International Journal of Teaching and Learning in Higher Education 2011, Volume 23, Number 3, 303-313
http://www.isetl.org/ijtlhe/ ISSN 1812-9129

Effective Teaching in Case-based Education: Patterns in Teacher Behavior and Their Impact on the Students' Clinical Problem Solving and Learning

Stephan Ramaekers, Hanno van Keulen, Wim Kremer, Albert Pilot, Peter van Beukelen
Utrecht University

Case-based learning formats, in which relevant case information is provided just in time, require teachers to combine their scaffolding role with an information-providing one. The objective of this study is to establish how this combination of roles affects teacher behavior and that, in turn, mediates students' reasoning and problem solving. Data on actual behaviors, intentions, effects and appreciation were collected using observations of case discussions, interviews, and a questionnaire in a mixed method, concurrent nested design. Cross-case analysis of the observed discussions revealed two patterns of combining the provision of information with scaffolding. Although students commonly responded to scaffolding interventions as intended, the results from the observations and the questionnaire showed that a pattern with a high level of concurrent scaffolding and provision of information should be avoided.

Introduction

Since the emergence of approaches such as case-based and problem-based learning, the way cases are used and their functions in the learning process have extended beyond simple illustrative purposes or opportunities to practice the application of discrete skills (e.g., Barnett-Clarke, 2001; Block, 1996). Which case characteristics effectively contribute to higher-order learning and how students, in their learning from cases, are optimally supported by their teachers depends on the aims and specific type of case-based learning (Barnett-Clarke, 2001; Dolmans & Wolfhagen, 2005). Research has identified three central conditions: high quality cases, a supportive instructional design, and competent teachers (Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2005; van Berkel & Schmidt, 2000).

High quality cases are meaningful and reflect the issues, problems, and circumstances that professionals are confronted with in reality (Anderson, Reder, & Simon, 1996; Hmelo & Day, 1999); provide similar information (and a similar sensory input) to the real situation (Kester, Kirschner, van Merrienboer, & Baumer, 2001; Minogue & Jones, 2006); and require the same (mental) activities and processes (Brown, Collins, & Duguid, 1989). They arouse curiosity, support the experience of a need-to-know (Edelson, 2002), and call for higher-order thinking (Newmann & Marks, 1996; Weiss, 2003) by using prior knowledge and probing understanding (Boshuizen & Schmidt, 1992).

A *well-designed educational format* provides direction to learning activities, which is particularly valuable to support self-directed and group learning. It clarifies the purposes of learning activities (Dolmans & Schmidt, 2000); offers guidance on effective task approaches, procedures, e.g. the 'seven step' method in problem-based learning, or templates (Merrill, 2007); and creates transparency about the roles of participants and criteria for (self-)assessment (Biggs, 1996). Reflection and feedback are considered essential components of a format for supporting the translation of experiences into learning (Hattie & Timperley, 2007; Salomon & Perkins, 1989).

The proficiency of competent teachers extends to the case content, as well as to ways to master this content and how to guide students in accordance with their needs. Although in many case-based learning formats teachers do not function as a main source of information, content expertise helps them recognize the particulars of the reasoning, assumptions, and (mis)understandings of students as well as issues of focus in scaffolding them (Dolmans et al., 2002). Understanding the ways a particular content can be mastered, as well as the typical difficulties that students might encounter and effective ways to help them overcome such hindrances, are beneficial for recognizing the complexities of a case and deciding if, when, and how to intervene in the process (Hattie & Timperley, 2007; van Driel, 2008). Appropriate teacher interventions raise case discussions to a higher level and stimulate students to engage in mastering this content (Hmelo-Silver, Duncan, & Chinn, 2007; Hmelo & Day, 1999). In terms of learning, the students' learning activities and degree of support (scaffolding) they receive should match the achievement of constructive friction (Vermunt & Verloop, 1999).

One of the issues of interest in case-based learning is the optimal timing of information. In many case-based learning formats, students receive all necessary information before or at the beginning of a case session. To simulate the way information becomes available in authentic practices, cases can be designed to allow the just-in-time provision of information. This supposedly also reduces the cognitive load on students handling complex cases (Kester, et al., 2001; Kirschner, 2002).

The just-in-time provision of case information means teachers must fulfill several roles almost simultaneously: providing students with the case-specific information they require, scaffolding them in the process of problem analysis and solving and judging their performances and levels of competence. Fulfilling different roles at the same time can be demanding (Boud & Feletti, 1998) and might lead to (unwanted) interactions between them (Robertson, 2005). This study concerns the ways teachers manage to fulfill these different roles and when students benefit most from this type of case-based learning design. It is guided by the following research questions:

1. How does the requirement to combine an information-providing role and a scaffolding role in this case-based learning format affect teacher behavior?
2. How does this teacher behavior affect the students' reasoning and the problem solving process?

