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Bernhard Ertl, Markus Reiserer & Heinz Mandl

Cooperative Learning in Videoconferencing:
The Influence of Content Schemes and Cooperation Scripts on
Shared External Representations and Individual Learning
Outcomes

March 2003



Ertl, B., Reiserer, M. & Mandl, H. (2003). *Cooperative Learning in Videoconferencing: The Influence of Content Schemes and Cooperation Scripts on Shared External Representations and Individual Learning Outcomes* (Research report No. 154). Munich, Germany: Ludwig-Maximilians-University, Department of Psychology, Institute for Educational Psychology.

Research report No. 154, March 2003

Ludwig-Maximilians-University Munich, Germany
Department of Psychology
Institute for Educational Psychology
Chair Prof. Dr. Heinz Mandl
Leopoldstraße 13, 80802 Munich
Telephone: ++49-89-2180-5146 – Fax: ++49-89-2180-5002
<http://lsmndl.emp.paed.uni-muenchen.de>
e-mail: mandl@edupsy.uni-muenchen.de, ertl@lmu.de,
markus.reiserer@verwaltung.uni-muenchen.de

Editor: PD Dr. Michael Henninger

e-mail: henninge@edupsy.uni-muenchen.de

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Abstract

Videoconferencing is expected to become increasingly important for tele-learning environments. This study investigates how to foster cooperative learning through videoconferencing. The selected learning environment was a peer-teaching scenario, which required the learners to teach one another theories. In this study the effects of different types of support for this cooperation were investigated. The main focus is on how both (1) content schemes and (2) cooperation scripts enhance the construction of shared external representations and foster learning outcomes. The results indicate that content schemes as well as cooperation scripts foster the construction of shared external representations. Furthermore, the learners with a cooperation script had higher learning outcomes than those learners without a cooperation script.

Keywords: Collaborative knowledge construction, video-conferencing, content schemes, cooperation scripts, external representations

Zusammenfassung

Videokonferenzen werden in Telelernumgebungen zunehmend wichtiger. Im Rahmen dieser Studie wird untersucht, wie man kooperatives Lernen in Videokonferenzen unterstützen kann. Als Lernumgebung wurde ein Peer-teaching Szenario gewählt, bei dem es die Aufgabe der Lernenden war, sich gegenseitig eine Theorie zu vermitteln. Dabei werden die Auswirkungen einer Unterstützung durch die Faktoren (1) Wissensschemata und (2) Kooperationskripts auf die Erstellung einer gemeinsamen externalen Repräsentation und auf den Lernerfolg untersucht. Die Ergebnisse zeigen, dass sowohl Wissensschemata als auch Kooperationskripts positive Effekte auf die Erstellung der gemeinsamen externalen Repräsentation haben. Lernende mit Kooperationskript wiesen zusätzlich einen höheren Lernerfolg auf als Lernende ohne Kooperationskript.

Schlüsselwörter: Gemeinsame Wissenskonstruktion, Lernen in Videokonferenzen, Wissensschemata, Kooperationskripts, externale Wissensrepräsentation

COOPERATIVE LEARNING IN VIDEOCONFERENCING: THE INFLUENCE OF CONTENT SCHEMES AND COOPERATION SCRIPTS ON SHARED EXTERNAL REPRESENTATIONS AND INDIVIDUAL LEARNING OUTCOMES

Introduction

Recent technical developments in the field of new communication technologies suggest that forms of communication used in an educational context which are transferred using the medium of videoconferences are reaching an increasingly higher significance. From this, it can be concluded, that text-based virtual educational offerings as they are currently known (see Reimann-Rothmeier & Mandl, 2001), could be enriched or even replaced by videoconferencing elements. The research to date in the area of communication and cooperation through videoconferences has focused on comparing videoconferencing with other media-based settings in which a comparison with face-to-face situations played an integral role. In contrast, less attention has been dedicated to the question of how cooperative learning in videoconferences could be beneficially supported through specific instructional measures.

