JrnlID 11412_ArtID 9267_Proof# 1 - 29/11/2017

Intern. J. Comput.-Support. Collab. Learn
https://doi.org/10.1007/s11412-017-9267-5

Visions of CSCL: eight provocations for the future of the field

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Received: 4 October 2017 / Accepted: 27 November 2017

Abstract The field of CSCL is at a critical moment in its development. Internally we face issues of fragmentation and questions about what progress is being made. Externally the rise of social media and a variety of research communities that study the interactions within it raise questions about our unique identity and larger impact on the world. To illuminate the complex issues involved and the multiple perspectives that exist on them, we conducted an iterative and generative consultation with members of the CSCL community through individual interviews and public interactive presentations. The result is a series of eight provocations for the field, each presented as a dialogue between the Provocateur/Provocatrice (who seeks to shake up the status quo) and the Conciliator (who seeks to build on the achievements of our current traditions). The provocations address the debated need for six things: one conceptual framework to unite our diverse tools and theories (#1), prioritization of learner agency over collaborative scripting (#2), scrupulous scrutiny of when "collaboration" and "community" are said to exist (#3), the pursuit of computational approaches to understand collaborative learning (#5), learning analytics and adaptive support to be a top priority in the field (#6), and the expansion of our focus to seriously address social media and large-scale learning environments (#7). In addition, the provocations highlight two areas in which perhaps we should desist: the attempt to reconcile analytical and interpretative approaches to understanding collaboration (#4), and the goal of achieving tangible change in the education system (#8). There are no resolutions offered in this paper; the interchanges presented are designed to lay out the complex constellation of issues involved and can be considered a dialogue that we are still in the process of having with ourselves as individuals and together as a community. We stress the urgency and importance for the field of CSCL to take up these questions and

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tensions, and critically, to work towards decisions and resultant actions. Our future as a scientific community — our very existence and identity, depends on it.

Keywords Collaboration · Computer-supported collaborative learning · CSCL · CSCL theory · CSCL methodology · Adaptive support · Collaboration scripts · Conceptual frameworks · Design principles · Educational data mining · Educational impact · Formal schooling · Informal learning environments · Large scale learning · Learner agency · Learning analytics · Mass collaboration · Online communities · Qualitative research approaches · Quantitative research approaches · Scalability · Social networks · Sustainability · Tool design

CSCL at an inflection point

More than two decades since its initial establishment, CSCL has reached its "adolescence." This is a moment of identity formation between the exuberant exploration of a nascent research community and the well-established structures of a mature field. There is ample evidence that the field made great advances in its early days, producing novel theoretical perspectives, metaphors, and frameworks for thinking about learning, as well as innovating new technological tools for supporting such processes (Ludvigsen et al. 2015; Resta and Laferrière 2007). However, some now feel that there is fragmentation and the collective progress is minimal. Others question what such progress is moving towards, seeing CSCL alternatively as an insular group of scholars or an indistinctive strand of emphasis within the larger Learning Sciences. In parallel, with the rise of ubiquitous social media, other research communities (e.g., Computer Supported Cooperative Work, Learning at Scale, Social Media and Society, Computer-Mediated Communication, Association of Internet Researchers) have begun to investigate new forms of group activity as well as study large-scale learning environments that try to instill a collaborative flavor. Yet these external communities and their research have remained largely disconnected from CSCL.

We thus arrive at a critical moment for the field. As new researchers enter the community and some of our core founders pass on the baton, we must collectively take on the task of negotiating the relationship between the initial tenets of the field, our progress thus far, and this larger, rapidly changing research context. The choices and actions that we take now (whether considered explicitly or not) will decide what the future of CSCL looks like. This paper is thus offered as an initial spark for deliberate conversation about these issues. Rather than providing a definitive direction, we hope it lays out the issues in a way that fosters a rich and open discourse about sensitive, controversial, yet ultimately vital questions for CSCL as a field of scientific inquiry and a research community.

Purpose and process of the visions of CSCL project

Purpose

This article is the culmination of a multi-year project to generate a vision of possible futures for CSCL grounded in a critical examination of the past and present. The aim was to take stock of the accomplishments and challenges in the field thus far in order to imagine, probe, and question desirable paths for the future. The desired accomplishment is two-fold:

first, to better articulate the unique identity and value of CSCL as a research community; second, to identify frontiers ripe for expansion that can help us find points of connection with our sister communities and collectively increase our relevance to the day's most pressing questions of learning.

The project was initiated by Carolyn Rosé during her presidency of ISLS in complement to ongoing work to review and characterize the existing body of CSCL research (Jeong et al. 2014; Tang et al. 2014). The purpose of this project differs from those efforts in several important ways. First, reviews look retrospectively at what has been done. They thus can only reflect established traditions of work, not portend new directions or divergences from the status quo. In contrast, this project sought to be progressive and controversial in its approach, offering up potentially radical new possibilities for the future of CSCL. Second, reviews focus on the published literature as an artifact that represents the knowledge base collectively constructed by a community of researchers. In contrast, this project focused on individuals and their experiences as members of the CSCL research community. Operationally defining the field in this way created three key differences. First, there is a difference in breadth and scope. The boundaries of an artifact review are defined rigidly (i.e., articles are found by searching for prescribed keywords in selected publications and publication indexes). This project allowed the boundaries for relevant work to be determined fluidly, giving the individuals involved discretion to include work they thought significant to the community, regardless of publication venue. Second, there is a difference in the nature of the claims made. While reviews attempt to objectively characterize the literature, this project embraced subjective human perspectives about CSCL work and the scholarly contexts in which it was constituted. It is thus admittedly less detailed about the specifics of prior research for the purpose of being more sensitive to the trajectories of the work being conducted, the texture of the world in which it took place, and the kinds of contributions that have been made and still need to be made. Finally, there is a difference in dispassion. While reviews are meant to be detached syntheses, this project sought to engage people's excitement about CSCL research that has been done and could be done.

