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## Towards a Framework to Link Them All. A Provocation in the Ongoing Debate on Collaborative Learning

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**Abstract:** Common ground is a well-studied concept in the CSCL (Computer-Supported Collaborative Learning) community. Interestingly, while well-studied, its discovery did not seem to lead to common conceptual ground within the CSCL community. Since its beginnings 30 years ago, the community has produced a variety of frameworks, studies and theories around the concept of collaboration, collaborative learning and, in particular, collaborative learning tools. Missing common ground is a problem for analyzing collaboration itself and comparability across studies, which researchers such as Rummel, Wise and Schwarz highlight in a recent exchange on the subject. In this paper, we analyze existing frameworks and whether contradictions between different frameworks exist. We further propose an attempt to a joint definition and framework as a starting point and provocation for discussion in the community.

### Introduction

Since the first definition of collaboration in scholar settings by Roschelle et al., almost 30 years have gone by. While their definition still holds today, the variety of collaborative activities, tools and environments has given rise to a variety of definitions, frameworks and theories in different fields (Stahl, 2021).

The variety of theories and frameworks can be attributed to the multidisciplinary of Computer-Supported Collaborative Learning (CSCL). Indeed, CSCL is a domain at the crossroads of psychology, learning sciences, computer science, sociology, linguistics, anthropology and communications (Hmelo-Silver & Jeong, 2021). Another reason for the variety of models might also be the fact that, while studying collaborative learning (CL), the research community itself is a community of collaborative learners, building on the works from others to create new insights. New theories emerge based on existing work and as a result from conducted studies. For work to be taken into account however, it has to be written, published and made available to the community. Importantly, it then has to be read and taken into account by other researchers. More than a dozen domains involved in CSCL make it difficult to gain and maintain a holistic view.

The many coexisting frameworks perfectly fit different contexts and usages, but add to the complexity of a global vision. This is also a problem for comparability of results: The findings of one work cannot easily be compared to others if the underlying perception of what is experimented is not the same or known at all. Yet, comparability is key if CSCL is to advance (Griffiths et al. 2021): In a context of oftentimes small sample sizes, collaboration not being automatic and research frequently carried out on humans in environments with a large number of uncontrolled conditions (Bachour et al., 2010), it is in the interest of the community to share common ground on the conceptual stance of collaboration.

Efforts to reunite CSCL knowledge are underway (Cress, Rosé, Wise, & Oshima, 2021): the community's latest edition of a comprehensive handbook has been published in 2021. The urgency of conceptual consolidation has been recognized by leading researchers (Wise & Schwarz, 2017) questioning if "one framework to rule them all" is an adequate response to the problem. We argue instead for a duality of an overarching framework in conjunction with existing contextual frameworks. Knowledge representations, such as ontologies allow the flexible mapping of concepts (and also linking ontologies between domains) to provide a common understanding. We propose such an ontological, bridging approach as a starting point for a common conceptual vision, without sacrificing the many theories on collaboration but providing mapping abilities between the different perspectives.

To this end, the first part of this paper examines existing attempts on common CSCL frameworks. The second part details the method deployed to establish a common framework. We then present our findings and discuss its potential and future use.

### Previous Work

Rummel's take on the "provocations" by Wise et al. (2017) is that it is very difficult, as a community, to reach common conceptual ground. There is also doubt on the extent to which common ground is required. Rummel (2018) for instance proposes a *taxonomy* to design collaborative activities and analyze collaboration in order to

contribute to the discussion of Wise et al. Objectively, the most urgent need in terms of consolidation is indeed an **analytics** and **design** framework due to the fast pace with which technology steadily increases possibilities of collaboration support and automated analysis. Meanwhile, it is clear that there is no *one* way of analyzing collaboration in the field, which makes comparison of studies and reproducibility difficult (Martinez-Maldonado et al., 2021). The same is true for design frameworks. The reason, in both cases, seems to be, that in order to analyze or design environments for collaboration or CL, the research community needs to agree on what those concepts mean in detail. Different ways of analyzing and designing collaborative environments are rooted in different visions of what needs to be observed and what needs to be supported by digital tools. Rummel’s taxonomy is no exception: It features for example “goals” and “delivery agents” which indicate a conceptual vision, for instance, for the role of an educator, and the goals of collaborative tools, for collaboration.