The discussion in this paper contributes to research in this area and investigates various support mechanisms for cooperative learning through videoconferences. Specific attention will be paid here to the creation of *shared external representations*. These are understood to be textual and graphical representations of knowledge structures, which the videoconference participants can create through a shared computer application. Shared external representations are of high importance to the cooperation in videoconferences because they are based on the premise that the learning partners, who are in diverse locations, share a common and equally accessible basis for content-specific discussions (see also Dillenbourg & Traum, 1999). These become even more important, when the cooperative partners are in possession of different learning and working materials, whose contents become accessible through the collaborative efforts with the other conference participants.

In the following section, common assumptions and findings on co-operative learning in videoconferences will be summarized. Then the role of external representations in learning will be explored. Based on this, some measures will be presented, which support the learner in creating shared external representations which also consequently promote learning outcomes: Content

schemes, which support cooperation on a content-level and cooperation scripts, which structure the course of the cooperation and the roles of the cooperative partners.

Cooperative Learning in Videoconferences

The effectiveness of cooperative learning is justified against the background of a *socio-cognitive perspective* (e.g. Renkl, 1997; Slavin, 1996; Webb, 1989). In these accounts the learners take an active position through self-directed work in learning groups, in which they have the opportunity to construct shared knowledge through exchanges with their learning partners. These types of co-constructive processes involve the learners explaining facts to one another, asking questions and giving each other feedback (see Fischer, 2002). Through these co-constructive processes, which become evident through discourse, cognitive processes are initiated, which are ultimately responsible for learning outcomes through this type of cooperation. From a socio-cognitive perspective, the resulting learning outcome is highly dependent on the degree to which these co-constructive processes are activated through discourse, which initiate the cognitive learning process on an individual level. The importance of the group, from a socio-cognitive perspective, is related to its ability to facilitate the initiation of activities, which are often used deficiently in the case of individual learning.

These formulations regarding cooperative learning can also be applied to the study of cooperative learning in videoconferences. Until now, the research on this topic concentrated on the comparison of a videoconference setting and face-to-face cooperation. The central question was the degree to which the cooperation through videoconferences could compare to the results achieved through direct communication with respect to cognitive processes and learning outcomes. In this case it was assumed, that videoconferences had a high potential amongst the existing (web-based) communication technologies, in order to create virtual cooperation arrangements, which show important characteristics of face-to-face communication (Clark & Brennan, 1991; McGrath & Hollingshead, 1994). Amongst these characteristics is the opportunity to have synchronous verbal exchanges, during which the conference participants are able to see each other. This opportunity should not, however, detract from the fact that videoconferences have certain limitations in comparison with face-to-face communication. For example, conventional systems do not allow for any eye contact between the participants at the diverse locations (Acker & Levitt, 1987). Also, independent of the technical quality of the videoconference, there are various aspects of non-verbal communication which are limited, often

through the fact that only a picture of the head and chest of the participants are transmitted and therefore the transmission of body position and gestures are limited (Bruce, 1996; Finn, Sellen & Wilbur, 1997). Despite these limitations, Fischer and Mandl (2002) have summarized that cooperative learning in videoconferences is comparable to face-to-face cooperation. Studies to date have shown, that videoconferences show no substantial disadvantages as compared to face-to-face cooperation, neither with respect to the different process variables, nor with respect to the success of learning outcomes (Fischer et al., 2000; Pächter, 2001; Schweizer, Pächter & Weidenmann, 2002). This can be the case as long as the videoconferences provide, in as far as technically possible, a disturbance-free communication without extensive delays in the communication (O'Connail, Whittaker & Wilbur, 1993).

The Effect of Shared External Representations Used in Cooperative Learning on Learning Outcomes

Videoconferences, even when they support a delay-free communication, differentiate themselves from face-to-face situations mainly in the respect that the participants are in diverse locations and are only able to communicate through the technical communication channels which are made available to them. An audio-video component makes it possible for the participants to see and hear each other. In addition to the audio-video component, it is often the case that desktop videoconferences also utilize shared computer applications, which the participants can use to create and work on documents together (Bruhn, 2002). From a psychological perspective, this functionality is important because it allows the creation of shared external representations. In the sense in which is understood here, the concept of shared external representations describes an externalization of knowledge which is created through cooperative efforts and that can be made accessible to all cooperative partners in textual or graphical form (Suthers, 2001; Fischer 2002).

