

# Effects of an Individual's Prior Knowledge on Collaborative Knowledge Construction and Individual Learning Outcomes in Videoconferencing

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**Abstract.** This paper deals with collaborative knowledge construction in videoconferencing. The main topic for investigation is how to predict individual learning outcomes, and in particular the degree to which an individual's prior knowledge and collaborative knowledge construction can influence individual learning outcomes. In this context, the influence of prior knowledge and two measures of instructional support, a collaboration script and a content scheme, were analyzed with respect to collaborative knowledge construction. An empirical study was conducted using 159 university students. Students worked collaboratively in groups of three within a case-based videoconferencing learning environment and were supported by instructional support measures. Results indicated that collaborative knowledge construction had a greater impact on individual learning outcomes than an individual's prior knowledge.

**Keywords:** prior knowledge, factual knowledge, applicable knowledge, cooperative/collaborative learning, teaching/learning strategies, videoconferencing, collaboration script, content scheme, collaborative knowledge construction, shared application

## INTRODUCTION

Recently, there has been quite a lot of research on collaborative learning in computer supported learning environments (cf. Andriessen, Baker & Suthers, 2003; Bromme, Hesse & Spada, in print; Dillenbourg, Eurelings & Hakkarainen, 2001; Kirschner, 2002; Koschmann, Hall & Miyake, 2002; Stahl, 2002). In this context, most researchers focus on how learners use the learning environment, on supporting collaborative learning or on the processes involved in collaborative learning. However, research generally does not consider sustaining effects of the collaborative learning environment. This means that – even if researchers study the increase in learners' knowledge – questions about the predictors of individual knowledge acquisition remain unanswered. However, the issue of predictors is crucial for research in computer supported learning environments. Many studies are able to prove the effects of support measures during the learning process, but can prove none or only few effects on individual learning outcomes (cf. Baker & Lund, 1997; Fischer, Bruhn, Gräsel & Mandl, 2002; Pfister & Mühlhoff, 2002; Weinberger, 2003). One reason for such results may be the influence of an individual's prior knowledge, which may negate effects of collaborative knowledge construction (cf. Dochy, 1992; Kalyuga, Chandler & Sweller, 1998, 2000, 2001; O'Donnell & Dansereau, 2000; Renkl, Stark, Gruber & Mandl, 1998; Stark & Mandl, 2002). Thus, finding predictors for individual learning outcomes can help to improve support measures for collaborative learning by focusing on relevant criteria.

This paper focuses on predictors for individual learning outcomes in collaborative net-based learning scenarios. The influence of prior knowledge and collaborative knowledge construction is investigated based on an empirical study. For further insights, the effects of support on collaborative knowledge construction are also researched, in particular the effects of a collaboration script and a content scheme.

## COLLABORATIVE LEARNING IN VIDEOCONFERENCING

Collaborative learning in small groups means that groups act relatively independent of a teacher with the goal of acquiring knowledge or skills (cf. Cohen, 1994; Dillenbourg, 1999). One major goal of collaborative learning is to support social interaction and encourage the learners' cognitive processes. In this context, learners' elaborations are seen to play a crucial role (cf. Webb, 1989; Webb & Palincsar, 1996) for expressing knowledge, ideas and beliefs to their partners (cf. O'Donnell & King, 1999; Palincsar & Brown, 1984; Rosenshine & Meister, 1994): learners work to co-construct knowledge collaboratively (cf. Bruhn, 2000;

