulainen & Mutanen, 1999; Veldhuis-Diermanse, 2002; Strijbos, 2004). Although these instruments provided a wealth of information, they were often developed for a specific context (e.g. discussion forums or chat environments) or applied in experimental settings only. Many of them are also quite complex and time consuming. Some studies made a detailed analysis of the interaction in tutorial groups in a PBL context (e.g. Koschmann, Glenn & Conlee, 1997; Frederiksen, 1999). However, these studies were limited to small fragments of the interaction and thus provided only partial information about the group interaction as a whole. Several other PBL studies have used questionnaires or interview instruments to address aspects of tutorials (e.g. Dolmans et al., 1998; Virtanen et al., 1999; Steinert, 2004). Although these studies did focus on the collaborative process, the instruments did not specifically measure the interactions in the group. There is no evidence as to whether the instruments described in the literature are suitable for authentic PBL settings and whether they are feasible in practice. In order to achieve a better understanding of the quality of the interaction in tutorials we would ideally need instruments that are both effective and easy to use. Such instruments might also be valuable to tutors who facilitate group work in higher education, since tutorial groups are not always perceived to be successful in practice (e.g. Hitchcock & Anderson, 1997; Dolmans et al., 2001, 2005; Moust et al., 2005). Such instruments might yield suggestions as to how to improve the depth of the discussions in the group.

The central aim of this thesis is to examine interactions in tutorials during the reporting phase in PBL in order to assess the effectiveness of PBL as a collaborative learning environment. First we needed to decide on the best method for investigating student interactions in small groups. In this thesis we addressed the following broad research question:

How can learning-oriented interactions in an authentic problem-based learning environment be measured and what happens in the interactions in a problem-based tutorial group during the reporting phase?

We focused on learning-oriented interactions in problem-based learning by exploring, developing and applying different quantitative and qualitative research methods, because multiple methodologies are needed to arrive at a better understanding of a multifaceted learning environment like PBL (Gijssels & Schmidt, 1990; Hmelo-Silver, 2003). The research was carried out in the authentic problem-based learning setting of tutorial groups in the PBL curriculum of Maastricht Medical School, the Netherlands. The research can be characterised as descriptive and process-oriented. It is embedded within the theoretical background of constructivist learning with emphasis on the social nature of learning.

Overview and research questions

In this section, a brief outline of the studies in this thesis is given. Figure 1.1 presents the conceptual framework of the research, consisting of concepts from collaborative learning research (grounded in constructivist theories of learning), i.e. elaboration and co-construction as learning-oriented interactions.

The main aim of the studies described in Chapters 2 and 3 was to find ways of measuring interactions in problem-based tutorials. The first study used an existing coding scheme, developed by Van Boxtel (2000) to analyse interactions of three tutorial group meetings of first-year and second-year medical students. The purpose of this study was to explore whether 1) elaboration and co-construction processes were identifiable in the group interactions and 2) Van Boxtel's coding scheme was suitable for making these processes visible (Chapter 2).

The second study examined whether interactions in the tutorial groups could be measured with an instrument that was easier to use in practice. This study reports on the development of a group interaction questionnaire. This questionnaire was administered to students in a PBL curriculum and validated by means of confirmatory factor analysis and regression analysis (Chapter 3).

The studies in Chapters 4 through 6 examined the learning-oriented interactions in problem-based tutorial groups. Chapter 4 presents a study in which the questionnaire developed in the previous study was used to measure students' perceptions of the occurrence and desirability of three interaction types. The questionnaire was administered to second-year medical students. One research question was: What are the students' perceptions of the occurrence and desirability of learning-oriented interactions in tutorial groups? Discrepancies between the actual occurrence and the desirability scores of these interactions were examined in order to determine whether there were indications that improvement of interactions was desirable.

A qualitative interview study (Chapter 5) explored students' perceptions of factors contributing to the effectiveness of the discussions in the reporting phase. First-year and second-year medical students participated in six focus group interviews about

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characteristics of effective group discussions in the reporting phase and possible improvements. In these interviews, a bottom-up approach was used with open-ended questions to ensure that students were not confronted with theories about effective group learning or the interviewers' opinions before the interview.

In the final study (Chapter 6) we observed what actually happens during problem-based tutorial group sessions using an adapted and simplified version of the coding scheme used in the exploratory study. We decided to directly observe the interactions so as to obtain a more comprehensive view of the interactions than can be achieved by indirect measurement. We observed and analysed the interactions of second-year medical students in four reporting sessions. The central question was: How much time is spent on the three different types of learning-oriented interactions compared with other (procedural and off-task) interactions and how are the types of interaction distributed over the meeting?

Finally, the findings of the preceding chapters are summarised and discussed in Chapter 7.

This thesis is based on five papers about the studies performed. Since every chapter was written to be read on its own, repetition and overlap across chapters are inevitable.

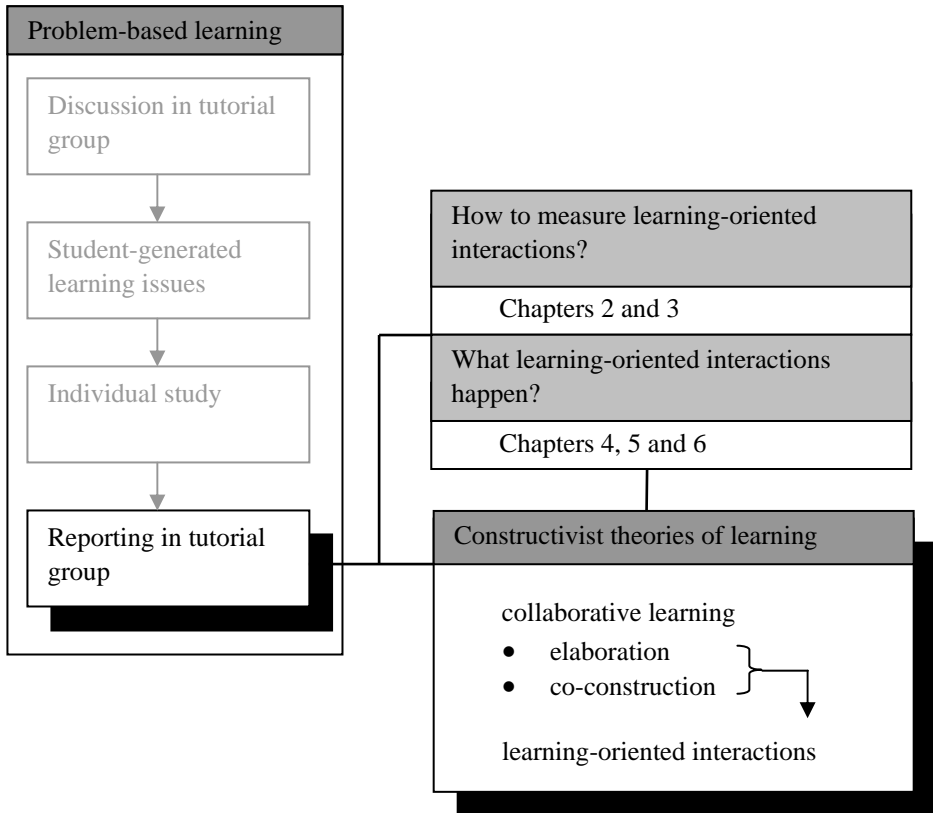


Figure 1.1. Framework of the research

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Exploration of a method to analyse group interactions in problem-based learning¹

Abstract

Many educational institutions use instructional approaches such as problem-based learning (PBL), in which collaborative learning plays an important role. There is little research, however, that describes which factors are responsible for the success of collaboration. The purpose of this study was twofold, i.e. to explore cognitive interactions taking place between students in tutorial groups and to examine whether the coding system of Van Boxtel (2000) is usable to analyse these interactions. The focus was on elaborations and co-constructions, which are indicators of individual and collaborative knowledge construction in a group. Videotapes of three PBL sessions were transcribed, in which tutorial groups of the Maastricht Medical School were discussing a problem. The results showed that cognitive interactions could be found in the tutorial groups and that it was possible to analyse them. Co-constructions seemed most easy to elicit from the transcripts.

Introduction

In a growing number of educational practices, students are expected to learn by collaborating in (small) groups (Van der Linden et al., 2000). Collaborative learning includes many different situations of group learning. Most research on collaborative learning is effect-oriented, which means that it is concerned with the effects of collaborative learning in comparison with the effects of other didactic teaching methods or learning situations. Process-oriented research investigates the collaboration process as such and looks at factors that can explain the effects of collaborative learning (Van der Linden et al., 2000). The present study is process-oriented. It investigates students' cognitive *interaction* processes in Problem-based learning (PBL), which is an example

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of a collaborative learning environment. Cognitive processes play an important role in students' learning processes. Nowadays, there is a great amount of knowledge on these processes in PBL at an individual level. There is, however, little research that focuses on cognitive interaction processes influenced by collaborative learning. Thus, more research on this topic is needed. In this paper, cognitive interactions between students in problem-based learning groups are explored.

The present study investigates the reporting phase of the PBL process. In this phase, the group meets again and students report what they have learned in relation to the learning issues which were formulated earlier. During the reporting phase interactions take place that are assumed to stimulate several cognitive processes, i.e. elaborations and co-constructions, which may lead to deeper understanding.

Elaboration is the process of considering a piece of knowledge in a richer, wider context (Regehr & Norman, 1996). It is initiated by *verbalising* the learning content during collaboration. There is a general agreement that elaboration is an important contributor to the cognitive effects of collaborative learning (Slavin, 1996) and of PBL more specifically (Schmidt et al., 1989; Schmidt, 1993). Elaborations have already been studied in a PBL environment. Schmidt et al. (1989) conducted an experiment in the problem analysis phase of PBL. The results suggest that problemanalysis is an effective procedure to activate knowledge and to elaborate on knowledge and that it facilitates comprehension of relevant new information. During the reporting phase in PBL students elaborate on what they have learned during individual study. De Grave et al. (2001) showed that lack of elaboration is an important contributor to the students' perception of an unproductive tutorial group.

Co-construction of knowledge is the shared thinking process of students who try to reach a shared understanding by means of interacting with each other (Van Boxtel, 2000). By doing this, two or more group members collaboratively construct new knowledge. Leseman et al. (2000) describe that the concept of co-construction entails three basic notions: first, to acquire and develop knowledge students have to be involved in active construction processes; second, there is a coherent link between the construction processes of an individual student and the construction processes of other students; and third, there is a reciprocity between the students participating in discourse.

The difference between an elaboration and a co-construction is that an elaboration is a cognitive process that takes place within one individual's thinking as a result of interaction with other group members, whereas a co-construction is a cognitive process of two or more students in the group constructing knowledge together (the cognitive processes are shared by more people). Elaboration, thus, involves individual knowledge construction, whereas co-construction involves collaborative knowledge construction. Van Boxtel (2000) indicates that a co-construction is a special case of an elaboration: a collaborative elaboration.

Some researchers have already tried to illustrate that elaborations or co-constructions (or both) take place in group learning. De Grave, Boshuizen and Schmidt (1996) conducted a study in which it was demonstrated that elaborations take place during the problem-analysis phase in the tutorial group. De Grave, Boshuizen and Schmidt used a coding system that turned out to be a useful instrument to gain insight

into cognitive elaboration processes of students in the problem-analysis phase of PBL. Van Boxtel (2000) conducted some studies demonstrating elaborations and co-constructions of dyads working on tasks in physics in secondary education. To identify elaborations and co-constructions, she analysed verbal interaction transcripts on an episodic level by making use of an utterance-level coding scheme. The coding system of Van Boxtel proved to be successful in mapping elaborations and co-constructions.

The study by De Grave, Boshuizen and Schmidt differs from Van Boxtel's study on several points. First, De Grave, Boshuizen and Schmidt investigate cognitive processes only on the level of individuals, while Van Boxtel focuses on both individual and collaborative interaction processes. Thus, De Grave, Boshuizen and Schmidt focus on elaborations only, whereas Van Boxtel investigates both elaborations and co-constructions. Second, the study by De Grave, Boshuizen and Schmidt was conducted in a PBL context, while Van Boxtel's studies are carried out in an experimental context.

The coding system of De Grave and colleagues will not be applicable, because it focuses only on elaborations and not on co-constructions. Van Boxtel's coding schemes, on the other hand, seem useful, because she investigated the same division in cognitive interaction processes as aimed at in this study: individual as well as collaborative knowledge-constructing processes, specifically elaborations and co-constructions.

There are some differences, however, between the context of Van Boxtel's studies and the context of this study. In Van Boxtel's studies three experiments are conducted in which interaction between dyads working on several small and structured tasks is investigated. In this study, the interaction is examined in a group of five to seven students who worked on complex and relatively unstructured problems, which are also used in the daily practice of PBL. Finally, PBL is a more authentic educational environment than the experimental learning environment in which students work on several small and structured tasks, as in Van Boxtel's studies.

The purpose of the present study is twofold. First, the issue is to investigate whether elaborations and co-constructions take place in the reporting phase of PBL. Second, it is aimed at examining whether the utterance coding scheme and the episodic coding scheme, both developed by Van Boxtel (2000), can be used to analyse these elaborations and co-constructions. Since elaboration is important to learn in the reporting phase of PBL and co-construction is also expected to contribute to the quality of synthesising information in the reporting phase, the coding system of Van Boxtel might be an appropriate instrument to analyse the desired interactions in PBL.

Method

Subjects

Two groups of first-year medical students and one group of second-year medical students of the Maastricht Medical School were included in this study. All students had experience with learning in the problem-based curriculum for at least half a year. The group interactions were recorded on videotapes. These videotapes were initially developed as audiovisual aids for teacher training sessions. The situations, as recorded, are representative authentic situations intended to demonstrate the reporting phase in

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PBL. This study is aimed at detecting elaborations and co-constructions constructed by students. The videotapes contain sections of the problem-analysis phase and the reporting phase in PBL. Only the sections representing the reporting phase were selected for this study. Although the students have formulated several learning issues in the session before selfstudy, the three sections contain the discussion of only one student-generated learning issue.

Materials

One group of first-year students discussed a problem, dealing with physical regulation mechanisms of hyperventilation. The problem is part of a theme. In this case, the theme deals with disturbing physical, psychological and social balances.

Problem: Dubois.

De Vries goes to the porter's lodge to give something to the porter. There he meets porter Dubois. Dubois' head is warm and red. This frightens De Vries and he asks: "What's the matter?" "I don't know," Dubois says, "I'm sweating all over my body, my heart is pounding and I'm short of breath. I hope I'm not having a heart attack." De Vries is frightened by Dubois, who is gasping for breath. He calls the doctor. However, the doctor does not find indications of a heart attack.

The other group of first-year students discusses a problem on the nervous system. This problem is included in the theme physical regulation of the body and the interaction between the different organs (see Appendix 1). The second-year students discuss a problem on vaccination of young children. The central theme of which the problem is a part, is development of human beings from child to adolescent (see Appendix 1).

Instrument and data-analysis

To analyse the data we made use of Van Boxtel's coding system. Our coding system differs from Van Boxtel's in the way that the utterance coding of propositional content is left out in our study and that some categories from the coding system are left out, just like the names of the categories, which have been changed a little. Only the way in which Van Boxtel's system is used in this study will be outlined below. To obtain more details on Van Boxtel's coding system, we refer to Van Boxtel (2000).

Van Boxtel (2000) describes that elaborations and co-constructions are likely to occur in asking and answering questions, reasoning and solving conflicts. This is why the researchers looked for these three aspects in the group interactions to detect elaborations and co-constructions. Van Boxtel used two coding schemes at different levels: coding of utterances and coding of episodes. The utterance coding scheme focused on communicative functions of the utterances. The episodic coding scheme was aimed at identifying elaborations and co-constructions. In the utterance coding scheme an utterance was considered an individual message unit that is distinguished from another utterance through a 'perceptible' pause, comma or period (Van Boxtel, 2000).

The utterances are coded on communicative functions they fulfil in the discussion. The utterance coding scheme in this study contained the following categories: statements, arguments, evaluations, questions, requests, proposals, confirmations, negations and repeats. Some of these categories contained subcategories. In the episodic coding scheme three types of episodes are distinguished: question episodes, reasoning episodes and conflict episodes. Table 2.1 illustrates the categories in the episodic coding scheme that are used in this study.

The episodic coding scheme of Van Boxtel is the main part of her coding scheme that is used in this study, because in this scheme the dynamic and co-constructed nature of the discourse can be described. However, to be able to identify episodes and to gain more insight into the contribution of each student in the social activity, her utterance coding scheme is partly used. The utterance coding scheme only functions as a means toward the episodic scheme.

Table 2.1. Episodic coding scheme (derived from Van Boxtel, 2000)

<i>Episode type</i>	<i>Categories</i>
Question	-Elaborated -co-constructed
Reasoning	-Elaborated -co-constructed
Conflict	-Elaborated -co-constructed

The sections on the reporting phase of PBL are typed out literally. Subsequently, the written text is divided into utterances, significant units of analysis. (This was done by the first author of this article.) Afterwards, the task-relevant utterances are coded. Finally, the episodes are coded. The coding procedure of both utterances and episodes is carried out by two researchers independently. Disagreements between the researchers occurred in about 25% of the utterances and 10% of the episodes. After discussing the disagreements, 5% of the utterances and none of the episodes remain in disagreement. The remaining disagreements are removed from the dataset.

Question episodes. To identify questions, all propositions with a question mark at the end are selected. Questions are not always the starting point of an episode. They can also be found in conflict or reasoning episodes. A distinction is made between an elaborated answer and a co-constructed answer. An answer is elaborated if (nearly) all relevant utterances (i.e. arguments) come from one student, whereas it is co-constructed when it is constructed by two or more students. Elaborated or co-constructed answers are defined as answers that contain more information than only ‘yes’, ‘no’, or an alternative. Elaborated or co-constructed answers can consist of several words to several sentences (Van Boxtel, 2000).

Reasoning episodes. A reasoning episode can be described as a sequence of utterances in which definitions, observations or hypotheses about the symptoms in the problem (propositions) are related to each other. A reasoning episode contains at least one utterance that is coded as an argument. A reasoning that contains arguments of only

one student is an elaborated reasoning episode. When two or more students equally construct a reasoning then it can be described as a co-construction of reasoning (Van Boxtel, 2000).

Conflict episodes. Conflict episodes were identified on the basis of negations, counter-arguments and critical questions (Van Boxtel, 2000). Only the content-related conflicts are selected. A conflict is elaborated when one student explains or justifies his or her statement (elaboration) or when two or more students substantially contribute to the resolution of the conflict through argumentation about the solution (co-construction).

Results

The results are described as a collection of examples that illustrate different forms of elaborations and co-constructions resulting from questions, reasoning and conflicts. Within the examples, the coding of utterances and episodes carried out with the help of Van Boxtel's coding system is also visible. In the episodes, irrelevant utterances are left out (indicated by "...” between two utterances.

Questioning

In this subsection one example of a co-construction and one example of an elaboration both resulting from questions are described. In both examples a group of seven students (three male, four female) have a discussion on the problem called "Dubois" (see also method section). The group is reporting the findings from self-study on the student-generated learning issue: "What are the causes and consequences of hyperventilation?" In the PBL-phase of problem analysis, the students formulated a few hypotheses on this topic. One of these was that hyperventilation leads to a number of carbon dioxide and oxygen changes in the blood. In Example 1 (Figure 2.1), the students are just starting to look for the chemical equation that belongs to the carbon dioxide and oxygen changes. At the moment of Example 2 (Figure 2.2), the students have found the chemical reaction that fits these changes and they try to apply it to the problem. Thus, the episode in Example 1 takes place somewhat earlier in the reporting phase than the episode in the second example.

In Example 1 a co-constructed answer is described, because the episode starts with an open question by student A which is answered by two students, specifically students B and F. Student B writes down the chemical equation on the whiteboard. Student F intervenes and adds a further step to the equation.

Example 2 demonstrates an elaborated answer. Student D wants to make the change process more concrete, by asking for more information to apply it to the problem "Dubois". In this episode it is student B who explains the most (provides the most arguments), so she elaborates on the question. It is, however, visible that student G is thinking along the same lines as student B, because she says: "Oh, then the equation moves to the left!"

Once again, this episode is taken from the discussion of the same group as in the first example and it occurs later than the first example.

A:	Did you also find the chemical equation?	<i>open question</i>
B:	Yes, I found it, yes.	<i>confirmation</i>
B:	It was er...let me look, that water H_2O + CO_2 combine to form H_2CO_3 .	<i>statement</i>
...		
D:	Can you just write it down?	<i>request</i>
Other students endorse this		<i>confirmation</i>
	(B walks to the flip-over at the right side)	
B:	$H_2O + CO_2 \leftrightarrow H_2CO_3$ was a balance	<i>statement</i>
B:	and then bicarbonate had been made up ...	<i>argument continuation</i>
...		
B:	...and that splits up into $H^+ + HCO_3^-$ again.	<i>argument continuation</i>
C:	Oh yes.	<i>acceptance</i>
F:	And there's another step possibly.	<i>argument continuation</i>
F:	Actually HCO_3^- takes another step, ... (calls the name of the student who takes the minutes, but unintelligible). It could be broken down once more into CO_3^{2-} and one H^+ ...	<i>argument continuation</i>
Others:	Oh!	<i>acceptance</i>
F:	...but that's only a very little about what happens.	<i>argument continuation</i>
B:	CO_3^{2-} (writes)	<i>repeat</i>

Figure 2.1. Example 1 - Co-construction based on a question

D:	Do you also know how it works exactly? What the chemical equation is?	<i>open question</i>
E:	What it is now, this hyperventilation? What happens then?	<i>open question</i>
B:	Well, in this case someone starts... starts breathing more	<i>statement</i>
B:	so, CO_2 decreases (writes).	<i>argument consequent</i>
B:	CO_2 , this decreases.	<i>repeat</i>
E:	Yes.	<i>confirmation</i>
G:	Oh, then the equation moves to the left!	<i>argument consequent</i>
...		
B:	So, H^+ also decreases.	<i>argument consequent</i>
B:	But what you get as a consequence, because H^+ decreases is that the pH-value increases.	<i>argument consequent</i>
B:	Therefore that the blood gets more basic.	<i>argument consequent</i>
F:	Mm mm.	<i>acceptance</i>

Figure 2.2. Example 2 - Elaboration based on a question

Reasoning

Examples 3 and 4 are reasoning episodes. Example 3 is taken from the same group as Examples 1 and 2. Thus, this example is chosen from the same reporting phase, with the students discussing causes and consequences of hyperventilation. In Example 4 a group of five students (one male, four female) reports on a problem that deals with the nervous system.

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Example 3 (Figure 2.3) starts when the students have discussed what the causes of the changes in blood gas values were (the chemical equation). Subsequently, student B suggests that there is another mechanism playing a role in hyperventilation. It indicates a different manner of breathing. This mechanism results from the fear Dubois has of having a heart attack. Students try to make a reasoning episode together on the mechanism of breathing.