External representations become increasingly meaningful, when the learning partners who are working together in the videoconferences are in possession of different pieces of knowledge, which should be exchanged through the cooperation. In cooperative learning the allocation of learning materials and knowledge is found in so-called resource interdependent approaches. In these approaches, the learning resources are allocated to the partners in such a way, that each participant has access to specific pieces of information. The cooperative effort is achieved by the learning partner communicating the contents of "their" resource, so that after collaboration all the learning partners have gained the broadest possible understanding of the contents. These types

of cooperative arrangements have a high potential to initiate cooperative learning processes, because they, on the one hand, ensure that the learning partners engage in the cooperative processes (otherwise the mutual communication of the contents would not be possible). On the other hand, in situations where different learning resources are distributed amongst the learners, there are sometimes difficulties for the learning partners who are not able to directly access the information. For this reason, they are depending on the contents of the „foreign“ learning resource being communicated adequately and completely by the learning partner, so that knowledge can be acquired from the contents. In studies which focus on cooperation using distributed learning resources, it has been shown, that the learning partners who do not have direct access to the learning material have weaker learning outcomes with relation to the learning contents discussed than the learning partners who are in direct possession of the material (Lambiotte, Dansereau, O'Donnell & Young, 1988; O'Donnell & Dansereau, 2000).

Shared external representations can help to counteract the problem of distributed resource approaches. In this way, the knowledge becomes accessible to all learning partners during the cooperative process. It can be assumed that the use of shared external representations help learning partners who do not have access to particular learning materials to achieve stronger learning outcomes, especially in learning situations which require the communication of knowledge through different learning resources.

Opportunities to Support Learners in the Creation of Shared External Representations to Enhance Learning Outcomes during Cooperative Learning in Videoconferences

The next section builds on the considerations outlined thus far and presents various ways to assist learners in the creation of shared external representations. Firstly, content-specific structures in the form of so-called content schemes will be considered, secondly we will consider the instructions, which aim to direct cooperation through so-called cooperation scripts.

Predefining Content Structures through Content Schemes

In contrast to cognitive schemes that relate to the memory organization (Anderson, Spiro & Anderson, 1978), the concept of *content schemes* as understood here relates to external structuring methods, which are performed in relation to the contents of the respective learning objects made available to the learner through self-directed learning. Suthers and Hundhausen (2001) explain

the effects of these types of external structuring methods through their function in making central characteristics of the learning object salient and thereby lead the learning discourse through their representation (*representational guidance*). The presence or absence of the central characteristics becomes apparent to the learners through the use of the structuring method and offers a contextual anchor, which helps the learning partners focus the discussion on the contents which are relevant to learning. In addition to this, representational guidance makes it possible through the use of pre-defined structures to identify any gaps in content, which can then be discussed more strongly. Suthers (2001) explored various forms of content-specific structuring methods. Suthers chose the acquisition of scientific theories as his area of study. He especially focused on making learners aware of how to differentiate between theoretical concepts and empirical findings and supporting them in the creation of relationships between theoretical concepts and the corresponding findings. In one investigation, three conditions were compared which differed in the form of the content-specific structures, which were made available to the participants in order to create shared external representations. It was shown that groups which created external representations on the basis of graphical or tabular pre-defined structures were substantially more successful at identifying the relationships between theoretical concepts and empirical findings, as opposed to groups which acted without such support. This result supports the idea that the content-specific structures were able to direct the creation of the external representation and thereby influence the learning discourse in the intended manner.

Studies that analyze the effects of content schemes in videoconferences have seldom been undertaken. One investigation on this topic was carried out by Fischer et al. (2000). In this study it was also the goal to support the learners in discerning the difference between theoretical concepts and empirical findings through working on case studies. The authors provided the participants with a mapping tool, which was intended to assist with the creation of shared external representations. This offered the learners specific structures that were specifically conceptualized and tailored for the case study. These were intended to encourage the learners to construct one (empirical) problem space and one (theoretical) conceptual space and then to create the relevant relationships between the elements of each space. It was shown that the structuring method using various content- and process variables could positively influence the learning discourse. However, in relation to the learning outcomes, this structuring method did not have any substantial effect.