Fischer, Bruhn, Gräsel & Mandl 2000; Roschelle & Teasley, 1995). In addition, learners externalize and elaborate on learning material by taking notes (cf. Gould, 1980; Molitor-Lübbert, 1989), e.g. in a shared computer application. In collaborative learning environments, learners often create these written representations collaboratively (cf. Baker & Lund, 1997; Dillenbourg & Traum, 1999; Klein, 1999; Suthers, 2001). During this process, they create a shared external representation of the subject matter, which can be helpful for collaborative knowledge construction (Ertl, 2003; Fischer et al., 2002). When constructing a shared external representation, learners must externalize their knowledge, that is, they must elaborate on and comprehensibly explain their knowledge to their learning partner (cf. Hayes & Flower, 1980; Peper & Mayer, 1986). Furthermore, creating shared external representations can encourage learners to solve conceptual or structural problems they may have with the subject matter (cf. Fischer & Mandl, 2002; Gould, 1980; Molitor-Lübbert, 1989) and influence the co-construction of knowledge (cf. Eigler, Jechle, Merziger & Winter, 1990; Fischer & Mandl, 2002). In videoconferencing, shared applications play a prominent role in such externalization processes: The shared applications offer a shared externalization forum, which is common to all the dispersed learning partners (Dillenbourg & Traum, 1999). In computer-supported learning environments, shared applications are often built as tools for the learners (cf. Spitulnik, Bouillion, Rummel, Clark & Fischer, 2003; Suthers & Hundhausen, 2001). Such tools support the active representation of knowledge and can support learners domain-specifically (cf. Dillenbourg & Traum, 1999; Roschelle & Pea, 1997), reduce consensus illusions and foster the integration of prior knowledge (cf. Fischer et al., 2002). However, studies show that it is not enough to simply provide a collaborative learning environment (cf. Johnson & Johnson, 1992; Lou, Abrami & d'Apollonia, 2001; Rosenshine & Meister, 1994; Salomon & Globerson, 1989; Slavin, 1995). The collaborative learning process and outcomes can be improved greatly when appropriate additional support is provided.

## Outcomes of Collaborative Learning

In this context, it is necessary to have a view on the conceptualization of learning outcomes. There are two main methods of assessing the benefits of a collaborative learning scenario: either individually on the learner level or collaboratively on a group level. However, there are differences in the interpretation of such learning outcomes (cf. Anderson, Reder & Simon, 1996; Greeno, 1997; Hertz-Lazarowitz, Kirkus & Miller, 1992; Salomon & Perkins, 1998; Slavin, 1995; Webb, 1989). The main questions surround the degree to which individual knowledge assessments can evaluate the effects of collaborative knowledge construction and the degree to which group assessment can indicate an individual's learning progress. Regarding individual learning outcomes, one can distinguish between conceptual knowledge and applicable knowledge (cf. De Jong & Fergusson-Hessler, 1996). According to this distinction, the term conceptual knowledge is used if learners can appropriately recite facts about the subject matter, while applicable knowledge means that learners can also apply their knowledge, e.g. in problem solving. In contrast to the clear conceptualization of individual learning outcomes, it is less clear how to measure the effects of collaborative knowledge construction on a collaborative level. In this context, Hertz-Lazarowitz et al. (1992) suggest that the product of the collaboration process, e.g. a final collaborative problem solution, should be considered as "group knowledge" or as a collaborative learning outcome. Other approaches stress the importance of learners' convergence in knowledge construction (cf. Fischer & Mandl, in press; Jeong & Chi, 1999).

Even if differences between individual and collaborative measures of learning outcomes may be attributed to characteristics of different learning tasks, the issue of the individual and social aspects of learning outcomes is of particular importance for cooperative learning in computer supported learning environments. In such environments, groups may be formed and disbanded quite quickly (cf. Walther, 1994; Walther & Burgoon, 1992). Therefore, the individual's benefit from the collaboration may become more important for the collaborating partners than social aspects of groups or the quality of collaboration (cf. Kerr, 1983). Thus, learners in such scenarios may desire maximal individual profit instead of a high quality collaborative knowledge construction. As a consequence, dysfunctional group phenomena may occur (cf. Salomon & Globerson, 1989). On the other hand, when focusing on high-quality collaborative outcomes, groups may apply strategies for maximizing group performance at the cost of neglecting group members with less knowledge. In such cases, the skilled learners may benefit quite a lot from collaboration, while less skilled learners may not benefit at all (cf. Dembo & McAuliffe, 1987; Salomon & Globerson, 1989; Webb, 1989). Thus, it is important to analyze both collaborative and individual learning outcomes when investigating group learning (cf. Salomon & Perkins, 1998).