Frameworks on general aspects of collaboration (Kirschner & Erkens, 2013) exist alongside frameworks with a focus on specific aspects of collaboration, providing a lens through which collaboration as a whole is explained, such as the framework of Hesse et al. for assessing collaborative skills. Researchers from associated fields provide frameworks with a focus on cognitive, gamified, pedagogical or conditional aspects (Griffiths et al., 2021), through a variety of forms (ontologies, lists, graphs etc.).

## Method

In order to build a consolidating core framework within this heterogeneous landscape, two issues of conceptual uncertainty in CSCL have to be addressed: for one, collaboration itself has no clear definition. Similarly, there is a multitude of learning theories and the variety of frameworks in CSCL is, as noted Rummel, coherent with the variety of perspectives on both learning and collaboration. As will demonstrate this paper, existing frameworks and theories are not mutually exclusive but merely put forward different facets of a coherent set of phenomena.

**Table 1**  
*CSCL Framework Creation Process*

N°	Stage	Method	Output
1	A joint definition of collaboration	Systematic Review	Definition
2	A core framework of collaboration	Systematic Review	Collaboration Framework
3	A collaborative Learning extension	Conceptual Integration	CL Framework
4	A CSCL mapping	Ontological Linking	CSCL framework mapping

Our framework creation process is outlined in table 1: Initially, we attempted a concise, compatible definition of collaboration (1). We compared different concept classes from systematic reviews of definitions and other sources (see table 2). Concept classes address fundamental entities. For example, collaboration may be seen as a state or a process. Both concepts are mutually exclusive but can be categorized as entities of a system. Categorizing definitions’ concepts this way revealed incompatible perspectives. After discussing contradicting properties, similar concepts were grouped into hierarchies or relationships, in which case the most inclusive concept was used in the definition (and related or lower level concepts were kept for the framework). Similarly, we focused the definition on mandatory collaborative properties, without which there is no collaboration. In contrast, properties enhancing collaboration are filtered and integrated in the framework.

Next, we created a common, abstract conceptual core of collaboration, extending on the definition (2), using contributions from CSCL, CSCW and research in other domains. Thereby, the core concepts remain compatible and the framework open to contributions from other domains. For each of the keyword queries in google scholar, Apa Psycinfo and ERIC “Conceptual collaborative learning framework”, “Conceptual collaboration framework for small groups”, “Conceptual framework for collaborative Problem solving”, “CSCL framework” and “CSCL ontology”, we examined the first 50 results. Complementary sources were the Journal of CSCL as well as the 2013 and 2021 edition of the handbook of international CSCL.

Jabareen et al. (2009) highlight the ambiguity on what a framework actually is among researchers. Thus, to filter the retained results and consequently attempt a joint version, we used his conceptual framework definition of “a network of linked concepts that together provide a comprehensive understanding of the phenomenon”. 42 papers matched this definition (other results contained all keywords, but would focus on frameworks on concepts or not provide insights about how the different concepts relate to each other). Frameworks were consequently categorized according to their perspective: skills, processes, general aspects, conditions, pedagogical approaches. We then compared *general* frameworks and integrated them into our conceptual core of collaboration (figure 1) before testing the core’s compatibility with different learning theories (figure 2). Then, we confronted our

conceptual stance with the remaining, more *specific* frameworks and other CSCL works (Figure 2Q4.4, Q4.5) to illustrate its compatibility and provide an artifact for a communitywide discussion.