All in all, the findings of content schemes in cooperative learning are not very differentiated and are still ambiguous (Bruhn, 2000; Suthers, 2001). Furthermore, the question of the role of content schemes in cooperative

learning with distributed learning resources has been largely ignored to date. So it can be assumed that for these types of scenarios, that content schemes can help the learner to structure contents by creating shared external representations. This should prove especially beneficially to those learning partners who are receiving new knowledge through the cooperation with the other learning partner, knowledge to which they did not previously have direct access.

Predefining Cooperation Scripts to Initiate Learning Effective Cooperative Processes

A further opportunity for promoting cooperative learning in videoconferences exists in the pre-definition of the so-called cooperation script. This initiative differs from the content schemes which were presented in the last section in that they are not based on the structuring of domain-specific contents, but rather attempt to direct the interaction of the learners so that certain rules and instructions of learning-supportive cooperation strategies are put into practice. There are several methods of instruction which can be categorized as script-based cooperation initiatives. Amongst the best known and – in the framework of face-to-face cooperation- most studied methods are *Reciprocal Teaching* (Brown & Palincsar, 1989, Palincsar & Brown, 1984) and *Scripted Cooperation* (e.g. O'Donnell & Dansereau, 1992). Without examining the detailed results here, it can be asserted that these types of cooperation scripts have proven themselves to promote cooperative learning. Therefore it is no surprise that script-based initiatives have also taken on a prominent role in the discussion of supporting web-based cooperative learning. Their implementation has taken place almost exclusively in the framework of text-based cooperative arrangements (e.g. Baker & Lund, 1997; Hron, Hesse, Reinhard & Picard, 1997). In the framework of video-based cooperative arrangements; however, the study of cooperation scripts has not taken place. It can be assumed that cooperation scripts in the context of this medium would also positively influence learning processes and learning outcomes. It is crucial here, that the cooperation script is tailored to the requirements of the specific cooperative situation. On the basis of considerations to date regarding the importance of external representations, this means that cooperation scripts in the context of videoconferences should specifically teach the learners how to create shared external representations. When using cooperation scripts when resources are cooperating using distributed resources, special attention should be paid that especially the learning partners who do not have direct access to the learning material are brought into the cooperative activities as intensely as possible. In this way, the best possible learning outcomes will result.

Research Questions

This study investigates the degree to which a content scheme and a cooperation script can effect the creation of a shared external representation. Following this, it will be examined to what degree both methods of intervention effect learning outcomes.

Research Question 1: To what degree do a content scheme and a cooperation script or their combination influence the creation of a shared external representation?

Research Question 2: To what degree do a content scheme and a cooperation script or their combination effect learning outcomes?

In order to examine the relevance of shared external representations with respect to learning outcomes, the relationships between characteristics of shared external representations and learning outcomes will be analyzed.

Research Question 3: To what degree is there a connection between shared external representations and learning outcomes?

Methods

Participants and Design

86 students of educational psychology participated in the study. The participants were randomly split into 43 dyads and were assigned to one of four conditions of a 2x2 factorial design; attention was paid to ensure the participants in general did not know each other before the study. Each of the twelve conditions was represented by 10 to 12 dyads. Two factors were varied for the study: content scheme (with/without) and cooperation script (with/without).

Learning Environment and Procedure of the Study

The study was part of a complex learning scenario. In this article, only the components of the learning scenario that are necessary for the understanding of data presented herein will be described. The learning environment was made up of one individual and one cooperative learning unit. After a pre-test, which determined the learning assumptions – e.g. previous knowledge – one person from each dyad worked on the individual learning unit. This was comprised of a text on genotype-environment-effects (1253 words), which contained both theoretical concepts and empirical findings. The person learning from the text functioned as the tutor during the cooperative learning unit. The second person

assumed the role of learner during the cooperation. For the completion of the text, the learner in the tutoring role had 25 minutes time to work on the text. After this time the students were told they had 10 minutes to prepare for the cooperation.