Process

The process by which this article was created was iterative and generative. Like any scholarly domain, the future of CSCL largely depends on the circulation of ideas between researchers in the area. The fact that the object of our research is collaboration strengthens the need to think together about what has been achieved so far and what should be done moving forward. Our charge was to draw on a diverse range of expertise and perspectives in the field to open up a conversation about the core values of CSCL (why are we engaged in this work, what do we believe will be the impact), assess our progress thus far (achievements, disappointments, challenges), and find out where people see the energy and excitement in the field going (what are the burning questions that need to be addressed over the next five to ten years). This was done through two rounds of individual interviews (via email) and two public presentations and discussions (at ICLS 2016 and CSCL 2017).

The questions we wanted people to address are large, open, and conceptual in nature. To concretize the endeavor and offer something specific to which to respond, we put

together a number of initial themes that we saw as capturing the zeitgeist of the CSCL community either because they represented core successes and challenges for the field of CSCL or offered promising new horizons for investigation. Importantly, these initial themes were a provisional starting point, designed to evolve over time. The initial ten themes were generated through a dialogue between our respective perspectives, which are grounded in different backgrounds and orientations. One of us (Baruch) has been a part of CSCL since its early days, but his eclecticism has led him to borrow ideas and methods from diverse fields (educational psychology, cultural psychology, mathematics education, et cetera) to understand learning processes, while one of us (Alyssa) came to the field after its initial establishment and draws strongly on quantitative and computational methods in her work (though rich qualitative inquiry is often used in complement). In response to the comments given after the first round of interviews and the presentation at ICLS 2016, two additional themes were generated. The total set of twelve themes can be found in Appendix A. In each of the two rounds of interviews, we wrote to leading scholars in the field asking them to respond in depth to two or three themes. In addition they were asked to suggest additional themes and additional scholars to include. Scholars were given the opportunity to comment both on themes related to areas in which they had made substantial contributions (and thus were intimately aware of the detailed issues involved) and also ones to which they had some distance and could provide a more generalist perspective.

All interviewees were active members of the CSCL community (through participation in the conference, the journal, or the CSCL committee) and efforts were made to include both senior and newer researchers as well as provide geographic distribution. We also deliberately sought out a diversity of perspectives on each theme, based on our knowledge of individuals' scholarship. Fourteen scholars were invited to share their thoughts in the first round of interviews and eighteen were invited in the second round. A total of twenty-three responses were received.

The public presentations offered a different forum for creating dialogue and generating input around these issues. The first presentation occurred as part of the Presidential Session at ICLS 2016 in Singapore after the first round of interviews had been conducted. It included an overview of the project and the initial ten themes plus an elaborated description of five of these. The presentation raised awareness in the community about the effort (helping further efforts to solicit input) and feedback from the panelists and audience members was used to refine the themes. In addition, contrasts with another presentation in the same session led to further reflection about the distinct nature of this work, as articulated above. The second presentation occurred as part of the Presidential Session at CSCL 2017 in Philadelphia. By this time, the second round of interviews had been conducted and all twelve themes had been elaborated. This presentation provided an opportunity to reframe the project outcomes, moving from descriptive themes to prescriptive suggestions. In the spirit of the overarching goal to imagine and generate dialogue around possible futures for CSCL, we offered the suggestions as a set of seven "provocations" — deliberately extreme implications and directions for the field designed to stimulate concrete community discussion of paths forward. Again, feedback from panelists and audience members was used to refine and expand the ideas, leading to the eight provocations presented here. In particular, feedback from this second public presentation was helpful in elucidating relationships and tensions between the different themes-cum-provocations.

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The provocations

A brief caveat and note on format

While these visions were conducted with extensive input from members of this community, we are the primary authors of this manuscript, and as such are solely responsible (or to blame, depending on your perspective) for the ideas and trajectories presented below. At the same time, we sought to sustain, rather than resolve, the tensions we encountered through the project. Thus, while the chorus of voices that contributed to the project has been reinterpreted through our eyes, we developed two protagonists to act as foils for representing the diversity of views in our community. The Provocateur/Provocatrice seeks to shake up the status quo; not to destroy, but to deconstruct the current situation as a way to advance the field. In contrast, the Conciliator sees strength in continuity and building on the achievements of our current traditions. The interchange between them can be considered both an inner and an outer dialogue; one that can occur across researchers but also within each one of us. In some cases, we have included language from what was said by our interviewees verbatim and in other cases we have reshaped the ideas through our own words; in no instance does the Provocateur/Provocatrice or Conciliator represent a particular individual. We hope that this format (particularly appropriate to our field) communicates the intent of this work to open up a space for dialogue into which all in the community are invited to take part.