Methods

To allow the exploration of the interactions between the educational setting, teacher interventions, and students' performances in natural circumstances, this study was embedded in on-going coursework. It employed a mixture of methods (observations, interviews, questionnaires) applied in a "concurrent nested design" (Creswell, 2003), with the observations of case discussions as the predominant method. To establish the principles of effective teaching in this format, the findings on teacher behavior, effects on the students' reasoning, and perceived effectiveness were weighted against current notions about effective teaching.

Setting and Educational Design

The Clinical Lessons (veterinary medicine, Utrecht University) aim to provide students with their first experiences of solving realistic clinical problems and train them to reason and decide on clinical situations in accordance with previously studied biomedical theories and guidelines for practice. They are designed to ease the transfer from mastering preclinical subjects (years 1–3) to their application during the clerkships (years 5 and 6).

The clinical lessons take up a large part of the weekly coursework and extend almost throughout the fourth year. The core of the clinical lessons consists of three complementary teaching formats: clinical practicals, demonstrations, and tutorials. The practicals and demonstrations involve real clinical patients, whereas the tutorials build on paper-based cases. In all formats, the students direct the exploration of the clinical problems and the case discussions to establish optimal "solutions." The teachers' primary roles are to provide students, just-in-time support with additional patient information or guide them in the process and assess their performances. Consistent with the notion of 'scaffolding' (Hmelo & Day, 1999), this support is limited to the degree that students need to handle the complexities of cases at a level that would otherwise be beyond their capacities.

The clinical lessons are taught by a group of experienced veterinary practitioners belonging to the university clinical staff. Their teaching experience ranges from one to over 20 years. Because this particular format has been introduced only recently, teachers have been provided with initial training on conducting clinical tutorials. Student groups receive instruction and support during their first clinical lessons to become familiar with the format, their roles, and mutual expectations.

This study focuses on the tutorials. In this format, the information-providing role of teachers is most pronounced. The design features of the tutorial format are:

a. Groups of 12 students prepare for the clinical tutorial collaboratively. They receive a case vignette beforehand with initial information about the problem and its context. On the basis of this vignette, they determine which additional patient information is needed, discuss strategic and procedural aspects of the case, and decide which topics to review before the tutorial actually takes place;
b. Each tutorial covers two cases. On average, there is about 50 minutes per case to explore and discuss findings, choices, and decisions. Starting from the results of their group's preparatory analysis, they further explore the case by following a similar procedure to that used for patient examination in reality. In the role of owner of the animal (patient) or as the referring veterinarian, their teacher provides them, on request, with the additional information they need to deal with the problem. Discussion on the case is led by the students;
c. During the case exploration, the students can take a "time-out" from the patient examination process to review their approach and problem-solving strategy, to reflect on their findings so far, and to decide how to proceed. Their peers observe the case exploration, participate in the (time-out) discussions, and provide feedback afterwards about the handling of the case;

d. The last part of tutorials is used for evaluative (self-)reflection and feedback from peers and the teacher. This covers the approach and results, as well as performances of the leading students. The student performances in the tutorials are graded individually 5–8 times a year.

Participants and Data Collection

During the academic years 2005–2008, 63 case discussions were observed and recorded on video- or audiotape to allow for an in-depth qualitative analysis. These observations related to 17 different student groups, 18 teachers, and 44 cases. All student groups and teachers were observed at least twice. No particular student groups or teachers were specifically selected for this study. Within the on-going coursework, nevertheless, tutorials were preselected for observation to cover a sufficient variety of cases, student groups, and teachers, as well as various moments throughout the year. Students and teachers provided informed consent to be audio- or video-recorded. The observing researcher (SR) did not actively participate in the case discussions.

In line with the concurrent nested design, interviews and a questionnaire were used to expand the understanding of observed behavior by revealing teacher preferences and student appreciation for particular aspects of the tutorials:

- Altogether, 16 observed case discussions were followed by a semi-structured, stimulated recall interview with the teachers to reveal their views about occurrences within the observed case discussions and their rationale for interventions;
- During the last year a questionnaire was used to establish the students' appreciation of certain case characteristics, the instructional format, and teacher performances, at a level of separate case discussions. Four students were asked to complete the questionnaire immediately after each case discussion. In total, 1814 completed questionnaires were returned, covering 627 (94.4%) of the sessions that took place. The full questionnaire is available from the first author.