The cooperative learning unit, in which the learners dealt with the theory of genotype-environment-effects, lasted approximately 40 minutes. The learners were given the task (1) to study the most important contents of the theory text, both the theoretical concepts and the empirical findings and (2) to discuss their own reflections, ideas and comments on the subject. Through the use of a shared text editor, the learners had the opportunity to create external representations of theoretical concepts and empirical findings together. Throughout the experiment, the learners found themselves in different locations; in this way there was no face-to-face contact between the participants. In the cooperative learning unit, the learners communicated via videoconference; this included the use of both an audio-visual communication channel and a Word document as a shared application to capture the shared external representations.

Following the cooperative learning unit the theme-specific knowledge was collected on an individual basis.

Realization of the Treatments

Both the factors of cooperation script and content scheme were used during the pre-structuring of the communication interface. In addition, the shared text documents were pre-structured for the learners with elements of the content scheme and the cooperation script. In the following, the three experimental conditions will be described; learners in the control group worked in the learning environment without any additional support.

Condition Using Content Schemes

In the condition using the content scheme, the learner had at his/her disposal a content scheme during the cooperative learning unit as a content-specific structuring method to capture shared external representations. The content scheme had the following categories: *theoretical concepts*, *empirical findings*, *consequences* and *individual judgement*. It was the learner's task to describe basic theoretical concepts in the category entitled *theoretical concepts*, to present the studies which supported the theory in the category entitled *empirical findings*, to present personal ideas on the usefulness and limitations of the theory in the category entitled *consequences*, and to present a personal evaluation of the theory and assessment in the category of *individual judgement*. The content scheme thereby helped the learner to differentiate

between theoretical concepts and empirical findings. It also supported them in elaborating on the theory text in their own words and also enabled them to couple this with their own prior knowledge. The fairly abstract categories of the content scheme were made more concrete by the questions contained in each category (see Table 1).

Table 1: Structure of the Content Scheme.

Theoretical Concepts	Empirical Findings
What are the most important concepts of the theory?	How was the theory examined?
What are the most important ideas of the theory?	Which findings did the theory support?
Consequences	Individual Judgement
Which pedagogical interventions can be concluded from the theory?	What do we like about the theory? What do we not like? Which of our own experiences confirm the theory?
Which limits of pedagogical interventions can be concluded from the theory?	Which of your own experiences contradict the theory?

Condition Using Cooperation Script

The cooperation script structured the cooperative learning unit in two different respects: First of all, it provided the learner with different phases in which to communicate the contents of the text. It also provided specific activities for each phase to be undertaken by the learners in both the tutor and learner role (see Table 2).

The *first* phase of the cooperation script served to promote the communication of the text by the tutor. The task of the learner in the tutor role, that is, the learner who had read the text first individually, was to explain the contents of the text. The partner in the learner role had the task to listen and to query the information as soon as something was not understood.

In the *second* phase the learners deepened their comprehension of the text. To this end, they worked together on a written external representation of the text in the shared text editor. The partner in the learner role had the task to summarize the contents and important points in the text editor; the learner in the tutor role was given the task to support him in this activity.

Table 2: Tasks of the Tutor and Learner Role in the Cooperation Script.

	Tutor Role	Learner Role
Phase 1: Communicate	Explaining the text material	Asking comprehension questions
Phase 2: Deepen the understanding	Supporting the Learner	Explaining and typing the information received in the shared text document
Phase 3: Reflection	Individual reflection and elaboration, based on the shared text document (individual)	Individual reflection and elaboration, based on the shared text document (individual)
Phase 4: Discussion	Discussing the text document on the basis of reflection with the partner	Discussing the text document on the basis of reflection with the partner and capturing the results of the discussion in the shared text document

In the *third* phase of the cooperation script both learning partners reflected individually. Then they were asked to generate their own reflections, ideas and comments about the content of the theory text using the shared text document.

In the *fourth* phase, the discussion of the text document and the individual reflection took place. The learners could bring their own thoughts from the previous learning phases to the discussion. It was the task of the partner in the learner role to capture important notes from the discussion in the shared external representation. The learner in the tutor role supported this activity.

