Techniques for Fostering Collaboration in Online Learning Communities:

Theoretical and Practical Perspectives

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Chapter 3
Fostering Collaborative Problem Solving by Content Schemes

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ABSTRACT

This chapter focuses on the facilitation of collaborative problem solving by the method of content schemes. Content schemes are content-specific pre-structures of learners' collaboration facilities that apply representational effects for the purpose of facilitation. They support learners to focus on particular issues of a problem solving process. The chapter presents results from two studies in the context of collaborative problem solving using videoconferencing. The first study compared learning facilitated by a content scheme and learning without facilitation; the second study compared the content scheme facilitation with facilitation by an enhanced version of this content scheme. This enhanced version focused learners on providing evidence for their claims. Results show that while the content scheme itself had a big influence on learning outcomes, the enhanced version had a rather small impact compared to the regular version. This result raises the issue about the complexity of facilitation methods. Complex facilitation may be too sophisticated for providing benefits to learning processes.

INTRODUCTION

Collaborative problem solving is estimated to be beneficial for learning processes and outcomes. Learners usually work collaboratively on case material in collaborative problem solving scenarios and this case material usually comprises of theory concepts and evidence (case information). By combining theoretical concepts with evidence from the case material, learners experience theory application. This approach allows them to reach a deeper understanding of the learning material (see Renkl, Mandl, & Gruber, 1996). Furthermore, learners share their perspectives on the case material within the collaborative setting and these different perspectives support them to apply their knowledge to different contexts outside the learning environment. In this context, Gijbels, Dochy,

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van den Bossche, and Segers (2005) call problem based learning one of the major developments of educational research, recently— mainly because problem based learning environments provide an active use of knowledge (DeCorte, 2003) with the goal to facilitate the transfer of the knowledge acquired and to avoid the acquisition of inert knowledge (see Renkl, Mandl &, Gruber 1996). Therefore, problem-based learning environments usually apply the principles of situated learning (see Lave & Wenger, 1991). Besides, literature on problem-based learning relies on different theoretical frameworks (see DeCorte, 1996; Glaser, Raghavan & Baxter, 1992), which commonly agree on an organised domain-specific knowledge base (or Joint Problem Space, according to Baker, Hansen, Joiner & Traum, 1999; Roschelle & Teasley, 1995) and meta-cognitive (often strategic) functions that operate on that knowledge (see Gijbels et al. 2005). With respect to the domain-specific knowledge base, Sugrue (1995) defines learners' knowledge structure as consisting of concepts, principles and links from concepts and principles to conditions and procedures for the application of knowledge. Considering strategic functions, he states the importance of planning and monitoring the problem solving process (see also Gijbels et al. 2005). Furthermore, learners have to negotiate shared meanings to establish a common knowledge base for collaboration. Thereby they engage in clarifying processes that are often referred to as 'grounding in communication' (see Clark & Brennan, 1991; Dillenbourg &Traum, 2006).

To sum up, processes of computer-supported collaborative problem solving can be characterised by three aspects (see Ertl, Kopp, & Mandl, 2006): *clarifying*, *strategic*, and *content-specific*.

Clarifying aspects of problem solving refer to several kinds of activities (e.g. discussion, actions, and gestures). Learners perform them in order to negotiate a "common ground" (Clark & Brennan, 1991) — a basis for their problem solving. By this, learners come to a common understanding of the task and create the Joint Problem Space (Baker et al., 1999; Roschelle & Teasley, 1995), which defines the central terms of a problem and brings the learners perspectives down to a common denominator.

The planning of the problem solving *strategy* and its evaluation is an important strategic aspect of collaborative problem solving processes. According to Bruhn (2000) it is necessary in collaborative learning where learners have to agree on their course of actions (e.g. timing and sequencing).

The *content-specific* work on the task is considered relevant for effective collaboration due to the presumed correlation between the quantity and quality of content-related communication and learning outcomes (Cohen & Lotan, 1995). According to Weinberger (2003) such work activities are social interactions (e.g. externalisation and elicitation of content) and epistemic activities (e.g. the definition, elaboration and argumentation of new content). Through successful engagement in these interactions learners work on a shared product or outcome, the collaborative problem solution, which can be seen as shared mental artefact (see Bereiter, 2002).