Coding and Analysis of Observations

Video and audio recordings of the observed tutorials were analyzed with ATLAS.ti. The unit of analysis was a single case discussion; the analysis procedure (Miles & Huberman, 1994) was made up of the following steps:

1. Based on the research questions and underlying conceptual framework, a provisional list of codes was developed and applied to the first series (13) of observations to examine for fit and power.
2. As the analysis of case discussions progressed, the code list was restructured and extended to include events not covered in the original scheme. Furthermore, some descriptive codes concerning student and teacher behaviors were replaced by inferential codes reflecting reasoning and scaffolding patterns.
3. When the analysis of new case discussions revealed no more new events (saturation), the final code list was made up of four main categories of codes: problem-solving phases, supportive learning phases, student behaviors, and teacher behaviors.
4. Discourse analysis and cross-case comparison were used to shed light on patterns in the teachers' scaffolding behaviors and the students' reasoning, as well as on changes during the year.
5. Irregular occurrences and behaviors were reviewed to check our understanding of the case discussions and hypotheses about the teacher–student interactions, and to disclose hidden themes or phenomena.

Table 1 shows an overview of the coding scheme. The "behavior" categories are nested within the "phases." Phases cover larger segments of a case discussion and together they make up the whole case. Behaviors concern single utterances. The first main categories of teacher behavior codes (T-ANSW, T-QUES and T-ADDS) express mostly teacher utterances in the role of "information provider," whereas the codes T-PROC, T-GROU and T-EVAL concern the "scaffolding" role. Students' utterances were coded interpretatively (Miles & Huberman, 1994), linking them to (cognitive) activities that make up "clinical reasoning": gathering, interpreting, and organizing information; establishing and testing hypothesis; drawing conclusions; and making and justifying choices and decisions. To determine the consistency of the coding, a randomly selected proportion (8%) of the recordings was coded independently by two clinical teachers and one research assistant. For the "problem-solving" and "supportive learning" phases, the inter-rater agreement was very good (K=0.92), whereas for "teacher behaviors" and "students' reasoning," it was good (K=0.75).

Results

First, an overview will show how a case discussion was made up of the various problem-solving and

Table 1
The Coding Scheme: Main Categories

Problem-solving Phases	Supportive Learning Phases
Initial case information (C-INFO)	Instruction beforehand (E-INFO)
Checking vital functions (C-VITA)	Time-out (E-TO)
Anamnesis (C-ANAM)	Evaluation (E-EVAL)
Initial problem description (C-PROB)	Teacher-guided discussion (E-COLL)
General patient assessment (C-GENA)	
Initial diagnostic hypothesis (C-INIT)	
Specific patient assessment (C-SPEA)	
Differential diagnosis (C-DDX)	
Choice of treatment modalities (C-RX)	
Execution of treatment (C-EXEC)	
Review of effectiveness (C-EFF)	
Teacher Behaviors	**Students' Reasoning (Behaviors)**
Providing answers (T-ANSW)	Choice of strategy (R-STRAT)
Asking questions (T-QUES)	Gathering information (R-GATH)
Adding statements (T-ADDS)	Organizing information (R-ORG)
Scaffolding the process (T-PROC)	Interpreting information (R-INTP)
Stimulating group interactions (T-GROU)	Making judgments (R-JUDG)
Guiding reflection and feedback (T-EVAL)	Making decisions (R-DECI)
	Justifying judgments and decisions (R-JUST)
	other (R-OTHR)

Note. The behavioral main code categories are made up of three to six subcategories to allow differentiation. For example, the additional statements are divided into case-related, general theoretical and general practical statements.

learning activities and the distribution of teacher and student behaviors. Next, the findings on behavior, interactions, and effects will be presented in the light of the two research questions.

Overview

The procedure that students followed to explore the case was essentially, as intended, similar to the structure and phases of a patient assessment. Figure 1 shows the sequence and relative duration of phases typical of the observed discussions. On average, nearly 70% of the time was spent on the case itself (problem-solving phases); the remaining 30% was used for discussing relevant background information and for reflection and feedback on the way the case had been handled and lessons to be learned (supportive learning phases).

Variations of the above, in particular the duration of phases, could be substantial. To some extent these variations can be attributed to differences between cases. For example, an acute posttraumatic case may require checking vital functions first. A second source of variation results from differences in the progress of students during the course. Whereas information gathering dominated the discussions at the beginning of the course, students gradually became more selective about the information they required and spent more time relating findings to each other and to their hypotheses, drawing conclusions, and making decisions.