Condition Using Cooperation Script and Content Scheme

In this condition, the cooperation script and the content scheme were used in combination. In the first phase of the cooperation script, the learners had only the central questions on the theoretical concepts and empirical findings available in the pre-structured document. However, the learners did not have the opportunity to make entries in the text document. During the second phase, the learners entered thought units on the topics of *theoretical concepts* and *empirical findings* in the shared text document. The third phase was carried out individually, in this phase the lead questions on *consequences* and on *individual judgement* were made visible on the screen. In the fourth phase the learners discussed these questions and noted them as shared external representations.

Tools

Creating the Shared External Representation

In order to operationalize the shared external representation with respect to the areas of theoretical concepts and empirical findings, a coding scheme was developed in which all thought units of the theory text were listed out separately in a clearly identifiable way and without thematic overlap. For each unit of meaning which was included in the document, the learners received one point; the points were either summed together into a score for theoretical concepts or for empirical findings.

For the evaluation of the personal elaborations, a similar method was employed. The sum was made of all valid thought units in the document.

Recording the Learning Outcomes: Cued Recall

To record the learning outcomes, the participants completed in a test in the form of cued recall-items on the most important contents of the theory text. In total, a score of 16 points could be achieved in the cued recall test.

Recording the Learning Outcomes: Free Recall

In the post-test free recall, the learners were asked to write out the most important contents of the theory text from memory.

Monitoring Variables

To monitor the learning assumptions, pre-knowledge was gathered based on the cued recall tests and some emotional-motivational variables. These included (1) tolerance for ambiguity using the scale of Dalbert (1996) and (2) the interest in the contents based on three items.

Results

Monitoring Learning Assumptions

The learners in all conditions did not differ in the amount of pre-knowledge which they possessed. The pre-knowledge was low in all conditions. Also in relation to tolerance for ambiguity and interest the learners did not differ in the various conditions. Therefore, the internal validity of the study cannot be called into question due to varying degrees of learning assumptions.

Shared External Representations (Research Question 1)

The presentation of results for the shared external representation reflects the areas of theoretical concepts, empirical findings and personal elaborations. Then, the differences between individual conditions within the complete context of the externally represented thought units will be presented.

Theoretical Concepts

In relation to the area of theoretical concepts, the learners captured, on average, 13.6 (of a empirical maximum of 22) thought units in the shared text editor (see Table 3). In this area there were significant main effects of both independent variables. On the one hand, the significant main effect of the factor of the cooperation script ($F(1,38) = 4,63$; $p < .05$) showed that the learners in the cooperation script condition captured more thought units in this area. On the other hand, the highly significant main effect of the factor of content scheme ($F(1,38) = 8.89$; $p < .01$) showed that this factor led to significantly less capture of thought units in the area of theoretical concepts.

Empirical Findings

If these results are compared with the area of empirical findings, it becomes clear that here the differences were shown to be the opposite, even if these were demonstrated to a lesser degree (Mean: 7.40 of 12; see Table 3). The learners in the content scheme condition were able to name more thought units from the area of empirical findings, and the learners from the cooperation script conditions were able to name less. These effects were not significant; however there was a tendency ($F(1,38) = 3.11$; $p < .1$) towards a better rating for the content scheme group. The main factor of the cooperation script was not significant ($F(1,38) = 3.32$; *n.s.*).

Elaborations on Theoretical Concepts and Findings

The third task for the learners was to generate elaborations which related to the learning material. Looking at the values in Table 3 reveals a clear effect of the factor content scheme: learners in the content scheme condition retained significantly more elaborations (Mean: 3.33 of max. 7; see Table 3) than learners without the content scheme. This effect can also be proven as statistically highly significant ($F(1,38) = 59.98$; $p < .01$). In addition, it becomes apparent that there is an interactive effect between the two factors of content scheme and cooperation script: when these two factors were combined in the condition content scheme and cooperation script and also in the control group, there were less personal elaborations named than in the condition of only content scheme or only cooperation script. This effect can also be proven as statistically highly significant ($F(1,38) = 9.27$; $p < .1$).

Table 3: Shared External Representations.