## Support Measures for Collaborative Learning

Collaborative learning in computer supported learning environments is often supported to avoid dysfunctional group phenomena, to improve the learning process and to foster knowledge acquisition. Well-known examples for such support are collaboration scripts (cf. Baker & Lund, 1997; O'Donnell & King, 1999; Pfister & Mühlhoff, 2002; Rummel, Ertl, Härder & Spada, 2003) and content schemes, which provide conceptual support (cf. Brooks & Dansereau, 1983; Dobson, 1999; Ertl, Reiserer & Mandl, 2002; Fischer et al., 2002). In the context of CSCL, collaboration scripts aim mainly at supporting collaboration strategies by assigning different roles to the learners and by sequencing or structuring the work. In contrast, conceptual support aims particularly at improving the comprehensibility of the subject matter's structure.

Such support measures are mainly directed at collaborative knowledge construction and are thought to substantially improve the process of collaborative knowledge construction. This is reflected in many studies (e.g. Baker & Lund, 1997; Ertl et al., 2002; Fischer et al., 2002; Rummel et al., 2003). However, even if many of these studies were able to reveal effects regarding the quality of collaborative knowledge construction, there are often mixed results regarding individual learning outcomes (cf. Baker & Lund, 1997; Fischer et al., 2002; Pfister & Mühlhoff, 2002; Weinberger, 2003). One reason for this may be the influence of an individual's prior knowledge.

## THE ROLE OF PRIOR KNOWLEDGE IN COLLABORATIVE LEARNING

An individual's prior knowledge is known to be an important prerequisite for *individual* knowledge construction and learning outcomes. Many theoretical approaches stress the importance of learners' prior knowledge when acquiring new learning material (cf. Gerstenmaier & Mandl, 1995; Glaser, 1989). Many empirical studies also highlight the influence of prior knowledge on individual learning outcomes (cf. Dochy, 1992; Kalyuga et al., 1998, 2000, 2001; O'Donnell & Dansereau, 2000; Renkl et al., 1998; Stark & Mandl, 2002; Weinert & Helmke, 1998). Thus, when assessing learning outcomes, the structure of an individual's prior knowledge may negate the effects of the collaborative knowledge construction.

In research on *collaborative* learning environments, an individual's prior knowledge is mostly neglected with respect to learning outcomes. Different levels of learners' prior knowledge are mainly used to explain group phenomena (cf. Salomon & Globerson, 1989), the quality of explanations (cf. Webb, 1989) or as a control variable for ensuring that learners do not differ significantly. In studies about the support of collaborative learning, an individual's prior knowledge often plays an important role in group composition (cf. Slavin, 1995; Cohen, 1994), while the influence of prior knowledge as a prerequisite for collaborative knowledge construction and individual learning outcomes often remains unclear. However, studies by O'Donnell and Dansereau (2000) investigating the effects of prior knowledge in collaboration indicate that an individual's prior knowledge also influences learning outcomes in the collaborative learning context. Furthermore, studies reveal that prior knowledge could interact with other factors in collaborative knowledge construction – such as instructional support measures for the learners (cf. Reiserer, 2003).

In summary, results show that prior knowledge influences individual and collaborative knowledge construction. In addition, studies indicate that there are interactions between an individual's prior knowledge and instructional support measures. To date, there have been no findings on the role of an individual's prior knowledge in the context of support measures for collaborative knowledge construction. There is also no information concerning the extent to which an individual's prior knowledge and collaborative knowledge construction may influence individual learning outcomes.

## RESEARCH QUESTIONS

For gaining insights on these issues, we conducted an empirical study using the following research questions:

- *Research question 1:* To what extent does an individual's prior knowledge affect the quality of collaborative knowledge construction supported by a collaboration script and a content scheme?
- *Research question 2:* To what extent do an individual's prior knowledge and the quality of collaborative knowledge construction affect learners' individual learning outcomes regarding conceptual and applicable knowledge?