F:	First you get anxiety, don't you?	<i>question verification</i>
B:	(writes)	
F:	And then you get the trunk muscles tensing.	<i>argument continuation</i>
	...	
B:	Then you start using other muscles, the respiration muscles.	<i>argument continuation</i>
F:	Yes. yes...	<i>confirmation</i>
F:	You actually start breathing in an abnormal way.	<i>argument continuation</i>
F:	Because of that tension of the trunk muscles you start breathing abnormally	<i>argument consequent</i>
F:	and at a certain moment even your diaphragm muscles get obstructed then.	<i>argument consequent</i>
B:	(writes)	
F:	There should be another step, actually!	<i>evaluation</i>
	...	
B:	A feeling of tightness.	<i>statement</i>
F:	Yes...	<i>confirmation</i>
F:	and tightness of the chest.	<i>argument continuation</i>
C:	I think you are more likely to be tired sooner, aren't you?	<i>question verification</i>
C:	When you really breathe with the respiration muscles, which you don't normally use	<i>argument condition</i>
C:	so that you really er...breathing rather high	<i>argument continuation</i>
C:	And you get tightness in your chest exactly at the same time	<i>argument continuation</i>
C:	and that pain in the chest like that.	<i>argument continuation</i>

Figure 2.3. Example 3 - Co-constructed reasoning

In Example 3 the students B and F are reasoning together and in the last part of the episode student C also adds some information. In this way, they have given a complete explanation of the breathing mechanism causing hyperventilation. The reasoning can therefore be characterised as a co-construction.

Example 4 (Figure 2.4) begins with a group that has just started to report on one of the learning issues: "What role does the nervous system play during a human reaction on stress?" Student C, who is acting as chair during this reporting session, invites the group members to give their findings concerning this learning issue. Another student (B) is ready to make notes on the whiteboard.

E:	Well, I found quite a clear diagram.	<i>statement</i>
E:	In it they divided ... the nervous system, or anyway the autonomous nervous system, they divided it into the orthosympathetic and the parasympathetic system	<i>statement</i>
E:	like we said last time	<i>argument continuation</i>
E:	but the nervous system, it er... it goes through a number of steps	<i>argument continuation</i>
E:	and in the orthosympathetic nervous system acetylcholine is the transmitter substance at the first intermediate step	<i>argument continuation</i>
E:	and with the... step from er... nerve to organ it's noradrenaline.	<i>argument continuation</i>
C:	Mm mm	<i>acceptance</i>
E:	And with the parasympathetic nervous system it's always acetylcholine.	<i>argument continuation</i>
C:	Yes.	<i>confirmation</i>
E:	In both of the two, in both steps.	<i>argument continuation</i>
	...	
B:	And what was this one? (writes)	<i>open question</i>
C:	It was noradrenaline, wasn't it?	<i>question verification</i>
E:	Yes.	<i>confirmation</i>
	...	
C:	and then the other one, acetylcholine.	<i>argument continuation</i>
C:	And then you got the target organ, didn't you?	<i>question verification</i>
E:	Yes.	<i>confirmation</i>
	...	
D:	Could you explain what acetylcholine is?	<i>open question</i>
E:	Acetylcholine is a er... a substance, a transmitter substance it's called.	<i>statement</i>
E:	With a certain stimulus it is released by the nervous end	<i>argument continuation</i>
E:	It's released by the nerve ending when there's a certain stimulus and it uses receptors to bind with the other, with the next piece of er... the nerve pathway	<i>argument continuation</i>
E:	and then it triggers a number of reactions	<i>argument continuation</i>
E:	which cause the stimulus to be conveyed further.	<i>argument continuation</i>
D:	O yes. Yes.	<i>confirmation</i>

Figure 2.4. Example 4 - Elaborated reasoning

Example 4 shows that student E initially refers to the group's previous brainstorming meeting in which they concluded that the nervous system can be divided into two parts. Then, she elaborates on how these two parts function. At the same time, she is interrupted by student B (the writer) and student C (the chair), who feel responsible for providing correct information on the whiteboard. They talk about what to write down and check it by asking student E verification questions. Subsequently, student D, who does not understand the word 'acetylcholine', asks student E to elaborate on this. An explanation about what it is and what its function is follows (provided by student E). Example 4 shows elaborated reasoning, because one student (E) is providing almost all arguments in the episode and the other students involved rely heavily on the information provided by student E.

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Resolving conflicts

In this subsection, two examples of conflicts are shown, a co-constructed as well as an elaborated conflict.

Example 5 (Figure 2.5) is taken from the problem on vaccination of young children and consists of two episodes. The group consists of six students (two male, four female). The students are involved in a discussion on the issue why children receive their ‘Polio and DTP’ and ‘MMR’ vaccinations exactly at the times mentioned in the problem description. The students get stuck solving this issue. The utterances of some students contradict each other.

D:	Hmm..., yes then we actually come now to that part of er... why er... why it is given at certain moments.	<i>statement</i>
F:	Mm mm.	<i>acceptance</i>
C:	That er... yes, at the time of brainstorm we had thought, because this was all dead anyway, that you could give this earlier, because this was alive. (points at the flip-over)	<i>argument reason</i>
A:	Yes	<i>confirmation</i>
A:	but maybe it's just so eh mm...that the MMR vaccines are all administered later	<i>argument counter</i>
A:	because the child still has hmm... the mother's antibodies	<i>argument reason</i>
A:	and ...which therefore er...have a neutralising effect	<i>argument continuation</i>
A:	and maybe then the effect of polio, irrespective of its inactivation, to er hmm... provoke an er... infection or a virus infection at such a young age er...	<i>argument continuation</i>
A:	so, has been neutralised a little bit more by the mother's antibodies.	<i>argument consequent</i>
	...	
C:	(Stands next to the flip-over to make notes) I don't understand completely what you mean actually.	<i>evaluation</i>
A:	No	<i>negation</i>
A:	I think something doesn't add up here, too.	<i>evaluation</i>
C:	Can you explain it once more?	<i>request</i>
	...	
A:	No	<i>negation</i>
A:	I'm just thinking, er...no	<i>negation</i>
A:	otherwise they could have administered MMR earlier, of course.	<i>argument reason</i>
	...	
C:	...I found that with measles, for example, compared to polio, that it therefore, that it should not be given before the age of twelve months	<i>statement</i>
C:	because it suppresses the passive maternal immunisation.	<i>argument reason</i>
A and some others:	Yes.	<i>confirmation</i>
C:	But I can't, for example, but I didn't find it with polio.	<i>argument counter</i>

Figure 2.5. Example 5 - Co-constructed conflict

In Example 5, student C repeats the consideration mentioned in the brainstorm phase of PBL. However, student A counters this consideration. Student C does not understand it and asks for clarification. Then student A puts doubts on her own reasoning. Student C tries to find another explanation for the vaccination timings, but she does not find one either. This example demonstrates a co-constructed conflict, because student A and student C are collaboratively trying to find a resolution to their conflict.

A:	I understood it had to do more with rest and with digestion.	<i>statement</i>
A:	Hmm... well, I get into a mess a bit when I have to start work with those er...hormones.	<i>evaluation</i>
C:	No, but maybe you could tell something about the parasympathetic nervous system, how it is in general, what effects it has.	<i>argument counter</i>
A:	Yes, it's just the opposite of what the sympathetic nervous system does, er... yes, just not activating those things but just letting everything be calm again	<i>statement</i>
A:	getting a white skin will be caused more by the parasympathetic nervous system and a red skin by the sympathetic.	<i>statement</i>
C:	That's the opposite actually of what you just said, isn't it? about that tightness. (speaks to student D) ...	<i>question verification</i>
E:	But I assume er... you can merge them ...	<i>argument counter</i>
E:	that... you have a fast and a slow response	<i>argument continuation</i>
E:	and with the fast response then everything goes more via noradrenaline	<i>argument consequent</i>
E:	so, which functions as a transmitter substance with the orthosympathetic nervous system.	<i>argument consequent</i>
E:	When you have a slower reaction	<i>argument condition</i>
E:	then adrenal gland ma...no, adrenal gland marrow yes, is stimulated...	<i>argument consequent</i>
D:	Mm mm.	<i>acceptance</i>
E:	...and adrenaline is released which has the same action...	<i>argument continuation</i>
C:	Mm mm.	<i>acceptance</i>
E:	...but the differences appear in the way that on er... on all organs there are receptors	<i>argument counter</i>
E:	and then α - and β -receptors are distinguished, they have usually been given names	<i>argument continuation</i>
E:	and α -receptors are particularly sensitive to noradrenaline	<i>argument continuation</i>
E:	and β -receptors are most sensitive to adrenaline...	<i>argument continuation</i>
E:	but so...er... the main difference is that noradrenaline only acts on, or it doesn't act on β -receptors, but it only acts on α -receptors.	<i>argument counter</i>

Figure 2.6. Example 6 - Elaborated conflict

Example 6 (Figure 2.6) is an episode from a reporting session showing an elaborated conflict. The problem discussed in this session deals with the same problem as in Example 4 (the nervous system). Example 6 is preceded by Example 4. Student A is asked by student C to explain what the function of the parasympathetic part of the nervous system is. What he explains is not in line with the earlier utterances of student D on this topic. After this, student E integrates the two viewpoints that seem, in fact, to contrast by describing the different roles of α and β receptors.

In Example 6 student E elaborates on the conflict and resolves it, simply by integrating the viewpoints of student A and student D.

Conclusion and discussion

The goal of this research was twofold. First, it aimed at exploring whether interaction processes of knowledge construction take place in the reporting phase of PBL. Second, its purpose was to investigate whether the coding system of Van Boxtel is usable to analyse them. It can be concluded from the results that it is indeed possible to describe examples of elaborations and co-constructions in problem-based learning by making use of Van Boxtel's coding system. Examples of interactions in different communicative situations (after questions, through reasoning and in resolving conflicts) are found. With the help of Van Boxtel's episodic coding scheme it was possible to distinguish elaborations and co-constructions. It was much easier, however, to find co-constructions than (individual) elaborations. In Example 1 for instance, it was shown that a question by one student led to the interaction process of two students resulting in a co-constructed description of the chemical reaction the group was searching for. In Example 3 two or three students come to a sound, co-constructed reasoning on the breathing mechanism with hyperventilation. Example 5 shows the interaction process based on a conflict, also characterised by co-construction. Examples of elaborations could also be found (see Examples 2,4 and 6), but it was not very easy.

The reason why it was relatively difficult to find examples of elaborations is probably that the interacting groups were relatively large (5-7 members). In these groups, there are more students who produce some significant input than in dyads, as used in Van Boxtel's studies. In larger groups it is less easy to extract individual reasoning and explanations, because individuals are interrupted more often by utterances of group members than in smaller groups. The episodic coding scheme of Van Boxtel thus seems more applicable to gain insight into co-constructions than in (individual) elaborations when applied to PBL groups. When researchers are interested only in individual elaborations in group interaction, the method of De Grave, Boshuizen and Schmidt (1996), who used a stimulated recall procedure to gain insight into individual cognitive processes in PBL, is more fruitful.

When examining the examples of co-construction in greater depth, it should be noted that not all group members contributed to these knowledge constructions. Mainly two or three students built them. The other group members did not contribute significantly. They only confirmed or accepted information by using words such as 'yes' or 'mm mm'. Example 1 is an illustration of this point. The co-construction is not

very compelling, because it is built by two students, student B and student F. The other group members did not contribute significantly. So, examples of collaborative knowledge construction took place in the PBL groups but these knowledge constructions were not built by all group members. The fact that some of the group members are less active during the discussion is not necessarily a problem, when the nonactive students in a session are not the same students all the time.

Another point to note concerns the coding system of the present study. In this system, an answer to a question (coded in the category 'Question', see Table 2.1) can also be categorised as a reasoning. Conversely, in a reasoning episode one or more questions might be asked. The same holds for episodes in which conflicts are solved. This is a consequence of the non-exclusiveness of the categories: question, reasoning and conflict. These three categories overlap to some degree.

The findings of this study imply that in order to stimulate joint construction of knowledge, attention has to be paid to encouraging students' generation of questions, reasoning and resolving conflicts in the tutorial groups, because it is shown in this study that these interactions stimulate co-constructions of knowledge.

Finally, some comments may be made for future research. The finding that relatively few students contribute to co-constructions raises the questions as to whether all students in the tutorial group contribute sufficiently to the discussion and what the optimal group size would be to stimulate co-constructions. More research is needed to find answers to these questions. Furthermore, as the coding procedure conducted in the present study turned out to be relatively complex and time-consuming, it would be useful to create and validate an instrument that makes detection of co-constructions easier (e.g. by using only one scheme instead of two).

Appendix 1 Problems

Problem 1: Dubois

De Vries goes to the porter's lodge to give something to the porter. There he meets porter Dubois. Dubois' head is warm and red. This frightens De Vries and he asks: "What's the matter?" "I don't know," Dubois says, "I'm sweating all over my body, my heart is pounding and I'm short of breath. I hope I'm not having a heart attack." De Vries is frightened by Dubois, who is gasping for breath. He calls the doctor. However, the doctor does not find indications of a heart attack.

Problem 2: Ramshackle vaccination

For several decades children in The Netherlands have been vaccinated against polio, and diphtheria, tetanus and pertussis (whooping cough) (Polio and DTP). A vaccination against mumps, measles and rubella (German measles) (MMR) has been added in recent years. All these vaccinations are provided in a vaccination programme. Nevertheless it seems legitimate to ask the question whether this programme is optimal.

Vaccination programme: The Netherlands

3 months	Polio and DTP
4 months	Polio and DTP
5 months	Polio and DTP
11 months	Polio and DTP
14 months	MMR
9 years	Polio and DT

Would children who are younger than three months not risk catching the polio virus for example? As regards the danger of catching mumps, measles or rubella at ages younger than 14 months we can only remain silent.

Problem 3: Karel van Beveren

Karel van Beveren works as a representative at a big grocery store. He is healthy, happily married and enjoys working.

He experiences some stressful weeks in the spring when he has to participate as a trade union representative of the employees in collective bargaining (Collective Labour Agreement).

He hates the meetings, because he has to take a position against the director of his company with whom he has a good relationship during the rest of the year. For both of them, collective bargaining is a necessary evil. Both react differently. Van Beveren notices that he often has to go to the bathroom before a meeting starts. The day before, the director often has a stomach ache. When the discussion gets heated, Van Beveren

turns red in the face, while the director's nose goes white. Van Beveren also gets clammy hands, whereas his director gets a dry mouth and thus he always has a glass of water in front of him. Van Beveren's heartbeat also increases during the meetings.

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Development and validation of a questionnaire to identify learning-oriented group interactions in PBL¹

Abstract

Collaborative learning attracts attention because of its potential as a powerful learning strategy. This also holds for PBL. However, group work in PBL sometimes encounters problems and the quality of interaction is not always at the desired level. The aim of the present study was to develop and validate a questionnaire to assess the quality of learning-oriented group interactions in PBL in an uncomplicated way.

The questionnaire, to be completed by students involved in PBL, contained items on three group interaction dimensions: exploratory questions, cumulative reasoning and handling conflicts. It was validated by means of confirmatory factor analysis and regression analysis, the latter to investigate the relation between the three-dimension model and the tutorial group's productivity.

The factors underlying the questionnaire were confirmed by the data in a linear structural analysis of the data. The regression analysis showed that the "exploratory questions" and "cumulative reasoning" factors explained together 26% of the variance of the tutorial group's productivity.

This study provided evidence for the validity of the questionnaire. The instrument contains tips for students and tutors to stimulate deep processing interactions in the tutorial group. Nevertheless, it seems useful to investigate the external validity of the questionnaire

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Introduction

In education nowadays considerable attention has been given to collaborative learning. In collaborative learning, students collaborate in small groups to achieve common learning goals. It is considered to be a powerful way of learning (Van der Linden et al., 2000). Problem-based learning (PBL) is often regarded as an example of a collaborative learning environment (Dolmans, Wolfhagen & van der Vleuten, 1998; Albanese, 2000; Schmidt & Moust, 2000). The interaction in a small group, the tutorial group, plays a central role in stimulating student learning (Schmidt, 1993; Savery & Duffy, 1995; De Grave, Schmidt & Boshuizen, 2001). This particularly applies to the reporting phase. This is the phase where students in the tutorial group interact with each other and try to synthesise the information acquired from their individual studies (Barrows, 1988; Schmidt, 1993). It has been shown that PBL encourages elaborations through interactions between students (Norman & Schmidt, 1992). These interactions that lead to elaborations can be called learning-oriented interactions. Interactions and elaborations were also found to be related to the success of tutorial groups (Dolmans, Wolfhagen & van der Vleuten, 1998; Das Carlo, Swadi & Mpofu, 2003). The studies by Dolmans, Wolfhagen and van der Vleuten (1998) and by Das Carlo, Swadi and Mpofu (2003) examined cognitive and motivational factors that influence the success (measured by the productivity) of tutorial groups and provided insight into students' perceptions. In a linear structural model developed by Dolmans, Wolfhagen and van der Vleuten (1998) a positive relation between interaction and tutorial group productivity was found as well as a positive relation between interaction and elaboration. These findings were reiterated by Das Carlo, Swadi and Mpofu (2003).

The problem, however, is that in practice tutorial groups are not always perceived as successful and sometimes the quality of interaction is not at the desired level (Hitchcock & Anderson, 1997; Dolmans, Wolfhagen & van der Vleuten, 1998; De Grave, Dolmans & van der Vleuten, 2002). According to teachers, PBL too often leads to situations in which students maintain an appearance of being actively involved in the tutorial group and show pseudo-interaction (Dolmans et al., 2001). In this situation, the synthesising of knowledge by elaborating does not take place. In order to diagnose problems with the quality of interaction in the tutorial group, instruments are needed. The results obtained from an instrument to measure the quality of interaction can be used to give suggestions for improvement of tutorial group functioning.

Van der Linden et al. (2000) and Dillenbourg et al. (1996) note that there is a scarcity of tools for observing and analysing interactions in the collaborative learning process. Van der Linden (2000) finds it remarkable that little attention has been paid to construction and validation of instruments to assess the interaction processes. Some researchers have developed instruments that take the complexity and dynamics of collaborative learning into account and analyse interaction processes at various levels and in several dimensions (e.g. Erkens, 1997; Kumpulainen & Mutanen, 1999; Van Boxtel, 2000). The common denominator in these instruments is that they are intended for use in observational studies, which makes them relatively complex, time-consuming and sometimes hard to manage.

The purpose of the present study was to develop and validate a questionnaire that is easy to manage, which is not time-consuming and does not require resource-intensive, complex coding procedures. This questionnaire was based on Van Boxtel's (2000) observational instrument and Mercer's (1995; 1996) typifications of talk, with the aim of measuring learning-oriented group interactions. This questionnaire was to be completed by the learners involved in PBL.

Van Boxtel (2000) studied interaction processes and emphasised that three specific interaction types are important to stimulate deep learning: asking and answering questions, reasoning, and resolving conflicts. By asking and answering questions students verbalise what they have learned and give elaborate explanations. Webb (1991) found a relationship between providing elaborate help and learning results. Elaborate help stimulates reorganisation of knowledge, awareness of knowledge gaps and consistent reasoning. In particular, asking higher-order questions tends to elicit elaborate answers (King, 1990). Reasoning is another way to stimulate deep learning. When students are reasoning, they have to make their thoughts explicit. They provide claims and arguments for these claims or relate the claims to other knowledge or experience. Finally, recognising and elaborating conflicts positively influence learning. When students recognise contradictions between their own and the group members' perspectives, they might be stimulated to generate explanations, justifications and reflections, and to search for new information (Brown & Palincsar, 1989). Sometimes, existing knowledge contradicts new information. Students can react in many different ways to such a situation, varying from not believing the new information to a radical change of thinking (Chinn & Brewer, 1993). They can also seek new knowledge to resolve these contradictions and construe new understandings from them (Webb, Troper & Fall, 1995).

Mercer (1995; 1996) described three types of talk and thought in groups: exploratory talk, cumulative talk and disputational talk. These types offer an analysis of the quality of observed talk and emerge from his studies on the talk of children working together on educational activities. "Exploratory talk occurs when group members engage critically but constructively with each other's ideas" (Mercer, 1996, p. 369). In this type of talk, students offer arguments and alternative hypotheses or explanations and these are jointly considered. In cumulative talk, speakers build positively but uncritically on what the other has said. In this type of talk, students construct a "common knowledge" by accumulation; it is characterised by elaborations, confirmations and repetitions (Mercer, 1996). Disagreement and individualised decision-making are characteristics of the third type of talk, disputational talk. In discourse, this type of talk is characterised by short exchanges consisting of assertions and counter-assertions (Mercer, 1996). According to Mercer (1996), exploratory talk has been found to be most effective for learning through collaborative activity.

The three interaction types specified by Van Boxtel (2000) and Mercer's (1995 1996) types of talk are closely linked. First, Van Boxtel's "asking questions" dimension corresponds to a large extent to Mercer's "exploratory talk". Both aspects have to do with critical engagement with the subject matter. Subsequently, Van Boxtel's "reasoning" dimension corresponds to Mercer's "cumulative talk". Both dimensions

focus on elaborating on other students' arguments without being critical. Finally, Van Boxtel's "resolving conflicts" dimension corresponds to Mercer's "disputational talk", because both dimensions deal with offering counter-assertions and conflicts about the learning content. However, when both dimensions are compared in more detail, a slight but not unimportant difference can be found. Van Boxtel's "resolving conflicts" dimension is assumed to be conducive to student learning, as it deals with elaboration on subject-matter conflicts, whereas Mercer's "disputational talk", on the other hand, is associated with unproductive, competitive activity, rarely including elaborations. Therefore, in the present study, the first and the second corresponding pairs are combined and added to Van Boxtel's "resolving conflicts" dimension to distinguish three types of learning-oriented interactions: exploratory questions, cumulative reasoning and handling conflicts.

The aim of this study, as mentioned above, was to develop and validate a questionnaire to assess the quality of learning-oriented interactions in PBL. The questionnaire asked students to judge the quality of interaction by identifying different types of learning-oriented interactions in a problem-based learning situation. The research question was: can indications be found for the construct validity of the questionnaire?

Method

Participants

A questionnaire was administered to all second-year students ($N = 240$) in the academic year 2001-2002 at the Medical School of Maastricht University. Second-year students were chosen because they are fairly experienced with the problem-based learning process.

Questionnaire

In a pilot study, five students and three educational researchers experienced in the field of problem-based learning were asked to assess a preliminary questionnaire of 12 items. The students who were chosen at random, were all at the beginning of their third year and thus had recent experience of the PBL process in the second year. The items were directly derived from the observational coding system developed by Van Boxtel (2000) and covered the three dimensions of learning-oriented group interactions: exploratory questions, cumulative reasoning and handling conflicts (Van Boxtel, 2000; Mercer, 1996). The first dimension was covered by including four statements representing the occurrence of open questions, critical questions, verification questions and alternative arguments (Van Boxtel, 2000). The second dimension contained five statements representing the occurrence of cumulative reasoning, more specifically reasoning in general (i.e. providing arguments), arguments (reasons), continuation arguments, conclusions and conditional arguments (Van Boxtel, 2000). The third dimension included three statements representing the occurrence of conflict and its elaboration, i.e. content-related conflicts in general, negations and counter-arguments (Van Boxtel, 2000). The students were asked to indicate whether each item was stated

unambiguously and whether the instruction was clear and complete. The pilot procedure resulted in the removal of one statement, which represented the occurrence of conditional arguments in the “cumulative reasoning” dimension. This statement was removed, because pilot students did not understand this item. Moreover, both the instruction to the questionnaire and some other statements were reformulated to make them clearer. In the end, the instrument consisted of 11 statements representing the three dimensions mentioned above. All students participating in this study were asked to indicate on a five-point Likert scale to what extent they agreed or disagreed with each statement (1 = “completely disagree” to 5 = “completely agree”). The questionnaire items are included in Appendix 1. In addition, students were asked to assess the productivity of the tutorial group (scale 1-10). This assessment was part of the program evaluation, which is administered to all medical students after each course.