Collaborative Problem Solving in Videoconferencing

Collaborative problem solving in videoconferencing implicates some peculiarities for the learners because they do not share physical space. In a videoconferencing scenario, learners are spatially dispersed but they can communicate in spoken words by a microphone and speakers. Furthermore, they can see the head and chest of their learning partners by video transmission (see Finn, Sellen, & Wilbur, 1997). The videoconferencing environment usually provides a shared application for working on the collaborative problem solution. This shared application is a shared work space on the computer screens of the learners. It enables them to take mutual notes and work on the same document collaboratively (see e.g. Ertl, 2003;

Fischer, Bruhn, Gräsel, & Mandl, 2002; Ertl, Fischer, & Mandl, 2006). All learners can see and modify this document and thereby every learner has the chance to participate in the process of constructing the collaborative problem solution. The spatial dispersion of learners may require extended coordination of the synchronous work on the document provided in the shared work space, which could result in increased verbal efforts (e.g. Acker & Levitt, 1987; O'Connaill, Whittaker, & Wilbur, 1993). For example, learners cannot point out aspects of the document to each other by using a finger and they may have to use the mouse pointer or describe the meant location verbally. Therefore, learners may invest more efforts in processes of clarifying communication and grounding (Clark & Brennan, 1991) for referring to particular elements of their shared artefact. Thus, the videoconferencing scenario could increase learners' need for grounding in communication.

In summary, learners' collaborative problem solving comprises of several activities like the content-specific application of theoretical concepts on problems and strategic processes for planning and monitoring the application of knowledge, and clarifying processes to resolve possible misunderstandings. These activities result in a shared mental artefact, the collaborative problem solution. Besides the advantages of problem-based learning, learning environments for collaborative problem solving contain some challenges for learners, and learners may sometimes not have the strategic skills necessary for developing a collaborative problem solution. Furthermore, the scenario of videoconferencing could provide further constraints and affordances for the learners. The following section will consider the issue of how instructional support could facilitate learners' collaborative problem solving with respect to its process and outcomes.

FACILITATING COLLABORATIVE PROBLEM SOLVING IN VIDEOCONFERENCING

Facilitation of collaborative problem solving can aim at different aspects of the learning process. Therefore, facilitation may introduce different facilitation methods. The main focus lies on strategies for fostering the collaborative problem solving process, which are often implemented by structuring tools. "Structuring tools aim at facilitating processes of collaborative knowledge construction by guiding interaction with constraints and affordances of the learning environment, by suggesting a structure to learners' collaboration or by providing support regarding the learning contents" (Weinberger, Reiserer, Ertl, Fischer & Mandl, 2003, p. 4). Some structuring tools aim at resolving issues of group phenomena and missing collaboration skills by the application of scripts for collaboration (see e.g. Ertl, Fischer, & Mandl, 2006; Fischer, Kollar, Mandl, & Haake, 2007; Rummel & Spada, 2005; Weinberger, 2003; Weinberger, Ertl, Fischer, & Mandl, 2005) or trainings for collaboration (see Rummel & Spada, 2005). Other structuring tools aim at content-specific facilitation, by providing content strategies and visualisation of content aspects. These can be implemented in a learning environment by methods like mapping (Fischer et al., 2002) or content schemes (Ertl, Fischer, & Mandl, 2006). The introduction of content-specific structuring tools to the learners can be realized by pre-structuring the shared artefact or the shared application in videoconferencing. In the context of this chapter, we will illustrate and analyze the facilitation method of the content scheme in detail.

Content Schemes

Content schemes use the mechanisms of task representation. They provide and modify the representational context of a task by visualising a structure or strategy. This structure often works as a template by providing placeholders for important dimensions or aspects of the content, e.g. a tabular pre-structure. Zhang and Norman (1994) postulate that such a modified representational context of a task may also change learners' subjective representation of this task. Ertl, Fischer, and Mandl (2006) discuss that the modified context may also introduce an implicit strategy for solving a task. Both, the modified subjective representation as well as the introduced strategy, may facilitate learners' ability to solve the task. An additional aspect of content schemes is the salience of contents (see Suthers & Hundhausen, 2003). The contents entered by learners in the scheme remain salient during the collaboration process. Furthermore, the template effect of a content scheme supports the salience of content dimensions: even if learners do not enter anything at all in the pre-structured table they can see which content dimensions are relevant for the specific problem solving process. Due to these aspects of salience, Suthers and Hundhausen (2001) postulate the concept of "representational guidance". Its implementation allows to guide learners and to focus their learning activities, particularly on contents which would have been neglected without the availability of a content scheme (see Ertl, Fischer, & Mandl, 2006; Ertl, Kopp, & Mandl, 2008). Consequently, representational guidance can be an important mechanism for providing learners with a strategy for collaborative problem solving.

