Integrating collaboration scripts, group awareness, and self-regulation in computer-supported collaborative learning

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In the field of Computer-Supported Collaborative Learning (CSCL) various approaches are applied to explain when and for whom collaborative learning can be beneficial as well as how the design of CSCL can be improved. This also applies to the central CSCL concepts of (1) group awareness, (2) collaboration scripts, and (3) self-regulation. All three concepts are concerned with learners' individual pre-requisites and the processes learners need to engage in for successful collaborative learning. Group awareness refers to being informed about the social context in which a collaborative situation emerges, especially regarding characteristics of the individual members of a collaborating group or the group as a whole (Bodemer & Dehler, 2011; Gross et al., 2005). Such awareness is vital for targeted social interaction and collaboration during CSCL. A collaboration script represents a shared plan for a specific social situation and is stored and retrieved as a cognitive schema or internal script (Fischer et al., 2013). Self-regulation, and its collaborative siblings, co-regulation and shared regulation (Järvelä & Hadwin, 2013), look particularly at how learning is metacognitively planned, monitored, evaluated, and adapted. All three approaches focus on the mechanisms needed for a smooth social learning process and how they are integrated into an individual's cognitive system. Since learners may struggle to engage in collaborative activities that may be most beneficial for their learning, CSCL research builds upon the ideas of group awareness, collaboration scripts, and self-regulation by designing support and scaffolding for learning activities expected to be related with the theoretically described cognitive mechanisms leading to learning. The three approaches (group awareness, collaboration scripts, and self-regulation) are intertwined at different levels and thus have the potential to be combined for effective CSCL designs (Strauß & Rummel, 2021). However, it seems that CSCL research has not yet taken full advantage of their synergies and the relations between the concepts and approaches are not fully explored. Therefore, this special issue introduces the three concepts and their interrelationships. It thus presents conceptual and empirical papers concerned with the two-fold and tri-fold combinations

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of group awareness, collaboration scripts, and self-regulation. In the following, we will describe the underlying mechanisms of group awareness and collaborations scripts including how they can be supported with the respective CSCL measures. Then, we explore self-regulation and its possible interplay with collaboration scripts and group awareness. We show how the three approaches may be connected to explain and support the mechanisms of social learning. Finally, we introduce the papers of this special issue and relate them to the question of how group awareness, collaboration scripts, and self-regulation are inter-related and can be combined and applied in CSCL.

Group awareness and group awareness tools in CSCL

Group awareness describes the perception of relevant social information within the collaborative learning situation. This is deemed essential for goal-oriented collaboration. Thereby, research frequently distinguishes between cognitive and social group awareness. Awareness of the socio-cognitive conditions within the learning group (cognitive group awareness) include the distribution of knowledge or opinions and may affect especially content-oriented collaborative learning processes and outcomes. However, successful collaboration also relies on social dynamics and awareness of socio-behavioral or socio-emotional aspects (social group awareness) may affect the group climate or the willingness to participate (Janssen & Bodemer, 2013). Both cognitive and social group awareness enable learners to regulate their collaborative learning processes and adapt them to the needs and opportunities the social configuration offers. Yet, a lack of group awareness may impede the activation and execution of useful collaborative practices. However, social conditions within a CSCL setting can be highly dynamic and thus, group awareness research is concerned with how learners monitor said conditions and how this affects collaborative practices and outcomes. While this is not limited to CSCL settings, the additional technological layer may present specific challenges for perceiving and understanding the social environment, especially when the used technology restricts rather than enriches communication channels. On the other hand, CSCL offers specific opportunities to support group awareness by providing relevant awareness information via so-called group awareness tools designed to foster an often very specific kind of group awareness deemed relevant in the particular setting. Group awareness tools uncover social context information by collecting, transforming and presenting relevant information in order to ease or guide collaborative learning in a unique way (Buder & Bodemer, 2008). While the importance of group awareness in CSCL is widely acknowledged, research on group awareness is frequently limited to its manipulation via group awareness tools, and attempts to research and measure the actual group awareness emerging in CSCL are rare (cf. Bodemer et al., 2018). Thus, despite its importance, the concept itself lacks a commonly agreed conceptualization able to provide a framework for structured research towards an understanding of the role of (non-supported) group awareness during CSCL.