Provocation 1: the blossoming of CSCL tools necessitates "one framework to rule them all"

P: The development of a profusion of tools for affording diverse forms of collaborative practices is a strength of the CSCL community. For example, there are shared workspaces with structured graphical representations and visual language semantics that learners can use to externalize their ideas and to synchronously co-construct shared representations. (e.g., Belvedere (Paolucci et al. 1995), Digalo/Argunaut (Schwarz and Asterhan 2011)), CoolModes/FreeStyler (Hoppe and Gassner 2002), or GroupScribbles (Roschelle et al. 2007)). Other systems and tools have been developed to support broader trajectories of asynchronous collaborative knowledge building and scientific inquiry; for example, WISE (Linn et al. 2003) and Knowledge Forum (Scardamalia and Bereiter 2003). However, this diversity also presents foundational challenges for the field as the multiplicity of ways collaboration is supported calls into question their constitution as a coherent set. In particular, it often seems as if a distinctive theory stands behind each design (e.g., Knowledge Building for Knowledge Forum (Scardamalia and Bereiter 1994), Knowledge Integration for WISE (Linn et al. 2003), Representational Guidance for Collaborative Inquiry for Belvedere (Suthers 2003)). We need a unified conceptual framework that allows us to consider the similarities and differences in the ways these tools are designed to achieve the common goal of collaborative learning.

C: Such a framework is being progressively constructed by the field as a whole; in fact, you could say that this is the overall undertaking in which we are engaged. We already have examples of phenomena we collectively consider as aspects of collaboration (e.g., joint attention, negotiation), technological and social elements that can support the elicitation of these phenomena (e.g., shared external representations, scripted roles), and principles for the design of these elements (e.g., create systems in which participants can monitor each other's activity and gaze, distribute information and/or responsibilities to create positive

interdependence). You are impatient for the synthesis of our progress, but it would be rash to codify our knowledge prematurely and create the impression of certainty when it is still very much in development.

P: You could be right if we were on a path towards consolidation, but I am not at all sure that there is (even an incomplete) set of phenomena that all would agree on as aspects of collaboration. Even more problematically, there are many overlapping concepts with as-yet unarticulated differences. For example, the notion of dialogic learning in which people explore an uncharted space together without the necessary goal of synthesis (Wegerif 2008) stands at odds with the ethos of argumentation as based in the rational debate of contrasting ideas. Could these both be considered different kinds of negotiation then, or is that yet a third way to characterize a collaborative process? What then of inter-subjective meaning-making, knowledge building, knowledge construction, knowledge creation, et cetera? I am not saying that you could not perhaps articulate ways in which you see these ideas as similar and different, but that there is no such shared understanding in our community. The existence of numerous similar but distinct concepts whose relationships are not well-articulated is severely problematic. It detracts from our collective progress since vertical development, refinement, and testing are occurring for multiple parallel streams at once without any horizontal integration. This creates particular problems for new scholars who often become overwhelmed by the options available and lack guidance on how to distinguish them or determine when each is appropriate to apply. Furthermore, the existing multiplicity of theories creates space (and perhaps even incentive) for researchers to initiate additional new parallel theoretical tracks instead of contributing to and expanding those that already exist. We need to tidy house by creating a framework of frameworks that articulates the characteristics and relationships between existing concepts and theories. This can illuminate when findings from one stream of research may be useful for another, indicate which theories are useful for which kinds of situations or learning goals, and identify when we are working with multiple concepts that occupy such similar conceptual space that the need for them to maintain distinct identities should be reconsidered.

C: You are correct that it is important to understand the relationships between related concepts, but this does not imply that they should necessarily be collapsed into a single construct. There are ongoing debates in many areas of the social sciences about the relative utility of unidimensional constructs, multidimensional constructs and multiple dimensions of distinct (but related) concepts (Edwards 2001). I think the recent work of Jeong and Hmelo-Silver (2016), which proposes seven overarching affordances of CSCL, begins to provide a realizable level of the harmonization you seek in the area of tool design. They identify seven activities that collaborative technologies can be designed to afford: 1) finding and building groups and communities; 2) engaging in a joint task; 3) communicating; 4) sharing resources; 5) engaging in productive collaborative learning processes; 6) engaging in co-construction; and 7) monitoring and regulating the collaborative learning. A focus on these common processes is how CSCL scientists identify themselves as belonging to the same family and articulate the relationships between their works.

P: I agree that their intent is in the spirit I suggest and provides a very nice taxonomy of areas for collaborative learning support and research that points at general intentions. It is good that these general intentions should be agreed upon as a starting point. But we need to go beyond a taxonomic design framework to one that offers descriptive and explanatory accounts (Antle and Wise 2013). You recall the enormous efforts involved in the cycles of design research; when scientists develop or use tools, they should be able to predict or to some extent foresee the behaviors that will ensue at a much greater level of specificity. Otherwise

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collaborative design must begin each time ab initio, which would be a Sisyphean and intolerable enterprise. The field cannot grow without more detailed principles for design.