Procedure

Copies of the questionnaire were distributed in the tutorial groups during one of their meetings in the fifth week of a six-week course in the second year. Completed questionnaires were collected during the next meeting, in the sixth week.

Analyses

The construct validity of the instrument was explored by the performance of a confirmatory factor analysis (AMOS) and a regression analysis. Initially, confirmatory factor analysis was carried out to assess the adequacy of the three dimensions underlying the items (Arbuckle, 1997). The confirmatory factor analysis addressed data at the student level. This was done because it was assumed that students within a tutorial group might differ considerably in their perception of what interactions take place in the group and what they experience to be effective forms of interaction. In addition to the confirmatory factor analysis, the data were analysed using regression analysis. The mean scores of each of the three interaction dimensions were used as the independent variables and the productivity of the tutorial group score as the dependent variable.

Results

The aim of this study was to develop and validate a questionnaire with the aim to gain insight into learning-oriented group interactions in PBL. Of the 175 questionnaires received (response rate 73%), one was excluded from the analysis because of incomplete data.

Descriptive statistics

The mean scores and standard deviations were computed for each item. The average scores per item varied between 3.3 and 3.8 (scale 1-5), with corresponding standard deviations varying between 0.7 and 1.0 (N = 174). The average score on the tutorial group’s productivity was 7.4 with a standard deviation of 1.2 (N = 141). Table 3.1 presents a distribution of the percentages of the tutorial group’s productivity score. The

percentage of students who ascribe an insufficient score (i.e. a score lower than six) to the productivity was rather low (5.7 %). A percentage of 14.2% of the students scored six (“sufficient”) and 80.1% of the students scored more than six, indicating that the tutorial group’s productivity was more than sufficient.

Table 3.1. Distribution of scores on productivity of the tutorial group

<i>Score (1-10)</i>	<i>Percentage</i>
≤ 4	2.1
5	3.5
6	14.2
7	28.4
8	34.8
≥ 9	17.0

Construct validity

A confirmatory factor analysis was conducted to assess the construct validity of the instrument. In this analysis, the three dimensions were considered factors. The AMOS program was used to determine whether the data confirmed this model (Arbuckle, 1997). The confirmatory factor model consisted of 11 items. In this model, observed variables 1 to 4 were affected by the first factor, observed variables 5 to 8 by the second factor and variables 9 to 11 by the third factor. All factors were considered to be correlated. All 11 items were assumed to be affected by a unique factor (error in each variable) and no pairs of unique factors were correlated (see Appendix 1 for the questionnaire items and the underlying factors). A confirmatory factor model is assumed to fit the data if three conditions are met: (1) the chi-square divided by the degrees of freedom should be lower than 2 and a p-value that differs from zero; (2) the root mean square residual should be lower than 0.07; and (3) the goodness-of-fit index and the adjusted goodness-of-fit index should be higher than 0.80 (Saris & Stronkhorst, 1984). For the three-factor model the conditions specified by Saris and Stronkhorst (1984) were fully met, because the results of the three-factor model as outlined above were: chi-square [$df = 41$] = 74.89, $p = 0.001$, a root mean square residual of 0.047, a goodness-of-fit index of 0.93, and adjusted goodness-of-fit index of 0.88 (Table 3.2). In order to further cross-validate the proposed model, the data set was split up into two random subsets. Set 1 consisted of a random set of 88 students and set 2 consisted of the other 86 students. For both subsets of data, the three-factor model fitted the data well; i.e. all conditions specified by Saris and Stronkhorst (1984) were satisfied (chi-square [$41df$] = 58.50, $p = 0.037$, a root mean square residual of 0.051, a goodness-of-fit index of 0.90 and adjusted goodness-of-fit index of 0.84, and chi-square [$41df$] = 60.80, $p = 0.024$, a root mean square residual of 0.059, a goodness-of-fit index of 0.89 and adjusted goodness-of-fit index of 0.82, for subsets 1 and 2 as shown in Table 3.2). A test of a one-factor model and a two-factor model in AMOS, containing the same items as the presented three-factor model, revealed that the fit of the data was worse. In general, the results of the confirmatory factor analysis indicated that the three-factor model

showed a good fit, since all conditions were consistently satisfied for the three-factor model. Table 3.3 gives the mean scores and standard deviations per factor. The mean scores vary between 3.4 and 3.7 (scale 1-5), with corresponding standard deviations varying between 0.6 and 0.7 (N = 174). The alpha coefficient was computed for each factor to determine the internal consistency of each factor. The results are also given in Table 3.3 and indicate that the internal consistency per factor varied between 0.56 and 0.70.

Table 3.2. Model fit of the data-set and two random subsets, number of respondents (N), Chi-square, degrees of freedom (df), significance level (p-value), chi-square divided by degrees of freedom (Cmin/df), root mean square residual (RMR), goodness of fit index (GFI) and adjusted goodness of fit index (AGFI)

<i>Data-set</i>	<i>N</i>	<i>Chi-square</i>	<i>Df</i>	<i>p</i>	<i>Cmin/df</i>	<i>RMR</i>	<i>GFI</i>	<i>AGFI</i>
Total	174	74.89	41	0.001	1.8	0.047	0.93	0.88
Subset 1	88	58.50	41	0.037	1.4	0.051	0.90	0.84
Subset 2	86	60.80	41	0.024	1.5	0.059	0.89	0.82

Table 3.3. Number of items, number of students (N), mean scores and standard deviations (SD) per factor and the coefficient alpha per factor

	<i>N items</i>	<i>N students</i>	<i>Mean</i>	<i>SD</i>	<i>Alpha</i>
Exploratory questions	4	174	3.4	0.6	0.56
Cumulative reasoning	4	174	3.7	0.6	0.70
Handling conflicts	3	174	3.5	0.7	0.63

Table 3.4 shows how the variables correlate with each other. As can be seen, all correlation coefficients were significant and positive. There was a fairly high correlation between the “exploratory questions” and “cumulative reasoning” factors (0.55). The correlations between the “exploratory questions” and “handling conflicts” factors and between the “cumulative reasoning” and “handling conflicts” factors were moderate (0.22 for both pairs of factors).

Table 3.4. Correlations between the three factor scores

		<i>1</i>	<i>2</i>	<i>3</i>
1	Exploratory questions	-	0.55**	0.22**
2	Cumulative reasoning		-	0.22**
3	Handling conflicts			-

** Correlation is significant at the 0.01 level (2-tailed)

The relationship between the scores on the tutorial group’s productivity on the one hand and the scores on the individual items and the mean scores on the three factors on the other hand also provide information about the construct validity of the instrument. At the item level, the correlations varied between -0.05 and 0.52 (six out of 11 of the correlations were significant at the 0.01 level; one correlation was significant at the 0.05

level; the remaining correlations were not significant). The three factors “exploratory questions”, “cumulative reasoning” and “handling conflicts” had correlations with tutorial group productivity of 0.49 ($p < 0.01$), 0.40 ($p < 0.01$) and 0.10 (not significant) respectively.

Regression analysis

To investigate the construct validity further, a stepwise regression analysis was conducted, using the tutorial group productivity as the dependent variable, and the mean scores of the students on the three factors as independent variables. This analysis provided insight into the extent to which the three-factor model explains the variance in tutorial group productivity. The results of this regression analysis ($N = 141$) showed that the regression model used two of the three independent variables, namely the mean score on the “exploratory questions” factor and the mean score on the “cumulative reasoning” factor, to explain the dependent variable, i.e. the tutorial group productivity. The standardised beta weight for “exploratory questions” was 0.393 (significance 0.000), while that for “cumulative reasoning” was 0.178 (significance 0.046). This implies that the “exploratory questions” factor contributes more to the tutorial group productivity than the “cumulative reasoning” factor. The variance explained by the “exploratory questions” factor was 24%, whereas that explained by the “cumulative reasoning” factor was 2%. In all, this regression model thus explains a quarter of the total variance in tutorial group productivity (26%).

Conclusion and discussion

The purpose of the present paper was to report on the development and validation of a questionnaire to assess learning-oriented group interactions that take place in PBL. The items of the questionnaire were derived from theories on collaborative learning that stress the importance of interaction to promote deep learning. These theories imply that critical engagement with the subject matter, reasoning and elaborating conflicts by group members promote learning and should therefore be stimulated in group learning. The results of a confirmatory factor analysis indicated that a three-factor model comprising 11 items fits the data well and that all statistical conditions specified by Saris and Stronkhorst (1984) were satisfied. The relatively small correlations between the “exploratory questions” factor and the “handling conflicts” factor and between the “cumulative reasoning” factor and the “handling conflicts” factor suggest that the factor scores provide sufficient evidence of differential variance in interactions in the various areas. The “exploratory questions” factor showed a fairly strong correlation (0.55) with the “cumulative reasoning” factor.

In the present study, part of the procedure to test the construct validity of the questionnaire was the relating of the variable tutorial group’s productivity to the three interaction factors (regression analysis). This variable was also used in the studies by Dolmans, Wolfhagen and van der Vleuten (1998) and Das Carlo, Swadi and Mpofo (2003) who found that much of the variance in tutorial group’s productivity was explained by several (cognitive and motivational) success factors in tutorial groups.

This suggests that the tutorial group's productivity is a suitable measure to gain insight into the success of a tutorial group.

The regression analysis showed that 26% of the variance in the tutorial group productivity score was explained by the "exploratory questions" (24%) and "cumulative reasoning" (2%) factors. This percentage is rather satisfying, for two reasons. First, the tutorial group productivity took all group meetings that had taken place in the course into account, because it was intended as an evaluation of the course as a whole, whereas the questionnaire included only the reporting phases and not the initial discussion phases. Students were asked explicitly to base their answers to the questionnaire on the reporting phases only. Second, when students assess a group's productivity they also take into account group-dynamic aspects, e.g. whether students participated actively during most of the meetings, which were not measured with this questionnaire. The fact that exploratory questioning explaining 24% of the variance in the dependent variable implies that the students perceive these learning-oriented interaction processes as the most important aspect of the tutorial group productivity. Cumulative reasoning explained only a small part of the variance in the tutorial group productivity, namely 2% ($p = 0.046$). These findings are consistent with those of Mercer (1996) who indicated that exploratory talk is the most effective kind of talk for collaborative learning. To sum up, the questionnaire is reasonably valid, which implies that it is indeed possible to assess learning-oriented group interactions in tutorial groups in a rather uncomplicated way.

The present study, however, was subject to some limitations. First, the aim of the study, to investigate whether it is possible to measure group interactions using a relatively simple instrument, seems intuitively contradictory to the need for instruments that take account of the complex and dynamic process of collaborative learning while analysing interaction processes. In developing observational instruments, researchers try to do justice to the complexity and dynamic process of collaborative learning. It would be pointless to try to approximate such complex instruments with a questionnaire. Hence, we realise that the questionnaire developed in the present study is only a rough instrument to measure these processes in PBL and is not suitable for providing a detailed description of them.

Second, a limitation of this study is that all measurements were student perceptions. It would be an improvement if the dependent variable was measured by means of another source, for example, by asking tutors to score the quality of group interaction.

Third, regression analysis showed that the "handling conflicts" factor did not contribute to the explanation of the variance in tutorial group productivity. A highly plausible explanation could be that students were not aware of conflicts during the reporting phase in the tutorial group, thus they did not recognise their interactions as conflicts. Another explanation might be that students perceive it as a negative aspect of group productivity, because of the uncertainty it involves.

Some recommendations for further research can be made. To begin with, the questionnaire should be validated further. This can preferably be done by conducting observations of tutorial groups and then comparing the results of observation with the scores given by the students in the questionnaire. This implies that in future studies we

Chapter 3

can make use of triangulation of data to increase the external validity of the questionnaire.

Second, the present study did not particularly focus on the reliability of the questionnaire while results showed that the internal consistency of the three factors was sufficient. More studies are needed to allow conclusions to be drawn about the reliability of this instrument.

Third, since it is not completely clear why the handling conflicts factor did not contribute to the tutorial group productivity, it might be interesting to explore whether the proposed explanations are valid or whether there are other explanations.

Finally, a questionnaire like that developed in the present study enables both students and tutors to gain insight into the interactions taking place in the tutorial group that promote learning. The three interaction dimensions can provide tutors with guidelines to assess and adjust the interaction process in order to improve this interaction process in PBL groups. Moreover, the questionnaire seems applicable not only to PBL groups in medicine, but also to any group where the members have shared learning goals.

Appendix 1 Items of the Group interaction questionnaire and the division in three dimensions²

1=completely disagree; 2=disagree; 3=neutral; 4=agree; 5=completely agree

Exploratory questions

- | | | | | | |
|--|---|---|---|---|---|
| Q1. Students asked questions that were relevant for obtaining a good understanding of the subject (they asked e.g. about characteristics, different meanings, reasons, concrete examples). (<i>open questions</i>) | 1 | 2 | 3 | 4 | 5 |
| Q2. Probing questions were asked by group members to scrutinise students' observations. (<i>critical questions</i>) | 1 | 2 | 3 | 4 | 5 |
| Q3. When a student was giving an explanation with respect to the problem, s/he regularly asked the others whether they thought the explanation was accurate. (<i>verification questions</i>) | 1 | 2 | 3 | 4 | 5 |
| Q4. The group was not satisfied with just one explanation. Alternative explanations were also suggested. (<i>alternative arguments</i>) | 1 | 2 | 3 | 4 | 5 |

Cumulative reasoning

- | | | | | | |
|--|---|---|---|---|---|
| Q5. Group members built on the ideas that were put forward. (<i>arguments in general</i>) | 1 | 2 | 3 | 4 | 5 |
| Q6. Observations that were put forward, were supported by arguments. (<i>arguments reason</i>) | 1 | 2 | 3 | 4 | 5 |
| Q7. Students' explanations led to additional explanations by other students. (<i>continuation arguments</i>) | 1 | 2 | 3 | 4 | 5 |
| Q8. Conclusions were drawn from the information discussed in the group. (<i>conclusive arguments</i>) | 1 | 2 | 3 | 4 | 5 |

Handling conflicts

- | | | | | | |
|--|---|---|---|---|---|
| Q9. Contradictory ideas or information concerning a subject were discussed in the group (one student introduced contradictory information or different students put forward different information or ideas). (<i>conflicts on knowledge</i>) | 1 | 2 | 3 | 4 | 5 |
| Q10. One student or several students was/were contradicted by the others. (<i>negations</i>) | 1 | 2 | 3 | 4 | 5 |
| Q11. When students expressed disagreement with regard to information presented by another student, they explained why they disagreed. (<i>counter-arguments</i>) | 1 | 2 | 3 | 4 | 5 |

² This questionnaire differs slightly from the one published in the article. This is an improved translation.

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Student perspectives about learning-oriented interactions in the tutorial group¹

Abstract

In group learning settings like problem-based learning (PBL), the quality of interaction is closely related to group success. However, research and practice have shown that the interaction in tutorial groups is not optimal. In the present study, a questionnaire was used to measure students' perceptions of occurrence and desirability of three interaction types, i.e. exploratory questioning, cumulative reasoning, and handling knowledge conflicts. The discrepancies between the perceptions of occurrence and desirability enabled us to illustrate how the questionnaire can be used to improve the group interaction process in the tutorial group.

The subjects consisted of all second-year Medical students of Maastricht University (N =240, response rate 73%). The questionnaire consisted of a list of eleven statements representing the three interaction types (factors). Students were asked to rate each statement on a five-point Likert scale for two types of perceptions, i.e. occurrence and desirability.

The average scores on occurrence and desirability of the interaction types varied between 3.4 and 3.7 (scale 1-5) and between 3.6 and 4.3 respectively. For two interaction types, significant differences between occurrence and desirability were found.

The scores for occurrence were reasonable, and the desirability scores were significantly higher than the occurrence scores for two of the three interaction types, i.e. exploratory questioning and cumulative reasoning. The results of the present study imply that in the students' opinion, the interaction process in the tutorial group can be improved. The questionnaire provides useful information to detect shortcomings in the tutorial group interaction.

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Introduction

The key feature distinguishing learning in group settings from learning in other settings is interaction among students (Webb, 1982). Interaction has been shown to have a large influence on group learning (e.g. Slavin, 1996; Webb & Sullivan Palincsar, 1996). This also holds for problem-based learning (PBL) (Savery & Duffy, 1995; De Grave et al., 1996), since student interactions in the tutorial group make up a substantial part of the problem-based learning process. After the period of individual study in PBL, students discuss what they have learnt in a tutorial group meeting, which is called the reporting phase of the PBL process (Barrows, 1988; Schmidt, 1993). In this phase, the quality of interaction is essential to make a tutorial group successful, as students have to test hypotheses, and share and construe knowledge to synthesise the information acquired from their individual studies.

In practice, tutorial groups are not always perceived to be successful by students and tutors (e.g. Hitchcock & Anderson, 1997, Dolmans et al, 1998; De Grave et al, 2002). Tutors argue that PBL sometimes leads to ritual behaviour, meaning that students maintain an appearance in the tutorial group of being actively involved and do demonstrate a lack of deep processing interactions (Dolmans et al., 2001). As a consequence, the specific kind of cognitive activities in the reporting phase, i.e. interactions that lead to elaborations, thought to be encouraged by PBL, do not in fact take place at the desired level. Lack of deep processing interaction occurs in several situations, for example, when students only read aloud literally what they have read in books to answer the learning issues in the reporting phase. This implies that they do not synthesise knowledge and do not apply it to the problem under discussion (Van den Hurk et al., 1999). Such a situation inhibits the quality of group interaction to a certain extent and thus the learning process.

Despite evident relevance, there is a scarcity of studies examining the PBL process, especially on interaction. Some studies have investigated factors that may cause tutorial groups to be successful or unsuccessful, and have provided insight into students' perceptions. Dolmans et al. (1998) focussed on motivational and cognitive influences on tutorial group processes. The authors developed a linear structural model representing the influences of cognitive and motivational processes on a tutorial group's success. They found that interaction, or the degree to which students learn from one another, contributed substantially to the tutorial group success in the students' opinions. Interaction had the highest weight in predicting a tutorial group's success. Elaboration, showing itself in students answering each other's questions or explaining the material to other group members, was found to be positively related to interaction. A positive relation between interaction and tutorial group success and a positive relation between interaction and elaboration were also obtained by Das Carlo et al. (2003). De Grave et al. (2001; 2002) explored students' perceptions of critical incidents in tutorial groups. Lack of interaction and lack of elaboration were perceived frequent success inhibitors in tutorial groups. A situation in which lack of interaction in the reporting phase may occur is, according to De Grave et al. (2001), when students have all read the same materials from the same book during individual study. As a result, fewer different viewpoints can

be discussed in the group. Lack of elaboration occurs, for instance, when students do not answer each other's questions in the reporting phase and do not try to relate concepts to each other. In other words, they do not discuss the learning issues in depth.

From the studies mentioned above altogether it can be concluded that interactions have the potential to exert considerable influence on the learning process, and that in practice the quality of interaction can be improved. Although these studies do not specify in detail what kind of interactions are intended to play a role in PBL, there are studies that are not conducted in a PBL setting, but do focus on the quality of interactions in collaborative learning environments in general. Two researchers who analysed the quality of interaction in collaborative learning environments by observing students' talk are Mercer (1996) and Van Boxtel (2000). Mercer (1996) described three types of talk and thought in groups: exploratory talk, cumulative talk and disputational talk. Van Boxtel (2000) distinguished three types of interactions being important to stimulate learning, i.e. asking and answering questions, reasoning and acknowledging and resolving conflicts on knowledge. The three types of interaction in these two divisions are closely linked to each other. First, exploratory talk is linked to Van Boxtel's (2000) "asking questions" dimension, because both aspects have to do with critical engagement with the subject matter. Second, cumulative talk (Mercer, 1996) corresponds to Van Boxtel's "reasoning" dimension, because both dimensions focus on elaborating on other students' arguments without being critical. Finally, Mercer's (1996) "disputational talk" corresponds to Van Boxtel's "resolving conflicts" dimension, because both dimensions deal with offering counter-assertions or arguments and elaborating conflicts about the subject matter. Mercer's exploratory talk and cumulative talk had been found effective for learning, in contrast to disputational talk which in his definition was not found to be effective. Van Boxtel's interaction types had all been found to positively influence student learning.

In the present study, the three pairs of corresponding dimensions were combined to distinguish three types of learning-oriented interactions: exploratory questions, cumulative reasoning, and handling conflicts. As elaborations have been shown to stimulate learning (Norman & Schmidt, 1992), learning-oriented interactions were defined here as interactions that lead to elaborations. In an earlier study (Visschers-Pleijers et al., 2003), a questionnaire was developed and validated to measure students' perceptions about the occurrence and the desirability of these three types of learning-oriented interactions.

The research question of the present study included three sub-questions: (a) What are the tutorial groups' perceptions of the occurrence of the three types of learning-oriented interactions? (b) What are the tutorial groups' perceptions of the desirability of the three types of learning-oriented interactions? (c) Are there discrepancies between the occurrence in the tutorial groups and the desirability of these interactions in the tutorial groups' perceptions? The discrepancies are important because they can be seen as indications for shortcomings in the interactions. It is hypothesised that there are discrepancies for all three types of interactions. Furthermore, an example of one tutorial group is described in the present paper to illustrate how the questionnaire can be used to provide suggestions for improvement of the quality of interaction in tutorial groups.

Method

Subjects and procedure

The subjects consisted of the second-year medical students (N=240) at the Medical School of Maastricht University. A total of 175 students, spread over 28 tutorial groups, were willing to fill in the questionnaire, yielding a response rate of 73%. The questionnaire was filled in at the end of a six-week second-year course during the academic year 2001/2002.

Instrument

A questionnaire consisting of a list of 11 statements, covering three dimensions of learning-oriented interaction types, was developed and validated. This questionnaire was constructed using the theoretical factors developed by Mercer (1996) and using Van Boxtel's (2000) communicative functions of interaction. From these studies three essential learning-oriented interaction types were derived: exploratory questioning, cumulative reasoning, and handling conflicts. These three factors lay behind the more specific learning-oriented interactions represented in the items in the questionnaire. The exploratory questioning factor underlay 4 items, i.e. open questions, critical questions, verification questions, and alternative arguments. The cumulative reasoning factor underlay 4 items, i.e. arguments in general, arguments indicating a reason, continuation arguments, and conclusive arguments. The handling conflicts factor underlay 3 items, i.e. conflicts on knowledge, negations, and counter-arguments. In Visschers-Pleijers et al. (2003) a complete validation of this questionnaire can be found, including a theoretical underpinning for item content and confirmatory factor analysis supporting the factor structure. The items of the questionnaire and the three factors are shown in Appendix 1.