The proportional distribution of the behavioral categories reflects that usually a substantial part of the case discussion was used to gather all relevant information (Table 2a): students asking questions and performing tests to ascertain the information needed to understand the problem in its context; and students testing their diagnostic hypotheses, possibilities, and assumptions. The teachers (Table 2b) provided the requested information and, as necessary, intervened in the process and stimulated students to rethink their choices and conclusions, elaborate on particular issues, or reflect on their approach and results.

The relatively large proportion of justifications by the students fits not only with the instruction to "think aloud," but also resulted from frequent questions from teachers about related theoretical issues. Nearly 80% of these justifications were teacher-initiated. The coefficients of variance (defined by *SD*/*mean*) show the relative variation for each category. They indicate that teacher differences were largest in providing unrequested information (additional statements), having

Figure 1
Typical Sequence and Relative Duration of the Various Phases in the Case Discussions

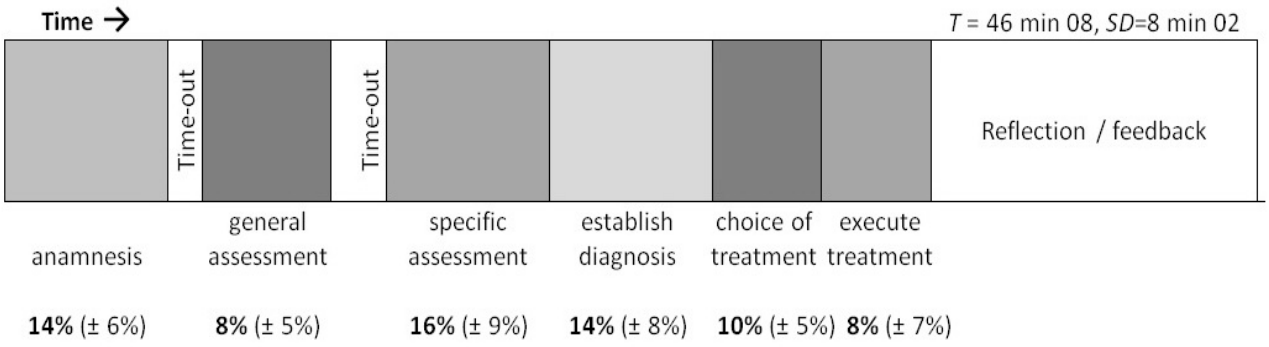

Table 2
Proportional Distribution of the Main Categories of Utterances
M and SD are Expressed in the Average Percentage of Utterances Per Case
(2a. student reasoning, 2b. teacher behaviors)

Student Reasoning	Utterances (in %)		
	Mean	*SD*	Coeff. of variance
Gathering information	49.0	16.0	0.33
Organizing info.	6.9	3.0	0.43
Interpreting findings	7.7	3.6	0.47
Making judgments	5.0	2.5	0.50
Decision making	5.4	2.3	0.42
Justification	14.4	6.1	0.42
Other	2.3	2.0	

Teacher Behaviors	Utterances (in %)		
	Mean	*SD*	Coeff. of variance
Providing answers	49.1	15.8	0.32
Asking questions	14.3	6.4	0.45
Adding statements	12.8	10.4	0.81
Process interventions	10.7	5.7	0.54
Group interventions	2.8	2.9	1.04
Reflection / feedback	10.3	8.2	0.79

group interventions, and guiding reflection and feedback. Appendix A contains three fragments from a case discussion transcript illustrating the nature of discussions and teacher–student interactions for the information-providing and scaffolding roles, as well as without any teacher interventions.

Teacher Roles and Behaviors

When focusing on teachers' role fulfillment and teacher–student interactions, the issue of matching the degree of scaffolding with a student's level of self-regulation came to the fore. A high level of self-regulation and a matching level of scaffolding were considered key features of the clinical lessons' design, and their importance were recognized by teachers. In actual practice, however, some teachers frequently exerted influence on the direction of the problem-solving process.

Sometimes the intentions of these interventions were explicit and clear; more often, teachers directed discussions in less obvious ways:

> T: Fine, good. I am glad, because my wife thought she [the patient – SR] had a broken jaw. . . . Luckily, you did not find anything like that. I am glad because with a broken jaw this calf would have become worthless, wouldn't it?
> S: Well yes, um . . . (case 080516LHD-3A)

Using their information-providing role to influence the course of the discussion was a scaffolding strategy the teachers commonly employed. For example, by referring to a sudden change in the patient's condition, unexpected complications, or an uncooperative owner of the animal, they urged students to speed up their patient assessment, extend their search for possible causal factors and mechanisms, or elaborate on the relevant theoretical issues.

