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One framework to rule them all? Carrying forward the conversation started by Wise and Schwarz

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Abstract In this brief squib, I take up the first of the provocations put forward by Wise and Schwarz in their recent article and make an attempt to spark further discussion. Specifically, I argue that instead of attempting to agree on an overarching, unified conceptual framework for CSCL from the top down, and rather than synthesizing findings from CSCL research from the bottom up, we could take a taxonomy of CSCL support dimensions as a starting point and engage in a concerted research effort with the aim of working towards a comprehensive framework of CSCL support. I therefore propose such a taxonomy, which currently comprises 12 dimensions. By referring to some of my own research, I demonstrate how the proposed process of providing evidence-based design principles for CSCL support that cut across and interleave the dimensions of the taxonomy could work.

Keywords Computer-supported collaborative learning · Taxonomy of support dimensions · CSCL support framework

Introduction

In their recent article, Wise and Schwarz (2017) engage in a dialogue with members of our research community around eight provocations for the field of computer-supported collaborative learning (CSCL) with the goal to spark visions for the future of the field. In this squib, I would like to briefly take up one of their provocations in an effort to carry the conversation forward. As defined by Stahl (2017, p. 113), "a 'squib' is a brief statement, intended to ignite thinking and discourse on topics of theoretical importance".

In the first provocation, Wise and Schwarz (serving as Provocateur/Provocatrice in the dialogue) engage in a discussion with the Consolidator around the question of whether "the blossoming of CSCL tools necessitates 'one framework to rule them all'" (p.427). It remained

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somewhat ambiguous in the paper whether the discussion of this provocation was concerned with the need for a meta-theory of CSCL, an overarching taxonomy of CSCL phenomena, a collection of principles for CSCL tool design, or a framework of CSCL support. As this ambiguity in the dialogue illustrates, it is difficult for us as a field to agree on common ground concerning our goal (i.e. fruitful collaborative learning) and its theoretical underpinnings at multiple levels.

In carrying the conversation forward, what I am proposing in this squib is that perhaps – as the Consolidator argues – in order to progress as a field, we do not need to achieve agreement on a fundamental theoretical level, but nevertheless that we can and should engage in a concerted empirical effort (using different methodological approaches) to explore and map the landscape of CSCL support. More specifically, I suggest that we use a taxonomy of CSCL support dimensions as a starting point for carrying out rigorous empirical research and engage in related theory-building in a joint effort, with the aim of working towards a comprehensive framework of CSCL support. This framework would move beyond a taxonomic account by providing evidence-based design principles for CSCL support that cut across and interleave the dimensions of the taxonomy.

A taxonomy of CSCL support dimensions

The taxonomy I propose as a starting point for this research builds on previous versions (see Rummel 2016, 2017; Rummel et al. 2016) and takes up previous work, which has produced several taxonomies of support for collaborating students (e.g. Diziol and Rummel 2010; Magnisalis et al. 2011; Soller et al. 2005; Walker et al. 2009). Table 1 provides an overview of the CSCL support dimensions that I am proposing to include in the taxonomy, which could form the basis for research that works towards a comprehensive framework of CSCL support.

The first dimension (*goal*) addresses the need to define upfront which goal(s) any support is aiming to achieve. Oftentimes in CSCL support, measures will serve several goals: First and foremost, the support will aim to improve the interaction between students; in doing so, a second aim will probably be to positively impact the outcome of the collaboration (i.e. a joint product or artifact) and/or the individual domain knowledge. Further (often implicit) assumptions about beneficial effects of the administered support (and the thereby improved interaction) may concern affective and motivational outcomes or the acquisition of social skill. My intention for listing *goal* as the first CSCL support dimension is to challenge CSCL designers and researchers to make their assumptions about effects of CSCL support explicit, and also to think about how effects on more proximal (i.e. student interaction) and more distant (e.g. individual domain learning) goals are related. Consciously defining goals and linking different goals improves our ability to assess the right variables for testing our research questions and can thus help the field of CSCL to proceed.

The second through fourth dimensions in Table 1 further define the general set-up of the support for a given CSCL scenario: The *timing* dimension concerns the question of when (i.e. at which point in time relative to the start of collaboration) the CSCL support is provided. The *implementation* dimension relates to the question of whether the support is realized in a fixed, adaptive or adaptable manner. If implemented in a fixed manner, the same type of CSCL support is provided to all learners, and everybody receives it at the same, fixed times. For instance, groups may receive a prompt with instructions every time they start a new task. If implemented in an adaptive manner, some groups may receive a prompt (if the CSCL system has diagnosed a need for further support), while others may not. In the adaptable condition, the