C: I admit that Jeong and Hmelo-Silver's (2016) list of affordances of CSCL does not create unity among CSCL researchers; rather it shows how researchers have a loose common ground. This is a preferable situation of "let a hundred flowers bloom" (Stahl and Hesse 2011, p. 139). Science needs a diversity of approaches and innovations — working under a single framework would be overly constraining and detrimental to creativity and discovery. At the same time, their work offers a common touchstone to which more specific design principles (which are not universal but applicable in particular contexts) can be tied. For example, for each of their seven categories they offer examples of technologies and design strategies that have been used. There is no single monolithic CSCL; this work helps us to articulate what are the different CSCLs and how we understand them.

P: This is a good beginning but we need to go much further. An overarching design framework needs to specify classes of design features, the particular affordances and constraints for action they offer, and the factors (of learners and learning situations) that help determine whether and how these affordances are taken up in actuality. Furthermore, we need much greater attentions to not just desirable, but undesirable affordances. For example, in our sister field of computer-mediated communication (CMC), studies have been conducted to point out common problems. In synchronous communication, one likely danger is violation of the normative ideal of precisely alternating turns with no (or minimal) gap, and no overlap between speakers (Sacks et al. 1974). In asynchronous communication, learners may feel less engaged due to lag in response time and written ideas may be misinterpreted without the opportunity for immediate repair (Herring 2001). These are well-recognized challenges for communication (and collaboration) that can be expected and guarded against through design.

C: While I agree with you that careful choices in knowledge anticipation of expected use is the hallmark of good design, you are chasing windmills in your desire for a single framework to drive this process. Yes, a designer must make defensible decisions about what concepts and principles to apply in a particular situation; that is the design way. You seem to believe that if we explicitly delineate a comprehensive, mutually exclusive set of concepts and principles we will then tend to get a design "right" on the first try. But this belies the nature of design as a situationally responsive negotiation by the designer with the environment (Nelson and Stolterman 2012). The elaboration of CSCL tools is theoretically conceived as the result of a design research program that includes interactive cycles of design and observed behaviors. This is critical as design is not deterministic, but the practice of creating opportunities and likelihoods, studying how activity plays out in practice, and adjusting accordingly. Such reiteration is too rarely undertaken in the CSCL; it is in this area — our design processes, not our design principles — that improvement is most needed. *Thus it is here that our disagreement resides — you seek more unity in theoretical constructs and design principles while I see the diversity of CSCLs as a strength that is brought to bear through the execution of iterative design processes*. But let us turn to another issue on which I believe our opinions diverge that is even more pivotal for the relation between design and collaboration — the issue of learner agency.

Provocation 2: prioritize learner agency over collaborative scripting

P: One of the original motivations for pursuing collaborative learning as a research agenda was the progressive goal of bringing some degree of autonomy to students in their learning.

However, the introduction of scripts, which prescribes the manner by which learners are expected to collaborate, suppresses this aim. Scripts were initiated to help people to become more effective at collaborating. Dillenbourg gave a pedagogical definition of collaborative scripts as "a more explicit didactic contract as to the manner by which collaboration should proceed" (Dillenbourg 2002, p. 62). However, more recently scripts have been described as computer-based scenarios designed to create and structure collaborative learning settings by associating groups of learners with specific tasks, roles, or resources, and/or constraining the mode of interaction among peers (Kollar et al. 2006). These definitions seem complementary, but are actually quite distinct. The first definition refers to a voluntary choice to engage in a didactical contract about the collaboration while the second implies some obedience to a demand from an external authority. Realizing this, we can no longer purse scripting at the expense of learner agency and must devise other ways to support collaborative learning.

C: You create a false choice, as scripting and agency are not actually inimical to each other. We should remember that the idea of collaborative scripting was first elaborated in the early days of the development of the underpinnings of the CSCL theory — when scientists realized that groups are not always productive in their interactions and that the availability of technological tools alone does not suffice to guide group-work (Stahl et al. 2006). You judiciously point at the risks inherent in collaborative scripts seen as orders to be obeyed. However, the field moved to address this initial contradiction through the more recently developed Script Theory of Guidance (Fischer et al. 2013). This theory palliates the problem conceptually by replacing the idea of the blunt reception and adherence to an external script with the notion of an encounter of the external script with an internal script on the part of the learner: "the learner's understanding of and behavior in this situation is guided by dynamically configured and re-configured internal collaboration scripts" (Fischer et al. 2013, p. 57). When learners do not use external scripts as intended, this is interpreted as an incompatibility of external and internal scripts (rather than simply as a failure to adhere). The goal of the external script is to help students acquire internal scripts that are productive. Supporting learners in developing a richer repertoire of effective practices for collaboration that they can employ in various situations enhances, rather than inhibits, their ability to manage their own collaboration. Therefore, collaborative scripts are not coercive but enable attuning between the needs of the learner and those of the task.

P: In the words of Fischer et al. (2013) external scripts act as "representations that may guide CSCL practices by either facilitating or inhibiting the application of internal collaboration script components of the participating individuals" (p. 61). The subliminal message according to this view, which stresses the acquisition of an internal script, is still a kind of obedience. While you refer to a nebulous future potential for learners to use internalized scripts for their own ends, in the moment of the scripted collaborative event they are still animated to obey an external will. The issue of over-scripting (Dillenbourg 2002), according to which collaborative scripts can be demotivating, produce stilted observance, or even deter students from successful moves makes salient the coercive character of collaborative scripts.