To investigate students' perceptions of the learning-oriented interactions, the students were asked to rate each item on two dimensions: 1) the perceived occurrence and 2) whether it was desirable for the interaction to occur in the tutorial sessions (desirability). Students were asked to indicate on a five-point Likert scale to what extent they disagreed or agreed with each statement (1 = "completely disagree" to 5 = "completely agree").

In addition to the 11 statements, an open-ended question was added about the value of the tutorial sessions: "Indicate the aspects that you generally perceive as either positive (informative) or negative (not informative) about the group interaction in a PBL reporting session." The data gathered from this open question are used to illustrate the students' perceptions of the occurrence and the desirability of some of the interaction types.

Analysis

Because we were interested in the quality of interaction of the group, data were aggregated at the tutorial group level by computing average scores across students for each group. Six groups were excluded from the analysis, because their response rate was lower than 70%. For these groups, fewer than six out of nine student responses

were available per group. This exclusion resulted in an analysis based on 22 tutorial groups. The research question, handling the perceived occurrence and desirability and their difference, was addressed using descriptive statistics (means and standard deviations) and paired samples t-tests. The analyses were conducted at the level of the three types of interactions (factor level) and at the item level. Significance levels were obtained by using Bonferroni corrections for the 14 multiple comparisons (11 items and 3 factors). For selection and description of the example of a tutorial group, the mean scores on occurrence and desirability per factor and per tutorial group were calculated.

Results

Descriptive statistics

Table 4.1 shows the average scores for occurrence and desirability for each of the three factors and the scores per item of the questionnaire. In addition a graphical representation of the average scores per item is shown in Figure 4.1.

Table 4.1. Average score on each factor and each item for occurrence and desirability (scale 1-5), SD, mean and standard deviation of the difference between occurrence and desirability. (N = 22)

Learning-oriented interactions	Occurrence of interactions		Desirability of interactions		Desirability - Occurrence	
	Mean	SD	Mean	SD	Mean	SD
F1 Exploratory questioning	3.4	0.2	4.1	0.2	0.7**	0.2
Q1 Open questions	3.7	0.3	4.4	0.2	0.8**	0.3
Q2 Critical questions	3.4	0.3	4.2	0.3	0.8**	0.3
Q3 Verification questions	3.4	0.4	3.8	0.3	0.4**	0.4
Q4 Alternative arguments	3.2	0.4	4.0	0.3	0.8**	0.3
F2 Cumulative reasoning	3.7	0.3	4.3	0.2	0.6**	0.2
Q5 Arguments in general	3.7	0.3	4.3	0.2	0.6**	0.3
Q6 Argument reasons	3.5	0.3	4.3	0.2	0.8**	0.3
Q7 Continuation arguments	3.7	0.3	4.3	0.3	0.5**	0.3
Q8 Conclusive arguments	3.8	0.4	4.4	0.2	0.6**	0.3
F3 Handling conflicts	3.5	0.3	3.6	0.3	0.1	0.3
Q9 Conflicts on knowledge in general	3.4	0.4	3.1	0.4	-0.3**	0.4
Q10 Negations	3.2	0.4	3.3	0.5	0.1*	0.3
Q11 Counter- arguments	3.9	0.3	4.4	0.2	0.5**	0.4

* Significant at the 0.05 level

** Significant at the 0.01 level

The factor exploratory questioning (F1) had the lowest average occurrence score (3.4; scale 1-5) and a standard deviation of 0.2. The factor cumulative reasoning (F2) scored highest on occurrence (3.7) and had a standard deviation of 0.3. The average score for the third factor, handling conflicts (F3) was 3.5 with a standard deviation of 0.3. At item level, the item counter-arguments (Q11) scored highest (3.9, SD = 0.3) on occurrence and the item negations (Q10) lowest (3.2, SD = 0.4).

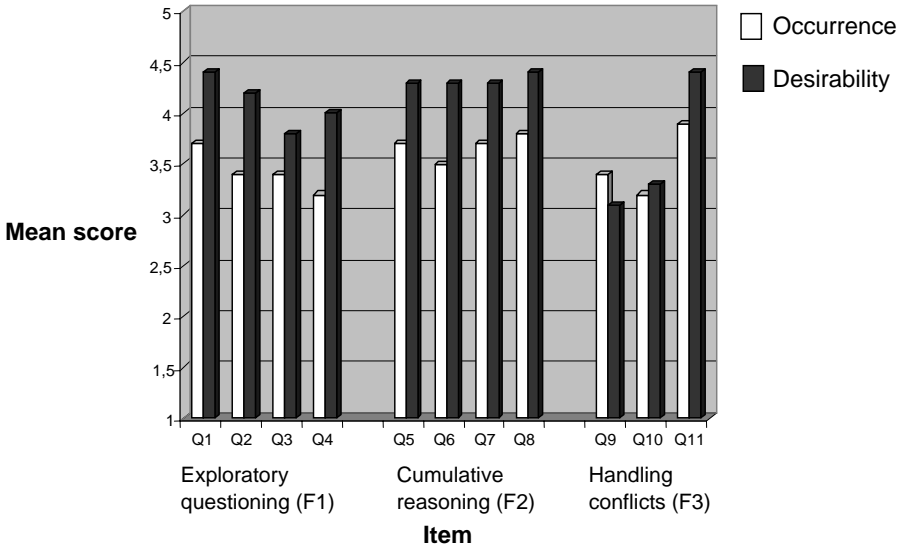


Figure 4.1. Graphical representation of the average score on each item for occurrence and desirability (scale 1-5; N = 22)

The average scores on desirability were 4.1 (scale 1-5) for the exploratory questioning factor (F1; SD = 0.2), 4.3 for the cumulative reasoning factor (F2; SD = 0.2), and 3.6 for the handling conflicts factor (F3; SD = 0.3). At item level, the items open questions, conclusive arguments and counter-arguments (Q1, Q8 and Q11) had the highest scores (4.4, SD = 0.2) and the item conflicts on knowledge (Q9) the lowest (3.1, SD = 0.5).

T-tests

Factor level analysis yielded significant differences between the occurrence and desirability scores with respect to the factors exploratory questioning (F1) and cumulative reasoning (F2). The desirability factor scores are higher than the occurrence scores, 4.1 versus 3.4 for exploratory questions and 4.3 versus 3.7 for cumulative reasoning. For the factor handling conflicts (F3) no significant differences were found. At item level, the average scores on desirability were significantly higher than the average scores on occurrence, except for two items. Conflicts on knowledge (Q9) had a significantly lower average desirability score than its average occurrence score, whereas the difference on negations (Q10) was positive but not significant. Counter-arguments

(Q11) showed a significant positive difference, which is in agreement with the results on the items in the other two factors. The items with the largest difference between occurrence and desirability were critical questions (Q2) and alternative arguments (Q4) for the exploratory questioning factor (F1). For the cumulative reasoning factor (F2), arguments indicating a reason (Q6) had the highest discrepancy. For the handling conflicts factor (F3), the same difference was found for the counter-arguments (Q11) item. Some examples of the written answers to the open question concerning perceptions of informative versus not informative reporting sessions are shown in Figure 4.2.

“If something was not understood, students continued to ask critical questions”. (F1, Q2; a student in tutorial group 23)

“I think it’s negative if something is held to be true without having a discussion about why it is true.” (F2, Q6; a student in tutorial group 25)

“Matters you were totally convinced about turned out to be untrue in the reporting session”. (F3, Q11; a student in tutorial group 14)

Figure 4.2. Selected comments made by students in response to the open question in the questionnaire, dealing with positive or negative experiences with group interactions in the tutorial group

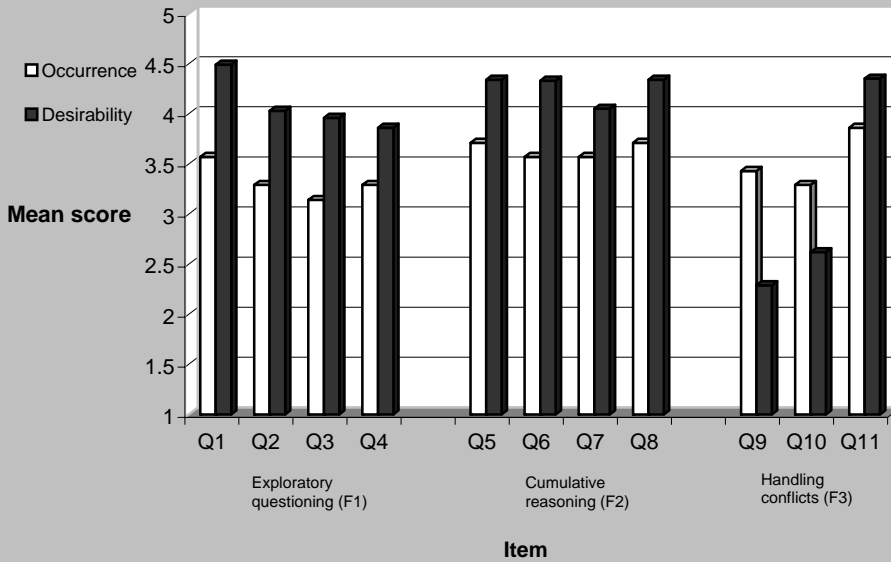
Example

To show how the questionnaire can be used to improve the quality of interaction an example of one tutorial group is described in Figure 4.3. This Figure explains the results of tutorial group 17 and provides suggestions for improvement of the quality of group interaction in this group.

Conclusion and discussion

The present study explored students’ perceptions of the occurrence and desirability of three types of learning-oriented interactions in tutorial sessions. It also investigated the discrepancies between these two perceptions in order to indicate where improvement is desirable. Furthermore, the present study demonstrated how the questionnaire can be used to improve the quality of interaction by means of describing an example of one tutorial group. The occurrence of all three interaction types (factors) exploratory questioning, cumulative reasoning and handling conflicts, and of most of the interactions (items) was reasonable. A major finding of this study is that for the interaction types exploratory questioning and cumulative reasoning the mean scores on desirability were significantly higher than the occurrence scores. These findings suggest that in the students’ perception the quality of the learning-oriented group interactions can be improved. In the students’ opinion, learning-oriented interactions like critical questions, alternative arguments and providing arguments for claims should occur more frequently or more explicitly during the group discussion.

Tutorial group 17 shows a positive discrepancy between occurrence and desirability for most of the items. The mean occurrence scores for the items of F1 vary from 3.1 to 3.6 and are relatively low. This means that in the students' perceptions the quality of group interaction can be improved in the tutorial reporting sessions. The largest positive discrepancies can be found for the items belonging to exploratory questioning (F1), in particular open questions and verification questions (Q1 and Q3). The items in F2, cumulative reasoning (Q5, Q6, Q7 and Q8) also show positive discrepancies between occurrence and desirability, meaning that improvement is desired. The mean occurrence scores are reasonable however, varying from 3.6 to 3.7, which implies that improvement is needed, but not as much as on exploratory questioning (F1). Two items show a different pattern, conflicts on knowledge and negations (Q9 and Q10; F3). For these items, the desirability scores were lower than the occurrence scores. In the opinion of the students of this tutorial group these learning-oriented interactions are not desirable; whereas they did occur in tutorial sessions (mean occurrence scores are close to 3.0)



The data suggest that students in this tutorial group perceived the interaction types exploratory questioning and cumulative reasoning as able to be improved, whereas they did not perceive it as desirable that the interaction type handling conflicts should occur more frequently or explicitly. Exploratory questioning can be stimulated by the group chair (who is a student) or the tutor who can ask the other group members to ask each other more open or verification questions. Cumulative reasoning can, for example, be stimulated by asking explicitly to motivate certain statements and by drawing conclusions or making summaries before going on to the next topic. Finally, a tutor can emphasise in the tutorial group that conflicts on knowledge may stimulate learning by, for example, confronting the students with a learning result they would not have achieved if they had failed to elaborate on the contrasting perspectives underlying the result. Students may experience the relevance of handling conflicts on knowledge then.

Figure 4.3. Tutorial group 17: the results, explanation of the results and suggestions for improvement of the quality of interaction

Another interesting result of the present study is that the scores on the interaction type handling conflicts showed a different pattern than we had expected. The handling conflicts type did not score significantly higher on desirability than on occurrence. The most remarkable finding is the score of the item conflicts on knowledge (Q9). It is the only item that showed a (significantly) negative difference between occurrence and desirability. A plausible explanation for the findings related to handling conflicts could be that students did not recognise their interactions as conflicts. Another explanation may be that students feel insecure when conflicts on knowledge occur. In this light, the following remark in the open-ended question by one student is illustrative:

“Because group members used different books which contained contradictory statements, confusion arises. As a result, you can’t draw any conclusion.” (a student in tutorial group 24)

Assuming that this explanation holds true for at least some students implies that these students in all probability will conform themselves to a single resource and thus will provide information in the reporting phase derived from the reading of only one book. This may lead to lack of interaction in the tutorial group, which was found to be an important success inhibitor of tutorial groups (De Grave et al., 2001; 2002). As a final explanation, the formulation of the item(s) could have been somewhat misleading for the students, because of the use of the word ‘conflict’. Students may have differed from the authors in the way they interpreted this word. Students might have a negative association with the word ‘conflict’ or interpret the word ‘conflict’ as being a social-affective conflict instead of a knowledge conflict. Maybe, students only recognise conflicts when there is an unproductive, competitive discourse characterised by disagreement and individualised decision making with hardly any elaboration in it. These discourse characteristics correspond to Mercer’s (1996) disputational talk. However, these characteristics are not in line with Van Boxtel’s resolving conflicts dimension, which reflects a productive, elaborative discourse in which conflicts with respect to knowledge are acknowledged and tried to be solved.

The example of one tutorial group, group 17, illustrated how the questionnaire can be used in practice. The questionnaire provides insight into students’ or tutorial groups’ perceptions of concrete examples of learning-oriented interactions. This allows us to provide students and tutors with guidelines on how to improve the quality of interaction in the group discussions.

The present study has some limitations. First, the two perceptions (occurrence and desirability) might be dependent on each other, because they were measured with the same instrument. A high score on occurrence may predict a high score on desirability. Second, there might be a bias in the data, because these are self-reported. The authors acknowledge that the questionnaire demands a sophisticated knowledge of group interaction issues by the responding students, which might influence the results. The following remark can be made concerning this issue of possible bias. Although, an important advantage of the questionnaire is that it can be used relatively easy within the time constraints of educational practice, users of the questionnaire should interpret its

results with some caution. The authors assume that users of the group interaction questionnaire with the aim to evaluate the group interaction would in practice not interpret the questionnaire results on their own, but would rather interpret them in the broader context of the tutorial group, e.g. by comparing the results with findings concerning group functioning from the regular program evaluation or tutor observations. Moreover, users can be advised to interpret the results as part of the evaluation of the tutorial groups in general.

Third, the present study investigated cognitive aspects of group interaction in the tutorial group. This is a limited perspective in the sense that the study did not pay attention to other contextual factors that may influence group learning, such as group dynamic processes or student motivation issues. Therefore, on the basis of the present study, the authors are not able to draw conclusions from these perspectives. It is thus possible that taking complementary perspectives into account would yield other conclusions.

Some suggestions for future research can be drawn from the present study. First, future research should take into account perceptions of the quality of group interaction of other respondents than students, e.g. tutors. Tutors' perceptions may differ considerably from students' perceptions. Second, observations and qualitative methods should be used to further investigate the interaction process in PBL in more depth. In the present study a questionnaire was used, because our aim was to obtain a global impression of the students' perceptions of the quality of group interaction in the reporting phases of PBL by using an instrument that is easily manageable in practice (in contrast to observational instruments which usually require complex and time-consuming analysis procedures). The three factors and the items are based on theories derived from observational studies. Third, not only the cognitive aspects of group learning, but also the motivational and social aspects need to be investigated, because both might influence each other. Finally, another topic that obviously needs further research is the interaction type "handling conflicts on knowledge" in tutorial groups. Interviews or focus group interviews with individual students or tutorial groups might provide more insight into the students' perceptions of this interaction type.

Appendix 1. The items in the Group interaction questionnaire

F1 Exploratory questions

- Q1. Students asked questions that were relevant for obtaining a good understanding of the subject (they asked e.g. about characteristics, different meanings, reasons, concrete examples). (*open questions*)
- Q2. Probing questions were asked by group members to scrutinise students' observations. (*critical questions*)
- Q3. When a student was giving an explanation with respect to the problem, s/he regularly asked the others whether they thought the explanation was accurate. (*verification questions*)
- Q4. The group was not satisfied with just one explanation. Alternative explanations were also suggested. (*alternative arguments*)

F2 Cumulative reasoning

- Q5. Group members built on the ideas that were put forward. (*arguments in general*)
- Q6. Observations that were put forward, were supported by arguments. (*arguments reason*)
- Q7. Students' explanations led to additional explanations by other students. (*continuation arguments*)
- Q8. Conclusions were drawn from the information discussed in the group. (*conclusive arguments*)

F3 Handling conflicts

- Q9. Contradictory ideas or information concerning a subject were discussed in the group (one student introduced contradictory information or different students put forward different information or ideas). (*conflicts on knowledge*)
- Q10. One student or several students was/were contradicted by the others. (*negations*)
- Q11. When students expressed disagreement with regard to information presented by another student, they explained why they disagreed. (*counter-arguments*)

Open question

Indicate the aspects that you generally perceive as either positive (informative) or negative (not informative) about the group interaction in a PBL reporting session.

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Student perceptions about the characteristics of an effective discussion during the reporting phase in PBL¹

Summary

To explore students' perceptions of factors contributing to the effectiveness of the discussions in the reporting phase of the problem-based learning process where students report and synthesise the results of self study.

Forty-eight first-year and second-year medical students participated in six focus group interviews about characteristics of effective group discussions and possible improvements. The data were analysed qualitatively in several stages.

The analysis yielded four main characteristics of effective discussions: asking for, giving and receiving explanations; integrating and applying knowledge; discussing differences with regard to learning content; and guiding and monitoring the content and the group process of the discussion. Integrating and applying knowledge included structuring, relating and summarising information and providing examples from practice. Discussing different opinions included discussing a variety of literature resources and disagreements. The main learning effects mentioned by the students were retention, understanding, integration and application of knowledge.

The students have clear ideas about what promotes effective discussions during the reporting phase. Their PBL experience has provided them with some insights that are in line with theory and research on collaborative learning. Future research should examine differences between students' and tutors' perceptions of the quality of the discussions. Introductions to PBL for students and tutors should include training in asking open but focused questions, supporting explanations by arguments and dealing with conflicts about learning content. Tutors should be trained in giving effective and personal

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feedback. Collaborative creation of external knowledge representations (i.e. concept maps), should be advocated as should variety of literature resources.

Introduction

Problem-based learning (PBL) emphasises collaborative learning and it fosters important employability skills. For example, research has shown that PBL develops self-directed learning and it is theorised that PBL stimulates learning in teams (Hmelo-Silver, 2004). Discussing problems in tutorials is a central feature of PBL. Research suggests that this feature enhances higher-order thinking skills, collaborative knowledge construction and a deep learning approach (De Grave et al., 1996; Biggs, 2003; Hmelo-Silver, 2004). In PBL, first there is a phase of problem analysis, which ends with a list of self-generated learning issues. Next, the students each study all these learning issues individually. Finally, in the reporting phase students discuss and synthesise the results of the self study so as to gain a deeper, more detailed understanding of the mechanisms or processes underlying the problem under study (Schmidt & Moust, 2000). Theoretical assumptions about the effectiveness of the reporting phase include elaborating on knowledge, i.e. testing, structuring, and synthesising knowledge (Schmidt & Moust, 2000). Only a few empirical studies have addressed the actual occurrence and practical relevance of these processes.

The reporting phase is characterised by group interaction. Social interaction appears to be crucial for tutorial group effectiveness (Savery & Duffy, 1995; Slavin, 1996; Staudinger, 1996; Dolmans et al., 1998), because it stimulates deep processing activities, such as self explanation and elaboration (Slavin, 1996; Dolmans et al., 1998; Schmidt & Moust, 2000; Van der Linden et al. 2000; De Grave et al., 2002). Group interaction can promote collaborative creation of shared understanding and thus collaborative knowledge construction or co-construction (Roschelle, 1992; Van der Linden et al., 2000). These processes involve interactions between different individual cognitions and between individual cognitions and shared group cognitions (Salomon, 1993). From a socio-cognitive view, these processes may explain the effectiveness of interactions in collaborative learning. The reporting phase in PBL has not been studied as a collaborative learning environment. In a previous study (Visschers-Pleijers et al., 2005) from the perspective of interaction research in the collaborative learning tradition (Van Boxtel, 2000; Mercer, 1996), we examined students' perceptions of the occurrence and desirability of three types of learning-oriented interactions in group discussions: exploratory questioning, cumulative reasoning and dealing with conflicts about knowledge. The students judged the frequency of these interactions as satisfactory, but recommended improvement in asking critical or probing questions (exploratory questioning) and developing arguments (cumulative reasoning). Group interaction in PBL can also be studied from the perspective of group process aspects, such as the role of the tutor (Dolmans et al., 2001).

PBL research focuses increasingly on the students' voice (Savin-Baden, 2000). It seems likely that how students perceive the learning situation will strongly influence their behaviour. Students' perceptions of learning in tutorials have mostly been

examined by using written materials, usually questionnaire surveys (Virtanen et al., 1999; De Grave et al., 2002; Visschers-Pleijers et al., 2005). The few extant interview studies (Hughes Caplow et al., 1997; Lindblom-Ylänne et al. 2003; Steinert, 2004) addressed general outlines and specific situations. Steinert's study of students' perceptions of small group learning in a non-PBL curriculum revealed a predilection for active student participation, group interaction, and positive group atmosphere (Steinert, 2004). Lindblom-Ylänne et al. (2003) found that effective group discussions in PBL benefited from support and advice from the group, learning new things from others and revision of knowledge. However, neither study showed why or how students thought as they did. We explored students' perceptions of the effectiveness of the reporting phase by addressing the following research questions:

1. What activities do students perceive as determinants of the effectiveness of the discussion during the reporting phase in PBL?
2. Why are these activities perceived as effective? In other words: What learning effects do these activities provoke?

Method

Educational background

The study was conducted in the PBL undergraduate curriculum of Maastricht University Medical School. Years 1 and 2 consist of mostly six-week modules. Groups of approximately ten students and a tutor meet twice weekly to work on a problem related to the module's theme. The first session comprises problem analysis and formulating learning issues for self study, the results of which are discussed in the reporting phase in the second session. Students also attend skills training and one or two lectures per week. Assessment is by end-of-module written tests, an OSCE and progress tests.

Focus groups

The focus group interview method relies on group interaction to generate rich data about relatively unexamined issues (Kitzinger, 1995). It is used to investigate opinions' of consumers, including students (Steinert, 2004; Barbour, 2005). Because it has been successful in unravelling not only what but also why and how participants think about issues (Kitzinger, 1995; Morgan, 1988) we used it to elicit students' perceptions of effective group discussions.

Participants

Students in Years 1 and 2 (n = 682; 341 per year) were randomly selected at the end of the academic year 2004-2005 from as many different tutorial groups as possible until six groups of five to ten participants could be formed. Using a multiple-category design (Krueger & Casey, 2000) we allocated students to three first-year and three second-year groups. Homogeneous year groups were thought to provide a safe environment to encourage sharing of experiences. Students were invited by the principal researcher

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verbally or by letter followed by two reminders. Fifty students agreed to participate. Due to illness of two students, 23 first-year and 25 second-year students participated. The students were of a young age (18-22 years), just coming from a secondary school, the majority was female, and all students were selected from the first and second year of university medical education. This is comparable to the full year classes studying medicine. They had at least one year of experience with PBL. After six group interviews, saturation of issues and themes was reached and no additional interviews were scheduled.