## METHOD

To answer these questions, an empirical study was conducted in the laboratory of Ludwig Maximilian University. 159 undergraduate students of Education took part in this experiment.

*Design of the Experiment.* The experiment comprised an individual and a collaborative learning unit (cf. figure 1). During the individual learning unit, learners acquired knowledge about attribution theory on the basis of a theory text. After working on this text, the learners' prior knowledge was assessed using an individual case solution and a short-answer test about conceptual knowledge. For the collaboration, three learners were

connected with a desktop video-conferencing system, which included an audio- and video-connection and a shared application. Using this videoconferencing environment, learners had to collaboratively solve a learning case according to attribution theory. During collaboration, groups of three learners worked in one of four conditions of a 2x2-factorial design. The variable factors were collaboration script (with vs. without) and content scheme (with vs. without). After the collaborative learning unit, learners' knowledge was assessed on an individual basis by asking them to solve a case and complete a short-answer test.

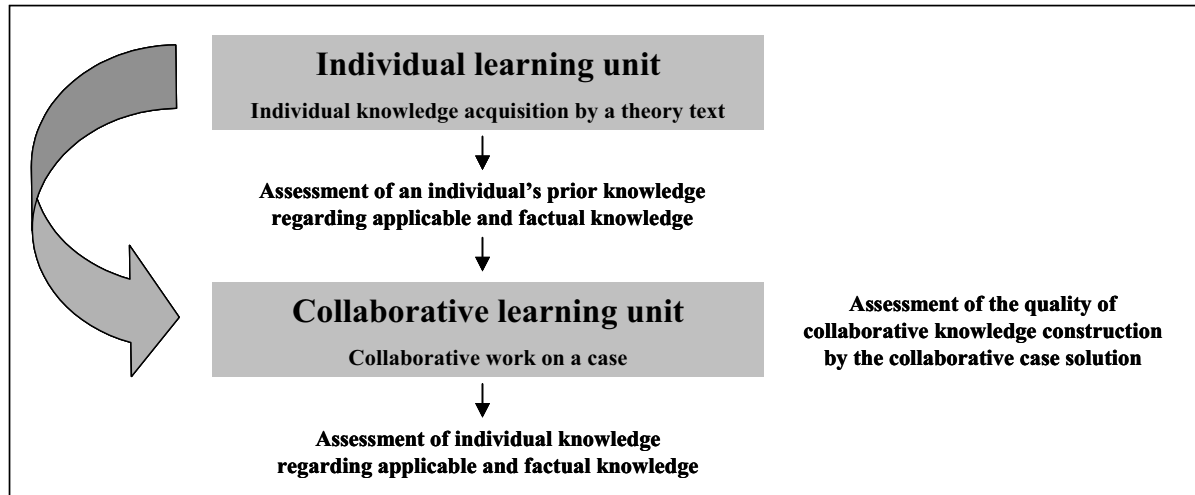


Figure 1: Design of the experiment

As instructional support for collaborative knowledge construction, a collaboration script, a content scheme and a combination of both were used and compared with a control condition. Both the collaboration script and the content scheme pre-structured the collaboration.

The *collaboration script/no content scheme* condition (13 Triads) structured the collaborative unit into four phases. In the *first* phase, learners had to read case material and extract important information on an individual basis. In the *second* phase, learners had to exchange information and resolve comprehension questions collaboratively. They used the shared application for writing down concepts that were important for the case solution. In the *third* phase, learners had to reflect individually and in the *fourth* phase, learners had to collaboratively develop the case solution.

The *no collaboration script/content scheme* condition (14 Triads) pre-structured the shared application that was realized as a table, divided into three main categories: *Cause*, for identifying possible causes for the problem described in the case, *Information* for case information and for giving evidence for the causes and *Attribution* for identifying the correct attribution pattern of the cause. The categories *Information* and *Attribution* each contained two subcategories: *Information* was divided in columns for *Consensus* and *Consistency* to make these two aspects of attribution theory salient. *Attribution* was divided into two sections according to the theories of Kelley (1973) and Heider (1958) to help learners attribute each cause to the relevant source.