Many studies provide evidence for the effects of content schemes in the context of individual learning settings (see Brooks & Dansereau, 1983; Kotovsky & Fallside, 1989; Kotovsky, Hayes & Simon, 1985; Larkin, 1989; Zhang & Norman, 1994; Zhang, 1997). During the last decade, their beneficial effects were further supported by their use to facilitate computer-supported collaborative problem solving (see e.g. Ertl, Fischer, & Mandl, 2006; Ertl et al., 2008; Fischer et al., 2002; Suthers & Hundhausen, 2001). Fischer et al. (2002) investigated the effects of structural visualisation and were able to show beneficial effects of the content scheme on the collaboration process and outcomes. Suthers and Hundhausen (2001) also reported similar effects with respect to tabular content schemes. Fischer, Bruhn, Gräsel, and Mandl (2000) and Bruhn (2000) discovered that content schemes changed collaboration processes in videoconferencing with respect to knowledge convergence, but without affecting the outcomes. The studies of Ertl, Fischer, and Mandl (2006) and Ertl et al. (2008) show the particular effect of content schemes on guiding learners and focusing their attention to specific contents.

Based on this background, this chapter will provide insights into facilitating collaborative problem solving in a computer supported audio-visual learning environment (videoconferencing). It has a focus on facilitation by a content-related pre-structuring of the collaboration processes: a *content scheme* to facilitate learners' task-specific strategies. The chapter presents different types of content schemes for the learners, which were analyzed in two empirical studies with regard to their influence on the actual *processes of collaborative problem solving* and the *quality of collaborative problem solutions*.

RESEARCH QUESTIONS

The chapter investigates how different types of content schemes can be used for collaborative problem-solving. As collaborative problem solving relies strongly on linking theoretical concepts with evidence provided by case material (see e.g. Kuhn, Weinstock, & Flaton, 1994; Sodian, Zaitchik & Carey, 1991; Suthers & Hundhausen, 2003), it is obvious that learners need to thoroughly examine evidence to receive the full benefits of collaborative problem-solving. However, such an examination of case materials is not always done by learners to an appropriate extent. The research described in this chapter has a focus on two aspects: the first study analysis in how far content schemes can facilitate collaborative problem solving (in general); the second study has a particular focus on the issue of evidence use, in particular the provision of case information. It investigates how content schemes can be improved to supports learners to consider more evidence from the case material in their collaborative problem solutions. This chapter has a focus on how content schemes can facilitate *processes* and *outcomes* of collaborative problem solving in video conferencing. The content schemes of both studies are compared with respect to their impact on the processes and outcomes, which is reflected in the following research questions:

Research question 1: In how far do different types of content schemes have an effect on learners' problem solving processes?

Research question 2: In how far do different types of content schemes have an effect on the quality of learners' collaborative problem solution?

METHOD

Learning Scenario

The focus of the two studies was on the effects of content schemes on collaborative problem solving in videoconferencing. In both studies, the problem solving approach was implemented in the learning scenario by giving the learners the role of school psychologists who worked on a case of a pupil's problems in school. In particular, they had to deal with the pupil's problems in mathematics, taking into account the three perspectives of the pupil's teacher, his mother, and the pupil himself. They received a case framework, which contained the background story and case information specific to the three particular perspectives. The learners had to make a collaborative analysis of the case in order to find possible causes for the pupils' problems according to the attribution theory. All three perspectives comprised of different case information (evidence) which was distributed among the three learners. This resource distribution was implemented differently in both studies. In the first study, the three different perspectives had a minor extent of shared evidence, which resulted in a lower task difficulty. In the second study, there was no shared evidence and therefore the task difficulty was higher.