## Results

### A definition of collaboration (1)

Establishing meaning through *evoking* and *linking* a concept to others in a short and concise manner provides the basis for a common understanding in a discussion. In table 2 we sum up presence and form of concepts from different definitions. The sources have been chosen to cover a variety of different perspectives, all concerned with providing a comprehensive vision: a dictionary definition, the perspective of transnational organizations such as the OECD, literature reviews and foundational works in collaborative learning. While in many cases, definitions overlap, this is not the case for the system entity type. While a *process* can be considered a series of related activities to reach a new state of a system, a state is a static snapshot of a system. Since research on collaboration has established the multifaceted nature of collaboration, an activity alone seems inadequate. Similarly, Vogel et al. (2017) point out the importance of transactive *actions* which contradicts the vision of a collaborative state. Roschelle et al. consider synchrony an attribute in their context of face-to-face collaboration. If synchrony was a distinctive, general feature of collaboration, asynchronous collaborations (e.g. meaning making in forums) would be excluded, even if the individual contributions still have the same goal and thus don't fit concepts such as cooperation or co-action (George & Leroux, 2001). Synchrony can thus not be considered an elementary feature of general collaboration. The elements of *joint effort* and *goals* are recurrent across definitions. The PISA 2015 definition does not explicit the common goal, but the "problem" actors try to solve. Definitions vary in terms of involved entities.

**Table 2**

*Definitions of systemic reviews and frameworks (red: opposing concepts, yellow: enhancing properties, green: concept present)*

Authors	1 System entity (s:state, p:process, a:activity)	2 Synchrony	3 Effort wt: working together je: joint effort	4 Objectives cg: common goal	5 Agency 2p: 2+ people 2a: 2+ agents	6 Common Ground	7 Pooling knowledge/skills	8 Outcome s: solution o: outcome	9 Open Communication	10 Trust	11 Mutual respect	12 Shared responsibility	13 Active Participation	14 Joint Decision Making	15 Problem Complexity	16 Horizontal Hierarchy	17 Complementary Expertise	18 Conflict Negotiation and Resolution	
Cambridge Dictionary 2023	s		wt	cg	2p														
PISA 2015	p		je		2a			s											
Roschelle et al.	p		je	sg															
Hesse et al 2015	a		je	cg				o											
Griffiths et al. 2021	p		wt	sg				s											
Alozie 2023	p		je	cg	2p			s											

While definitions by Roschelle, Hesse and Griffiths do not explicitly include the need for more than one entity, their works repeatedly evoke multiple participants of collaborative activities. To this extent and in the light of progress in artificial conversation agents (e.g. ChatGPT), it seems wise to keep an abstract notion of two or more entities. Less common attributes of collaboration (among definitions) are open communication, horizontal hierarchy and complementary expertise. Those attributes have proven important for improving collaboration but are not essential: Collaboration occurs in settings with strong hierarchies (companies, armies, etc. challenging 16). In CL settings, students often have a very similar expertise (challenging 17). Passive behaviors like social loafing impact collaboration negatively but may not lead to the collapse of collaboration among other members (challenging 13). Similarly, open communication may impact collaboration in the long run, but members may decide to not communicate situational concerns and still collaborate (challenging 9).

Joint decision and conflict management are necessary processes in collaboration since there is usually no external entity to guide or mediate the group's cognitive conflicts. The role of mediators (teachers etc.) is often cited as a counterexample. However, the essence of collaboration is to confront and negotiate a shared perception based on prior differing perceptions of group members. This is also the reason why trust, mutual respect and shared responsibility are implicit, essential properties of collaboration. If collaboration can be considered one or more processes, then the presence of an outcome is also implicit. Those considerations can be summed up as follows: **Collaboration** is a set of processes (1, 8, 15) in which 2 or more entities (5) engage in a joint effort (3) towards a common goal (4) managing conflicts and taking decisions by themselves (10, 11, 12, 14, 18).