Condition	Theory Concept		Empirical Findings		Elaborations	
	M	(SD)	M	(SD)	M	(SD)
Control Group	14.58	(5.48)	7.83	(4.63)	0.83	(0.94)
Content Scheme	9.60	(3.75)	8.60	(2.84)	6.50	(2.07)
Cooperation Script	16.18	(2.48)	5.27	(3.04)	2.09	(1.81)
Cooperation Script and Content Scheme	13.60	(4.30)	8.00	(1.89)	4.50	(1.43)

Figure 1 shows the sum of all thought units which were jointly represented externally. It becomes clear that the learners in the combined condition were able to externally represent the most thought units, while the learners in the control group produced the least external representations. In all conditions the sum of the external representations from the theory text – the sum from theoretical concepts and empirical findings – were about the same, with the exception of the content scheme condition, in which this sum was noticeably lower.

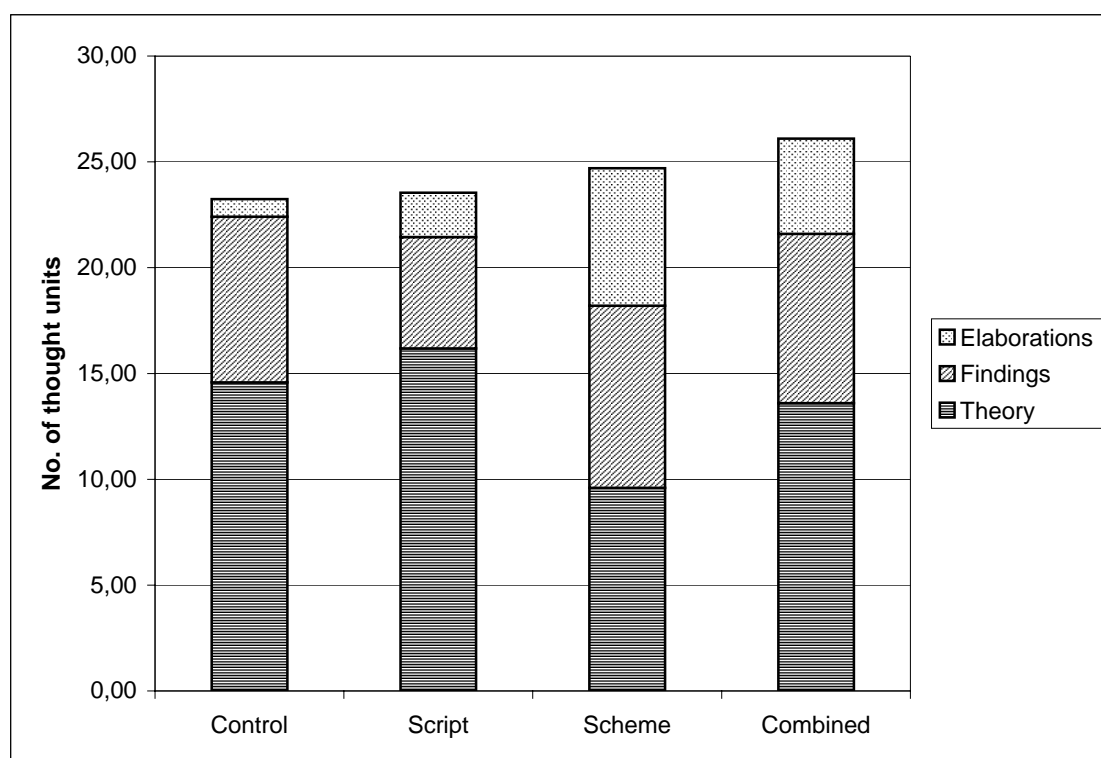


Figure 1: Distribution of the thought units on theory, findings and elaborations in the different conditions.

Individual Learning Outcomes (Research Question 2)

The individual learning outcome was recorded through both post-tests, the cued recall and the free recall.

Cued recall

The results of the learners in cued recall were between 45% and 57% of the total number of points (Mean: 7.93; theoretical maximum: 16), therefore there were neither floor nor ceiling (see Table 4). The learners in the condition with the cooperation script descriptively achieved a better learning outcome; this effect was not significant. Statistically only a tendency can be shown ($F(1,39) = 3.54; p < .1$).