The experimental sessions comprised of two learning activities. At first, in an individual learning activity (25-30 minutes) learners had to read a text about the attribution theory of Kelley (1973) and Heider (1958) with the aim to familiarise with the main concepts of this theory. Secondly, in a collaborative learning activity (40-50 minutes) groups of three learners had to solve the case of the pupil's problems at school together. Therefore, it was necessary to extract and compile evidence of the three different perspectives from the case framework and to classify it according to the attribution theory. All learners were instructed to exchange their knowledge about evidence of their respective perspective. During the collaboration process, learners were connected via a desktop videoconferencing system that included an audio- and video-connection. A shared application – in particular a joint word processing document – was available on the computers of all three learners (it could be edited by each of them) to support their collaborative problem solution.

Participants and Design

Both studies applied the same learning scenario but provided facilitation to a different extent. The experimental design of study 1 compared a control condition with a content scheme treatment (general focus). In this study, 78 undergraduate students of educational science took part (26 triads, see Table 1). In study 2, the general content scheme applied in study 1 was compared to a content scheme with enhancements for introducing evidence in the process of collaborative problem solving (evidence focus). In that study, 60 students of

Table 1. Design of the two studies

Content Scheme			
	without	with	enhanced
Study 1 (general)	13 triads	13 triads	--------
Study 2 (evidence)	--------	10 triads	10 triads

education science and psychology took part (20 triads, see Table 1). As Table 1 indicates, both studies had the general content scheme in common and compared it with another treatment. In both studies, the participants, some framing conditions, and the instruction with respect to the application of evidence were slightly different, and thus they will be analyzed separately in the following.

Realisation of the Treatment and Use of the Content Scheme

Applying the content scheme aimed at fostering collaboration domain-specifically by visualising important dimensions of the content. Thereby, the content schemes focused learners' attention on the different aspects important for analysing attribution patterns. In both studies, learner triads with the support measure of the *content scheme* or *enhanced content scheme* received it during the collaborative problem solving activity. Both types of the content scheme were made available to the learners via the shared application of the videoconferencing setting. Learners without content scheme worked with a shared application which was not pre-structured. In turns, all three learners had the possibility to insert information in the shared application – either in the pre-structured tables of the content schemes or in the unstructured document.

In the *content scheme*, the causes for the pupil's problems in mathematics were the starting point for the collaborative problem solving process. Learners had to identify the different causes provided in the case materials of the three different perspectives of the pupil, teacher and mother. The next category comprised of the theoretical concepts of the attribution theory: consensus and consistency. Regarding this category, learners had to identify the respective information from the case information and determine whether the particular instance had a high or low value. Based on these determinations, the learners had to find the corresponding attribution patterns according to the theoretical work of Kelley and Heider (see Table 2).

The *enhanced content scheme* had basically the same structure as the content scheme but was designed with two additional rows to support learners' differentiation between theory and evidence (see Figure 1). Thus, the enhancement provided different layers for each cause, one for theory (dark grey) and the other one for evidence (light grey).

Both types of the content schemes did not give an explicit strategy to the learners but rather vi-

Table 2. Content scheme with exemplary case information and attribution

Causes	Case Information		Attribution Pattern	
	Consistency	Consensus	by Kelly	by Heider
Subject of Mathematics	High, all pupils have difficulties in Math in 8^{th} grade	High, difficulties during complete duration of 8^{th} grade	object	External Stable

Figure 1. Enhanced content scheme with exemplary case information and attribution

	Causes	Case information		Attribution pattern	
		Consistency	Consensus	Kelly	Heider
Theory		High	High	Object	External Stable
Evidence	Subject of Mathematics	all pupils have difficulties in Math in 8th grade	difficulties during complete duration of 8th grade		
Theory					
Evidence					
Theory					
Evidence					

sualized the important aspects of finding causes, connecting them with evidence information about consensus and consistency and finally determining the attribution pattern.

Dependent Variables

The study analyzed the problem solving processes and the quality of the collaborative problem solution for evaluating the effectiveness of the treatments.

Analysis of the Problem Solving Process

For the problem solving process analysis, the spoken discourse of the learner groups was transcribed and segmented into turns. Each turn was coded according to a fixed coding scheme (see Table 4; Ertl, Kopp & Mandl, 2006). The coding scheme provided three main categories: (1) content-specific negotiation, (2) strategic negotiation, and (3) clarifying negotiation (grounding). Besides this, the coding scheme provided also a category for off task and sub-categories. These last two categories are of minor importance for the analysis performed in this chapter and therefore the focus will be on the three main categories in the following.