Instrument

The interview protocol followed the general interview guide approach (Patton, 1990) and suggestions from other studies, such as asking participants to give concrete examples (Krueger & Casey, 2000; Rubin & Rubin, 2005). Students were asked about characteristics of effective discussion in the reporting phase and how improvements could be made.

Procedure

The interviews were scheduled at convenient times for the students (lunch time with refreshments provided). WdG, an educational psychologist, experienced in small group teaching (PBL), moderated the interviews. AVP, an educational psychologist, explained the interview procedure, assured confidentiality, obtained informed consent, took notes, asked for additional clarification when desired and audio recorded the interviews. In order to stimulate equal input from all participants, the students were asked to write down answers to each interview question before the interview. The interviews lasted between 90 and 120 minutes. Students received a €15,- voucher for participation.

Analysis

The interviews were audio recorded and transcribed literally. For the analysis we used an iterative procedure of sequential stages similar to the constant comparison method (Glaser & Strauss, 1967; Wester, 1995). The transcripts were read and initial codes assigned to text fragments using the computer software package ATLAS-ti (Version 4.1). Trustworthiness was enhanced by independent reading and coding of transcripts by AVP (all transcripts) and WdG and JJ, an experienced medical teacher (three transcripts each). AVP summarised all interviews, capturing all the discussion themes. The summaries were sent to the students for participant verification. All students but one agreed that they were accurate and complete. The summary commented on was adapted accordingly. Four major themes were identified and illustrative quotations selected by the three analysts. The analyses were compared and disagreements discussed until consensus was reached.

Results

Students' perceptions are reported for the four main themes identified (Table 5.1): 1) asking for, giving and receiving explanations; 2) integrating and applying knowledge; 3)

discussing different opinions and perspectives with regard to learning content; and 4) guiding and monitoring the discussion. The emphasis is on positive effects, although some negative aspects are reported as well. The numbers in brackets refer to students and focus groups. Students' perceptions show considerable consistency across groups, although diverging opinions were also voiced.

Guidance by group members in specific roles (tutor, discussion leader, scribe) (theme 4) is assumed to have an indirect effect by stimulating group interactions relating to the other themes. To prevent repetition of arguments, the question why activities are effective was not answered for theme 4.

Table 5.1. Main themes and categories discussed in the focus group interviews

Asking for, giving and receiving explanations

Reporting by giving and receiving explanations

Asking content-related questions

Integrating and applying knowledge

Structuring, relating and summarising information

Applying theory and providing examples from practice

Discussing unclear information or different opinions with regard to learning content

Discussing a variety of literature resources and opinions

Discussing disagreements and different interpretations

Guiding and monitoring the tutorial group discussion

Guiding and monitoring the content of the discussion

Guiding and monitoring the group process

Asking for, giving and receiving explanations

Reporting by giving and receiving explanations

Explaining findings to other students and building on each other's information challenges the students to think carefully and present good arguments to convince the others. Explaining and repeating information in students' own words with books closed enhances the learning process because:

- group members share interpretations of the resources studied;
- learning about concepts relevant to the subject matter increases understanding;
- information is remembered better;
- students check their ideas and discover what they do not fully understand;
- group feedback to students explaining subjects triggers further in-depth discussion;
- the main line of the discussion is adhered to;
- information explained in students' own words is easier to use than information straight from books.

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“As you are explaining what you’ve found, or you realise hey, maybe it isn’t as logical as I first thought, then you are elaborating (...) again.” (S8,3).

A criticism reported is that two days of self study are insufficient for the thorough preparation needed to make this process effective, causing important details to be overlooked occasionally.

Asking content-related questions

Asking questions is seen as the main stimulus for discussions that produce self-generated explanations. Useful questions are:

“Well, you say this and you say that. How come?” (S5, 3)

“Very focused as well, i.e. not asking you to explain the same thing all over again” (S2, 2)

Questions foster different learning processes:

- storage and retrieval of information in memory;
- catching every student’s attention;
- checking understanding;
- integration of knowledge;
- checking preparation for the reporting phase.

One student remarked that a ‘freeloader’ could disguise poor preparation by asking many questions.

Integrating and applying knowledge

Structuring, relating and summarising information

Students appreciate well structured discussions in which the main points are discussed followed by details.

“The discussion leader asks someone to give a general description possibly followed by more in-depth discussion of details, I think that’s the best way to do it. You can use the general description as a steppingstone for the details.” (S5, 2)

(...) “because of all the details, you cannot remember the larger picture ... When you go from the main points to the details then you remember both, you still have the main points in your head.” (S7, 2),

Another important learning activity is linkage between: 1) ideas from the brainstorm and the reporting phase; 2) knowledge obtained in the reporting phase and activities like skills training and lectures; and 3) information discussed in different reporting phases. Summarising is important, although one student said it could seem

artificial. Collaborative creation of schemes (external representations) of biomedical processes or mechanisms on the whiteboard is helpful in structuring, relating and summarising information. Structuring, linking and summarising information keeps the outline of the discussion clear and promotes:

- integration of knowledge;
- understanding;
- storage of information in memory and retrieval.

Specific advantages of composing external representations are:

- increased group interaction, including explanations in students' own words;
- synthesis of information as a visible result of the discussion;
- more concrete information than 'book information'.

Questions about the accuracy of figures or details and irrelevant topics are considered unhelpful.

Applying theory and providing examples from practice

Theory, i.e. basic biomedical knowledge, should be applied not only to the problem in hand but also to other, slightly different problems.

“Not just one example from clinical practice given by the tutor, but maybe a whole patient case. (...) I'm doing a test and I'm thinking: “What was that again? Yes, I know, the man in that case, he had it too, so it's this and that.” I mean, then I really see it within the broader picture and then you can link it to other things in your mind and I think that really helps you remember.” (S9, 3).

Application of basic knowledge to different examples from practice or students' own environment, e.g. family, friends, can:

- foster understanding and retention of learning content;
- make dry theoretical notions come to life;
- stimulate integration of theoretical and clinical knowledge;
- facilitate access to theoretical knowledge stored in memory;
- facilitate application of theoretical knowledge.

One student pointed to the limited generalisability of personal examples.

Discussing different opinions and perspectives with regard to learning content

Discussing a variety of literature resources and opinions

Learning issues should be studied from various perspectives and students should study different and varied literature resources.

“There must be variety in the literature we use, just to stimulate the discussion and um, well that all different aspects are looked at that can be looked at” (S6, 5)

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Variety in literature can:

- stimulate discussion;
- make learning material more concrete;
- enhance synthesis of information;
- stimulate active knowledge processing, resulting in improved integration and understanding, expressed by consensus.

If all students read the same book or article, they will never be sure if their limited perspective is reliable.

Discussing disagreements and different interpretations

Disagreements, opposing views, unclear information or different interpretations are beneficial, since they:

- stimulate in-depth discussion;
- force students to think carefully and support their views with convincing arguments.

Consensus reached after discussion promotes learning:

“Yes, well people’s differing views. At some point (...) everybody has something that doesn’t quite fit and then you sort of feel like how can it all come together? It seems to me that then you mostly get a satisfactory conclusion” (S5, 3).

Students sometimes remain unsure about the accuracy of findings and interpretations, causing lengthy discussions, speculation, talking at cross purposes and disagreements, with some students just giving up.

Guiding and monitoring the tutorial group discussion

Guidance and monitoring by the tutor and the discussion leader with appropriate frequency and timing are crucial. Too much guidance silences students and obstructs integration of knowledge. Too little guidance may cause uncertainty about the accuracy of the information discussed and the direction the discussion should take.

Guiding and monitoring the content of the discussion

The tutor and the discussion leader should:

- stimulate linkage of old and new information and application of knowledge to current and new problems;
- stimulate discussion by focused, goal-oriented questions;
- help to keep the discussion structured and distinguish main issues and details;
- keep to a time schedule (one hour) to balance scope and depth of the discussion;
- not talk about content, except briefly when the group falls silent or gets sidetracked.
- summarise the discussion at several points;
- make arrangements for dealing with points that remain unclear after the reporting phase, for instance formulating a new learning issue;

- explain things that remain unresolved after the discussion, give relevant additional information and ‘correct answers’ to close an unproductive discussion.

“One time about the anatomy of the shoulder, there was a fierce debate and two people were totally in disagreement, but they both had really good arguments: “Yes, but you can make this movement and that movement” (...) Eventually, the tutor gave the right answer and well that’s something you’re not likely to forget.” (S3, 6).

Minute taking by the scribe is useful to guide further study and structure the discussion. It is a difficult task, which occasionally hampers and delays the discussion.

Guiding and monitoring the group process during the discussion

The discussion improves when the tutor and discussion leader:

- encourage participation of all students to obtain and integrate information;
- regularly evaluate the group process, especially by providing specific feedback:

“... that someone notices, hey some people are a bit quiet and others more dominant and (...) a tutor deliberately talked about this with the students like well, you should talk a bit more and you, you tend to dominate the discussion, you might give others some space and that worked really well. I think that especially when you talk about it deliberately and in the right way, things may change.” (S10, 5)

The students can enhance the effectiveness of the discussion by:

- creating a safe learning environment where information is shared and mistakes tolerated;
- agreeing on some ground rules: sitting in an active posture, listening well, not talking at the same time.

Conclusion and discussion

The students identified concrete instances of aspects that according to the literature promote effective discussion. Students described in their own words themes reflecting theoretical concepts from research on group interaction, such as elaboration and shared knowledge (Salomon, 1993; Slavin, 1996; Schmidt & Moust, 2000) It appears that the students’ experience with tutorials has given them an excellent insight into group learning.

Two of the identified themes match three types of learning-oriented interactions: exploratory questioning, cumulative reasoning and handling conflicts about knowledge (Mercer, 1996; Van Boxtel, 2000; Visschers-Pleijers et al., 2005). ‘Asking for, giving and receiving explanations’ comprises exploratory questioning and cumulative

reasoning, whereas ‘discussing unclear information or different opinions with regard to learning content’ strongly resembles handling conflicts about knowledge.

The above-mentioned studies by Steinert (2004) and Lindblom-Ylänne et al. (2003), support our results with regard to characteristics of an effective tutorial group discussion. Virtanen et al. (1999) also found that students attributed the success of tutorials largely to proper discussions with much interaction and knowledge sharing. These similarities suggest that the PBL reporting phase does not differ substantially from other collaborative learning settings. The present study supplies additional information about and explanations for students’ perceptions of characteristics of effective group discussions.

The students see application and integration of knowledge not only as a learning effect, but also as a productive activity, for example collaborative creation of external knowledge representations that helps them integrate knowledge.

The results concerning guidance and monitoring suggest that tutors should steer a middle course between a ‘laid back’ approach and an overly ‘directive’ one. The finding that tutors should evaluate the group process regularly was confirmed by Dolmans et al. (2001).

Students gave useful and detailed information about why they consider certain activities useful or not. They perceive retention and understanding, integration and application of knowledge as the main learning effects of the discussion during the reporting phase. Schmidt and Moust (2000) also reported that PBL enhances students’ long term retention of information. Hughes Caplow et al. (1997) also mentioned the integration and application of knowledge to patient cases as an aspect of PBL contributing to students’ learning.

Limitations of this study are limited generalisability - probably to small group learning contexts only (Barbour, 2005) - and bias due to participants being volunteers, implying that the study group was motivated to participate and probably also to study according to the PBL approach. Non-participants might have provided less information, due to a negative attitude towards PBL. However, the strong willingness to participate among students, as manifested by easy recruitment of participants, suggests that bias is limited.

It seems worthwhile to study tutors’ perceptions of an effective reporting phase and compare them with the findings of this study. One may expect similar findings as in the first three themes described in the results, but the tutors’ perspectives on their role in guiding and monitoring the tutorial group discussion might differ noticeably from the students’ perceptions. The use of convincing arguments during the discussion deserves attention as well. Students see that as an important factor in the reporting phase, but little is known about what makes an argument convincing and when group members are prepared to change their views or accept someone else’s. Finally, our study was limited to the cognitive perspective. Motivational effects were ignored, although the students did report them. These motivational effects merit further investigation.

Some of the findings can be used to improve the introduction of students and tutors to PBL. Effective group interaction might be promoted through practical training, e.g. in asking open but focused questions, supporting explanations by arguments, dealing with

conflicts about learning content, et cetera. Tutors might benefit from training in group evaluation, focused on providing effective and personal feedback. Tutors and students should be alerted to the effectiveness of collaborative creation of external representations in the reporting phase. Concept maps, representing students' knowledge structures might be particularly effective. Variety in literature resources may be achieved by assessment requiring students to study different books and articles (Stoyanova & Kommers, 2002).

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Chapter 5

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Analysis of verbal interactions in tutorial groups: A process study¹

Abstract

Collaborative learning, including PBL, is a powerful learning method. Group interaction plays a crucial role in stimulating student learning. However, few studies on learning processes in medical education have examined group interactions. Most studies on collaboration within PBL used self-reported data rather than observational data. We investigated the following types of interactions in PBL tutorial groups: learning-oriented interactions (exploratory questioning, cumulative reasoning and handling conflicts about knowledge), procedural interactions and irrelevant/off-task interactions. The central question was: how much time is spent on the different types of interaction during group sessions and how are the types of interaction distributed over the meeting?

Four tutorial group sessions in the second year of the PBL undergraduate curriculum of Maastricht Medical School were videotaped and analysed. The sessions concerned the reporting phase of the PBL process. We analysed the interactions using a coding scheme distinguishing several verbal interaction types, such as questions, arguments and evaluations.

Learning-oriented interactions accounted for 80% of the interactions, with cumulative reasoning, exploratory questioning and handling conflicts about knowledge accounting for about 63%, 10% and 7% of the interactions, respectively. Exploratory questioning often preceded cumulative reasoning. Both types occurred throughout the meeting. Handling conflicts mainly occurred after the first twenty minutes.

Task involvement in the tutorial groups was high. All types of learning-oriented interactions were observed. Relatively little time was spent on exploratory questions and handling conflicts about knowledge. PBL training should pay special attention to stimulating discussion about contradictory information.

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Introduction

Collaborative learning has gained increasing acceptance in education as a strategy for producing learning gains (Cohen, 1994; Van der Linden et al., 2000). In collaborative learning, students are encouraged or required to work together on learning tasks (Lehtinen et al., 2001). Collaborative learning can promote deep learning (as opposed to surface learning), which means that students strive to develop a critical understanding of the material and integrate new learning into existing knowledge (Newman et al., 2003). An example of a collaborative learning environment is problem-based learning (PBL) (Koschmann et al., 1996; Dolmans et al., 1998; Albanese, 2000; Schmidt & Moust, 2000), which is used in many medical schools and various other educational institutions around the world.

Research within collaborative learning settings in general, and PBL settings in particular, has shown that interaction strongly influences student learning (Cohen, 1994; Slavin, 1996; Webb & Sullivan Palincsar, 1996; Van der Linden et al., 2000) and group effectiveness (Dolmans et al., 1998; Das Carlo et al., 2003). Dolmans et al. (2001) and Virtanen et al. (1999) argued that collaborative learning is no guarantee of successful learning, but they stressed the importance of stimulating interactions between students. Few studies have focused on the actual interaction process in collaborative learning. Several studies in medical education have investigated the collaboration process indirectly, for instance by examining students' perceptions through questionnaires, focus group interviews or other self-reporting methods (Dolmans et al., 1998; Virtanen et al., 1999; De Grave et al., 2002; Willis et al., 2002; Steinert, 2004; Visschers-Pleijers et al., 2005). A limitation of these studies is the bias that is inherent in self-reporting. Dillenbourg et al. (1995) emphasised that more attention should be paid to studies in which the collaboration process is no longer regarded as a black box. Researchers should zoom in on collaboration to better understand what is happening and under which circumstances interaction can be effective. Researchers have made the same observation with respect to PBL (Koschmann et al., 1997; Hak & Maguire, 2000; Mifflin, 2004). Hak & Maguire (2000) stated: "Research to date has largely neglected to focus on the actual activities and learning processes ...".

One of the few process-oriented, observational studies in a PBL context was performed by De Grave et al. (1996), who investigated cognitive processes within PBL tutorial group sessions by observing and videotaping a group of second-year medical students during the problem analysis phase of the PBL process. They found that the majority of the verbal interactions could be categorised as theory building or data exploration at task level and they examined when and where in the problem analysis phase theory-building occurred. They found that theory-building occurred throughout the problem-analysis phase. The focus of this study was on the intrapersonal processes of theory building and conceptual change and not on the types of interpersonal interactions that could be identified in the discourse.

LEARNING-ORIENTED INTERACTIONS: Utterances reflecting on-task activities

Exploratory questioning: Group members engage critically but constructively with each other's ideas by asking higher-order questions or by providing and considering alternative explanations.

Open question: Question that: ask for new information; elicit elaborative explanations (features, meaning, examples, differences or similarities, reasons, consequences).

Critical question: Checking or calling into question another person's utterance.

Verification question: Question in which one's own ideas or reasoning is checked.

Alternative argument: A logical extension of a previous utterance reflecting reasoning which represents an alternative explanation for an explanation already given.

Cumulative reasoning: Group members build positively but uncritically on what is said by a group member; this may lead to an automatic consensus and group members construct a "common knowledge" by accumulation.

Statement: An utterance in which (usually factual) information is provided. Such an utterance does not reflect reasoning and/or it is read aloud passively (usually literally from notes or books) without the student using his or her own words.

Other argument: A logical extension of a previous utterance reflecting reasoning and which turns out to be an active way of formulating things and thinking aloud, e.g. continuation arguments, reasons, conditional arguments and conclusions. Alternative and counter arguments are excluded from this category.

Other question: A disjunctive question (i.e. a question asking for a choice between two or more options) or a request for evaluation eliciting a short answer.

Judgment acceptance/confirmation: Confirmation or acceptance of a previous content-related utterance.

Handling conflicts about knowledge: Group members acknowledge and discuss contradictory information, characterised by expressing disagreement, negation of previous utterances and/or counter arguments.

Counter argument: A logical extension of a previous utterance reflecting reasoning which contradicts the previous utterance.

Judgment negation/disagreement: Negation of a previous content-related utterance (usually "no") or a negative answer to a (short, disjunctive) question.

Evaluation: Content-related personal opinion or judgment with regard to your own or someone else's knowledge and understanding of the problem.

PROCEDURAL INTERACTIONS: Utterances related to the collaboration process that focus on handling, organising or executing the problem (e.g. division of roles, order of reporting learning issues).

OFF-TASK/IRRELEVANT INTERACTIONS: Utterances not related to the task, i.e. neither to the collaboration or problem solving process nor to the content of the problem (e.g. remarks about computer problems) or a period of silence.

Figure 6.1. The coding scheme. Definitions of the different types of interactions and their subcategories

The present study is aimed at expanding our understanding of interaction processes occurring in the reporting phase of tutorial group sessions. The method used to achieve this is observation and analysis of the verbal interactions among group members. We derived a list of different types of interactions from two studies on collaborative learning performed in non-PBL contexts (Mercer, 1996; Van Boxtel, 2000). Three categories of interactions were defined, i.e. learning-oriented interactions, procedural interactions and irrelevant/off-task interactions. The learning-oriented interactions were based on Van Boxtel's (2000) interaction types and Mercer's (1996) productive "modes of talk" and were subdivided into exploratory questioning, cumulative reasoning and handling conflicts about knowledge (Figure 6.1). These subgroups differ somewhat in levels of deep processing. Cumulative reasoning is a more shallow type of interaction than exploratory questioning and handling conflicts about knowledge, because it entails

automatic consensus, with students hardly challenging each other's contributions and thus no constructive conflict to stimulate the learning process. Nevertheless, all three learning-oriented interactions are assumed to be indicative of more in-depth learning compared with the procedural and irrelevant/off-task interactions.

We assumed that a tutorial group is effective if the group is engaged in learning-oriented interactions most of the time. An effective tutorial group would be highly involved in the educational task (i.e. solving the problem), as would be evidenced by more time spent on productive, learning-oriented interactions compared with procedural and irrelevant/off task interactions. We expected to find a considerable amount of learning-oriented interactions in the group sessions and to find all three types of learning-oriented interactions, with relatively more time being spent on cumulative reasoning than on exploratory questioning and handling conflicts.

The research questions addressed in this study are:

1. How much of the time of the tutorial group meeting is spent on the different types of verbal interaction? How much time is spent on learning-oriented interactions compared with procedural and irrelevant/off-task interactions?
2. How are these different interaction types distributed over the duration of the tutorial group meeting?

Method

Subjects

For participation in the study, we randomly selected four second-year tutorial groups from the total of 300 students in the second year of the Maastricht undergraduate medical curriculum. Second-year students were chosen, because they are fairly experienced with the problem-based learning process. The groups consisted of 8-10 students. Two tutors, each facilitating two of the four groups, participated in the study. Both students and tutors gave informed consent. Students enter the undergraduate medical curriculum of Maastricht Medical School immediately after secondary education. In the first two years of the curriculum there are two tutorial group meetings per week in which students work on problems. In the first session they analyse the problem and identify learning issues and in the second meeting they report the results of their independent study activities and try to resolve the problem by discussing and synthesising the information they have obtained.

Procedure

The groups were in the fourth week of a six-week block halfway through the second year. Groups are newly formed for each block. The four tutorial groups were observed during the second session of the week, i.e. the reporting phase. In this phase, the quality of interactions is particularly important as students have to test hypotheses, share and construe knowledge to synthesise the information acquired from their individual studies. The sessions lasted approximately one hour, which is the usual duration for these sessions. Group interactions were recorded on video-tape in professional video-studios which were very similar to the rooms regularly used for tutorial group sessions. In these

rooms a computer and a digital projector are provided to be used in note taking and video display of case presentations.

Material

Each of the four groups worked on the same problem from the block unit on “Puberty and Adolescence”, which covers among other topics sexually transmitted disease (STD) and risk behaviours. The problem concerned Bob, an adolescent who through risk behaviour got malaria. The students had to explain the underlying processes.

Unit of analysis

We analysed the videotapes of the four groups to categorise the verbal interactions. The unit of analysis was the utterance, which was defined as an individual message unit which: 1) was expressed by one subject (i.e. group member) and dealt with one topic (i.e. a change of topic meant the beginning of a new utterance; and 2) had one single communicative function, i.e. a single message or expectation that was communicated by the speaker (e.g. a question, an argument, an evaluation) (Van Boxtel, 2000; Rourke et al., 2001). The length of an utterance could vary from one word to several sentences.

Coding scheme

We analysed the verbal interactions in the tutorial groups using Van Boxtel’s (2000) coding scheme (which was adapted from the coding scheme developed by Erkens, 1997) in order to identify the different communicative functions of the utterances. The coding of the communicative functions was determined not only by the linguistic form but also by the retrospective and prospective effect on the discourse. We adapted Van Boxtel’s (2000) coding scheme by simplifying - e.g. combining several codes into one new category -, adding, omitting or renaming some of the categories. This resulted in a coding scheme consisting of five exhaustive and mutually exclusive categories of interactions: learning-oriented interactions (i.e. exploratory questioning, cumulative reasoning and handling conflicts about knowledge), procedural interactions and irrelevant/off-task interactions. The three types of learning-oriented interactions were partly inspired by Mercer’s (1996) “modes of talk”. Each type of interaction comprised one or more coding categories. Figure 6.1 presents the interaction types and coding categories and their definitions.