In the *collaboration script/content scheme* condition (13 Triads), the collaborative unit as well as the shared application was pre-structured. In the *first* phase, learners had to individually complete the content scheme with a paper and pencil. In the *second* phase, the main tasks included the exchange of information and a collaborative collection of all attributions in the shared application. In the *third* phase, learners compared their own notes with the information that had been collected. In the *fourth* phase, learners were asked to develop the solution and to formulate a collaborative case solution in the shared application.

Learners of the *no collaboration script/no content scheme* condition (13 Triads) received no additional support or structure for solving the case collaboratively.

## Data Sources

For the analysis, several data sources were included to assess the individual's prior knowledge, the quality of collaborative knowledge construction, and individual learning outcome. A treatment check was also conducted.

*An individual's prior knowledge: conceptual knowledge.* Conceptual knowledge was measured by a short-answer test for recalling theory concepts. Learners had to complete sentence openers, e.g. "According to Kelley, an event can be attributed to these three causes:". This test consisted of 8 items ( $M = 26.3$ ;  $SD = 9.51$ ; empirical max. = 43). The reliability of this test was sufficient (Cronbach's  $\alpha = .69$ ).

*An individual's prior knowledge: applicable knowledge.* Concerning an individual's prior applicable knowledge, learners worked on a case individually. For the assessment, this case solution was analyzed with respect to theory concepts and case information. Items used correctly for the individual case solution were summed up as a score ( $M = 15.0$ ;  $SD = 6.68$ ; empirical max. = 31). For ensuring inter-rater reliability of data, two evaluators marked analysis 10%. The consistency between these evaluations was high ( $\kappa_w = .91$ ).

*Quality of collaborative knowledge construction.* To assess the quality of the collaborative knowledge construction, the product of the collaborative knowledge construction – a collaboratively solved case – was analyzed with respect to correctly used theory concepts and case information. According to the different categories of the attribution theory, a coding system was developed in which all causes, information and attributions were listed in an identifiable way without any overlap. On basis of this coding scheme, a sum was defined as a measure of the quality of the collaborative knowledge construction. For ensuring inter-rater reliability of data, two evaluators marked analysis 10%. The consistency between these evaluations was high ( $r = .87$ ).

*Individual learning outcomes: conceptual knowledge.* Conceptual knowledge in the post-test was measured by a short-answer test for recalling theory concepts. This test consisted of 8 items, which were similar to the items of the pre-test. The reliability of this test was sufficient (Cronbach's  $\alpha = .62$ ).

*Individual learning outcomes: applicable knowledge.* For determining individual learning outcome (applicable knowledge), learners solved a case individually after collaboration. Similar to the pretest case, the posttest case was analyzed with respect to correctly used theory concepts and case information. Scores were given for case information and theoretical concepts. For ensuring inter-rater reliability of data, two evaluators marked analysis 10%. The consistency between these evaluations was high ( $\kappa_w = .90$ ).

*Treatment check.* A treatment check was made to ensure that there were no differences regarding learning prerequisites within the four experimental conditions. This served as a control for an individual's prior knowledge and the learner's motivation. Furthermore, the effects of content scheme and collaboration script were controlled regarding the quality of collaborative knowledge construction and the individual learning outcomes.

*Data analysis.* For verifying the effects of content scheme and collaboration script, a multivariate analysis of variance (MANOVA/GLM) was calculated for the quality of collaborative knowledge construction and the individual learning outcomes. This used the content scheme and collaboration script as factors and an individual's prior knowledge as covariate. Linear regressions were computed to find predictors for the quality of collaborative knowledge construction and individual learning outcome. Non-significant predictors were excluded from analysis.

Table 1: Means and SDs of collaborative knowledge construction and individual learning outcomes.