C: You are applying a view of scripts as something learners comply with but this is not an inherent characteristic; it is equally possible (and preferable in my opinion) to adopt a sociocultural approach to understand how scripts function as artifacts that learners appropriate. In a recent paper, Tchounikine (2016) offers an alternative perspective to the Script Theory of Guidance. He regards external scripts as artifacts that learners interact with when engaging in a collaborative situation. Learners do not obey the script, but appropriate it through a cognitive process that involves the recognition and conceptualization of the task to be achieved. In

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addition, the script does not exist as an isolated element of instruction. Other aspects, such as details of the institutional context, elements of motivation, norms around learning and collaboration, and prior social/power relations between collaborators may influence its appropriation and the unfolding of collaborative interactions as well. For this reason, Tchounikine (2016) dissociates the appropriation of macro-scripts (that create a high-level didactical contract with the teacher's objective) from that of micro-scripts (which prescribe learner behavior at the level of individual actions). In other words, in an atmosphere in which collaboration becomes a value, collaborative scripts do not reflect coercion but function as reminders that collaboration is worthy. Furthermore, when choice is constrained but not eliminated, it can actually enhance agency by creating a manageable, rather than overwhelming decision space for the learner to operate in.

P: Very well. Let us agree that one way or another, students habituate themselves to collaborate and that the coercion of scripts is in fact effective to support certain desired aims such as the negotiation of meaning (Beers et al. 2005) and knowledge convergence (Weinberger et al. 2007). At the same time, we must also acknowledge that collaborative scripts often inhibit other desired ends such as self-expression, emotion, and community development. Thus we have a deontological decision to make — when "productive negotiation" and "learners' collective self-determination" are at odds, which do we value more?

C: Again, this choice is a false one. First, you suggest an unrealistic ideal of learners as unfettered in their potential for self-determination. Collaborative interactions are always situated in some historical, social, and institutional context. Thus it is not useful to imagine learners, individually or collectively, as ahistorical actors working off a blank slate. Second, scripting does not have to be inimical to that agency which is possible. Consider for example the use of one particular kind of scripting: the required use of message labels designed to support metacognition (e.g., "I need to understand…." see Scardamalia and Bereiter 2006). While in any given example of use the set of labels are pre-determined, this simply provides a frame for the types of contributions that can be made. It is the students themselves who decide which particular label to use when they make a contribution. A teacher could also discuss with the class what labels should make up the set in the first place (as a taxonomy of recognized contributions in the kind of dialogue they want to engage in). This would promote community development (and could create space for self-expression and emotion if they become community values). Thus it is not the scripts themselves, but how they are sometimes used with which you take issue.

P: What you describe is a lovely and idyllic vision in which the students take part in scripting their own collaboration but this is a difficult and time-consuming endeavor that is not commonly undertaken. And giving students a quite limited number of prescribed ways that they are allowed to contribute cannot be said to allow for true agency. Since scripts are almost universally imposed from an external source, this becomes a part of their character. Thus we must look to other ways to support collaboration. This becomes even more important when you recognize that as a coercive technique, scripting is limited to situations in which we indeed have a great deal of control, so they cannot be the preferred tool for working in informal environments such as Facebook, Blogs, or Twitter (see Provocation 7). There are a variety of alternatives to scripting. For example, rather than constraining activity *during* collaboration, guidance (and constraints) can be placed on planning, monitoring, and reflection, and revision of collaborative interactions *before* and *after* it (Schwarz et al. 2015) to support self−/co−/socially shared regulation. We can also develop technologies that do not constrain people's activity or provide explicit rules-to-be-followed but instead provide learners with information

about collaboration for reflection and action. Two promising areas of development here are group awareness tools (e.g., Bodemer and Dehler 2011) and learning analytics (e.g., Wise et al. 2014; see also Provocation 6). By making people aware of the qualities of their peers, characteristics of the contributions made thus far, or the knowledge development of the group collectively, these tools put the learners' agency to the front of CSCL focus and afford desirable actions among willful learners.

C: This direction is exciting as a parallel research track to scripting, but should not replace it. Certainly the extensive scripting literature can help inform the design of awareness tools and learning analytics that are most likely to be beneficial for good collaboration. For example, drawing on the ArgueGraph script that pairs learners with different positions to encourage argumentation (Dillenbourg and Jermann 2007), a group awareness tool could be created that lets learners see the positions held by their peers and provides guidance about how to select a good learner partner (but does not compel them to work with a particular person). However, these more implicit tools that do not prescribe a certain user behavior are not likely to be as effective as scripting. They allow for too much freedom for learners at the expense of productive interactions and allow them to waste their time. A better approach is to not abandon scripts, but rather to progressively fade them out. Scripts function then as tools for instilling desirable norms around productive collaborative practices. This is not yet another imposition of external will but the provision of a tool-set to support learners in enacting their agency, which of course is exercised within the existing sociocultural context. Remember that unsupported collaborative processes will often be dysfunctional and learners need the ability to modify and improve these problematic practices over time (Borge et al. 2015). I confess however, that the study of implementation of collaborative scripts in long-term experiments in which their fading out is initiated has not been undertaken yet.

P: This is not surprising! In order to undertake long-term experiments, you are obliged to negotiate with educators. This negotiation is not a simple matter and is not seriously handled by our community. We should recognize that so far, collaborative scripts pertain more to the experimental realm than the educational one. This disconnect may in part explain the lack of impact that our field has had on educational practice (see Provocation 8), offering yet another reason to move away from scripts as the favored approach to supporting collaboration.