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t1.1 **Table 1** Taxonomy of CSCL support dimensions

t1.2	1. Goal	– interaction/group processes – outcome/result of the collaboration (i.e. an artifact) – individual domain knowledge – social skill (i.e. collaborative competence) – affective outcomes (e.g. satisfaction with the collaboration) – motivational outcomes (e.g. learning motivation, attitude towards future collaboration)
t1.3	2. Timing	– prior to the collaboration (e.g. instruction, training, group formation) – during the collaboration (e.g. prompts, resources): immediate, delayed – after the collaboration (e.g. reflection)
t1.4	3. Implementation	– fixed (one size/time fits all) – adaptive (i.e. automated) – adaptable (i.e. user-based)
t1.5	4. Delivery agent	– human – digital persona (i.e. pedagogical agent) – digital system
t1.6	5. Target	– cognitive (i.e. domain help) – metacognitive (e.g. reflection, employment of learning strategies) – social (e.g. managing the interaction) – affective (e.g. coping with frustration) – motivational (e.g. participation)
t1.7	6. Granularity	– task level – step level – turn level
t1.8	7. Availability	– visible – on demand
t1.9	8. Directivity	– no advice – implicit (i.e. enabling conditions, resources) – explicit: general advice – explicit: specific guidance
t1.10	9. Foundation	– no information on state (i.e. just alert) – show state (i.e. raw data) – show aggregated data (i.e. mean or other indicators) – show interpretation of state (i.e. assessment good vs. bad)
t1.11	10. Addressee	– individual – group
t1.12	11. Mediation	– direct (provided to learner/group in need) – indirect (mediated; e.g. presented to peer, teacher, parent)
t1.13	12. Coercion	– no action required – some/any action is required – specific action is required

support settings can be customized by the users in the given CSCL setting. For instance, groups could choose at the outset of their collaboration whether, when, and how they want to receive support (see other dimensions below). Alternatively, it may be the teacher who gets to adapt the support settings (see the utopian scenario in Rummel et al. 2016, for an example). The dimension *delivery agent* specifies how the support is provided to the learners: whether it is a human actor (e.g. teacher) who interacts with the learners, or a digital persona (e.g. pedagogical agent) that appears in the CSCL settings as a "simulated human"; or whether the support is provided by the system without the appearance of a persona (e.g. through prompts or by making certain tools and features available to the learners).

The fifth dimension – *target* – is a difficult yet important one, because it emphasizes that there is a distinction between the variables on which CSCL support aims to ultimately have an impact (i.e. the *goal* dimension), and the variable(s) the support targets. For instance, in a given

CSCL scenario, a collaboration script (Fischer et al. 2013) could be implemented to help students with managing their interaction (i.e. the support could be targeting social aspects), while the ultimate goal of implementing the script would be to improve individual domain learning. As with the goal dimension, my intention with the target dimension is to challenge CSCL researchers and designers to consciously and precisely define the goals of the support they design and how they expect their support to meet these goals.

The following dimensions (6–12) further specify how CSCL support is administered. The dimension *granularity* asks whether support is given more coarsely (i.e. at the task level) or in a more fine-grained fashion at the step level or even the turn level. The dimension *availability* concerns the question of how readily accessible the support is to the learners, or to put it differently, how salient the support is made for the learners. Will it always become visible automatically (e.g. in the form of prompts that pop up on the screen)? Or will learners only see the support on demand (e.g. if they click on a help button)? The dimension *directivity* defines whether and how explicitly and concretely the support gives directions for possible or desired behaviors on the part of the learners (i.e. the individual learner or the group, cf. dimension addressee). The dimension *foundation* specifies how much and what kind of information about the state of their collaboration is provided to the learners as part of the support. The dimension *addressee* defines whether the support is given to the group as a whole or merely to individual group members. The dimension *mediation* concerns the question of whether the support is given directly to the learner or group in need, or whether it is mediated through other actors in the setting (e.g. the teacher or a peer).

Finally, the last dimension *coercion* addresses the extent to which learners have to react to the support. The question is whether or not certain types of actions are required by the learner(s) in response to the support. For instance, under the condition of high coercion, learners are required to react to the support by taking specific action in order to continue their collaboration, while in the middle category they may just have to press ok. Under the lowest coercion condition, in which learners are not required to take any action, they may not even have taken notice of support provided to them.

The proposed dimensions are not a final set. The taxonomy could certainly be amended and requires further discussion and revision. It represents a work in progress and every time I think about the dimensions, I find myself making changes. But my intention for the squib was not to present a perfect, definitive set of CSCL support dimensions. Rather, as argued above, I advocate using the taxonomy as a starting point for a research agenda. In the next section, I want to show how we could use the proposed taxonomy as a basis for developing a *comprehensive framework of CSCL support* that would allow us to orchestrate support across the multiple dimensions and to make predictions that can inform design. The point I wish to make here is that in CSCL, we need research that consciously (and not just incidentally by confounding dimensions in the CSCL support implemented) cuts across different support dimensions, in order to arrive at a clearer understanding of how CSCL support can be designed to provide nuanced and flexible support to collaborative learners in computer-based settings.

Towards a comprehensive framework of CSCL support dimensions

By applying the proposed taxonomy of CSCL support dimensions to some of my own research, I will try to show that varying other dimensions can sometimes change the results and shed more light on the differential effects of an initially investigated first dimension.