Internal and external collaboration scripts

Internal collaboration scripts are understood as cognitive schemata activated by the learners to engage in behavior and social interactions during collaborative learning situations. The script theory of guidance distinguishes four script components that are related in a

sequenced and hierarchical way (Fischer et al., 2013). These script components are (1) scriptlets, representing the single activities individuals have to be engaged with in a collaborative learning situation; (2) scenes, comprising sets of scriptlets for different individuals in a sequential order, (3) plays, describing the overarching goal of the social scenario and comprising all scenes and their sequence; and (4) roles, to inform how specific scriptlets are assigned to individuals in the social scenario and how they are related to each other within each scene. Depending on the interpretation of a social situation and the perceived goals, learners activate a specific internal collaboration script that prescribes the play, scenes, scriptlets and roles, which guide the learners' behavior and activities in that scenario. The scripts can be flexibly adapted by, for instance, integrating new components or changing the sequences of components to serve best the specific conditions emerging in different social situations. To be functional for collaborative learning, the components of collaboration scripts integrate activities that are supportive for the individual acquisition of knowledge and skills through collaboration. Such components are, for instance, mutually building on each other's contributions (e.g., Chi & Wylie, 2014) or problem-solving activities, such as negotiation, sharing ideas and maintaining communication (Liu et al., 2015). Learners may have struggles with autonomously activating the most appropriate and functional internal script in a given social learning situation. To support learners to activate a functional script and improve the internal script they have at their disposal, external collaboration scripts are offered to the learners in the form of socio-cognitive scaffolding (Noroozi et al., 2012; Vogel et al., 2017). These external collaboration scripts mostly consist of a sequence of prompts that reflect the script components on the play, scene, and scriptlet level the learners should ideally activate at specific points during the collaborative learning process (Kollar et al., 2006). Learners who are guided through such an ideal collaborative learning process are enabled to gradually adapt the components of their activated internal script and will benefit better from learning together (Fischer et al., 2013).

Regulation and its interplay with collaboration scripts and group awareness

Learners need to understand the task they are engaged in, set their learning goals, and plan how their goals can be reached. For this, it is important that they apply learning strategies to work towards the achievement of their goals, evaluate their success, and adapt their strategies if necessary (Winne & Hadwin, 1998). When learners are faced with collaborative learning, self-regulation skills are needed to engage in activities regulating each other's learning strategies and in the social learning processes (Järvelä & Hadwin, 2013). Learners, however, often lack the level of self-regulation skills demanded when exposed to social learning scenarios and awareness and scripting approaches may be adopted to support regulatory processes (Miller & Hadwin, 2015). The strategies learners use in a social situation lead to outcomes the learners may evaluate against internal standards, feeding back into the current collaborative learning process itself, and informing the learners about the progress and success of the applied strategies (Winne & Hadwin, 1998). When relating self-regulation to collaboration scripts, it may be the metacognitive knowledge about the learning processes that is used to reconfigure the currently activated internal script. This can be done by activating script components learners already have at their disposal as parts of other scripts used in various social situations. Further, new script components can be acquired and integrated for a reconfiguration of a script that is better adapted to the outcomes of monitoring

and evaluating the social learning processes (Fischer et al., 2013). Collaboration scripts that are offered externally in CSCL environments can target self-regulation skills by scaffolding learners' strategies involved in regulating their learning to enhance their outcomes through self-, co-, and shared regulation (Chen & Chiu, 2016; Järvelä & Hadwin, 2013). The empirical studies by Kielstra et al. (this issue) as well as Zimmerman and Land (this issue) allow particular insights into the relevance of learning regulation in CSCL supported with collaboration scripts. Here, the scaffolding of regulation is integrated into the collaboration script support. The way the collaboration script may directly boost self-regulation and activities of social learning regulation is related to an integration of self-regulation into the components of the different collaboration script levels. In the study by Vogel et al. (this issue) self-regulation skills are integrated as individual pre-requisite required to benefit from learning with collaboration scripts. This refers to self-regulation being possibly located on a meta level beyond the collaboration script itself, enabling learners to activate and reconfigure most appropriate internal collaboration scripts.