Analysis

For the coding, we used ‘The Observer’, computer software that is intended for quantitative analysis of primary sources of observational data, such as videotapes (Noldus, 2003). The videotapes were analysed directly without transcripts being made.

Two of the authors (AVP and BdL) independently coded a randomly selected part (about 20%) of one of the four videotaped sessions in order to estimate inter-rater reliability (Cohen’s Kappa). Inter-rater reliability was 0.71 (SE= 0.01), which is “substantial” according to Landis & Koch’s (1977) criteria. BdL was trained by AVP. AVP also coded all the other videotapes. In order to give an impression of the researchers’ interpretations, Figure 6.2 presents a discourse excerpt.

Chapter 6

To calculate the amount of time spent on each of the types of interactions (first research question), the means and standard deviations were calculated for each category in the coding scheme across the four tutorial groups. The scores on the interaction types were calculated by summing the mean scores per coding category, i.e. the score on exploratory questioning was calculated by summing the mean scores on the open questions, critical questions, verification questions and alternative arguments. The scores on the other interaction types were calculated similarly (Figure 6.2).

(Start time: 13.44)
E: Well, I find something about worldwide. There are two-hundred and fifty million people infected and over one million die of the infection (*statement*)
D: I have got a question about this. I also found these numbers (*other argument*)
D: but I also found something about double these numbers, like five-hundred million infections and 2 million deaths. (*counter argument*)
D: I don't know which one is true. (*other question*)
B: I read about two-hundred and fifty clinical cases, but I think there are a lot of people who don't go to the hospital so it don't, doesn't become a clinical case. So it isn't... there are no statistics about that. (*other argument*)
D: Okay. (*judgment acceptance/confirmation*)
T*: Just one remark. If you read something about numbers always look what the numbers refer to. Okay? so, you have 250 million and you 500 million, that's quite a difference, so always look what the number means and how it's ex.... how it's, how the research was done, which groups are involved, so you can explain the numbers, 'cause it doubles. (*procedural*)
T: 250 million is a lot, 500 million even more. (*other argument*)
D: Yeah, that's my question, 'cause I found both numbers; 250 and 500 million. (*statement*)
E: 250 was the clinically diagnosed number, so maybe they can make an estimate, 'cause they do know how many people do come to the hospital and how many people don't. (*other argument*)
(End time: 15.30)
*T is the tutor

Figure 6.2. An excerpt from the discourse of one tutorial group

In order to answer the second research question, i.e. the distribution of the different interaction types over the duration of the tutorial meeting, we made a graphical representation of the temporal occurrence of the types of interactions in each group (see Figure 6.3). To support these findings a sequential analysis was executed in 'The Observer', providing transition probabilities between two succeeding coding categories.

Results

Table 6.1 shows the mean percentages of session time spent on each of the five types of interactions.

Table 6.1. Mean percentages, standard deviations and coefficients of variation of time spent on each interaction category and on the three main types of learning-oriented interaction for all groups (n=4).

Category	Mean time %	SD time (%)	Coeff var
<i>Exploratory questioning</i>	10.1	1.4	0.14
Open question	6.0	1.8	0.30
Critical question	0.7	0.3	0.43
Verification question	2.7	1.6	0.59
Alternative argument	0.7	0.5	0.71
<i>Cumulative reasoning</i>	62.8	3.9	0.06
Statement	33.6	5.7	0.17
Other argument	25.1	5.6	0.22
Other question	1.7	0.7	0.41
Judgement acceptance/confirmation	2.4	0.8	0.33
<i>Handling conflicts about knowledge</i>	7.0	2.3	0.33
Counter argument	3.2	1.5	0.47
Judgement negation/disagreement	1.4	0.9	0.64
Evaluation	2.4	0.9	0.38
Procedural	10.1	5.7	0.56
Irrelevant/off-task	10.0	3.8	38.0
Total	100		

We present time as a percentage of total session time, because the duration of the reporting phases varied between the four groups from 39 to 68 minutes. Variation was due to differences in speed of discussion and/or detail of reporting. Most of the time (62.8%) was spent on cumulative reasoning. Exploratory questioning took up 10.1% of the time and handling conflicts about knowledge 7.0%. Procedural interactions accounted for 10.1 % and irrelevant/off-task interactions for 10.0% (Table 6.1). Exploratory questioning consisted mostly of open-ended questions (6%) and critical questions and alternative arguments accounted for 0.7% of session time. The time students spent on cumulative reasoning consisted mostly of statements (33.6%) and other arguments (25.1%), with 1.7% being used for other questions. Nearly half of the 7% of session time devoted to handling conflicts about knowledge was spent on counter arguments (3.2%), with judgement negation/disagreement accounting for 1.4% (Table 6.1). Because of the non-uniform mean time across categories, the coefficient of variation (defined by $SD/mean$), which represents the relative variation for each category, was also presented in Table 6.1. The coefficients of variance indicate that the four groups did not differ much in the amount of time spent on exploratory questioning

and cumulative reasoning and differ most for the procedural and irrelevant/off-task interactions.

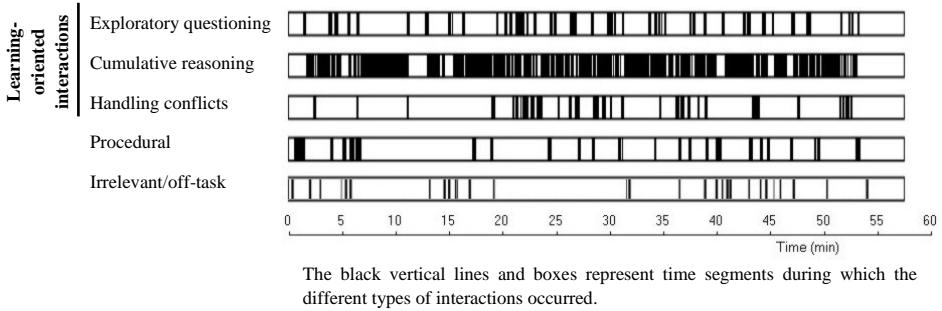


Figure 6.3. Time spent on the different types of interactions in the meeting of one of the tutorial groups.

Figure 6.3 shows how the different types of interaction were distributed over one of the group sessions. It shows at which points in the session the various types of interaction occurred. Exploratory questioning was spread throughout the session, although the amount of time devoted to instances of exploratory questioning increased slightly after twenty minutes. Cumulative reasoning also took place throughout the session, but it took up considerably more time. It was the only type of interaction that sometimes continued for as long as several minutes. Occurrences of handling conflicts about knowledge were rare early in the sessions (approximately in the first twenty minutes), but they increased in frequency after that, especially during the second twenty minutes of the session. Procedural interactions occurred mainly in the first seven minutes and at a somewhat lower rate between the seventeenth minute and the end of the reporting phase. Finally, irrelevant/off-task interactions were mainly found in the first seven minutes, between the thirteenth and twentieth minute and between the thirtieth and fiftieth minute. The meetings of the other three groups showed comparable trends in the temporal distribution of the different interaction types.

Conclusions and discussion

This research from a collaborative learning perspective provides new insights into the interactions in authentic (non-experimental) problem-based tutorial group discourse. It sheds light specifically on interactions that are assumed to promote learning (learning-oriented interactions). The present study contains also information about where and when in the reporting phase learning-oriented, procedural and irrelevant/off-task interactions occurred.

The results show that learning-oriented interactions predominated, accounting for almost 80% of total session time. This implies that the students concentrated their attention mainly on the content of the learning task. Only a small amount of time was spent on other types of interaction (10% on procedural and 10% on off-task

interactions). This confirms our expectation that the tutorial groups would show a high task involvement, manifesting itself in a high number of productive, learning-oriented interactions. These results are in line with those reported on the problem analysis phase in PBL by De Grave et al. (1996). They also found very few verbal interactions on the procedural and off-task level. The fact that only relatively little time was spent on procedural and irrelevant/off-task interactions may be attributable to the pre-set working procedure of the tutorial group meetings. In the problem-based tutorial groups in the undergraduate medical curriculum of Maastricht University, students analyse problems in different phases, i.e. defining and analysing, brainstorming, formulating hypotheses, testing hypotheses, identifying learning issues and sharing knowledge (Schmidt, 1983). Students are thoroughly trained in using this approach during the first weeks of their first year, which may contribute to their efficiency in dealing with problems and the limited need for regulatory or co-ordinating interactions. The role division in the group (“chair”, “secretary”, “tutor” and “group member”) may also contribute to the efficiency of the reporting procedure.

Almost two-thirds of the duration of the group session was taken up by cumulative reasoning interactions, predominantly statements and other arguments. In the reporting phase, students recount the results of their independent study activities to the other students. Statements and other arguments (cumulative reasoning) are the most logical interactions to expect at this stage of the problem solving process. Much less time was found to be devoted to exploratory questions, which were mostly open questions. The results also showed that both exploratory questioning and cumulative reasoning were distributed relatively densely over the whole of the meeting, although the instances of cumulative reasoning lasted longer. These findings can be explained if we take a closer look at the usual procedure in these reporting sessions. An explanation for the use of open questions in the first half of the meeting, could well be that the chair invites the students to report all the information they have found for each learning issue. The students respond by reporting their findings and additional information, which probably explains the use of statements and other arguments. In the second half of the meeting, a tutorial group usually gets involved in a discussion in which relationships between findings are sought and findings are synthesised, which tends to induce the use of other arguments (such as continuation arguments and conclusions) elicited by open questions from several group members. Figure 6.3 suggests that exploratory questioning, such as open questions or critical questions, often preceded cumulative reasoning, such as statements followed by other arguments. The long episodes of cumulative reasoning suggest that statements and arguments were often followed by arguments of other students. This was supported by the sequential analysis.

Very little time was spent on handling conflicts, especially expressing negations, disagreements and evaluations. These results support findings from an earlier study (Visschers-Pleijers et al., 2005), which demonstrated that, according to students, providing arguments occurred more frequently than interactions like negations and counter arguments. Moreover, the increase in interactions relating to handling conflicts that is seen from the middle part of the group meeting might indicate that contradictory findings or unclear observations are made explicit only later in the session. Still, in light

of the theoretical underpinnings of PBL, which state that PBL stimulates learning by inducing cognitive conflicts resulting from discrepancies between individual students' knowledge and the problem they are working on (De Grave et al., 1996), the authors find it remarkable that the students were found to spend only a small percentage of session time on handling conflicts about knowledge and exploratory questioning. These findings could be explained by the need of the students to reach consensus about core information soon. Another possible explanation is the influence of video recording during the sessions. However, this is evaluated afterwards and the influence turned out to be very small.

The present study has some limitations. Firstly, all interactions, except for the irrelevant and procedural interactions, were learning-oriented, i.e. conducive to learning. This study was not aimed at investigating unproductive types of interactions, such as disputational interaction, characterised by disagreement and individualised decision making (Mercer, 1996). Secondly, the results do not offer insight into the relative frequencies of the contributions to the verbal interactions by the students and the tutor, respectively. Several questions may be raised in this respect, such as: what was the nature and rate of the tutor's participation in the verbal interactions in the group compared to that of the students? Thirdly, we examined only four reporting group meetings with students experienced with PBL. The authors did not investigate whether the interaction types and patterns are similar to those in other stages in the PBL process and to those of other student groups. Therefore, further studies should explore whether the results can be generalised to other settings. These results form a basis for further hypothesis testing.

Several recommendations for future research can be drawn from the present study. It would be interesting to investigate differences between tutorial groups as well as the effect of different problems (tasks) on the nature and frequencies of interactions in the tutorial group. Cohen (1994) and Van Boxtel (2000) emphasised that task characteristics substantially impact on the type and number of interactions. Tasks without a straightforward solution are believed to be more suitable for collaborative learning (Cohen, 1994). In addition, it would be useful to find out how the tutor influences the discussion by comparing the nature and frequency of tutor participation with that of the students.

Finally, some suggestions for educational practice can be derived from our findings. To optimise the quality of interactions in the group, training in the use of PBL for tutors and students should focus more on interactions that occur when students scrutinise each other's observations, such as asking critical questions and providing counter arguments. One of the ways of doing this might be to urge students to formulate critical questions during the reporting phase and provide students with suggestions how to ask such questions.

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Chapter 6

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Conclusions and discussion

The research presented in this thesis was aimed at gaining a better understanding of what happens during authentic problem-based tutorial group discussion. We developed, used and applied different methods to analyse and describe learning-oriented interactions in an authentic PBL context, as multiple methodologies are needed to better understand a multifaceted learning environment like PBL. The studies are descriptive and process-oriented. The research focused on two themes: 1) the measurement of learning-oriented interactions in problem-based tutorial group discussion, and 2) gaining deeper insight into the actual interaction process by describing the nature of these interactions as they occur and are perceived to occur during the reporting phase of the problem-based learning process. In this final chapter, we present the main conclusions of the two themes of the research. The results are discussed and limitations are indicated. Finally, suggestions for further research and educational practice are provided.

Main conclusions

In this paragraph an overview of the findings are outlined from the studies to answer the research questions. General conclusions that can be drawn on these findings are formulated.

The measurement of learning-oriented interactions in the problem-based tutorial group

The first two studies in this thesis were aimed at answering the question: How can learning-oriented interactions in an authentic problem-based learning environment be measured? In these studies, two instruments were used, i.e. a coding scheme for identifying learning-oriented interactions in videotaped PBL tutorial group meetings, and a questionnaire addressing student perceptions on the occurrence of learning-oriented interactions in their tutorial groups.

Chapter 2 described an exploratory study fitting within the theme of measurement of interactions. In this study, transcripts of three videotaped PBL reporting sessions of first-year and second-year university students were analysed. Van Boxtel's (2000)

coding scheme, consisting of coding categories was used to find examples of elaborations and co-constructions, which indicated individual and collaborative knowledge construction. This study showed several examples of elaborations and co-constructions in the form of questions, reasoning episodes and conceptual conflict episodes, thus Van Boxtel's coding instrument turned out to be useful in analysing the interactions. While analysing the transcripts, more co-constructions than elaborations were found (although frequencies were not reported, since this study was not aimed at investigating how many elaborations and co-constructions occurred). The coding procedure was complex and time-consuming. Therefore, we tried to find another instrument to measure interactions in the tutorial groups: an instrument which use is less time-consuming and that is more manageable in practice.

Chapter 3 described the development and validation of a questionnaire to assess learning-oriented interactions in problem-based tutorial groups in practice. The questionnaire which contained eleven items on a five-point Likert scale was completed by second-year university students. A confirmatory factor analysis identified three learning-oriented interaction dimensions, inspired by the work of Van Boxtel (2000) and Mercer (1995; 1996): exploratory questioning, cumulative reasoning and handling conflicts about knowledge. These three types of learning-oriented interactions are characterised by, for example, describing relationships between different concepts, asking questions to verify that one has understood correctly what was said by others, and recognising contradictions in the learning content which stimulates generation of explanations and justifications. Such interactions are manifestations of elaborations and co-constructions and it was shown that these boost learning (Van der Linden, 2000, Van Boxtel, 2000; De Grave, Boshuizen & Schmidt, 1996; Brown & Palincsar, 1989). The relation between the three-dimension model and the tutorial group's productivity was investigated by regression analysis. This analysis showed that 26% of the variance in tutorial group's productivity was explained by the dimensions exploratory questioning and cumulative reasoning. The questionnaire turned out to be valid as the three learning-oriented interaction dimensions fitted the data well.

As mentioned before, we found more co-constructions than elaborations when applying the coding scheme used in Chapter 2. In our coding scheme, a questioning, reasoning or conflict episode was coded as a co-construction if it was constructed by two or more students in a tutorial group. If it was constructed by one individual student, it was called an elaboration. Thus, a co-construction actually is a collaborative elaboration. From Chapter 2, we also concluded that co-construction episodes were built by few students, mostly two or three, whereas the whole groups were much larger (5-7 students). This does not necessarily mean that the other students were idly sitting around the table. It is plausible that they were listening to the discussion and were constructing their own knowledge, however, these individual thinking processes that were not verbalised could not be measured with our instrument. A study by Moust et al. (1986) suggested that students not directly participating in the discussion elaborate as much as those who did participate and consequently learn as much.

The questionnaire we developed in Chapter 3 provided some concrete descriptions of learning-oriented student interactions that can occur in tutorial groups. These

descriptions can function as guidelines for tutors, and students themselves to improve the interaction process in the tutorial group, for example, the description “Probing questions were asked by group members to scrutinise students’ observations” indicates whether students have a critical attitude toward the information presented in the tutorial group. If such critical questions are not asked in the group, the questionnaire can draw the tutor’s or the students’ attention to this. From Chapters 2 and 3 we can conclude that both Van Boxtel’s (2000) observation instrument and the questionnaire can be used to measure learning-oriented interactions in problem-based tutorial groups. However, they differ in the level of detail and richness of information they provide. With the questionnaire, one can get a view of the occurrence of learning-oriented interactions in a large number of tutorial group meetings, providing a global picture of the interaction process in tutorial groups. It may therefore be useful for tutors who want to evaluate the interaction in the tutorial groups they guide. With the observation instrument (coding scheme) one can deepen this global picture with a richer and more detailed picture of the actual interaction process in a few tutorial group meetings. Together, the questionnaire and the coding scheme thus enable us to acquire a broad and in-depth sight on the interaction process in PBL tutorial groups triangulated from different sources of information. These two instruments were used, and in case of the coding scheme used and adapted, in the studies in Chapters 4 and 6 to gain insight into the nature of learning-oriented interactions in the reporting phase of PBL.

The nature of learning-oriented interactions in the reporting phase: student perceptions and observations

The last three studies in this thesis were aimed at answering the question: What actually happens in the problem-based tutorial group with regard to learning-oriented interactions during the reporting phase? To examine the actual process of interactions we made use of different sources: student perceptions and observations.

Chapter 4 addressed a study in which the questionnaire we developed in an earlier study was used to detect shortcomings in the interactions during tutorial group discussion. Second-year students were asked to indicate how they perceived the occurrence and desirability of several learning-oriented interactions in the reporting phases of their own tutorial group. The results showed relatively high scores on the occurrence of the learning-oriented interactions, mentioned in the questionnaire. The desirability scores were significantly higher than the occurrence scores for the interaction dimensions exploratory questioning and cumulative reasoning. This implies that in the students’ opinion, the interaction process in the tutorial group can be improved. Some earlier studies also reported that improvement of the tutorial group process, of which interaction is an important part, is desirable, since many students and faculty members have experienced problems with tutorial groups (Hitchcock & Anderson, 1997; Dolmans et al., 2001; 2005; Moust et al., 2005). For the interaction dimension handling conflicts about knowledge the desirability scores were not higher than the occurrence scores. For some items from the questionnaire the scores were even smaller, which means that in the students’ perception such conflicts occur more often than desirable. This is in contrast with the literature suggesting that cognitive conflicts

can have positive effects on student learning (e.g. Dillenbourg et al., 1995; Van Boxtel, 2000; 2004; De Grave, Boshuizen & Schmidt, 1996). The study of De Grave, Boshuizen and Schmidt (1996), for example, showed that cognitive conflicts in the problem-based tutorial group lead to students' conceptual change. Also in one of our later studies (presented in Chapter 5) students describe a positive relation between discussing conceptual conflicts and learning. Our deviating results in Chapter 4 might be explained by a possibly neagtive interpretation of the term 'conflict' by the students. Maybe they thought that the term 'conflict', as formulated in the questionnaire, indicated a social conflict, such as a quarrel in the tutorial group. Another explanation might be the students' preference for finding the right solutions during group discussion and reaching consensus. Further studies are needed to find out how students perceive the relation between discussing conflicts with regard to the learning content and their learning. This study provided suggestions for improvement of the interactions. For example, the group chair and/or the tutor can stimulate the other students to provide elaborate explanations accompanied by arguments, by asking open-ended questions, and to be more critical about other students' statements by asking probing questions. Apparently, the students believe that learning can be enhanced if they ask more questions, elaborate more and provide more arguments, in other words if they learn more actively. This view of the students corresponds with recent notions about active learning and therefore supports these views, in which students are challenged to construct their own knowledge base by exerting their mental abilities while learning and by interacting with other students (Van Hout-Wolters, Simons & Volet, 2000; Hmelo & Evensen, 2000). The fact that the questionnaire does not provide information on why students have certain perceptions led us to set up an interview study to gain a more detailed understanding of student perceptions about learning-oriented interactions.

In Chapter 5 student perceptions were investigated in more detail by means of focus group interviews. However, in contrast with the closed questions in our earlier studies (Chapters 3 and 4), in this qualitative study students were asked in an open-ended way which factors contribute to an effective tutorial group discussion during the reporting phase and why. The aim of this study was to concretise learning processes during tutorial group discussions as described in literature on collaborative learning. Three groups of first-year students and three groups of second-year students were interviewed about characteristics of effective group discussion and possible improvements. The analysis yielded four main characteristics of effective discussions during the reporting phase: asking for, giving and receiving explanations, integrating and applying knowledge, discussing differences with regard to learning content and monitoring the content and the group process of the discussion. These findings support results found by Steinert (2004) and Virtanen et al. (1999) who found that students attributed the effectiveness of a tutorial group discussion largely to proper discussions with much interaction and knowledge sharing. Thus, students had clear ideas about what promotes effective discussions. In addition to the four main characteristics of effective discussion, the study presented in Chapter 5 yielded an answer to the questions why these characteristics promote an effective discussion. This answer was given by mentioning the main learning effects. The main learning effects were retention, understanding,

integration and application of knowledge. Gaining deeper understanding was also mentioned by students as a learning effect of tutorial group discussion in a study by Lindblom-Ylänne et al. (2003). Apparently, the students confirm suggestions and findings from earlier research that discussing problems enhances long term retention of information, higher order thinking skills, such as testing, structuring, synthesising and applying knowledge (Schmidt & Moust, 2000; De Grave, Boshuizen & Schmidt, 1996; Hughes Caplow et al., 1997). Thus, in accordance with our expectations, the students' perspective on effective group discussion is for the most part in line with findings from the literature about learning in problem-based tutorial groups.

Although the studies described in the Chapters 4 and 5 provided us a more detailed understanding about learning-oriented interactions based on student perceptions, we decided to conduct an observation study on the nature of interaction processes taking place in the tutorial group. Even though we knew from one of our previous studies reported in Chapter 2 that observations would be rather complex and time-consuming, we thought that observations would be a useful addition, as triangulation of different instruments and data sources provide the richest and most comprehensive view on the nature of the actual interaction process during problem-based tutorial group discussions. Chapter 6 describes this observation study.