Free Recall

With respect to the free recall there were no noteworthy differences between the individual conditions, the variance within the individual groups in each condition were relatively high. Learners with the content scheme could report the most thought units freely from memory, learners in the control condition the least (Mean: 7.74 of max. 18; $F(3,38) = .10; n.s.$).

Table 4: Individual Learning Outcomes.

Condition	Cued Recall		Free Recall	
	M	(SD)	M	(SD)
Control Group	7.15	(3.49)	7.09	(4.87)
Content Scheme	7.28	(1.79)	8.30	(3.83)
Cooperation Script	9.07	(2.45)	8.00	(2.97)
Cooperation Script and Content Scheme	8.27	(1.70)	7.60	(5.99)

Relationship between Shared External Representations and Learning Outcomes (Research Question 3)

The third research question covered the relationship between the shared external representations and learning outcomes. Here there was a significant correlation of average size between the theoretical concepts which were found in the shared document and the theoretical concepts which could be given by the partner in the learner role during the post test (see Table 5). All other correlations were not significant.

Table 5: Shared External Representation (SER) and Learning Outcomes for all Learners.

	Free Recall	Cued Recall
Theory Concept SER	.33*	.02
Empirical Findings SER	-.23	.11
Elaborations SER	.15	.01

Note: * The correlation is significant at a level of 0,05 (two sided).

Discussion

The results of the empirical study show the meaningful effects of both the cooperation script and content schemes with respect to the creation of shared external representations. The factor cooperation script was shown to be especially effective in the area of the theory concept, in which the learners who were supported by the cooperation script were able to retain more theoretical concepts than the other learners. The factor content scheme showed its influence in the areas of empirical results and elaborations: The learners using content schemes generated more written externalizations in these content areas than learners without content schemes.

The effectiveness of content schemes can be attributed to the fact that the learners were encouraged to externally represent more thought units with relation to empirical findings and elaborations due to representational guidance – also shown in the study carried out by Suthers (2001).

The effectiveness of the cooperation script that encouraged learners to externally represent more theoretical concepts can be explained by the fact that they were encouraged to deal with the most important aspects of the theory text twice. In Phase 1 of the cooperation script the learner in the tutor role communicated the most important aspects of the text, in phase 2 the partner in the learner role repeated these contents and recorded them. In this way the learners mainly focused on theoretical concepts, which appeared to them to be subjectively more important. In Figure 1, when comparing the condition of the cooperation script with the combined condition, it becomes clear that the total sum of the thought units with respect to theory and results, which are noted in Phase 2, were almost the same in both groups. However, on the basis of the representational guidance of the content scheme, there were more thought units on empirical findings externalized in a written format in the combined condition.

The supporting mechanisms also had an effect on the success of the learning outcomes; this can be proven through tendencies. It can be seen that the learners with the support of the cooperation script scored better in the cued recall test than the learners in other conditions. The effect of the cooperation script indicates that through the cooperation script it was possible to ensure that the partner in the learner role was an active participant. This led to a more successful learning outcome. The fact that there was no substantial difference between the groups with respect to free recall could be attributed to the relatively short time which the learners had available for this test.

When analyzing the relationship between shared external representations and learning outcomes, a central result is that the number of theoretical concepts that were noted in the external representation shows a correlation to the number of theoretical concepts, which the partner in the learner role was able to provide in the post-test. This relationship is of importance because the partner in the learner role did not have access to the theory text and therefore relied on the shared external representation as a key anchor for the contents of the theory text. This relationship indicates the important role of the shared external representation in cooperative learning using distributed resources. The lack of a correlation in the area of personal elaborations could be due to the fact that the learner elaborated on contents, which were of little relevance to the post-test.

In conclusion, it can be asserted that both the cooperation script and also the content scheme demonstrate positive effects when used as supportive instructional measures during cooperative learning in videoconferences. This applies to both the content scheme, which works on a content-specific level and also to the cooperation script, which works to structure the cooperation. The results of this investigation also indicate that jointly created external representations are of central importance for cooperative learning in videoconferences. Such connections had been largely neglected in cooperative learning research in the past; that is why it is essential for future research in this field to gain deeper insights into this area. This can especially be achieved through detailed process analysis of how the creation of external representations effects the structure and contents of the learning discourse.

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