Self-regulation theories assume that in order to regulate their learning, learners need to monitor internal and external conditions to match appropriate learning activities (Winne & Hadwin, 1998). Within collaborative learning settings, this includes monitoring social conditions of the situation. Thus, group awareness – related to the monitoring of social conditions – is inherently linked to the regulation of learning in CSCL. Further, group awareness tools to support collaborative learning explicitly build on self-regulated learning mechanisms as they do not prescribe learning activities, but merely provide information about social conditions enabling self-regulation while simultaneously relying on learners' skills to utilize the information in a beneficial way (Bodemer, 2011). First attempts have been made in developing group awareness tools specifically targeting regulation of learning in CSCL (e.g., Järvelä et al., 2016) and to connect group awareness with the activation and implementation of collaborations scripts (Schnaubert et al., 2020; Strauß & Rummel, 2021; Tsovaltzi et al., 2015). However, explicitly connecting group awareness, collaboration scripts, and self-regulation in empirical and theoretical research remain scarce. The conceptual connection between group awareness and self-regulation introduced in the paper by Schnaubert and Bodemer (this issue) will help to specify how group awareness is anchored in human cognition, how it is regulated, and how it is used in turn to regulate cognitive and interaction processes in social situations. Furthermore, the empirical study by Rojas et al. (this issue) will reveal how both self-regulation and group awareness can be embedded in collaboration scripts and eventually affect collaboration, regulation of learning in groups, and collaborative problem-solving.

Application of group awareness, collaboration scripts, and self-regulation in the selection of papers in this special issue

This special issue brings together one conceptual paper, four empirical papers, and one discussion relating the CSCL topics group awareness, collaboration scripts and self-regulation. The triangle represented by the three topics demand looking at both their bilateral and trilateral interconnections. Depending on the current state of research regarding each connection, different research approaches are needed and represented within the collection of papers (see Fig. 1).
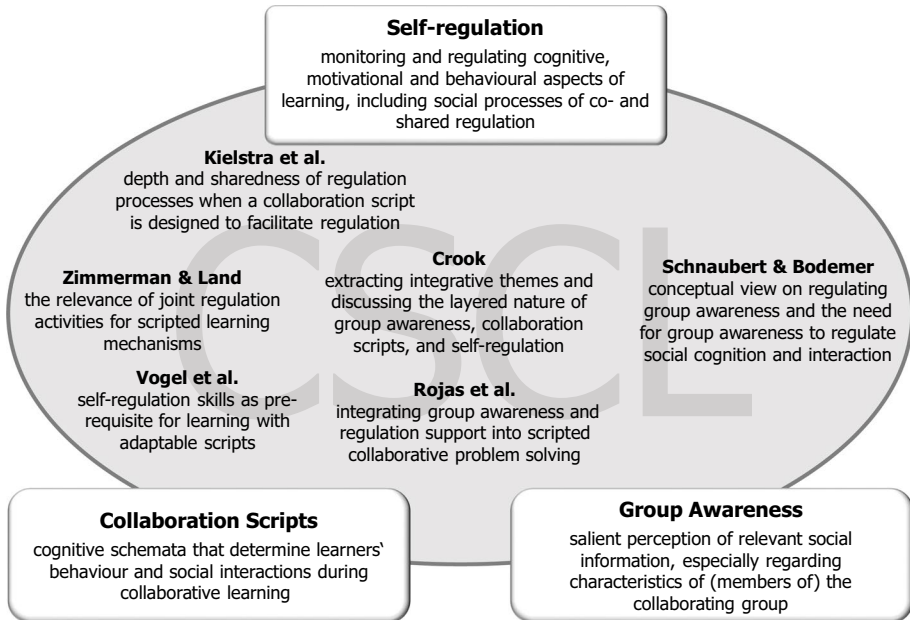
Fig. 1 Group Awareness, Regulation and Collaboration Scripts in CSCL – map of the special issue's papers

Linking group awareness and self-regulation conceptually

Our first paper in the collection tackles the lack of a common conceptual understanding of group awareness and its relation to self-regulation in collaborative learning scenarios. To this effect, the paper "Group awareness and regulation in Computer-Supported Collaborative Learning" by Lenka Schnaubert and Daniel Bodemer opens with a treatise on the concept of group awareness, thereby integrating group awareness and self-regulation on multiple levels. So far, group awareness has been approached mostly by empirical studies using group awareness tools to facilitate CSCL. Therefore, the contribution made here aims to offer a theoretical basis for these empirical approaches by conceptualizing group awareness and explicating facets of the concept. The authors provide a view on group awareness as a conscious, current, and individual, yet also social cognition perceived as valid within the social situation. In a second step, Schnaubert and Bodemer apply a metacognitive regulation perspective to the regulation of group awareness and further describe the role of group awareness for regulating social cognition and interaction in CSCL. Finally, they discuss implications regarding working memory processes, the design of group awareness support, the measurement of group awareness, and group awareness' intermediary position between individual and social processes in CSCL. The article forms a strong basis for systematic theoretical and empirical research on group awareness and its application in group awareness tools to facilitate CSCL.