C: I told you that I admit and regret that long-term experiments in which the enactment of collaborative scripts is first coerced and then faded out has not been done. Your view about collaborative scripts is quite monolithic and you are unrealistic in your aspirations for unconstrained learner agency. We must take into consideration the social context of collaboration and the role of institutional factors. Educational programs should instill social norms that establish collaboration as a natural behavior that is a part of the micro-culture of the class or of the school (Cobb et al. 2001). Of course this instilment neither happens spontaneously nor can it be simply imposed. Norms need to be negotiated, and when they are appropriated as part of the local culture then no more coercion is needed. *I think that, in the end, there is a values-based choice to be made: for you, the realization of individual student agency is both possible and of such paramount importance to tolerate less-than-perfect efficiency in collaborative processes; in contrast, I believe that individual self-determination is always tempered by complex social and institutional factors and see it as quite reasonable to temporarily prioritize the optimization of pre-defined learning goals.* But now, my dear friend, I would like to move away from questions of design to delve into the core concern of our community: the existence of collaboration in social interaction, and the subsequent constitution of a community of learners as a result of the iterated enactment of collaborative practices.

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Provocation 3: "collaboration" and "community" should be scrutinized scrupulously rather than assumed as a matter of ideology

P: Since the establishment of CSCL as a scientific community, its instigators have brought forward the centrality of collaboration and of the constitution of a community of learners as foundational to learning. These were inspirational ideas set against the context of a cold cognitive world in which learning was supposed to happen. However, rather than proposing the value of collaboration and community for learning as scientific questions to be answered, it seems instead that there has been an ideological claim of their inherent value to which adepts adhere enthusiastically, but blindly. That is, rather than ask "if, when and for what ends collaboration and community are truly beneficial," it is presumed a priori that they are something to be strived for and investigations seek to probe the details of under what conditions they are likely to occur and document the nuances of their enactment in the world. There is a need for CSCL researchers to become more critical of the foundational premises of collaboration and raise questions such as those asked in our sister fields such as CSCW, psychology, and organizational science about *if or when collaboration is really beneficial* and *whether it is interaction that makes it really effective or it is some other factor(s)* (e.g., Nokes-Malach et al. 2015).

C: First, I must point out that your argument willfully ignores the evidence that exists to document the value of collaborative learning. For example, a systematic examination of the research by Chi and Wylie (2014) supports the effectiveness of "interactive constructive" learning activities (defined in a way that very much parallels our community's notions of collaboration) over individually constructive ones. More importantly, the accusation that CSCL is an ideology implies a division between values and science that is not as straightforward as some people would like to think. Scientific knowledge inherently relates to human interests (Habermas 1972). This is true of natural sciences as well as educational sciences but the interests in the natural sciences are often less subject to dispute than those in the educational sciences, which are always bound up with some vision of the good life. Universalizing a particular point of view on this topic is then often seen as ideology. For example, literacy education is presented in many studies as if it was an unproblematic good. But in oral cultures, literacy education can mean outsiders coming in and stealing their children away because practices of literacy make an oral worldview less comprehensible (Dehaene 2009). Thus ideology as to the goals of education is always present to some extent and does not preclude scientific inquiry. The CSCL community is self-consciously founded on a commitment to the value of collaborative learning as an educational goal and focus of research, but also on a commitment to science as a means of shared inquiry. What makes a domain scientific is not the complete absence of anything that might be related to values but scientific cultural practices like integrity, transparency, systematicity, peer review, supporting multiple perspectives, responding to challenges with further reasoning and inquiry, et cetera (Wegerif et al. 2013).

P: I agree that the ethical-ideological value of collaboration as an object of study does not necessarily prevent scientific inquiry, but any area of scientific study has presuppositions that can and should be subjected to reflective investigation as part of the science. So we should systematically probe the nature and value of CSCL in theory as well as in practice rather than simply taking it for granted. Furthermore, such investigation requires clarity about when "collaboration" can be said to have taken place or "community" exists. Right now use of these terms is approaching the status of meaningless jargon in which every situation of group

work is described as collaboration and any cohort of people who come together for some period of time are labelled as a learning community. Such loose usage of these terms dilutes their meaning and weakens their ability to serve as a shared object of focus for our community. It also exacerbates the earlier problem by extending the unquestioned value of collaboration/community to almost any situation involving some kind of interaction between learners.

C: It seems you have created a paradox for yourself. Here you say that we should apply strict criteria to justify the alleged presence of collaboration or community, but I know that you also believe that the field has been too restricted in the kinds of social environments studied and should expand its scope to consider new forms of group work enabled by social media and large-scale learning environments (see Provocation 7). These cannot both be possible.