In cross-case analysis of teacher behaviors, two patterns emerged. The main characteristics of both patterns are presented in Table 3. In the first (DS), the fulfillment of the scaffolding role was separated from information provision and delayed until between phases in the problem-solving process. In the second pattern (CS),

teacher roles were executed concurrently, and corrections or directions were provided almost immediately in the process. In this pattern, little or no time was usually spent on reflection and feedback afterwards.

Reasons for Interventions (interview results)

In recall, teachers expressed three grounds for their interventions in specific situations: doubts about the relevance of the particular information students had requested, disagreement with the students' choices or decisions in the case approach and a low work speed. Their intentions when scaffolding were explained in terms of *control* (i.e., checking the students' knowledge), *correction* (i.e., making sure that misunderstandings are corrected), stimulating students to think aloud (i.e., share their thoughts) and stimulating *elaboration* (i.e., raising the discussion to a higher level).

Observed Effects on the Problem-solving Process

On the face of it, the students mostly responded to the teachers as expected: they used the additional case information and adjusted to changes in the case, reviewed or provided reasons for their choices, elaborated on relevant issues, or reproduced the requested theoretical background. In discussions with minimal scaffolding, students themselves initiated a time-out whenever they wanted to reflect on the results of their approach and decide on how to proceed. In cases with a high level of concurrent scaffolding, major changes in the students' problem-solving strategy and reasoning were teacher-initiated.

By and large, student responses did not openly reveal how they valued their teacher's interventions. In three of the observed cases, however, the discussion was visibly affected by a high level of concurrent scaffolding early in the process (pattern CS). In response to these interventions, the students' reasoning apparently lost direction, and the discussion became almost completely teacher-led. A substantial part of the time (nearly 60%) had the character of a micro-lecture and focused on theoretical backgrounds. When trying to return to the case, the students seemed more focused on what they assumed their teachers expected from them than on the case itself; "Well, I guess you would like to hear now a first problem description about this farm?" (case 051011LHD-1A). Afterwards, the students expressed their discomfort with the situation and disappointment.

Students' Appreciation (Questionnaire Results)

To expand the understanding of the observed behavioral patterns and how these patterns affect the students' learning motivation, a questionnaire was used including a number of questions about the fulfillment of teacher roles, measured at the level of separate case discussions.

On a five-point scale ranging from 1 (disagree) to 5 (agree), the students' overall appreciation of the tutorials was high (authentic problems: M= 4.43 SD= 0.67; motivating issues: M= 4.21, SD= 0.73; opportunity to practice clinical reasoning: M= 4.19, SD= 0.70; perceived learning effect: M= 4.24 SD= 0.70) and significantly but only slightly less (ΔM= 0.12, ΔSE= 0.03) than for the clinical practicals with real patients. The students expressed that they considered teacher differences in their way of facilitating the tutorials as the main area of anxiety.

The "perceived learning effect" had a positive significant correlation with the quality of the feedback, the amount of time spent on reflection, the transparency of teacher expectations, and the clear switches between the different teacher roles (Table 4, Pearson's r). Its negative correlation with the frequency of scaffolding was also significant but weak. To compare the relative contribution of these variables to the perceived learning effect, multiple regressions were conducted using the forced entry method. The standardized beta coefficients showed the relative largest contribution of "instructive feedback" (β= 0.29). The model, based on the teacher-related variables, explained 26% of the total variance (adjusted R^2= .26). The instructive aspects related to the case characteristics, and the educational format were excluded from the model.

Discussion and Conclusions

The observations revealed no serious drawbacks of the format of combining the provision of information with scaffolding. In general, teachers managed to fulfill both roles and, unlike other studies on facilitating case discussions (e.g., Spronken-Smith & Harland, 2009), they barely expressed dissatisfaction about inefficiencies, the lack of structure in student discussions, underutilization of their expertise, or uncertainty about when or how to intervene. The just-in-time provision of case information created an opportunity to engage students in a process of clinical problem solving in which the availability of information resembles authentic practice and students highly appreciated this.