A turn was coded as content-specific negotiation, if learners dealt with evidence or theoretical concepts in order to construct the collaborative problem solution. The category of strategic negotiation comprised of activities of discussing a strategy for problem solving, planning subsequent steps and evaluating the current progress or quality of the collaborative problem solution. Clarifying negotiation aimed at reaching a shared understanding among learners. It was directed to establish grounding in communication (see Clark

Table 4. Coding scheme for learners' problem solving processes

Category	Turn
Content-specific	E.g.: "In the 8th grade, all pupils have problems with math."; "Do you have some information about consensus?"
Strategic	E.g.: "We should summarise, somehow."; "Should we go ahead with another cause?"
Clarifying	E.g.: "I can't understand you."; "Jasmine took the perspective of the pupil's mother."

& Brennan, 1991), to resolve problems in understanding the specific perspectives represented by each learner, and to deal with challenges in handling the learning environment from a technical perspective. In both studies, two different raters analyzed 10% of the discourses to ensure objectivity. The inter-rater reliability of the coding scheme was good (study 1: κ =.88; study 2; κ =.94).

Analysis of the Quality of Collaborative Problem Solution (Outcome)

For measuring the quality of collaborative problem solution, the status of the joint problem solution was analyzed at the end of the collaboration process. The joint problem solution was created by the learners during their collaboration process: learners noted the results of the case solution in the shared application. Correctly identified evidence, correct determinations of consensus and consistency and correct attributions were marked and summed up to a score. The maximum score was 200 (100 points for the correct identification of all evidence, 100 points for correct identification and application of all theoretical concepts). The closer the score of a learners' problem solution was to the maximum, the higher was its overall quality. To ensure objectivity of the analyzes, two raters coded 10% of the tests. In both studies, the inter-rater reliability of coding was good (study 1: r=.87; study 2: r=.87).

RESULTS

Problem Solving Processes

The first research question considered the effect of the content schemes on learners' problem solving processes. In study 1 (general), the proportion of learners' turns in the three categories of content-specific negotiation, strategic negotiation and clarifying negotiation showed little difference between the treatment with content scheme and the treatment without support (control treatment). In both treatments, the majority of turns was related to the content of the problem solution. Learners in the treatment without content scheme uttered 83% of content-specific talk, and learners supported with content scheme produced 86% content-specific turns. The strategic planning of the problem solving process was second: 14% of the turns made by learners in the treatment without content scheme, and 13% of the turns of learners in the treatment with content scheme were related to the strategic planning of the collaborative problem solution. Clarifying negotiation had the smallest share of the discussions in both treatments (without content scheme: 3%, with content scheme: 1%). Descriptively, learners with content scheme used less strategic and less clarifying negotiation than learners in the control group. This enabled learners with content scheme to work more content-specifically.

In study 2 (evidence), the number of learners' turns in the three process categories again showed little difference between the two treatments. The majority of turns comprised of content-specific negotiation (with content scheme: 90%; with enhanced content scheme: 87%). The second most frequent turns in both treatments were related to clarifying negotiation. Learners in the treatment with content scheme produced 7% clarifying turns, and learners who were supported with the enhanced content scheme used 8% of their discourse for clarifying. Strategic planning of the problem solution was used to the least extent in both treatments of study 2 (evidence). The discourse of triads in the content scheme treatment comprised of 3% strategic talk, and learners supported with the enhanced content scheme dedicated 5% of their discussions to strategic planning. Comparing the treatment of the content scheme with the treatment of the enhanced content scheme, the frequencies of clarifying and strategic negotiation increased for learners who received support by the enhanced content scheme. In consequence, learners in the treatment with enhanced content scheme had a minor proportion of content-specific negotiation.