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I begin by reporting accumulating evidence for one dimension on the proposed taxonomy: the *timing* of support.

A growing body of research demonstrates potential benefits of delaying instruction (Productive Failure, PF: e.g. Kapur 2014; Kapur and Rummel 2012; Loibl, Roll & Rummel, 2016; Loibl and Rummel 2014a; Invention to prepare for future learning: e.g. Roll et al. 2009, 2011; Schwartz and Martin 2004). In these learning settings, students in small groups collaboratively solve problems on yet unknown concepts prior to receiving instruction. Across different domains and different student populations, the cited studies have found evidence of beneficial effects of delaying instruction as compared to providing instruction before collaborative problem-solving (i.e. PF > InstructionFirst). The results are particularly pronounced for the acquisition of conceptual knowledge. Furthermore, in two studies (Loibl and Rummel 2014b), we found that providing cognitive support during the initial collaborative problem-solving did not further improve student learning. Taken together, this briefly outlined body of work provides evidence for the benefits of providing support after the collaboration.

However, upon closer inspection of the instruction provided in the classic studies by Kapur (e.g. 2010; 2012), it became apparent that there was a difference between the PF and the InstructionFirst conditions, beyond the timing of support (see Loibl and Rummel 2014a): In the InstructionFirst condition, the teacher directly presented the canonical solution to students. In the PF condition, the teacher took up typical student-generated solutions and compared and contrasted them to the canonical solution during instruction. Thus, when comparing the two conditions, the two dimensions *timing* and *foundation* of support were confounded. And there was reason to believe that the confounded dimension (i.e. building instruction upon typical student-generated solutions and interpretative discussion thereof) might have been relevant for the benefits found for the problem-solving prior to instruction. Research demonstrated that students process the canonical solution more deeply when they realize impasses and errors in their own problem-solving (e.g. Van Lehn et al. 2003). Taking these findings together, it seemed important to further scrutinize the way in which the delayed instruction should be given. We thus conducted a study with a two-factorial design, that is, varying the two dimensions timing and foundation independently (Loibl and Rummel 2014a). For conceptual knowledge acquisition, we found a significant interaction effect and post hoc contrasts, which revealed that PF was only more effective than InstructionFirst if student solutions were compared and contrasted as a foundation of the instruction.

Moreover, we came to wonder whether delaying was best for all realms that support can target (Westermann and Rummel 2012). The *target* of the support in the research discussed above was always the cognitive realm; that is, the instruction that was given (or delayed) concerned domain-related aspects. Against the background of other findings from research on CSCL (e.g. Rummel and Spada 2005), we suspected that it might perhaps be useful to provide support on the social realm during the collaboration, while delaying only the cognitive support. We found that providing social support ensured fruitful interactions between students during their collaborative problem-solving, while it did not undermine the positive effects of delaying cognitive domain-related support.

Conclusion

To conclude, the above examples from my own research aimed to demonstrate how carefully testing for the effects of varying dimensions from the proposed taxonomy (cf. Table 1) can lead

to important insights relevant to the design of CSCL support. As already stated, it was not my intention to introduce a perfect, definitive framework for CSCL support. Rather, the proposed taxonomy of CSCL support dimensions and the exemplary research I discussed were meant to support my point that we need research cutting across the dimensions of the taxonomy and thus directed at forming a comprehensive framework of CSCL support that will allow us to make decisions about designing CSCL environments in a nuanced and not overly simplistic manner, and to orchestrate support across the multiple dimensions.

Yes, even just the taxonomy I introduced covers 12 dimensions and thus an enormous scope for combination possibilities. But there are many of us! This will have to be a collaborative effort. In order to contribute to evolving the envisioned framework of CSCL support, it would be a huge win if we all managed to relate to the proposed taxonomy of CSCL support dimensions in our research.

The large scope for combination possibilities in the proposed taxonomy also points in another direction. We will never be able to fully cover all the ground by applying one type of research methodology (e.g. conducting series of controlled experiments only). Different methodological approaches are needed to tackle the challenge of exploring and mapping the landscape of CSCL support and to work towards a comprehensive framework of CSCL support.

The framework of CSCL support I envision might help to overcome the diverging viewpoints evident in the dialogue around the first provocation in the paper by Wise and Schwarz (2017), because of how it would originate from a joint, directed research effort. Put differently, my proposal is for us, as a field, to contribute through our research (conducted with the different methodological approaches we take) in a principled manner to an underlying foundation for CSCL. The difference in what I am proposing lies in the direction of the development: Rather than starting with an attempt to agree on an overarching conceptual framework from the top down, and rather that synthesizing accumulating evidence for designing CSCL support from research from the bottom up, I propose that we use a taxonomy of CSCL support dimensions, such as the one I put forward in this squib, as a "kernel" or "skeleton" around which we build a comprehensive framework of CSCL support. In this process, bottom-up movement would go hand in hand with discussions at the conceptual level (e.g. in workshops and symposia at our CSCL conferences), but progress could be made in a joint, concerted fashion, without having to wait for a theoretical consolidation or empirical synthesis first.

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