	Collaborative Knowledge Construction		Individual Learning Outcome (Conceptual Knowledge)		Individual Learning Outcome (Applicable Knowledge)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total	58.00	18.73	29.10	7.75	18.58	6.88
Max.	92.00		42.00		32.00	
Control	47.18	14.24	29.92	7.41	15.82	5.71
Script	43.00	11.79	28.49	8.40	15.95	5.74
Scheme	66.62	13.40	26.50	9.37	18.48	7.77
Combined	73.46	15.22	31.21	4.40	22.79	5.93

## RESULTS

The treatment check disclosed that there were no significant differences regarding prior knowledge and motivation between the four experimental conditions. Furthermore, the effects of the interventions concerning collaborative knowledge construction and learning outcome were calculated including an individual's prior knowledge as covariate. With respect to the quality of collaborative knowledge construction, the content scheme had a large effect. Learners with content scheme clearly applied more concepts than learners without content scheme (cf. table 1;  $F_{(1,144)} = 127.33$ ;  $p < .01$ ;  $\eta^2 = .47$ ). With respect to individual knowledge acquisition, learners in all conditions benefited greatly during collaboration. The content scheme also proved to be effective for individual learning outcomes with respect to applicable knowledge. Learners with the content scheme scored higher ( $F_{(1,144)} = 21.84$ ;  $p < .01$ ;  $\eta^2 = .13$ ). With respect to conceptual knowledge, there were no significant differences. Regarding the collaboration script, there were no significant effects regarding the quality of collaborative knowledge construction and the individual learning outcomes. An interaction between the factors of collaboration script and content scheme could not be found, despite the fact that learners with both interventions scored descriptively the highest regarding all outcome measures (cf. table 1).

## Research Question 1

Research question 1 was about predictors of the quality of collaborative knowledge construction. As the results in table 2 show, over 45 % of the variance regarding the collaborative knowledge construction could be predicted by prior knowledge and the support measures. The strongest predictor was the content scheme, while the individual's prior knowledge (conceptual) played only a marginal role. The collaboration script and the individual's prior knowledge (applicable) were not significant as predictors. The high amount of predicted variance shows that an individual's prior knowledge as well as the intervention highly influenced collaborative knowledge construction. Unexplained variance may be attributed to other individual learner prerequisites or characteristics of the collaboration process that were not measured in this study.

Table 2: Multiple regression for predicting the quality of collaborative knowledge construction by prior knowledge, content scheme and collaboration script.

	Collaborative knowledge construction (standardized $\beta$ -weights*)
Prior knowledge (conceptual)	.18
Content scheme	.68
R <sup>2</sup>	.49
Adjust. R <sup>2</sup>	.48

\* Only statistically significant predictors ( $p < .05$ ) are listed

## Research Question 2

Regarding predictors for individual learning outcome, the results are quite different (cf. table 3 and 4). With respect to applicable knowledge, 40% of the variance could be predicted by the individual's prior knowledge and collaborative knowledge construction. In the context of applicable knowledge, collaborative knowledge construction exhibited a greater influence than each single measure of an individual's prior knowledge<sup>1</sup>. The content scheme did not prove to be a significant predictor. However, the content scheme may have had an indirect influence, as it is the main predictor for the collaborative knowledge construction. The collaboration script, again, did not prove to be a predictor.

Table 3: Multiple regression for the prediction of individual learning (applicable knowledge) outcome by prior knowledge, content scheme, collaboration script and collaborative knowledge construction.

	Individual learning outcome (applicable knowledge, standardized $\beta$ -weights*)
Prior knowledge (conceptual)	.27
Prior knowledge (applicable)	.22
Collaborative knowledge construction	.40
R <sup>2</sup>	.41
Adjust. R <sup>2</sup>	.40

\* Only statistically significant predictors ( $p < .05$ ) are listed

When analyzing conceptual knowledge, 60 % of total variance was predictable (cf. table 4). The main predictor was conceptual prior knowledge; applicable prior knowledge played a minor role. Neither the collaborative knowledge construction nor the interventions proved to be significant predictors. However, it must be stated that both tests for conceptual knowledge comprised similar items, even if arranged differently.