With regard to the optimal teacher strategies for student support and the identified behavioral patterns, the findings were less unconditional:

- Various definitions and perspectives on scaffolding exist, (e.g., Hmelo-Silver, et al., 2007; Jonassen, 1996), but they commonly share two elements: the provision of *just enough* support to enable students to carry out a task and the *gradual fading*

Table 3
Characteristics of the Two Behavioral Patterns

Pattern CS: Immediate scaffolding, concurrent with provision of information	*Pattern DS*: Delayed scaffolding, separated provision of information
• replies to students' questions frequently contain additional information or counter questions, suggesting a direction about how to proceed or what should be covered by the patient assessment • teachers use questions and 'micro-lectures' to discuss relevant theoretical issues • the case discussion ends with an explanation of the optimal approach by the teacher. Little or no time is taken for reflection and feedback on the students' approach of the case	• the provision of information is limited to the information requested by the students • interim time-outs are used to scaffold reflection on findings (clarity) and choices about how to proceed (focus) • case discussion ends with an evaluative reflection on the content and process and the provision of feedback, containing feed forward for future case(s

Table 4
Tabulated Results from Multiple Regression

Perceived Learning Effect (n = 1814)	*B*	*SE*	β	Zero-order (= Pearson's r)
Constant	2.239	0.113		
Our discussion was frequently scaffolded by the teacher	–0.056	0.016	–0.126 *	–0.074 *
The switches between teacher roles were clear to me	0.116	0.017	0.303 *	0.153 *
The teacher's expectations about me were clear	0.089	0.017	0.265 *	0.122 *
The time spent on evaluative reflection was sufficient	0.116	0.020	0.357 *	0.142 *
The feedback I received was instructive	0.231	0.020	0.431 *	0.290 *

Note. R = .51, R^2 = .26, * p < .001

of this support. Theoretically, these elements link the effectiveness of teacher support to facilitating a high level of active engagement and self-directedness in thinking and learning activities, as well as to task fulfillment at a near next level that otherwise would be beyond a learner's current capacities. In practice, however, what is "just enough" is difficult to establish and context-bound. Students adrift or a superficial level of discussion might be signs indicating a mismatch between the required and offered level of support, but these were also observed as temporary states in the problem-solving process which students themselves overcame.

- In the concurrent scaffolding pattern (CS), role interactions were regularly observed. To some extent, these interactions fit in the concept of authentic cases. For example, including unexpected changes in the case is not only a way of directing the students' discussion to but also of creating opportunities to practice with handling authentic complications and incidents (Jonassen, 2004). Nevertheless, by exaggerating case dynamics and using similar incidents or circumstances, e.g. an uncooperative patient caretaker, repeatedly to direct case discussions, teacher interventions became predictable, artificial and less appreciated. As one student expressed: "You are just waiting for the moment something unexpected occurs. With this teacher, you don't know when it is going to happen, just you know that something will happen." (case 070423P-4B)

Taken only from the observed behavioral responses, the students mostly seemed comfortable with the extent of the scaffolding and easily adjusted to the directions offered by their teachers. Under the surface of their immediate responses, however, the discourse in discussions sometimes showed clear differences between the two teaching patterns in favor of delayed scaffolding and feedback (pattern DS):

- From the way they were phrased, immediate teacher interventions appeared to be triggered mostly by disagreement or doubts about the students' approach and an

intention to check or correct the students' understanding of certain case aspects. Student responses to these interventions usually remained limited to brief answers. Interventions to encourage in-depth discussion, explicitly expressed in terms of "think aloud" or "elaborate", were scarce and used by those teachers who delayed most of their scaffolding and feedback.

- Small disturbances in the course of a discussion typically occurred in situations of immediate scaffolding about complex issues. This finding corresponds with studies concerning feedback when students have to deal with complex issues (Hattie & Timperley, 2007). It has been suggested that such complex issues require greater degrees of processing, and delayed interventions provide an opportunity to do so.
- The three deviant case discussions signified that early and continued interventions resulted in the students focusing on assumed teacher expectations and on "survival", a mode of student behavior as described in Boekaerts' dual processing self-regulation model (Boekaerts, de Koning, & Vedder, 2006).

The existence of differences in impact between the two scaffolding patterns is supported by the questionnaire results. Students attributed the effectiveness of their learning from the tutorials to features of teacher behavior that are part of the pattern with delayed scaffolding, reflection and feedback. Differences between teachers, a lack of clarity about their intentions, expectations and role behaviors, and their implicit ways of directing discussions were perceived by students as negatively affecting the reasoning process.

The aim of this study was to disclose how teachers combine the roles that are part of a case-based learning format with the just-in-time provision of information, and how this, in turn, influences students' reasoning and problem solving.

Regarding the teachers' role fulfillment, the results from the observations and the questionnaire about separate case discussions support the conclusion that, in most cases, teachers can effectively combine the roles of providing information and scaffolding. When necessary, they provided students with guidance and questioned assumptions or interpretations, and they stimulated students to deepen their analysis, broaden their scope, and relate specific case features to general theoretical notions. Nevertheless, including the just-in-time provision of case-specific information in this instructional format also created additional opportunities to influence the students' discussions, opportunities some teachers used to direct student discussions beyond the level of scaffolding.