Even if both studies are not directly comparable, we can see differences with respect to the effects of the pre-structuring provided in each of them. In study 1 (general), the structure provided by the content scheme reduced strategic and clarifying talk, and therefore enabled learners to focus more on content- specific negotiation. Yet, the opposite happened in study 2 (evidence): the additional structure, which was provided by the enhanced content scheme increased the learners' need to engage in strategic and clarifying talk and therefore reduced their content-specific negotiation. Furthermore, we can see that learners of study 2 (evidence) had a higher proportion of content-specific talk, needed much more clarifying, but were less engaged in strategic talk than learners of study 1 (general). These observations may have been caused by differences in the instruction given to learners in both studies. In study 2 (evidence), the instructions focused learners more on evidence and the distribution of resources. As learners of study 2 (evidence) had no shared evidence, they may have needed to invest more clarifying activities (grounding) to establish a shared knowledge base.

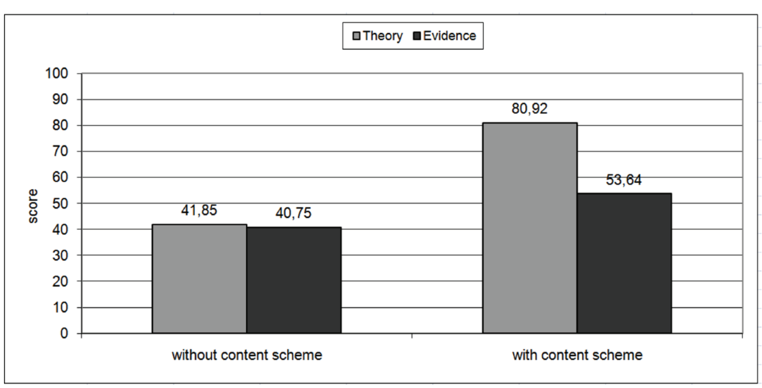
Quality of Collaborative Problem Solution (Outcome)

The second research question focused on the effect of the content schemes on the learners' collaborative problem solution. Figure 2 presents the values of the quality of collaborative problem solution for study 1 (general) for the categories of theory and evidence. Learners in the treatment with content scheme achieved a higher quality in their collaborative problem solution than learners in the treatment without content scheme. Especially, the results for the identification of theoretical concepts improved dramatically for learners using the content scheme. Furthermore, these learners also identified on average 25% more evidence than learners without content scheme.

Figure 3 presents the results regarding the quality of collaborative problem solution of study 2 (evidence). The data shows that learners in the treatment with enhanced content scheme scored slightly better than learners who were supported with the general type of the content scheme. This result relates to both categories, theory as well as evidence.

The comparison of these outcomes reveals some differences in the effect of the content-specific facilitation method. In study 1 (general), a great impact of the content scheme was re-

Figure 2. Study 1 (general) Average quality of problem solution with and without content scheme, by theory and evidence (0-100 points each)



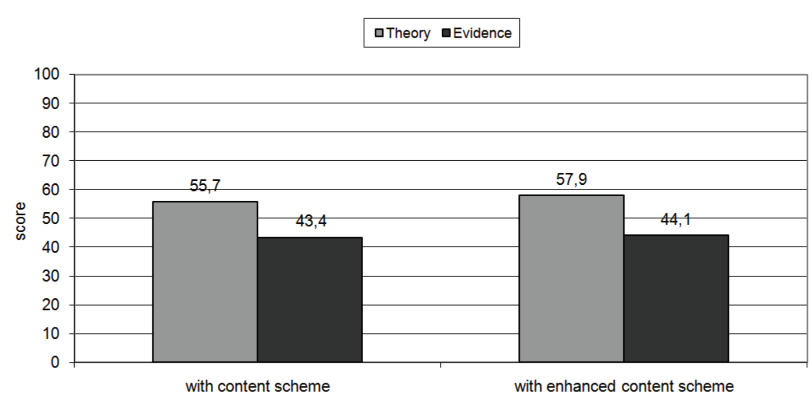
ported: the quality of the theory concepts identified by learners almost doubled and a huge gain in evidence identification was observed. Such an impact could not be reported for the enhanced content scheme in study 2 (evidence). It just provided marginal gains in theory as well as in evidence identification by learners. This may be obvious for the category of theory, as the enhanced content scheme did not provide more facilitation for this category than the general content scheme. However, the results for the category of evidence raise the question why the enhanced content scheme did not show any greater effect. Comparing the outcomes of both studies, the higher task difficulty of study 2 is reflected in the theory scores of the general content scheme condition of both studies, which dropped from 81 to 56 points. However, the outcomes show also a reduction in the difference between theory and evidence. In study 2, learners identified a higher proportion of evidence in both treatments as compared to the theory identified in the content scheme treatment of study 1.