This study measured interactions in a quantitative way which enables comparison of the results with results from future studies on group interactions in PBL group meetings. The central question was: How much time is spent on learning-oriented interactions and on other interactions (procedural and off-task interactions), and how are the different interaction types spread over the duration of a tutorial group meeting (reporting phase)? Four tutorial group sessions of second-year students were observed and analysed by using a coding scheme based on Van Boxtel (2000) and by executing a sequential analysis. Task involvement in the tutorial groups seemed to be very high and all types of learning-oriented interactions were observed. These findings are similar to those in De Grave, Boshuizen & Schmidt (1996) and Geerligs (1995), who also focused on different levels of interactions or thoughts, such as task-oriented, procedural and task-irrelevant, and suggest that students in a problem-based environment are most of the time actively involved in task-oriented interactions or thoughts. Cumulative reasoning was the dominant type of interaction, accounting for almost two-third of the interactions. We also found that exploratory questioning episodes often preceded cumulative reasoning episodes and that handling conflicts episodes mainly occurred in the last part of the tutorial group reporting meeting. In our opinion, cumulative reasoning is an effective way of interacting in problem-based tutorial groups, however, the discussion could be optimised if there would be more episodes of exploratory questioning and handling conflicts about knowledge. In the literature, no comparable observation studies in PBL have yet been found, so this study gives a first impression of the nature of the interactions in a problem-based tutorial group. The findings might be explained by taking a closer look at the usual procedure to deal with problems in the reporting sessions. The start of such sessions, usually contain the reports of the findings of the students, leading to exploratory questioning and cumulative reasoning. This normally takes most of the time. Later, when the findings of the students are related to each other

and possible conceptual conflicts arise, handling conflicts episodes occur. Our findings might give rise to many questions for further research which we will discuss later.

In Chapters 4, 5 and 6 group interactions in problem-based tutorial group sessions (reporting phase), particularly learning-oriented interactions, and student perceptions about these interactions were investigated. The results in Chapters 4, 5 and 6 complement each other. From the three studies together, we can conclude that learning-oriented interactions, as they are described in the literature (Van Boxtel, 2000; Mercer, 1995; 1996) all occurred in the reporting phase in PBL. From Chapter 4 it turned out that, generally, students experienced these interactions as being effective for their learning. Chapter 5 illustrated that the students themselves came up with aspects perceived to make a tutorial group discussion effective, in which many of the learning-oriented interactions can be recognised, and that they are perceived to enhance deep learning. So, Chapter 5 provided information about the student perceptions of effective discussion processes and their accompanying learning effects. From Chapter 4 we can conclude that the tutorial group discussion in the reporting phase leaves some desire for improvement. All three Chapters provided us with suggestions on how to improve the tutorial group discussions, for example by providing guidelines for students (more specifically discussion leaders) and tutors to assess and adjust the interactions during the discussion. Finally, we can state that from these three chapters, we have received an in-depth picture of the occurrence, desirability and improvement of learning-oriented interactions in the reporting phase of PBL.

General conclusions

As mentioned in Chapter 1, many of today's curricula in higher education are grounded in constructivist theories of learning, where active and collaborative learning play a pivotal role. Problem-based learning is an instructional approach that is consistent with these current insights on learning. However, there has been little research on whether and how PBL enhances active and collaborative learning. A way to study this is to examine the interaction process in problem-based tutorial groups. With the studies presented in this thesis, we have set a step in this direction by focusing on our main problem definition, i.e.:

How can learning-oriented interactions in an authentic problem-based learning environment be measured and what happens in the problem-based tutorial group with regard to these interactions during the reporting phase?

In answer to this problem definition, we can draw some general conclusions. With respect to the first part of the problem definition, the measurement of learning-oriented interactions, we can conclude that we can measure interactions in problem-based tutorial groups with the instruments developed and used in the present thesis. The instruments measured the interactions either in an indirect way (by means of questionnaires and focus group interviews) or in a direct way (by means of observations). The indirect way is an efficient way of gaining useful information about

the nature of interactions. Observations, however, give a richer and more comprehensive view of the actual interaction process, but are usually more complex and time-consuming. The choice of a certain type of instrument depends on the level of detail and richness of information that is needed and on the aim of the research. If one is interested in how students perceive the problem-based learning environment in terms of the interactions that take place, then a questionnaire is a suitable instrument that also provides students and tutors rapid feedback. If one is interested in what actually happens during the tutorial group meeting, more specifically what types of interactions take place during the discussion and how students build on each other's ideas, observation of interactions and accompanying analysis between students is the obvious method of study. For most practitioners in education, questionnaires or focus groups may rapidly provide sufficient information. However, educational practitioners and also researchers, who might have higher demands, may want to triangulate the data from different methods and sources, including observations, to get a more holistic view of the interaction process in problem-based tutorial groups.

With regard to the second part of the problem definition, what happens in terms of interactions taking place in tutorial groups, we can state that insight has been gained in the interaction process in an authentic problem-based learning environment in university education, more specifically in the reporting phase. By studying learning-oriented interactions, the deliberate focus of this thesis was on cognitive aspects of the interaction process. The main results were that learning-oriented interactions occur in the group discussions, that students perceive these interactions, i.e. exploratory questioning, cumulative reasoning and handling conflicts about knowledge, as effective and perceive that these interactions enhance deep learning. From these results we can draw the conclusion that PBL promotes active and collaborative learning, although the results indicate that there is room for improvement. Our research is a start in trying to get a clearer understanding of how PBL does or does not work and under which circumstances. By using multiple methods and triangulating data from different instruments, we tried to obtain a better understanding of learning-oriented interactions in PBL. However, more process-oriented research in PBL is needed, not only from a cognitive perspective, but also from a motivational and emotional perspective and how these perspectives influence each other in tutorial groups (Hak & Maguire, 2000; Miflin, 2004; Dolmans et al., 2005; Dolmans & Schmidt, submitted). This will be shortly revisited in the paragraph describing critical reflections and suggestions for further research.

Critical reflections and suggestions for further research

A strong aspect of the studies described in this thesis is that they were process-oriented studies carried out in an authentic learning environment, a problem-based, undergraduate medical curriculum. More specifically, all studies were conducted in the context of the reporting phase in problem-based tutorial groups. An advantage of studying the learning process in a real-life educational setting is that one gains insight into the factual picture and can obtain better insights in how PBL actually works in

practice, without interventions that might change the process that one is trying to understand better. Another strong feature of our studies is that our research makes use of different methods to investigate learning-oriented interactions, with multiple sources and different types of data. Below, some critical reflections on our research are presented followed by suggestions for further research.

Studying the quality of interaction by using mixed methods

In our studies we have shown that learning-oriented interactions occur in the tutorial group discussions. It is important to continue process-oriented research in PBL in the future to gain better understanding in whether PBL works or not and how. To do this, first, the instruments used and/or developed in our studies can be applied and further validated externally in more and different problem-based learning settings, for example in other faculties and universities. Different learning disciplines, different PBL approaches and different types of PBL problems can yield varying results with respect to nature, amount and patterns of learning-oriented interactions. Second, our instruments can be used together with other instruments within one study, since we agree with Hmelo-Silver et al. (2003) who argue that no one methodology is sufficient to understand a multifaceted phenomenon like the interaction process in problem-based tutorial groups. Measurement of interactions in PBL is a complicated undertaking. It would be best if mixed methods were used within one study (triangulation).

We have not measured the effectiveness of the tutorial group discussions with respect to learning results. We think it is hard to assess learning effects of tutorial group discussions in PBL, since each discussion takes place in a specific context with a specific purpose one wants to achieve with the interactions. Although we think that it is difficult to measure the effectiveness of problem-based tutorial group discussions, it is not impossible. It could be useful, next to conducting process-oriented studies to better understand the interaction process in PBL, to investigate how the interactions in a discussion in the reporting phase of PBL can be made more effective for student learning. In our opinion, this can only be done by both investigating the interaction process and by using a very specific and sensitive outcome measure, for example, a concept map or an essay produced by students during, or directly after the group discussion in the reporting phase of PBL. The interaction process can be influenced directly by changing the task instructions, for example by manipulating the time that is allowed to be spent on certain types of (learning-oriented) interactions. There are also other interesting variables influencing the nature and amount of interactions during a tutorial group discussion, such as the quality of the problem (Schmidt et al., 1995; Cohen, 1994; Van Boxtel, 2000). Another interesting variable, also mentioned by the students interviewed in the study reported in Chapter 5, is the tutor performance (Schmidt et al., 1995). A way to positively influence the interactions in PBL by changing one or more of these variables would be through conducting experiments. For example, a study can be designed in which the nature and amount of learning-oriented interactions in the reporting phase in tutorial groups is investigated when using well-structured versus ill-structured and complex problems. In this case we would expect that ill-structured and complex problems would cause an increase in exploratory questioning

episodes and handling conflicts about knowledge episodes during tutorial group discussion. In all kind of future studies suggested above, we think that it is important to investigate interaction processes (and possibly effects of these processes) in an authentic learning environment, like PBL, in which collaborative learning is integrated completely in the regular curriculum.

Handling contradictory information

Our studies described in Chapters 3 and 4 yield some unexpected results with regard to one type of learning-oriented interactions discerned in several of our studies, i.e. handling conflicts about the learning content. From literature (e.g. Dillenbourg et al. 1995) we expected a positive effect of conflict about the learning content on the group productivity. In Chapter 3 and 4, using a questionnaire, we found that handling conflicts does not strongly influence tutorial group productivity according to the students and that they actually find conflicts about the learning content less desirable. We presented several possible explanations for these interesting findings. One explanation was that students would rather not be confronted with conflicting information, since it causes uncertainty. Another explanation was that students did not recognise their interactions as conflicts. In Chapter 5 using focus group interviews, we were able to study this aspect in further detail and found a more nuanced picture. Students think that different opinions and disagreements stimulate in-depth discussion. But they seem to prefer consensus, possibly since consensus makes it easier to study for the exams. Probably, they strongly focus on finding “the right solution” to the problem and try to avoid tensions and social conflicts between students in the tutorial group. This suggests an interesting topic for further research: examining how the interactions in the tutorial group during the reporting phase, especially discussing contradictory information, leads to conceptual change in students. Such a study would be a useful addition to the study by De Grave, Boshuizen and Schmidt (1996) that focused on processes of conceptual change in the problem-analysis phase of PBL and demonstrated that cognitive conflicts lead to conceptual change.

Operationalising elaboration and co-construction

In the conclusions of Chapter 2, we stated in our operationalisation of the concepts of elaboration and co-construction that a co-construction actually is a collaborative elaboration. This indicates that it is hard to distinguish between these two concepts while operationalising them in a coding scheme for observation. In their definitions, elaboration and co-construction can be distinguished from each other: elaboration is the deep processing of knowledge, which can be expressed by verbalisation of the learning content (Slavin, 1996); co-construction is the continuous process of the creation of a shared understanding of the task, concepts, procedures and strategies that are used (Roschelle, 1992). It is in their manifestations in a group discussion, the actual verbal interactions, that they are intertwined and therefore difficult to separate. For example, if a student poses a question to verify whether a given explanation was accurate (verification question), this is a manifestation of co-construction. Subsequently, another student may answer confirmatively to this question, followed by an explanation in

which he or she provides detailed justifications. Since this is an answer to the verification question, it is part of the co-construction. However, since the detailed justifications the student gives, requires deep processing activities (e.g. structuring and relating knowledge), this answer is also an elaboration. This example suggests that the distinction between elaboration and co-construction made in our coding scheme described in Chapter 2, is somewhat artificial. To circumvent this problem, we operationalised three types of learning-oriented interactions that are manifestations of elaborations and/or co-constructions without drawing a strict line between the two. In future research, it would be interesting to develop a coding scheme for use in a PBL context that allows for discussion episodes coded as “co-constructed elaboration”, as was done in Van Boxtel (2000). This might be more fruitful than strictly distinguishing between the two concepts, since we have experienced in Chapter 2 this to be a difficult task.

Implications for educational practice

Implications for educational practice mainly arise from the answer to the second research question that is what actually happens in the problem-based tutorial group with regard to learning-oriented interactions during the reporting phase. The results from Chapters 4, 5 and 6 provide several suggestions for the improvement of the quality or depth of the discussion in the reporting phase of PBL. An important finding of Chapter 6 was that relatively little time was spent on discussing conflicts about the learning content and exploratory questioning and that most time was spent on cumulative reasoning, which might lead to an automatic consensus. According to Chapter 4 exploratory questioning contributed the most to the tutorial group productivity. This is confirmed by the results of Chapter 5 in which students indicated that asking for explanations and discussing different opinions and perspectives contributes to an effective discussion in the reporting phase. By stimulating exploratory questioning and discussion on conflicts with regard to the learning content, the depth of the discussion can be improved. Some suggestions are given below.

First, concept mapping techniques while working on the PBL problems can be used. Students should be asked to make a concept map of the most important biomedical concepts and their relations collaboratively during the reporting phase. This is an application of the shared interaction scenario, described by Stoyanova and Kommers (2002), in which all group members work interactively on a collaborative concept map. This scenario may be very appropriate and it enables the full potential of the concept mapping method (Stoyanova & Kommers, 2002). Using concept mapping to enhance the depth of the discussion in the tutorial group was also suggested by Moust et al. (2005).

Second, training sessions, in which students and tutors are introduced to the PBL approach, can be focused more on dialogue and discussion skills (see also Mifflin, 2004). Nowadays, such introductions mainly concentrate on procedural aspects of working in PBL, such as how to apply the different steps of the Seven Jump (Schmidt, 1983). When discussing the particular group roles that are common in PBL (i.e. tutor, chair and

scribe) in such training sessions, more attention should be given to learning-oriented interactions and how these interactions can be provoked. If students and tutors know better which types of interaction lead to a deep learning approach, such as asking and answering critical questions, they can actively and directly improve the discussion.

Van den Hurk et al. (1999) found that thorough preparation for the reporting phase during self-study, e.g. by making summaries and trying to explain concepts in their own words, is beneficial for the depth of the discussion in the reporting phase. As a third suggestion, it might be helpful to provide the students some structure for self-study, for example by letting the students compose small study teams (cf. Moust et al., 2005) within their tutorial groups to prepare for the reporting phase. In small groups of three or four students, they can be asked to give a presentation in which the students synthesise their findings. Students can also form independent self-study groups, in which they can explain, clarify and summarise topics for each other, since such groups can help them to clarify difficult concepts and correct misunderstandings (Hendry, Hyde & Davy, 2005). It is essential, however, that all students study all self-generated learning issues and not distribute learning issues among themselves, because this might cause a shallow discussion and hinder learning-oriented interactions, i.e. elaborations and co-constructions in the reporting phase.

Our studies on the measurement and nature of learning-oriented interactions suggest that problem-based tutorial group discussions stimulate ways of learning advocated by today's educational research: active and collaborative learning. In this thesis, we attempted to link our research in an authentic problem-based learning environment with theoretical insights in collaborative learning, particularly focused on cognitive aspects of student interactions. This research gives rise to several theoretical questions, which should be addressed in further process-oriented studies, either with or without measuring learning effects. More studies should follow, linking the world of collaborative learning with the practice of authentic *tutorial group discussion in problem-based learning*.

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Summary

Active learning is an important topic in higher education today. An important characteristic is learners' active engagement in constructing their own knowledge. This is considered more effective than lecture-based teaching with students as passive recipients of knowledge imparted by teachers. Other ideas related to active learning are that knowledge building benefits when students interact with other students and when students interact with the learning environment. These ideas originate from constructivist views on learning. In educational practice we find these ideas reflected in learning environments where students work on assignments in small groups (*collaborative learning*). Interaction among students stimulates deep learning because it promotes elaboration of knowledge (*elaboration*). Deep learning is enhanced when students gain understanding of a problem and its related concepts and processes by talking about the problem as a group. This results in joint knowledge construction (*co-construction*). In this thesis, the term learning-oriented interactions designates interactions involving these processes, which occur in a collaborative learning environment.

The central theme of this thesis is the interactions in small tutorial groups in *problem-based learning (PBL)*. PBL is a complex learning environment characterised by collaborative learning processes. Outcomes of learning are difficult to measure in this type of learning environment because they are affected by different variables, such as the type of learning task, tutoring style, and students' cognitive learning outcomes. This has sparked a growing interest in process-oriented research. This type of research focuses on what is going on during interactions in tutorial groups. We used this approach for the research reported in this thesis. All the studies were performed among undergraduate medical students in years 1 and 2 of the PBL curriculum of the Faculty of Medicine, Maastricht University, the Netherlands. The Maastricht medical course offers small group tutorials interspersed with independent study activities. Groups of eight to ten students work together to solve authentic problems. They brainstorm to explore the problem, define learning objectives and pursue these during independent study activities. The results of these activities are reported in the next group meeting where the results are discussed and the available information is synthesised in an attempt to resolve the problem. The initial problem analysis phase, the activation of prior

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knowledge in particular, has been the subject of numerous studies. The reporting phase has, however, rarely been studied. It is this phase that takes centre stage in this thesis. The aim was to gain insight into the effectiveness of PBL, especially the reporting phase, as a collaborative learning environment. We started by identifying and applying instruments that were suitable for charting learning-oriented interactions. Our studies were aimed at describing the interaction processes in authentic problem-based tutorial groups. The research questions are:

1. How can we measure learning-oriented interactions in an authentic problem-based learning environment? and
2. What are the characteristics of the interactions that occur in PBL tutorial groups during the reporting phase?

The first two studies addressed the question: What is a suitable method for measuring learning-oriented interactions in an authentic problem-based learning environment?

The study reported in **Chapter 2** investigated the occurrence of elaboration and co-construction of knowledge during the reporting phase and the suitability of a coding system developed by Van Boxtel (2000) for mapping these processes. Elaboration and co-construction were regarded as indicators of individual knowledge construction and of co-construction of knowledge, respectively. Three reporting phases in three different tutorial groups were videotaped. The tapes were watched, transcribed and analysed. Different types of elaboration and co-construction were observed including asking and answering questions, reasoning, and discussing cognitive conflict. The coding system proved suitable for analysing the interactions. An interesting finding was that co-construction appeared easier to identify than elaboration. An explanation for this may be that (individual) elaboration in tutorial groups is intertwined with co-construction, and as a result the two processes are hard to tell apart. Usually only a few students (three at the most) were involved in co-construction. This does not necessarily imply, however, that the students who were listening without actively participating in the discussion did not engage in knowledge construction. We cannot establish this for certain, however, because we did not measure individual thought processes. Because the coding method proved to be quite complicated and time consuming, we looked for a more simple, less time-consuming instrument for analysing interactions in tutorial groups in PBL.

Chapter 3 describes the development and validation of a suitable and feasible questionnaire to examine learning-oriented interactions in problem-based tutorials. The questionnaire contained eleven items and students and/or tutors were asked to indicate on a five point scale their degree of agreement or disagreement with the statements in the items. The list was completed by all students in the second year of the undergraduate medical curriculum (240 students). Confirmatory factor analysis supported the presence of three dimensions or types of learning-oriented interactions: exploratory questioning, cumulative reasoning and discussing cognitive conflict (based on Van Boxtel (2000) and Mercer (1995, 1996)). These learning-oriented interactions comprise manifestations of elaboration and co-construction that occur during the discussion in the tutorial group when students ask questions to verify findings, describe relations between concepts or identify and discuss contradictions in learning content. The study also examined

whether there was a relation between these three types of learning-oriented interactions and the group's productivity. Productivity was derived from the regular curriculum evaluation at the end of each module. Twenty-six per cent of the variance in productivity was explained by 'exploratory questioning' and 'cumulative reasoning'. The good fit of the three types of learning-oriented interactions with the data lends support to the validity of the questionnaire. Further studies will have to determine its external validity. Because the questionnaire contains concrete descriptions of learning-oriented interactions, tutors and students can use it to identify the strengths and weaknesses of the interactions in their tutorials and if necessary take remedial action. For instance, a low score on 'critical questioning' indicates that the group does not engage sufficiently in critical appraisal of the reported information. This can be used as an incentive to be more critical in following group sessions.

The last three studies in this thesis addressed the second research question: What are the characteristics of the interactions in PBL tutorial groups during the reporting phase?

Chapter 4 presents a study of defects in the interactions during the reporting phase. All students in the second year of the undergraduate medical curriculum (240 students) were asked to complete a questionnaire containing items about both the occurrence and the desirability of a number of learning-oriented interactions during the reporting phase. Most of the interactions appeared to occur quite frequently. Nevertheless, in relation to exploratory questioning and cumulative reasoning, the students gave significantly higher scores for desirability than for actual occurrence. This suggests that they thought the interaction could be improved. This can be achieved by increased use of open and critical questions, and more extensive explanations supported by arguments. With regard to cognitive conflict, the scores on desirability did not exceed those on actual occurrence. Some items even scored lower on desirability than on occurrence. This contradicts results from earlier studies which showed that cognitive conflict can indeed improve students' learning results. A possible explanation for our diverging findings may be that the students interpreted the term 'conflict', as formulated in some items of the questionnaire, in a negative way. Maybe they thought that the term 'conflict' indicated a social conflict, such as a quarrel in the tutorial group. Another explanation may be that they thought discussions about cognitive conflict might cause confusion and create obstacles to consensus. Further research is needed to establish which factors caused our results.

Chapter 5 describes a study examining students' perceptions about the effectiveness of the discussions during the reporting phase for enhancing their learning. We performed a qualitative study that was more detailed than the study reported in chapter 4 with the aim to arrive at a concrete and detailed description of the learning processes during the reporting phase. In six focus groups, second year and first year medical students identified factors they perceived as contributing to the effectiveness of the discussions in the tutorial group and indicated why they thought these factors did so. The students were also asked to make suggestions for improvements. Based on their experiences in tutorial groups, the students described an effective discussion and its characteristics. Four factors were considered important contributors to the quality of the

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discussion: 1) asking for, giving and receiving explanations; 2) applying and integrating knowledge; 3) discussing differences with regard to learning content; and 4) guiding and monitoring the content of the discussions and the group process. Contrary to the results reported in chapter 4, the students indicated that they thought learning was enhanced by discussing discrepancies and/or contradictions in information from the literature. The students said this helped them remember, understand, integrate and apply knowledge. In a number of respects this study confirms findings from previous studies of the learning process in problem-based tutorial groups. According to the students, the group discussion can be made more effective in enhancing their learning by addressing effective interaction strategies in introductory PBL sessions, for instance, by training in asking open-ended questions, supporting explanations with arguments, and discussing contradictory findings from the literature. Tutors should also be better trained to give effective, personal feedback. Finally, it may be helpful to encourage students to create concept maps of key concepts and relations between those during the reporting phase and consult different resources during independent study activities.

Chapters 4 and 5 describe studies offering insights into the interactions in tutorial groups during the reporting phase from the students' point of view. Chapter 6 presents an observation study that was intended to yield further understanding. Although we concluded from our experiences described in chapter 2 that the coding system we used was complicated and time consuming, we used a coding scheme again in this study because we expected the use of different instruments and data sources to yield a richer and more complete picture of the interactions in tutorial groups.