P: It is not a paradox at all. We can both deepen our commitment to the core and also expand the bounds of our vision. What unites these endeavors is the need for greater precision in our definition and application of terms. For example, Barab and Duffy (2000) describe some core characteristics of a community as the presence of a shared culture and history (which includes common goals, practices, and negotiated meanings) and the ability to reproduce itself (with change and growth) over time. This is a useful definition, grounded in the sister fields of anthropology and sociology. If we apply it faithfully, however, then the majority of classrooms (which are reconstituted each year with a new group of students and teachers) cannot rightly be considered communities. This is not a problem if we acknowledge the differences between classrooms and ongoing communities and adjust our language accordingly. For example, if a classroom has established common goals, practices, and negotiated meanings but will not be able to reproduce itself beyond the course of the school-year, it could be labeled as a *community pro-tem* ("community for the time-being"); other classrooms that do not establish a shared culture might not qualify for this characterization and instead classified as *community pas du tout* ("community not at all") to indicate that potential for community existed but was not fulfilled. The ability to distinguish these very different situations then allows us to investigate more precisely the value that each does (and does not) provide.

C: Intense precision in terminology is all well and good, but you must remember that it comes at a cost; the attention it demands is not available for other pursuits. For example, in his latest work, Stahl (2015) demonstrated an extremely cautious use of the term "collaborative learning" driven by the application of rigorous methods. To do so, he carefully analyzed the full longitudinal interaction of a single triad of students learning to engage in dynamic geometry online. Through identifying the moment-to-moment negotiation of dozens of specific group practices that corresponded to the curriculum, software, and pedagogy of Virtual Math Team's design-based research efforts, he was able to document the group as engaged in the process of collaborative meaning-making. However, if we must undergo such labor-intensive work in every study simply to establish that collaboration or community is present, then this will become the entirety of our work, leaving little capacity to investigate important questions about specific aspects of collaborative processes when then do occur.

P: I maintain that the question as to whether or not true collaboration is being achieved on any particular occasion should be an empirical matter, not one treated as an article of faith or by fiat. Stahl's research presents one methodological approach to establish this, but it is certainly not the only one. The overarching principle is that we need a clear definition of the phenomenon (preferably one that is commonly accepted; see Provocation 1) and evidence that shows that the criteria required to establish its presence are met. This actually becomes an exciting research agenda in and of itself as we must then answer the question of what are satisfactory indicators of our theoretical notions of collaboration. For example, the notion of

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joint attention has long been considered an important element of collaboration (Tomasello 1995). Is the evidence of shared gaze a useful indicator of this? Is it a sufficient one? It is likely that we may need the convergence of multiple signals to distinguish episodes (or moments) of collaboration; for example, shared gaze plus coordinated gestures plus coherence in talk.

C: What you suggest may be possible when dealing with collaboration as an in-the-moment phenomena, but it creates an intractable burden when dealing with the notion of community. The idea of learning communities centers on the changes that a group of people undergo collectively and individually over an extended series of consecutive activities as knowledge, norms, dispositions, and beliefs are developed. This, of course, also takes place in the context of pre-existing norms and power relations, et cetera, of the institutional or social environment. But to say that one can never adopt a community-oriented lens without first making some grand longitudinal study unnecessarily constrains our ability to conduct useful research. The empirical establishment of transformation for a group of people in a community also does not necessitate scrutiny of collaboration as an in-the-moment phenomena. The evolution of patterns of interaction or of social norms over some period of time may suffice (see Zhang et al. 2009; Schwarz et al. 2015, respectively). You are too orthodox concerning the identification of collaboration or the definition of community at the expense of generating an understating of the social context of interaction and its evolution. This does not, however, negate the value of conducting more focused studies of community-building processes. The notion of learning communities provides a lens into the dynamic interplay between people's ideas and their broader identities. Meaning-making processes at the small-group, individual, and collective levels take place during intertwining temporal sequences, over various time spans, and we need to study various aspects and threads of this to ever hope to approach some understanding of the whole.

P: What you tell me here is not based on findings. In the best case, this is a research program. We may accept some basic belief in collaboration to motivate our steps in our research, but we still need to be critical about its existence and value. More and more voices have begun to raise these questions and point out that people who are co-present while learning together are not necessarily collaborating, groups of learners do not always comprise a community, and that collaboration and community may be more or less appropriate as learning strategies depending on the goals desired. A salient example of the necessity to discern collaborative from non-collaborative moments in group-work was stressed by Dillenbourg (1999) in the early days of CSCL when he distinguished between collaboration and cooperation in group-work. This distinction is fundamental and shows the importance of collaboration while stressing its limits as a single phenomenon to explain all group-work. It is reasonable to think that both collaboration and cooperation can be beneficial to group-work in different situations, but I don't know of any systematic study that looks at the appropriate balance between work in which individuals coordinate goals but not activity (cooperation) and work in which individuals coordinate activity (collaboration). It is not done. Instead, everything becomes labelled collaborative by default rather than as the consequence of analysis. This is bad ideology. Criticality is necessary to more clearly define the reach and limitations of our field. In the end, this will allow us to advocate for collaboration more precisely, judiciously, and with stronger rationale, and therefore more convincingly. *Thus while for you, continually establishing the presence and value of collaboration and community is an overly exacting demand that distracts us from moving our research forward, I see it as our very raison d'être and thus the path along which the field must advance.* What is perhaps an even greater challenge, however, is that to identify collaborative moments requires important

decisions about the methods and methodology by which this is done. Such choice takes us, my dear friend, to a longstanding and complicated issue in our field that I would like to discuss with you now.