## A collaborative Core Framework (2)

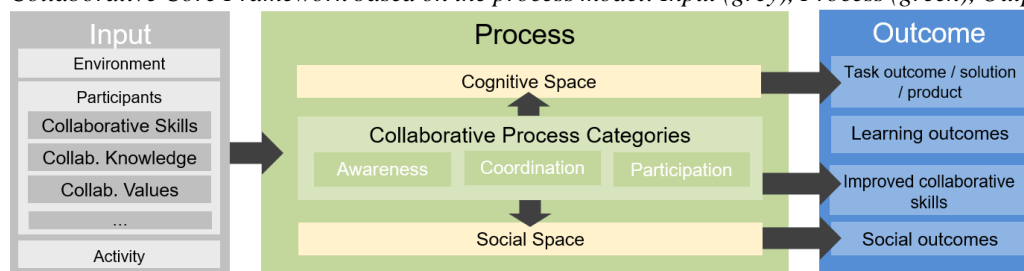
The previous definition of collaboration aligns with the **process** model used by different authors (Alozie et al., 2023; Mateescu et al., 2019; Simon et al., 2022). Alozie et al. (2023) group concepts into the categories “Input, Process” (sharing knowledge and resources) and “Output Process” (knowledge, artifacts). This process is then extended by norms (shared goals, reciprocal engagement, responsibility and accountability, mutual trust and respect, non-hierarchical shared power and voluntary participation) impacting the collaborative processes. Frameworks vary mostly in their focus. Hesse et al. analyze and assess individual collaborative skills. Kirschner et al. (2018) provide a theory of cognitive collaborative load for groups. Neumayr et al. (2018)’s framework focuses on collaborative coupling styles. The works of Laal (2013) and Johnson and Johnson (2004) focus on conditions favoring collaboration (social skills, promotive interactions, group processing, positive interdependence, individual/group accountability, etc.) whereas Vogel (2017) provides a scripting framework.

Those perspectives are not mutually exclusive: The problem, task or activity, the environment (tools, resources, constraints) and the individuals with their individual knowledge, collaborative and cognitive (task-related) skills, as well as their values, form the **input** of the overall collaborative process (see Figure 1).

The **output** of a collaboration can be categorized in task-related outcomes (products, artifacts, etc.), and learning outcomes: during collaboration, members are confronted with their peers’ task-related perspectives, solution strategies and values challenging their own. This turn on collaboration shows its interest for learning and work alike: Collaboration triggers learning processes but also allows to achieve an outcome related to a complex task. Consequently, CSCL will adapt the conditions to optimize learning outcomes whereas CSCW acts on more fixed circumstances. Participants engaging in a collaboration also have the opportunity to practice and improve their own collaborative skills, forming a third outcome of collaboration. Finally, relationships and individuals’ modified values beyond the collaboration represents a social outcome (Griffiths et al., 2021).

**Figure 1**

*Collaborative Core Framework based on the process model: Input (grey), Process (green), Output (blue)*



Kirschner et al. (2018) developed a perspective of cognitive load on collaboration. Human cognitive resources (ability to concentrate, reflect or engage in creative activities and transactive interactions) are considered limited and thus, CSCL specifically strives to reduce cognitive load on particular aspects to channel cognitive resources on aspects tied to learning objectives. The theory also provides *raison d’être* for collaboration in complex problem settings: the group can pool individual knowledge and rely on a shared memory (transactive memory system) extending cognitive resources. In the context of a framework, it provides a general property of collaborative processes which is the cognitive load. There is an ongoing debate on the unit of analysis among CSCL researchers, but the collaborative load theory accounts for both group and individual considerations of collaborative processes.

Collaborative processes are dynamic in nature. In their fundamental CSCL contribution, Roschelle and Teasley (1995) defined collaboration as opposed to cooperation: collaboration differs to cooperation in that collaboration requires a continuous, common effort of a group or dyad to maintain common ground, whereas cooperation is the division of subtasks to a common goal on which group members work in parallel but without requiring mutual understanding. George & Leroux (2001) pointed out that collaboration and cooperation are not unrelated and generally occur in alternating patterns: Collaboration is cognitively intense and cannot be maintained over long periods of time (Kirschner et al., 2018). Inversely, cooperation requires a minimum of common ground. George & Leroux (2001) characterized collective activities as series of collaborative and cooperative phases. Indeed, when teams collaborate, collaboration may dynamically shift from collaboration between all members to collaboration in subgroups. Using the group as the unit of analysis, the group can be in a cooperative phase even if all members still collaborate (in subgroups). Engeström (2008) included cooperation as a key concept to describe collaboration in its framework.



