Measuring knowledge convergence: Achievement similarity and shared knowledge in computer-supported collaborative learning

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Abstract

Learning in small groups may result in convergent knowledge outcomes or foster possible prior differences between learners. Few studies, however, measure convergence or divergence of knowledge as an outcome of small group learning. This contribution analyzes knowledge convergence/divergence as an outcome of learning in small groups with the concepts of achievement similarity and shared knowledge rooted in two different theoretical frameworks. Achievement similarity means that learners acquired similar amounts of knowledge regardless if they share similar knowledge. Shared knowledge means that learners acquired similar knowledge. In order to test application-oriented knowledge, learners had to individually apply concepts of a psychological theory in analyzing a problem case. Trained coders identified correct relations between theoretical concepts and case information. These data were used to compute both, achievement similarity and shared knowledge. A 2×2 factorial design was used (number of triads = 32; N = 96) to examine the following questions: (1) can theoretical concepts of achievement similarity and shared knowledge be measured independently and (2) to what extend are these measures of convergence sensitive enough to indicate effects of specific instructional interventions? We examined effects of two instructional interventions on achievement similarity and shared knowledge. Achievement similarity was conceptualized as difference between the amount of known theoretical concepts of an individual learner and the average of his or her group. As a measure for achievement similarity, standard deviations of learners within one group were used to indicate dissimilarity and multiplied by -1 to indicate similarity. Shared knowledge was measured as number of pairs within one group, which applied the same theoretical concept in the individual analysis of the problem case. Results show that the different instructional interventions significantly and independently affect both convergence measures. Validity and interpretability will be discussed against the background of theoretical approaches to learning in small groups.

Summary

Learners in small groups may or may not achieve knowledge convergence (Fischer & Mandl, 2001). Even though knowledge convergence/divergence has been a major concern in approaches to computer-supported collaborative learning (CSCL), it has been widely neglected in quantitative studies on the subject. This contribution presents two different conceptualizations and methods towards analyzing knowledge convergence/divergence.

Conceptualizing, measuring and facilitating knowledge convergence/divergence can be based on different theoretical approaches towards learning in small groups that have been termed cooperative and collaborative learning (Dillenbourg, Baker, Blaye, & O'Malley, 1995).
A major aspect of the *cooperative learning approach* is to distribute responsibilities for sub-tasks to individual members of a learning group (e.g., Slavin, 1994). The different sub-tasks will lead to different perspectives of learners, but typically, the grade of the individual group member depends on the overall success of the group. Therefore, the focus of the cooperative learning approach is to facilitate *achievement similarity* of learners, i.e. two or more learners acquire similar amounts of knowledge, but do not necessarily know the same concepts.

Achievement similarity is an often discussed, but rarely measured concept in cooperative learning approaches. Organizational psychology reviews, however, provide measures for achievement similarity (Cooke, Salas, Cannon-Bowers, & Stout, 2000). According to Cooke and colleagues, achievement similarity can be conceptualized as difference between the amount of known theoretical concepts of an individual learner and the average of his or her group. The *collaborative learning approach* supposes that learners negotiate and share their knowledge resources with the goal to acquire *shared knowledge* (e.g., Roschelle, 1996). Shared knowledge means that two or more learners possess identical knowledge concepts. Against this background, CSCL research often faces the question how shared knowledge of distributed learners can be facilitated. So far, however, measures for shared knowledge have not been systematically investigated and applied.

In order to facilitate achievement similarity and shared knowledge we varied process-oriented instructional interventions, namely computer-supported collaboration scripts. These scripts pre-structure a specific set of activities in CSCL. An epistemic script pre-structures the contents of learner's individual contributions and aims to foster achievement similarity. A social script pre-structures how learners negotiate and share their knowledge resources and aims to foster shared knowledge.
We examine the following questions regarding this study: (1) can theoretical concepts of achievement similarity and shared knowledge be independently measured and (2) to what extend are these measures of convergence sensitive enough to indicate effects of specific instructional interventions?

Methodology

A 2×2 factorial design with the factors epistemic script (with vs. without) and social script (with vs. without) was used (number of triads = 32; number of participants = 96).

Data source. In order to test application-oriented knowledge, learners had to individually analyze a problem case. This individual post-test was used as a data source for the knowledge convergence measures. The written case analyses of the learners were segmented (87% rater agreement) and analyzed by coders with sufficient inter-rater agreement ($\kappa = .90$). The data was segmented and coded with respect to the specific concepts that learners knew to apply in comparison to an expert solution.

(1) *Achievement similarity.* We counted the concepts that learners of one group knew to apply in the post-test and the ones they did not know. Standard deviations of learners within one group were aggregated (indicating achievement dissimilarity) and multiplied by -1 to indicate achievement similarity. (2) *Shared knowledge.* We identified the single concepts that learners knew to apply in the post-test. On grounds of single comparisons within the groups of three the shared knowledge concepts were aggregated. When all three learners of one group knew to apply the same concept, a shared knowledge value of 3 was credited to the learning group. If only two learners knew to apply this concept, a shared knowledge value of 1 was credited. In any other case, a shared knowledge value of zero was assigned.

Results
Achievement similarity. The scripts significantly influenced the achievement similarity of learners. Learners supported with the *epistemic script* acquired a more similar amount of knowledge concepts, whereas learners with the *social script* were more dissimilar than learners without any script.

Shared knowledge. With regard to shared knowledge no significant effect of the *social script* and no substantial interaction effect can be observed, but a strong negative effect of the *epistemic script*. Groups who were supported with the epistemic script showed substantially less shared knowledge concepts in the individual post-tests.

Conclusions
Results show, that the different scripts significantly and independently affect both convergence measures in the intended way. Both convergence measures, achievement similarity and shared knowledge, were sensitive to the effects of the script. The study has also shown that the assumed theoretical differentiation between achievement similarity and shared knowledge could be empirically supported. There are, however, also shortcomings of the measures. Knowledge convergence/divergence measures can be misleading without considering effects of systematic variation on individual knowledge acquisition. For instance, exceptionally high or low achievement of learners may automatically lead to higher convergence, simply because the likelihood of similarity will be higher. Therefore, we will discuss the development of convergence measures, which regard likelihood and/or systematic variation on individual knowledge acquisition.

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