Chapter 6 describes an observation study involving quantitative measurement of group interactions. We performed a quantitative study, because it facilitates comparison of results with those of future studies into group interactions in PBL. The key question was: how much time do groups spend on learning-oriented interactions and how much on other (procedural and off-task) interactions, and how are the different types of interactions distributed over the session? We observed four second year tutorial groups. The group sessions were videotaped and we analysed the tapes using a coding scheme based on Van Boxtel (2000). In the analysis, we distinguished between three types of learning-oriented interactions (exploratory questioning, cumulative reasoning and discussing cognitive conflict). Procedural and off-task interactions were also included in the analysis. We performed sequential analysis to determine the order of occurrence of the types of interaction over the course of the group session. Learning-oriented interactions took up 80% of the session and procedural and off-task interactions both 10%. This led us to conclude that the tutorial groups were strongly focused on their learning tasks. All three types of learning-oriented interactions were seen to occur. By far most of the time (63%) was devoted to cumulative reasoning with exploratory questioning and discussing cognitive conflict taking up 10 and 7% of the time, respectively. Exploratory questioning was often seen to be preceded by cumulative reasoning. These two types of interaction occurred at all stages of the session. Cognitive conflict did not occur until the second half of the session. This may be explained by the structure of the reporting phase: students report the findings from their independent study activities and after that discuss the connections among and discrepancies between

these findings. Although cumulative reasoning is an effective interaction, the reporting phase could be made more effective by spending more time on cognitive conflict and exploratory questioning.

Chapter 7 presents the general conclusions and a discussion of the research. Recommendations are made for further research and education practice. From the results of chapters 2 and 3 we conclude that the instruments we developed and used are suitable for measuring group interactions during the reporting phase in problem-based tutorial groups. The questionnaire we developed provides a global picture of the quality of group interactions quickly and efficiently. The coding scheme we developed for analysing observational data yields rich and unique information. It is, however, far more complicated and time consuming than the questionnaire. Which method is preferred will depend primarily on the purpose of the analysis. The main conclusions from the studies in chapters 4, 5 and 6 are:

- Types of interaction – such as exploratory questioning, cumulative reasoning and discussing cognitive conflict – described in the literature as effective in stimulating student learning do occur during the reporting phase in problem-based tutorial groups. Cumulative reasoning is the dominant type of interaction. The depth of the discussions can be enhanced by stimulating the other two types of learning-oriented interactions.
- The students perceived the above-mentioned learning-oriented interactions as effective for their learning thereby supporting current views of the effectiveness of active and collaborative learning.

The strengths of the research in this thesis are that it is process-oriented and that we performed the studies in an authentic learning environment using a variety of instruments and data sources. However, further process-oriented studies are needed to elucidate which conditions determine the effectiveness of PBL as a learning environment. This thesis presents a first step in this direction. In addition to process-oriented studies, we recommend further research directed at ways of improving the interaction in problem based tutorial groups in order to enhance student learning. The learning effects of the reporting phase were not addressed in this thesis. Measuring those would require a specific and sensitive instrument, for instance a concept map or an essay to be written by the students during or immediately after the reporting phase. Some practical suggestions for improving the quality of discussions during the reporting phase are: using concept mapping techniques, more attention for skills related to dialogue and discussion in student and tutor training for PBL, and modifying the independent study activities so that they provide better preparation for the reporting phase.

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Samenvatting

Actief leren is een belangrijk actueel onderwerp in het hoger onderwijs. Bij actief leren construeert de student zijn of haar eigen kennis. Dit wordt beschouwd als effectiever dan onderwijs waarbij de docent doceert en de student het gedoeerde passief opneemt. Een ander uitgangspunt bij actief leren is dat interactie tussen studenten en tussen studenten en de omgeving een gunstige invloed heeft op de kennisconstructie. Deze ideeën komen voort uit de constructivistische visie op leren. In de praktijk worden deze opvattingen vaak toegepast in leeromgevingen waarin studenten in kleine groepjes aan leertaken werken (*samenwerkend leren*). Interactie tussen studenten kan leren meer diepgang geven doordat verdiepende cognitieve processen (*elaboraties*) in gang gezet worden. Diepgaand leren wordt bevorderd als studenten al discussiërend samen inzicht verwerven in een probleem en de ermee samenhangende concepten en processen. Dit leidt tot gezamenlijke kennisconstructie (*co-constructie*). De term *leergerichte interacties* verwijst in dit proefschrift naar interacties tijdens het samenwerkend leren waarbij deze processen een rol spelen.

Het onderwerp van dit proefschrift is de interactie in onderwijsgroepen in *Probleemgestuurd onderwijs (PGO)*. PGO is een complexe leeromgeving die gekenmerkt wordt door samenwerkend leren. In een dergelijke leeromgeving zijn leereffecten moeilijk te meten doordat zij onderhevig zijn aan verschillende variabelen, zoals het soort probleemtaak, de begeleidingsstijl van de tutor en de cognitieve leerresultaten van de studenten. Dit heeft geleid tot een groeiende belangstelling voor procesgericht onderzoek. Centraal in dit soort onderzoek staat wat zich afspeelt tijdens interacties in onderwijsgroepen. Dit is de benadering die gekozen is voor het onderzoek in dit proefschrift. Alle onderzoeken zijn uitgevoerd bij eerste- en tweedejaarsstudenten aan de Faculteit der Geneeskunde van de Universiteit Maastricht. In het probleemgestuurde onderwijs aan deze faculteit werken studenten in onderwijsgroepen van acht tot tien studenten samen aan het oplossen van authentieke probleemcasus. Na een eerste verkenning analyseert de groep de casus en stelt leerdoelen op, die vervolgens als leidraad voor zelfstudie dienen. De resultaten hiervan worden nabesproken in de volgende groepsbijeenkomst. Hierin rapporteren de studenten hun bevindingen en streven gezamenlijk naar een synthese van de informatie. Naar de initiële fase van probleemanalyse, vooral het activeren van voorkennis, is al veel

onderzoek gedaan. De nabespreking is echter weinig onderzocht. Centraal in dit proefschrift staat de groepsdiscussie tijdens de nabespreking. Het doel van het onderzoek was vergroting van inzicht in de effectiviteit van PGO, met name van de nabespreking, als omgeving voor samenwerkend leren. Als eerste stap in het onderzoek hebben wij gezocht naar geschikte methoden om leergerichte interacties in kaart te brengen. Deze methoden hebben wij toegepast in ons onderzoek. Alle studies zijn beschrijvend en gericht op interactieprocessen in authentieke probleemgestuurde onderwijsgroepen. De onderzoeksvragen zijn:

1. Hoe kunnen we leergerichte interacties meten in een authentieke PGO leeromgeving?
en
2. Wat is de aard van de interacties tijdens de nabespreking in een onderwijsgroep in PGO?

De eerste twee studies betreffen de vraag: Wat is een praktisch toepasbare methode om leergerichte interacties in een authentieke PGO leeromgeving te meten?

Hoofdstuk 2 beschrijft een onderzoek naar elaboratie en co-constructie van kennis tijdens de nabespreking in PGO. Onderzocht is of deze processen voorkwamen en of ze met behulp van een codeersysteem (observatieschema), ontwikkeld door Van Boxtel (2000), in kaart gebracht konden worden. Elaboratie en co-constructie werden in dit explorerende onderzoek gezien als indicator van respectievelijk individuele en gezamenlijke kennisconstructie. Van drie nabesprekingen in drie verschillende onderwijsgroepen zijn video-opnames gemaakt, die vervolgens bekeken en getranscribeerd zijn. Verschillende soorten elaboratie en co-constructie werden waargenomen, waaronder vragen stellen en beantwoorden, redeneren, en het bespreken van conceptuele tegenstrijdigheden. Het codeersysteem van Van Boxtel (2000) bleek geschikt om de interacties te analyseren. Opvallend is dat voorbeelden van co-constructie makkelijker aanwijsbaar waren dan voorbeelden van elaboratie. Een mogelijke verklaring is dat (individuele) elaboratie in groepsdiscussies verweven is met co-constructie en daardoor moeilijk apart te onderscheiden is. Ook bleken er meestal maar enkele (hooguit drie) studenten betrokken te zijn bij co-constructie. Dit hoeft overigens niet te betekenen dat de andere studenten zich afzijdig hielden. Het is niet onwaarschijnlijk dat studenten die naar de discussie luisterden ook bezig waren met kennisopbouw. Met zekerheid kunnen we dit echter niet vaststellen, omdat individuele denkprocessen niet gemeten zijn. Omdat de codeerprocedure nogal ingewikkeld en tijdrovend bleek, is gezocht naar een eenvoudiger en minder tijdrovende methode om interacties in probleemgestuurde onderwijsgroepen te analyseren.

Hoofdstuk 3 beschrijft de ontwikkeling en validering van een praktisch bruikbare vragenlijst over leergerichte interacties in probleemgestuurde onderwijsgroepen. De vragenlijst bestond uit elf items en studenten en/of tutoren (docenten) konden op een vijfpuntsschaal aangeven in hoeverre ze het met de bewering in een item eens of oneens waren. De lijst is ingevuld door een volledige lichte tweedejaarsstudenten geneeskunde (240 studenten). Een confirmatieve factoranalyse bevestigde dat er drie dimensies of soorten leergerichte interacties te onderscheiden waren: explorerende vragen stellen, cumulatief redeneren en bespreken van conceptuele conflicten

(gebaseerd op Van Boxtel (2000) en Mercer (1995; 1996)). Deze leergerichte interacties bestaan uit vormen van elaboratie of co-constructie die ontstaan als de deelnemers tijdens de groepsdiscussie bijvoorbeeld vragen stellen om kennis te verifiëren, relaties tussen concepten beschrijven of tegenstrijdigheden in de leerinhoud constateren en bespreken. Ook is onderzocht of deze drie soorten leergerichte interacties samenhangen met de productiviteit van de onderwijsgroep. De productiviteit werd ontleend aan de reguliere programma-evaluatie aan het eind van elk onderwijsblok. Zesentwintig procent van de variantie in productiviteit werd verklaard door ‘explorerende vragen stellen’ en ‘cumulatief redeneren’. Omdat de drie soorten leergerichte interacties goed bij de data pasten, kan geconcludeerd worden dat de vragenlijst valide is. De externe validiteit van de vragenlijst moet nader onderzocht worden. Doordat de vragenlijst concrete beschrijvingen van leergerichte interacties in onderwijsgroepen bevat, kunnen tutores en studenten de lijst gebruiken om sterke en zwakke punten in de interacties in de onderwijsgroep op te sporen en waar nodig aan te pakken. Zo valt uit de score op het item ‘kritische vragen’ af te leiden hoe kritisch de studenten gerapporteerde informatie beoordelen. De tutor en de groep kunnen een lage score aangrijpen om in volgende bijeenkomsten alerter te zijn op dit punt.

De laatste drie studies in dit proefschrift zijn gewijd aan de tweede onderzoeksvraag: Wat is de aard van de interacties tijdens de nabespreking in een onderwijsgroep in PGO?

Hoofdstuk 4 beschrijft een studie waarin wij met behulp van de ontwikkelde vragenlijst tekortkomingen in de interacties tijdens de nabespreking hebben opgespoord. Een volledige jaargroep tweedejaarsstudenten geneeskunde (240 studenten) werd verzocht de vragenlijst in te vullen. De studenten beantwoordden items over het optreden van een aantal leergerichte interacties tijdens de nabespreking. Ook werd hun mening gevraagd over de wenselijkheid van deze interacties. De meeste leergerichte interacties bleken vrij vaak voor te komen. Toch gaven de studenten ten aanzien van explorerende vragen stellen en cumulatief redeneren significant hogere scores voor de wenselijkheid dan voor het optreden. Blijkbaar vonden de studenten dat de interacties in de onderwijsgroep verbeterd konden worden. Verbetering is mogelijk door meer open en kritische vragen en meer uitgebreide uitleg onderbouwd met argumenten. Ten aanzien van conceptuele conflicten scoorde wenselijkheid niet hoger dan het voorkomen. Sommige items scoorden lager op wenselijkheid dan op het optreden. Dit is in tegenspraak met de resultaten van eerder onderzoek, waaruit bleek dat conceptuele conflicten de leerresultaten van studenten juist kunnen verbeteren. Een mogelijke verklaring voor onze afwijkende bevindingen is dat de studenten de term ‘conflict’ in enkele items negatief geïnterpreteerd hebben. ‘Conflict’ is mogelijk opgevat als sociaal conflict, bijvoorbeeld ruzie tussen groepsleden. Ook kunnen de studenten gedacht hebben dat discussies over een conceptueel conflict tot verwarring kunnen leiden en consensus in de weg staan. In vervolgonderzoek moet gezocht worden naar verklaringen voor deze bevinding.

Hoofdstuk 5 beschrijft een onderzoek waarin de mening van de studenten gepeild is over de leerzaamheid van de discussie tijdens de nabespreking. Dit kwalitatieve

onderzoek was gedetailleerder dan het onderzoek in hoofdstuk 4. Het doel was de leerprocessen tijdens de nabespreking concreet en gedetailleerd te beschrijven. In zes focusgroepbijeenkomsten bespraken tweedejaars- en eerstejaarsstudenten welke factoren volgens hen bijdroegen tot de effectiviteit van de groepsdiscussie tijdens de nabespreking en waarom dit zo is. Ook werd de studenten gevraagd verbeterpunten te formuleren. Op basis van hun ervaring met onderwijsgroepen beschreven de studenten een leerzame discussie en de kenmerken daarvan. Er werden vier factoren genoemd die belangrijk zijn voor de kwaliteit van de discussie: 1) vragen om, geven en krijgen van uitleg; 2) toepassen en integreren van kennis; 3) discussiëren over verschillende bevindingen uit de literatuur; en 4) begeleiden en monitoren van de inhoud van de discussie en het groepsproces. In tegenstelling tot de bevindingen die gerapporteerd zijn in hoofdstuk 4, gaven de studenten in dit onderzoek aan dat ze het leerzaam vonden om over verschillen en/of tegenstrijdigheden in de literatuur te discussiëren. Dit bevordert volgens de studenten dat kennis onthouden, begrepen, geïntegreerd en toegepast wordt. Deze studie bevestigt in een aantal opzichten bevindingen uit eerder onderzoek naar het leerproces in probleemgestuurde onderwijsgroepen. Volgens de studenten kan de effectiviteit van de groepsdiscussie verbeterd worden door in introductiebijeenkomsten over PGO aandacht te besteden aan effectieve interactievormen, bijvoorbeeld door training te geven in het stellen van open vragen, het onderbouwen van uitleg met argumenten en het discussiëren over tegenstrijdige bevindingen uit de literatuur. Bovendien moeten tutoren beter getraind worden in het geven van effectieve, individuele feedback. Ten slotte, zou het zinvol zijn om studenten aan te sporen om tijdens de nabespreking gezamenlijk schema's op te stellen van de belangrijkste concepten en de relaties daartussen (zogenaamde 'concept maps') en tijdens de zelfstudie verschillende literatuurbronnen te raadplegen.

Het onderzoek dat beschreven wordt in hoofdstuk 4 en 5 geeft inzicht in het interactieproces in de onderwijsgroep vanuit het gezichtspunt van de studenten. Het onderzoek betrof de visie van de studenten op de aard van de interacties in de onderwijsgroep tijdens de nabespreking. Het daarop volgende onderzoek (hoofdstuk 6) was een observatiestudie om meer inzicht te krijgen in de interacties in aanvulling op de resultaten van de studies beschreven in hoofdstuk 4 en 5. Hoewel we in hoofdstuk 2 constateerden dat observatie met behulp van een codeersysteem ingewikkeld en tijdrovend is, hebben wij deze methode toch gekozen voor deze studie in de verwachting dat verschillende onderzoeksmethoden en gegevensbronnen uiteindelijk een rijker en completer beeld geven van de interactieprocessen in de onderwijsgroep.

Hoofdstuk 6 is gewijd aan een observatieonderzoek waarin de interacties in de onderwijsgroep kwantitatief in kaart zijn gebracht. Dit is gedaan om vergelijking met de resultaten van toekomstige studies naar groepsinteractie in PGO te vergemakkelijken. De centrale vraag was: hoeveel tijd wordt in de groep besteed aan leergerichte interacties en hoeveel aan andere (procedurele en niet-taakgerichte) interacties en hoe zijn de verschillende soorten interacties verdeeld over de bijeenkomst? Vier tweedejaars onderwijsgroepen zijn geobserveerd. Er werden video-opnames gemaakt en de groepsinteracties werden geanalyseerd met behulp van een codeerschema gebaseerd op Van Boxtel (2000) dat onderscheid maakt in de drie typen van leergerichte interacties

als beschreven in hoofdstuk 3 en 4 (explorerende vragen stellen, cumulatief redeneren en bespreken van inhoudelijke conflicten). Ook procedurele en niet-taakgerichte interacties werden bij de analyse betrokken. Door middel van sequentiële analyse werd onderzocht in welke volgorde de verschillende soorten interacties tijdens de bijeenkomst optraden. Het bleek dat leergerichte interacties gemiddeld 80% van de tijd in beslag namen en procedurele en niet-taakgerichte interacties beide 10%. Hieruit hebben we geconcludeerd dat de onderwijsgroepen sterk taakgericht waren. Alle drie soorten leergerichte interacties werden waargenomen. Aan cumulatief redeneren werd verreweg de meeste tijd besteed, namelijk 63%. Explorerende vragen stellen en bespreking van inhoudelijke conflicten namen respectievelijk slechts 10 en 7% van de tijd in beslag. Verder bleken explorerende vragen vaak vooraf te gaan aan cumulatief redeneren. Beide soorten interacties werden tijdens de gehele nabespreking waargenomen. Daarnaast bleken inhoudelijke conflicten zich pas in de tweede helft van de nabespreking voor te doen. Dit kan verklaard worden vanuit de gebruikelijke structuur van de nabespreking: eerst rapportage van de bevindingen uit de zelfstudie, gevolgd door discussie over samenhang en verschillen tussen de bevindingen. Hoewel cumulatief redeneren een effectieve vorm van interactie is, zou de discussie tijdens de nabespreking verbeterd kunnen worden door meer tijd te besteden aan inhoudelijke tegenstrijdigheden (conflicten) en explorerende vragen stellen.

In **hoofdstuk 7** worden de algemene conclusies van het onderzoek gepresenteerd en besproken. Daarnaast worden aanbevelingen gedaan voor verder onderzoek en de onderwijspraktijk. Uit hoofdstuk 2 en 3 kunnen we concluderen dat interacties tijdens de nabespreking in onderwijsgroepen in PGO gemeten kunnen worden met de door ons ontwikkelde en toegepaste instrumenten. De ontwikkelde vragenlijst geeft snel en efficiënt een globaal beeld van de kwaliteit van de groepsinteracties. Observatie met behulp van het toegepaste codeerschema levert rijkere en specifiekere informatie op, maar deze methode is aanzienlijk ingewikkelder en vraagt meer tijd. Welk type instrument de voorkeur verdient, hangt primair af van het doel van de analyse. De belangrijkste conclusies uit hoofdstuk 4, 5 en 6 luiden als volgt:

- Interactievormen - zoals explorerende vragen stellen, cumulatief redeneren en bespreken van inhoudelijke tegenstrijdigheden - die in de literatuur beschreven zijn als effectief voor het leren van studenten, komen aan bod tijdens de nabespreking in onderwijsgroepen in PGO. Cumulatief redeneren blijkt de overheersende interactievorm. De diepgang van de discussies kan verbeterd worden door de twee andere leergerichte interactietypen te stimuleren.
- de studenten zijn van mening dat genoemde leergerichte interacties effectief zijn. Hun mening sluit daarmee aan bij hedendaagse inzichten over de effectiviteit van actief en samenwerkend leren.

De sterke kanten van dit onderzoek zijn dat het procesgeoriënteerd was en uitgevoerd werd in een authentieke leeromgeving met behulp van verschillende analysemethoden en databronnen. Er is echter meer procesgericht onderzoek nodig om beter te begrijpen onder welke omstandigheden PGO als leeromgeving al of niet effectief is. Dit proefschrift is een eerste stap in die richting. Aanbevolen wordt om, naast procesgeoriënteerd onderzoek, nader te onderzoeken hoe de interactie tijdens de

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discussie in onderwijsgroepen in PGO verbeterd kan worden teneinde het leren van de studenten te versterken. In dit proefschrift zijn geen leereffecten gemeten. Daarvoor zou een specifieke en gevoelige effectmaat nodig zijn, bijvoorbeeld een concept map of een essay geproduceerd door de studenten tijdens of direct na de nabespreking. Praktische suggesties om de kwaliteit van de discussie tijdens de nabespreking te verhogen zijn: het gebruik van concept maptechnieken, meer nadruk op dialoog- en discussievaardigheden tijdens PGO-trainingen voor studenten en tutoren, en verbetering van de voorbereiding op de nabespreking tijdens de zelfstudie.

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Dankwoord

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Dankwoord

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Curriculum Vitae

Astrid Visschers-Pleijers was born in Heerlen, the Netherlands on May 31, 1975. In 1993 she finished secondary education at the Grotius College in Heerlen. Between 1993 and 1994 she studied Mathematics at the University of Technology in Eindhoven. From 1994 to 1997, she continued her studies at the Fontys University of Applied Sciences in Sittard, where she obtained her teaching certificate for teaching mathematics in lower secondary education. She received her M.A. in Educational Sciences from the Radboud University of Nijmegen in 2000. Her Master's thesis, written at the Educational Service Centre of the Eindhoven University of Technology, concerned student perceptions of free riding behaviour in collaborative learning environments. After her graduation, she started her PhD project on tutorial group discussion in problem-based learning at the Department of Educational Development and Research of Maastricht University. Between 2005 and 2006 she taught mathematics and didactics at the Faculty of Education, Zuyd University in Heerlen, a teacher training college for primary education. She will join the Division of Social and Spatial Statistics of Statistics Netherlands in Heerlen at the end of 2006.

Curriculum Vitae

Astrid Visschers-Pleijers werd geboren op 31 mei 1975 te Heerlen. In 1993 slaagde ze voor haar VWO-examen op het Grotius College te Heerlen. Tussen 1993 en 1994 studeerde ze Technische Wiskunde aan de Technische Universiteit Eindhoven. Van 1994 tot 1997 studeerde ze Wiskunde aan de Tweedegraads lerarenopleiding van de Fontys Hogeschool te Sittard, waar zij in 1997 haar diploma behaalde. Vervolgens studeerde ze Onderwijskunde aan de Radboud Universiteit Nijmegen (voorheen Katholieke Universiteit Nijmegen). Haar afstudeerscriptie, geschreven bij het Onderwijs Service Centrum van de Technische Universiteit Eindhoven, gaat over percepties van studenten ten aanzien van meeliftgedrag bij samenwerkend leren. Na haar afstuderen in 2000 begon ze als Promovendus aan haar project over de groepsdiscussie in probleemgestuurde onderwijsgroepen bij de Capaciteitsgroep Onderwijsontwikkeling en Onderwijsresearch van de Universiteit Maastricht. Van eind 2005 tot de zomer van 2006 werkte ze als docent Rekenen-wiskunde en didactiek aan de Faculteit Onderwijs (PABO) van de Hogeschool Zuyd te Heerlen. Vanaf eind 2006 zal ze gaan werken als onderzoeker bij de Divisie Sociale en Ruimtelijke Statistieken van het Centraal Bureau voor de Statistiek te Heerlen.

In the ICO Dissertation Series dissertations are published of graduate students from faculties and institutes on educational research within the following universities: University of Twente, University of Groningen, Maastricht University, University of Amsterdam, Utrecht University, Open University, Leiden University, Wageningen University, Technical University of Eindhoven, and Free University (and formerly University of Nijmegen and University of Tilburg). Over one hundred dissertations have been published in this series. The most recent ones are listed below.

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