In answer to the second research question: just-in-time provision of case information enabled students to practice solving clinical problems while obtaining patient information in a timescale that resembles authentic clinical practice. Although the students' direct behavioral responses to frequent interventions during case discussions were mostly characterized by adaptation, they considered the pattern of delayed scaffolding and feedback more beneficial for their learning. Possible explanations for their willingness to adapt to most ways of scaffolding might lie in an awareness of being assessed as well, positive experiences in most other case discussions or with other teachers facilitating the tutorials, or much appreciation for aspects such as the authenticity of the case, its clinical relevance, and constructive cooperation with their peers.

The findings in this study emphasize that in this instructional format providing clarity on teacher roles and expectations, delayed scaffolding and facilitation of reflection and feedback are conditional for student learning and motivation. Furthermore, as students do not easily show when teacher interventions interfere with their problem solving process, effective teaching requires monitoring the student's behavioral responses and attending to signs of anxiety.

This study was primarily based on observations, with additional interviews and a questionnaire to confirm or extend the findings from the observations. This methodology, applied to a large number of cases in this study, yields an abundance of qualitative data and, therefore, requires rigorous data organization, focus, and bounding. The scope of this study was limited to the analysis of behaviors, interactions, and effects from the perspective of role fulfillment. Furthermore, the cases were assumed to be of a constant quality, that is, to have more or less a similar impact on teacher behavior and interactions. The third limitation of this study concerns the use of perceived learning as the outcome measure. In doing so, the possibility, for example, that friction in the teacher – student interaction might also have beneficial effects on long-term learning outcomes is ignored. Further studies using outcome measures based on student performances to reveal the effectiveness of teacher behavior on competence development have been taken up and will be reported subsequently.

References

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher, 25*(4), 5-11.

Barnett-Clarke, C. (2001). Case design and use: Opportunities and limitations. *Research in Science Education, 31*(2), 325-329.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education, 32*, 347-364.

Block, K. K. (1996). The "case" method in modern educational psychology texts. *Teaching & Teacher Education, 12*(5), 483-500.

Boekaerts, M., de Koning, E., & Vedder, P. (2006). Goal-directed behavior and contextual factors in the classroom: An innovative approach to the study of multiple goals. *Educational Psychologist, 41*(1), 33-51.

Boshuizen, H. P. A., & Schmidt, H. G. (1992). On the role of biomedical knowledge in clinical reasoning by experts, intermediates and novices. *Cognitive Science, 16*(2), 153-184.

Boud, D., & Feletti, G. (1998). *The challenge of problem-based learning*. London: Routledge.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-41.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Dolmans, D. H. J. M., Gijselaers, W., Moust, J., De Grave, W. S., Wolfhagen, I. H. A. P., & van der Vleuten, C. P. M. (2002). Trends in research on the tutor in problem-based learning: Conclusions and implications for educational practice and research. *Medical Teacher, 24,* 173-180.

Dolmans, D. H. J. M., & Schmidt, H. G. (2000). What directs self-directed learning in a problem-based curriculum? In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp. 251-262). Mahwah, NJ: Erlbaum.

Dolmans, D. H. J. M., & Wolfhagen, I. H. A. P. (2005). Complex interactions between tutor performance, tutorial group productivity and the effectiveness of PBL units as perceived by students. *Advances in Health Sciences Education, 10*(3), 253-261.

Edelson, D. C. (2002). Design research: What we learn when we engage in design. *Journal of the Learning Sciences, 11*(1), 105-121.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Hmelo-Silver, C., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Sweller, Kirschner and Clark. *Educational Psychologist, 42*, 99-107.

Hmelo, C., & Day, R. (1999). Contextualized questioning to scaffold learning from simulations. *Computers & Education, 32*(2), 151-164.

Issenberg, S. B., McGaghie, W. C., Petrusa, E. R., Gordon, D. L., & Scalese, R. J. (2005). Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review. *Medical Teacher, 27*(1), 10-28.

Jonassen, D. H. (1996). Scaffolding diagnostic reasoning in case-based learning environments. *Journal of Computing in Higher Education, 8*(1), 48-68.

Jonassen, D. H. (2004). *Learning to solve problems: An instructional design guide*. San Francisco, CA: Pfeiffer.

Kester, L., Kirschner, P. A., van Merrienboer, J. J. G., & Baumer, A. (2001). Just-in-time information presentation and the acquisition of complex cognitive skills. *Computers in Human Behavior, 17*(4), 373-391.

Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning and Instruction, 12*(1), 1-10.

Merrill, M. D. (2007). A task-centered instructional strategy. *Journal of Research on Technology in Education, 40*(1), 33-50.

Miles, M. B., & Huberman, M. A. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd revised ed.). Thousand Oaks, CA: Sage Publications.

Minogue, J., & Jones, M. G. (2006). Haptics in education: Exploring an untapped sensory modality. *Review of Educational Research, 76*(3), 317-348.

Newmann, F. M., & Marks, H. M. (1996). Authentic pedagogy and student performance. *American Journal of Education, 104*(4), 280-313.

Robertson, D. R. (2005). Generative paradox in learner-centered college teaching. *Innovative Higher Education, 29*(3), 181-194.

Salomon, G., & Perkins, D. N. (1989). Rocky roads to transfer: Rethinking mechanisms of a neglected phenomenon. *Educational Psychologist, 24*(2), 113-142.

Spronken-Smith, R., & Harland, T. (2009). Learning to teach with problem-based learning. *Active learning in Higher Education, 10*, 138-153.

van Berkel, H. J. M., & Schmidt, H. G. (2000). Motivation to commit oneself as a determinant of achievement in problem-based learning. *Higher Education, 40*, 231-242.

van Driel, J. (2008). Van een lerende vakdocent leer je het meest [You learn the most from a

learning teacher]. Inaugural speech, Universiteit Leiden.

Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9*, 257-280.

Weiss, R. E. (2003). Designing problems to promote higher-order thinking. *New Directions for Teaching and Learning, 95*, 25-31.

STEPHAN RAMAEKERS is lecturer and consultant on curriculum development in Higher Education at the Center for Teaching and Learning at Utrecht University. His Ph.D. research focuses on the use of authentic, complex tasks to enhance the development of problem-solving competence.

HANNO VAN KEULEN is lecturer in Higher Education development at the Center for Teaching and Learning at Utrecht University. He is also professor of science and technology education at Fontys University of Applied Science, the Netherlands. His research interests are with staff and educational development in higher education and the innovation of science and technology education in primary education.

WIM KREMER is professor Farm Animal Health at the Faculty of Veterinary Medicine, Utrecht University. His research interests relate to the professional development of veterinarians. He is responsible for the Master program in Farm Animal Health.

ALBERT PILOT is professor of Curriculum Development at Center for Teaching and Learning at Utrecht University and Professor of Chemistry Education in the Department of Chemistry of that university. His research focuses on curriculum development, professional development of teachers and context-based education.

PETER VAN BEUKELEN is professor of Quality improvement in Veterinary Education at Utrecht University. His research interests are: clinical reasoning, active learning, workplace and lifelong learning. Current research concerns staff development and individual assessment of teaching competence.

Appendix
Sample case discussion (080507 Horse case 2B)

The case concerns a two-day-old foal, which initially seemed healthy but now does not want to drink and prefers lying down [SR].

t=03:24
S: You did not expect this foal to be born yet?
T: Well, as a matter of fact we already expected him last week.
S: The last days, did you notice the mare's nipples wax? Perhaps any secretion from the teats?
T: Well, at some point her udder began to swell and already within hours a foal was born
S: No milk leaking before he was born?
T: Not that I have noticed.
S: Not to your knowledge. Did you see her giving birth?"
[. . .]

t=18:34
S1: I think this is. . . um . . .
S2: A positive undulation sign and constipation.
S1: Should we carry out some additional assessment tests?
S2: Let's first establish a list of differential diagnostic possibilities, as there are a few things we need to keep in mind. For example a rupture of the bladder does not necessarily lead to apparent clinical signs.
S1: And such rupture could exist besides meconium constipation.
S2: Yes, they could exist next to each other. At least it is not a case of lysis . . . and sepsis seems unlikely, because he would have had fever?
[. . .]

t=30:54
T: So, what's next?
S1: It appears to be a persistent case of meconium constipation. We would like to use analgesics, as he is still not drinking and the problem has already existed for quite some time. Also, because the constipation persists, we propose purgative rinsing, more rigorously. For this, we would like to give him paraffin oil, using a stomach tube.
T: which analgesic did you have in mind?
S1: Flunixin. Only then, we would have to use a stomach pulser . . . should we add some other medication? To protect him from side effects?
S2: Well, it will be administered only once.
S1: Okay, just because Flunixin is only used once, we will not add any other drugs.
T: I sense, as the owner of this animal, some doubts about your choice of analgesic. What is it about?"
[. . .]