SUMMARY AND DISCUSSION

The aim of this chapter was to describe how content schemes may influence problem solving processes and outcomes. Therefore, we presented two studies: study 1 (general) compared the effect of a *content scheme* with a control treatment in which learners did not get content-specific support; study 2 (evidence) investigated effects of an *enhanced content scheme* for dealing with evidence in problem solving. The general content scheme treatment used the same facilitation method for both studies and could therefore serve as baseline for the comparison of the two studies. The results showed differences between both studies with respect to problem solving processes and to learning outcomes. We attribute these differences to the increased task difficulty of study 2 (evidence), which resulted from a different distribution of evidence in the case material of learners. Furthermore, the specific focus on evidence in the instructions provided for learners in study 2 (evidence) might have influenced the problem solving processes and outcomes. Considering these two limitations for our discussion, we can emphasize the following findings:

In study 1 (general), the content scheme affected descriptively the collaborative problem solving by reducing the proportion of learners' strategic planning and their need for clarifying negotiation. By this result, we presume that the content scheme introduced an implicit strategy to the collaboration process, which enabled learners

Figure 3. Study 2 (evidence) Average quality of problem solution with content scheme and enhanced content scheme, by theory and evidence (0-100 points each)



to work more content-specifically. Thereby, the content scheme may have substituted learners strategic actions (see also Ertl, Kopp, & Mandl, 2006). Furthermore, the content scheme provided learners with a clear gain in the quality of learning outcomes – with respect to theory as well as with respect to evidence. This result underlines research results which show that content-specific pre-structuring can be an important facilitation method in collaborative settings and strengthens the findings of earlier research with respect to the instructional value of representational guidance (see e.g. Ertl, Fischer, & Mandl, 2006; Suthers & Hundhausen, 2003).

Study 2 (evidence) aimed at improving the general content scheme with an evidence-specific enhancement. Yet, this treatment did not meet the expectations with regard to its effectiveness. Based on our theoretical assumptions, there are three possible explanations for the results. First of all, the effect of representational guidance and salience may be limited by the complexity of the content scheme. According to Suthers and Hundhausens (2003) the concept of salience works with a clear indication of missing items to learners through the provision of representational guidance. However, this effect may decrease with a growing complexity of the intervention: each field in the provided pre-structured template may receive proportionally less attention from the learners. A second explanation postulates an interaction of the complexity of an intervention with the learner's experiences (see Dobson, 1999). Dobson discussed that a beneficial tool needs to correspond with the learners' abilities. If the tool was too powerful, it may have exceeded the learners' skills to use it and therefore learners may not take the full benefits of it. Third, one may consider that the amount of evidence provided by the learners was relatively high (about 75% of the theory concepts). It may be the case that the enhanced content scheme introduced a deductive strategy to substantiate theory claims by evidence, instead of an inductive approach. This would mean that learners started the problem solution with naming theory concepts and then searched for evidence which fits to the theory, instead of identifying existing evidence first and classifying it by theory concepts—and for such a strategy the proportion of identified evidence (75%) may already be a ceiling effect.

IMPLICATIONS AND FUTURE RESEARCH

This chapter provided insights in the strengths and limitations of content schemes for facilitation of collaborative problem solving. It would be of further interest to see how the specific processes of content-specific, clarifying and strategic negotiation correlate with the outcomes, and if particular processes can predict outcomes in a certain way. However, for a comparison of these aspects the frames of both studies were too different. The learning setting as well as the intervention had an effect on the problem solving processes, and the results for this research question would hardly be interpretable. The differences in the clarifying, strategic and content-specific problem solving processes of both studies (see "Results: Problem Solving Processes") are an indicator for these effects. Ertl, Kopp, and Mandl (2006) as well as Helling (2006) identified strategic activities as an important predictor for collaborative outcomes (see also Gijbels et al., 2005). Yet, in the context of studying the facilitation of problem solving strategies this issue would need a more differentiated analysis than would be possible in the scope of this chapter.