The role of self-regulation when learning with collaboration scripts

When it comes to collaboration scripts, there is already a strong theoretical foundation for researching and designing CSCL scripts to support learners' social practices while learning

together. Therefore, the papers in this special issue that are focusing on the relationship between collaboration scripts and self-regulation present empirical studies about different collaboration scripts built on the already well-established theoretical concept (Fischer et al., 2013). The three studies concerned with collaboration scripts and self-regulation are implemented in a broad range of formal and informal learning settings. They also allow a variety of insights by adopting different methodologies, such as design-based research, qualitative analyses of learning and regulation processes, and quantitative experimental comparisons.

In their paper "Adaptable scaffolding of mathematical argumentation skills: The role of self-regulation when scaffolded with CSCL scripts and heuristic worked examples", Freydis Vogel, Ingo Kollar, Frank Fischer, Kristina Reiss, and Stefan Ufer present two experiments in which they compared differently structured and adaptable scaffolding using collaboration scripts and heuristic worked examples. University freshmen in mathematics participated in the study and learned in dyads with various tasks related to mathematical proofs and argumentation. In this study, the minimally structured collaboration script presented a sequence of prompts to engage repeatedly in scenes of argumentation, while the maximally structured script added further prompts and sentence openers to scaffold the use of argument components. The adaptable collaboration script asked learners regularly to select the minimally or the maximally structured script for their next step. The study focused on the role of learners' self-regulation skills when learning with collaboration scripts and finds that self-regulation in CSCL is particularly needed for learning with minimally structured or adaptable collaboration scripts allowing learners to assess their own needs and select the script accordingly. When learning with the adaptable script, the regulation that was carried out predicts learning outcomes. Yet, more insights into learners' actual use of regulating activities during collaborative learning would shed more light on mechanisms relevant to the learning beneficial use of these activities. In this regard, the following studies integrate qualitative analyses of collaborative activities when learning with collaboration scripts.

The paper "Supporting socially shared regulation during collaborative task-oriented reading" by Jolique Kielstra, Inge Molenaar, Roel van Steensel, and Ludo Verhoeven provides a more detailed analysis of shared regulation within small groups when learning with a collaboration script for task-oriented reading over a four-session period. This study shows how a collaboration script can be designed to not only demand but also facilitate regulation, particularly metacognitive strategies, by assigning roles and providing targeted support for planning, execution and reflection stages of the collaborative regulation process. The authors conduct conversation analyses based on coding schemes by Molenaar et al. (2014) and De Backer et al. (2016). In this way, they assess regulation of task-oriented reading with a specific focus on low- and deep-level metacognitive regulation. Additionally, shared regulation was measured by analyzing metacognitive episodes and identifying types of intra-group social metacognitive interaction (ignored, accepted, shared, co-constructed). Further analyses explore the trajectories of the depth and the sharedness of regulatory activities across the lessons. This study shows that while metacognitive regulation can be quite frequent when learning with a collaboration script designed to elicit metacognitive processes, deep-level metacognitive utterances are rare, and students mostly accept each other's suggestions and much less frequently co-construct or share metacognitive interaction – despite the use of the script.

With the paper "Supporting children's place-based observations and explanations using collaboration scripts while learning-on-the-move outdoors" by Heather Toomey Zimmerman and Susan M. Land, the boundaries of CSCL are expanded by implementing CSCL

scripts to informal learning outdoors using handheld devices to learn about biology while immersed in nature. In a design-based study with two iterations, the authors show how a computer-supported collaboration script can be developed to support students to regulate their learning through collaborative sense-making and peer negotiation during interdependent coordination of the group task. Learners were assigned to small groups to learn about the tree cycles using a mobile application allowing students to explore biology knowledge, take pictures, and apply the descriptions of the different tree cycle stages to them. The integrated script mainly helped students to organize learning together by providing checklists and distributing roles to each learner of a small group. The study shows that in both iterations, the learners significantly gained biology knowledge. More interestingly, qualitative analyses of the learning processes show how joint regulation activities may mediate the possible effects of the different script components in both iterations. The analyses hint at scaffolded information sharing and coordination activities that may particularly be related to an increase in science knowledge. In contrast, for collaborative sensemaking, negotiation and coordination showed to be more relevant. With improvements in the second iteration with synergistic collaboration script support, the learning processes showed an improvement in negotiation activities during learning.