<sup>1</sup> When analyzing the effects of collaborative knowledge construction and an individual's prior knowledge (conceptual and applicable) in separate regressions, each of them would be able to predict about 23% of variance. Thus, one could state that the quality of collaborative knowledge construction and an individual's prior knowledge have nearly the same influence on individual learning outcomes with respect to applicable knowledge.

Table 4: Multiple regression for the prediction of individual learning outcome (conceptual knowledge) by prior knowledge, content scheme, collaboration script and collaborative knowledge construction.

	Individual learning outcome (conceptual knowledge, standardized $\beta$ -weights*)
Prior knowledge (conceptual)	.68
Prior knowledge (applicable)	.16
R <sup>2</sup>	.61
Adjust. R <sup>2</sup>	.60

\* Only statistically significant predictors ( $p < .05$ ) are listed

## SUMMARY AND CONCLUSION

These results show that the effects of an individual's prior knowledge are quite varied in the quality of collaborative knowledge construction and individual learning outcome. For collaborative knowledge construction, the influence of an individual's prior knowledge is quite small compared to the influence of support measures. A further outcome is that conceptual knowledge proved to be a significant predictor in contrast to applicable knowledge, which was not a significant predictor. This is an interesting result, considering the fact that collaborative knowledge construction is a task of applying knowledge. Thus, one would expect applicable knowledge to be a predictor. However, considering the content scheme as a strategy for applying knowledge, the presence of this "professional" strategy may have negated the influence of individuals' naïve strategies measured in the pretest. Therefore, the collaborative knowledge construction may have relied in particular on the conceptual knowledge of the individuals and the strategies offered by the support.

The impact of prior knowledge increases when looking at individual learning outcomes. However, in this context, one has to distinguish between applicable and conceptual knowledge. With respect to applicable knowledge, the quality of collaborative knowledge construction still had the most influence. However, looking at the values in table 3, one can assume that the influence of collaborative knowledge construction and both measures of an individual's prior knowledge is somehow balanced<sup>1</sup>. The collaboration did not have an influence on conceptual knowledge. Even if all learners improved their level of conceptual knowledge during collaboration, the main predictor was an individual's prior knowledge. However, this effect may be attributed to the similarity of the test items in the pre- and the post-test.

These results can explain differences between individual and collaborative learning outcomes on the basis of different variables influencing both measures. One can assume that for collaborative knowledge construction, the collaboration effect, including the effect of instructional support measures, is much stronger than individual learners' prerequisites. This means that collaborative knowledge construction can be modified quite fundamentally by instructional support. In contrast, regarding individual learning outcomes, individual prerequisites have a greater influence and may negate the effects of collaborative knowledge construction. This has to be considered when designing instructional support for collaborative learning.

## IMPLICATIONS

There are several implications of these findings. First, collaborative knowledge construction can be influenced much more by a well-designed intervention than by an individual's prior knowledge. Secondly, an individual's prior knowledge gains in importance regarding individual learning outcomes, but collaborative knowledge construction still greatly influences this area. These results help explain the effects of many studies which find differences regarding collaborative knowledge construction and individual learning outcomes. However, more research in this context is necessary to be able to generalize these results. Furthermore, the influence of learners with different levels of prior knowledge should be analyzed with respect to group processes and individual learning outcomes.

The educational implications of these findings involve the design of collaborative learning environments. In learning environment research, interventions are often directed either towards achieving a better collaboration process or an improved learning outcome. However, to achieve sustainable learning environments, one has to consider the effect of interventions, the collaborative problem solving process and an individual's prior knowledge. Results of this study show that collaborative knowledge construction can have greater impact than learners' individual prerequisites. This means that carefully designed learning environments may balance out the differences in learners' individual prerequisites. However, such mechanisms must be verified by various process analyses.

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