Furthermore, the issue of the interaction of content schemes and videoconferencing should be analyzed in more detail. The shared work space may receive much more of learners' attention in virtual settings than in physically co-present settings due to the fact that it is the main interaction channel of learners in such settings. Issues in this context were further explored by Ertl, Kopp, and Mandl (2006). In their study, they analyzed how far learners' discussions were related to the creation of the shared external representation. Furthermore, the Fischer et al. (2002) study compared learning processes and outcomes in a videoconferencing condition with a face-to-face condition. Both studies were able to show peculiarities of content-specific support in videoconferencing. Further research may investigate the effects of such support in the three different settings videoconferencing, face-to-face with computer support, and face-to-face without computer support to gather in deep insights of the effects of content schemes.

This chapter presented the method of content scheme, which relies on the concept of representational guidance, for facilitation of collaborative problem solving on a content-specific level. Other methods, like collaboration scripts, focus on pre-structuring the interaction of learners in collaborative settings. Collaboration scripts aim at the instructional introduction of beneficial collaboration strategies and prevention of undesired group effects. Studies have shown that the combination of scripts and schemes provides best effects for collaboration outcomes (see e.g. Ertl, Fischer, & Mandl, 2006). Scripting research nowadays deals with flexible scripting which relates to generic scripts for different purposes (see e.g. Dillenbourg & Jermann, 2007; Haake & Pfister, 2007). Further research in the context of content schemes should also focus on the issue of flexibility. In this context, future content scheme approaches should consider how schemes interact with a learner's prior knowledge. Ertl, Kopp, and Mandl (2005) could show that the facilitation by content schemes was able to balance out differences in the learners' prior knowledge (see also Ertl, 2009; Ertl & Mandl, 2006). This opens the chance for the flexible provision of particular content schemes adapted to different prior knowledge levels that can particularly facilitate learners on lower competence levels.

CONCLUSION

In this chapter, we analyzed and compared collaborative learning processes and outcomes of two different content scheme treatments and a control condition from two studies. By this procedure, we were able to show the impact of two content schemes on problem solving processes and outcomes of learners in a videoconference setting. The general content scheme showed a facilitating effect for the content-specific work on the task by providing an implicit strategy for problem solving and it improved the learning outcomes by focusing learners' attention on the relevant theory concepts and evidence required for a high quality problem solution. The enhanced content scheme was subject to certain limitations with regard to its facilitating effect: its complexity increased the learners' need for clarifying negotiation, and it reduced the salience of theory and evidence dimensions by splitting the learners' attention between both aspects. Also, the enhanced content scheme implied a rather deductive strategy which may have prevented learners from starting the problem solving process with the identification of existing evidence, followed by the application of theory concepts on this evidence.

From both studies, we can draw implications for the implementation of content schemes in educational practice. First of all, content schemes are a powerful means to support collaborative problem solving. The application of content schemes in collaborative problem solving in videoconferencing makes important aspects of the problem solving salient during the collaboration process. This could enable learners to build an implicit strategy for problem solving (see Ertl, Fischer, & Mandl, 2006). However, the impact of the tool is limited. If content schemes get more and more complex, their supportive effect may be limited to a particular level. Additionally, influences from the learning setting and task presentation, as well as the combination of the content scheme approach with scripting approaches, should be considered for the purpose of facilitating learners' collaborative problem solving processes and outcomes.

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KEY TERMS AND DEFINITIONS

Application Sharing: Mechanism that allows collaboration partners to work with the same application on the same document simultaneously.

Content Scheme: A content-specific representation of the structure of a particular topic.

Collaboration: Tight working together with a strong commitment of collaboration partners.

Collaborative Learning: Method of learning by which a group of learners collaborate to achieve improved learning results.

External Representation: A material display of knowledge and information which may include facts but also procedures and structures.

Instructional Design: The didactical rationale for a learning scenario which includes instructional elements as well as the application of tools.

Learning Case: Description of a real-world scenario, which helps learners to apply their knowledge.

Mental Artefact: Immaterial product, which collaboration partners construct during the process of collaboration.

Shared Problem Space: The shared knowledge of collaboration partners which is necessary to solve a problem collaboratively.

Videoconferencing: Users use webcams and headsets to have a face to face conversation via internet. Videoconferencing is often combined with the use of a shared application to enable users to work collaboratively with the same software tool.