In Simon et al. (2022), we analyzed common features from frameworks by Hesse, Mateescu and Meier to identify three main categories of collaborative processes: **Awareness, Coordination and Participation**. Participation is referred to as “an observable action of engagement in communication”, capturing both verbal and nonverbal exchanges. Awareness regroups internal processes that maintain awareness on social, cognitive and behavioral activities of peers. Coordination refers to task and social conflict resolution as well as decision making strategies.

Collaborative processes have been categorized differently by Kirschner et al. (2015), arguing that there are social processes, nourishing a **social space** (e.g. through encouraging peers) and task-related processes to establish common conceptual ground among group members. Their framework distinguishes cognitive from social performance. We thus integrate the notion of a social and **cognitive space** (Roschelle & Teasley, 1995) in the collaborative core to which members contribute through participative processes. Group members organize and structure both spaces through the use of coordinative processes to regulate contributions to the social and cognitive space. For those contributions to be constructive, members have to be aware of the social group dimension (Behavioral Awareness: “When can I contribute something?”, Social Awareness: “In which mental state are my peers?”) and the cognitive dimension (“Who knows what?”) (Ma et al., 2020). Processes of all three categories are thus implied in creating and maintaining both cognitive and social space. Verifying the coherence with Kirschner’s theory of collaborative load, we find that a cognitive load can be attached to all three process categories and processes for both cognitive and social contributions. Kreijns et al. (2013) define the social space as a place where trust, motivation, interpersonal relationships and the sense of community is developed and maintained.

The cognitive space refers to a common understanding of problems and solutions. The group actively engages in its construction (requiring active participation), management (upon arrival of new evidence) and repair (negotiate diverging visions).

Another main component of many frameworks (Hesse et al., 2015; Johnson & Johnson, 2004; Laal, 2013; Meier et al., 2007) includes conditions or process input. This aspect is based on the works of Johnson & Johnson (2004) who observed that for successful collaboration, social skills, promotive interaction and group processing abilities as well as positive interdependence and individual/group accountability have to be present among group members. Regarding the definition of collaboration, we can objectively regroup and extend the conditional aspect to participants, environment and the problem/task. Collaborative skills consequently are a property of the group’s members. This vision is still compatible with CSCL if computer support is considered a tool and tools a part of the environment in which the activity takes place.

Script theory is another perspective on collaboration and group interactions. It states that for a certain type of situation, humans have procedures and organize their internal knowledge about those situations in “internal scripts” (e.g. a script “restaurant visit” may include the process of waiting to be seated, being handed a menu, etc.). External scripts are explicit instructions for procedures to follow in a situation (e.g. flight preparation protocols). Internal collaborative scripts are part of the input group members bring to a collaborative setting, similar to collaborative skills. Collaborative scripts are a type of knowledge about collaboration (together with knowledge about collaborative processes). Finally, collaborative values refer to priorities on aspects of successful collaboration (such as equal access to resources). These three dimensions are negotiated and organized among a group through coordinative processes in the social space. Research on team compositions confirms the presence of those procedures and predispositions (Kreijns, Kirschner & Vermeulen, 2013).

The previously discussed, different aspects are combined in Figure 1. Conditions are the input of the global collaborative process that requires common social and cognitive spaces on which operate Awareness, Coordination and Participation processes. The potential outcome of this global process is the task outcome, the “lessons learned”, improved collaborative skills and social outcomes, such as relationships.

### A collaborative learning extension (3)

The previous, collaborative framework provides a common vision on collaboration. In order to establish common ground on CSCL, we examine this model’s compatibility and possible links with learning theories. Individuals have to acquire skills, knowledge and values to become functional parts of modern society. Wenger et al. (1991) describe learning as the legitimate peripheral participation in a community. Indeed, skills, knowledge and values are acquired by participating in the activities of a community. Teaching in turn can be defined as the activity of actively steering and optimizing acquisition by those “new members” (Lave & Wenger, 1991). The appeal of collaboration as a vehicle for learning is thus immediate and fourfold, considering the output of the previously defined framework.