Overall, the three studies on collaboration scripts and self-regulation show that particularly less structured CSCL scripts leaving degrees of freedom to the learners and possibilities to adapt their scaffolding may demand more self-regulation skills from the learner. Better self-regulation skills and appropriate regulation activities can improve learning effectiveness as highlighted in the study by Vogel et al. (this issue). However, it is important to make careful choices when designing scripts. The qualitative analyses show that the demands for self-regulation when learning with CSCL scripts can be balanced by integrating self-regulation activities in script scaffolds. On the one side, scripts can take over parts of the regulatory processes. One example of this is distributing roles and assigning specific activities to each role as can be found in the scripts designed by Zimmerman and Land (this issue). On the other side, the scripts can explicitly scaffold regulation activities as shown in the study by Kielstra et al. (this issue). This may then lead to better regulation during the learning processes and eventually improve learning outcomes.

Combining group awareness, collaboration scripts, and self-regulation

The fourth empirical paper "Integrating collaborative script and group awareness to support group regulation and emotions towards collaborative problem solving" by Matias Rojas, Miguel Nussbaum, Orlando Guerrero, Pablo Chiuminatto, Samuel Greiff, Rodrigo Del Rio, and Danilo Alvares combines both collaboration scripts and group awareness during collaborative problem solving. Here, learning regulation and group awareness are understood as innate aspects of collaborative problem-solving skills. Hence, the study experiments with CSCL scripts integrating group awareness as well as self-, co-, and shared regulation of learning. The script for this study has been implemented into a computer game that requires three learners to play together on separate devices on 46 tasks designed in a way that demands group coordination, collaboration and joint problem solving. The script itself builds upon OECD's (2017) twelve skills from the collaborative problem-solving matrix. The study compares triads of elementary school students randomly assigned to either the control condition, which learned as usual, or the experimental condition, which learned with the computer game and the introduced script. The results show that the computer game with the embedded script led to an increase in

regulation activities, particularly towards co-regulation and shared regulation. Qualitative analyses provide further insights into how the regulation processes and emotions emerged when learning with the CSCL script integrating support for both group awareness and learning regulation. The study and its results encourage future CSCL research combining group awareness, collaboration scripts, and self-regulation.

The special issue is completed by Charles Crook's commentary "CSsCL: The performance of collaborative learning" discussing the approach of combining group awareness, collaboration scripts, and self-regulation from a variety of CSCL viewpoints. Charles Crook is a Professor in Education and has been the director of the Learning Sciences Research Institute at the University of Nottingham. He is a distinguished expert and pioneer in the field of CSCL. When he published his seminal book "Computers and the Collaborative Experience of Learning" in the year of 1994, it was one of the first of its kind applying educational and psychological concepts of teaching and learning to the design of digital environments for social learning (Crook, 1994). The book may have been ahead of its time as most of the ideas and concepts introduced in it are still central and can be found being reflected in the contemporary CSCL research. Therefore, Charles Crook offers a unique perspective on this special issue, which builds on his exceptional expertise within the field. In the commentary, themes are extracted that link the papers of this special issue and their approaches to combine group awareness, collaboration scripts, and self-regulation. Thereby, he particularly discovers how regulation as well as group awareness have layered features and how this affects our conceptual understanding of both. While discussing the boundaries of collaboration scripts, Crook further extends the theatre metaphor and suggests a particular perspective on the integration of script learning in CSCL. Related to the distinction between internal and external collaboration scripts, it is discussed how scripts may stand at the crossroad of computer support on the one side and collaborative learning on the other side. The discussion may inform and spark ideas for future integration of scripts, regulation, and group awareness in CSCL research and future directions of approaching CSCL research from diverse perspectives.

This special issue tackles the interconnection of three concepts integral for understanding the dynamics of CSCL. Although the breadth and depth of this triad cannot be fully charted by one collection of studies, let alone one single study, the papers in this issue provide building blocks and perspectives that lay cornerstones and open new doors in this endeavor. Apart from the theoretical and empirical insights provided by the research presented in this issue, we hope that it will spark a lively scientific discussion regarding the three concepts within the Learning Sciences and a surge in theoretical and empirical research systematically exploring their interconnection and deeply considering the layered and intertwined nature of the concepts in CSCL.

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