While still being actively researched, institutions have identified collaboration as the “super skill” of the 21st century and aim to teach students the necessary skillset (Praharaj, 2022). Coincidentally, engaging in



alike (◊ 2.2). Hesse et al. have established an extensive list of collaborative skills and relevant indicators to assess those skills. Those indicators can be conveniently associated to the components of the presented framework. The NISPI framework aims to detect collaboration based on non-verbal cues. Conversation analysis in turn can be considered a framework for verbal participative processes (◊ 2.1).

Previously discussed features of collaborative processes (◊ 3) are their cognitive load (◊ 3.1) and dynamic nature (◊ 3.2). Awareness processes (◊ 3.3) are widely acknowledged to be fundamental for collaboration and CL. Beyond the already mentioned social, behavioral, cognitive and task awareness processes, awareness on collaborative processes, also known as metacognition, has been identified, allowing group members to reflect on their emotional and cognitive state and alter them accordingly (Cress et al., 2021) (◊ 3.4).

Coordination (◊ 3.5) can occur in the cognitive space in the form of strategies to solve a problem or accomplish a task or in the form of meta-strategies (group processing) monitoring and altering solution strategies depending on their performance. Coordinative processes are also required to channel and account for the social space. The notion of social presence is still debated (Weidlich, Kreijns, Rajagopal & Bastiaens, 2018) but broadly refers to the peer's perception of a member within a group through their communicative activities. Bachour et al. (2010) have shown the positive impact on mirroring tools showing the group participation of group members and highlighting the importance of a balanced participation for collaboration.

Participation (◊ 3.6) can occur verbally and nonverbally. Verbally, researchers highlight the importance of transactive communication for successful collaboration. Transactive communication (◊ 3.7) refers to group members mutually building on previous contributions. Communication can also focus on the social space to mediate conflicts or motivate each other (Johnson & Johnson, 2004; Vogel et al., 2017).

Griffiths et al. (2021) provide a hierarchical structure of collaborative processes for the social space (◊ 4): the foundational relations are built on communication and trust (◊ 4.1), which allows for the negotiation for shared values, which in turn encompass shared goals and common understanding. Once this step is taken, team members show active engagement by sharing responsibilities and active participation (◊ 4.2). Finally, collaboration takes place when decisions are taken and negotiated collectively (Griffiths et al., 2021). While the serial nature of their perspective is problematic as the processes of active engagement have been observed to occur in parallel to the construction of shared values and relationship building (Kreijns et al., 2013), it provides a structure of the social space and the links between its properties. Kreijns et al. provide a framework for the integration of social space and social presence (◊ 4.3), stating that through participation, members build their social visibility in a group (◊ 4.4). Kreijns et al. hypothesize further that the social presence in turn impacts further participation of participants (◊ 4.5). The aforementioned link demonstrates the use of this framework to include ongoing research results. The framework can be further used as a documentation of study setups (highlighting the type and quantity of each object).

## Conclusion

In this paper we presented an updated definition of collaboration and an attempt to structure part of the CSCL community's acquired conceptual knowledge in the form of a multilevel, modular framework. Its compatibility with two learning theories and other frameworks and CSCL findings was highlighted. Its design features align with a vision and a need for *collaborative research* in CSCL. As various authors have outlined before, the complexity of the phenomenon requires community wide collaboration. We hope for this work to trigger the implication of the different authors in a collaborative effort to discuss, criticize and consequently create a collaborative framework for collaboration (of which Figure 2 is but an initial, incomplete attempt).

Building common ground is no isolated, punctual effort and must be maintained throughout the collaborative process. In order to do so, the community must give itself appropriate *tools* and engage in group processing. We suggest the use and adaptation of knowledge graph building tools, frequently experimented in collaborative research (Scardamalia, 2002). The result can serve as a *map* for new and established CSCL members: to navigate the conceptual CSCL landscape, to quickly gain insights into research, but also for the community to build on and discuss concepts driven by their study results. Further perspectives include the integration of frameworks on collaborative computation, completing the list of e.g. the participative processes and their interaction with the cognitive space, detailing links (particularly for the frameworks on collaborative analytics).

In the tradition of collaborations of this kind, we hope to further consolidate a Joint Problem Space for CSCL (as well as a social space). Who if not the international CSCL community would be better suited to conduct and excel at such a collaborative endeavor?

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