Provocation 4: the co-habitation of analytical and interpretative approaches in CSCL is actually a situation of co-alienation that cannot be surmounted

P: CSCL offers a set of questions and problems that cut across disciplinary boundaries, bringing together a diverse collection of researchers whose backgrounds lie in fields such as sociology, computer science, anthropology, psychology, et cetera. These traditions each draw on different kinds of methods in how they do their work; specifically, in the types of questions they ask, kinds of evidence they bring to bear, and the ways in which standards for rigor are constructed (Jeong et al. 2014). The main issue concerns how we manage conversations across these intellectual traditions, and the answer thus far is not very well. It is not just that publications and programs of research rarely integrate both approaches but that substantive dialogue across them fails to occur. Researchers tend to isolate themselves with others of a like mind; we are polite, but do not engage deeply with each other's work. This is because methodological diversity is about more than just methods. It stems from differing (often incommensurate) views on what it means to understand something and the kinds of knowledge claims that are valuable to pursue; epistemology is what is at stake. It also often represents fundamentally different theoretical assumptions about the relationship of the individual to the group. These underlying differences are rarely discussed explicitly, and when they are it appears that the unspoken motivation is often to establish one approach as superior to the other (e.g., "studying collaboration as a small group phenomena will let us learn more than taking an individual-in-social-context or community-level perspective"; "research that affords some degree of generalizability provides greater value than in-depth study of a single collaborative episode"). Without a genuine willingness to understand contrasting approaches, the situation that we would like to think of as "co-habitation" is actually one of "co-alienation" from which there is no path forward.

C: Of course, there is a gap between different methodological traditions; this is not a secret nor unique to our field. But you are too pessimistic in your belief that we cannot achieve productive dialogue across it. The key is to treat the scholarly contributions of researchers who were trained in disciplines different than your own with respect. Thus, one useful thing the field can do is to increase awareness about differences in methods and the fundamental assumptions they make. A deeper appreciation of the different kinds of knowledge CSCL researchers see as useful and valid ways to generate them will help us understand each other's work better. It is also critical to cultivate an openness of mind to receive and evaluate the work *on its own terms.* That is, to evaluate the research with respect to the paradigm in which it resides, rather than imposing one's own framework on it. It seems obvious to say, but it is invalid to condemn a deep interpretative analysis of a collaborative episode because the size of the sample is too small to offer any generalizability; that is not the intent. (It is, however, quite valid and important to question how and why the chosen episode was purposefully selected.) Conversely, it is equally invalid to critique a study that looks at regularities in sequences of argumentative moves for its lack of sensitivity to the nuances of ever-evolving emergent context of the discourse. The problem is that these kinds of comments tend to be presented as critiques of the way a *particular* example of research was conducted, but actually they call into doubt the value of the *entire* underlying paradigm of research. This raises the question of

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whether the critic would *ever* be willing to accept the standards of evidence of a differing tradition. Our field has already stated its commitment to methodological diversity; we now need to follow through on the practicalities that respect for other traditions entails. This will lay the groundwork to synthesize findings across different methodological boundaries (e.g., Jeong and Hmelo-Silver 2016) and to develop analytic frameworks for different methods to co-exist and be integrated.

P: You attempt to provide a solution but you actually highlight the central problem of a lack of mutual esteem that makes this situation irresolvable. Interpretative stances draw on approaches from social anthropology, Bruner's (1990) narrative psychology, and various approaches to interaction, discourse, and dialogue analysis. There is a fundamental concern with meaning-making as a central object of study (Koschmann 2003) and the unique and evolving context of the discourse as it is collectively constructed. Analytical stances finds their roots in cognitive psychology, educational psychology, and computer science. They are also concerned with meaning-making (Suthers 2006) but it is considered quite differently, for example, through measurable characteristics of interaction like transactivity. This is where the crux of the matter lies. Some taking an interpretive stance would say that this is not dealing with meaning-making in a profound way; that analytic scholars side-step dealing with meaning-making because they don't yet know how to handle it. But from the analytic perspective, modelling how characteristics of discourse play a role in meaning-making makes a valuable contribution to our understanding of it. In reverse, some taking an analytical stance would argue that documenting the unique nuances of a single group's collaborative interactions is limited in what it can tell us about meaning-making as a larger phenomenon, while interpretive scholars see great value in the analytic and theoretical constructs that emerge from such analyses. This situation yields multiple accounts of the same collaborative event that do not speak to each other. Do you remember Kurosawa's movie *Rashomon* about four witnesses who are present at the same scene of murder and who tell four different stories? Each story is reasonable from the point of view of the observer but is totally incompatible with the other stories. In this case, the interpretative approach stresses the unpredictable emergence of actions in a social context, but their predictability is the very basis of the analytical approach. The result is a theoretical and methodological gap that is irreconcilable and prevents the field from building up a communal knowledge base.

C: The gap is not between approaches but within each. If these internal gaps are addressed, then the conversation across them can proceed. On the interpretative side, there is very often a gap between theory and data, and between method and the object of study. For example, many studies present rather long, largely informal, blow-by-blow narratives of "what is happening" in an interaction between students. Usually there is a theory behind the account (e.g., situated cognition), and yet there is often a gap between theory and the interaction data: how is the theory fitted onto the data in a systematic way? But there is more: when a systematic analysis approach is applied — for example, conversation analysis — it does not seem to directly address meaning-making, i.e., the elaboration of shared thinking in interaction. Conversation analysts either refuse to mention "thinking," or else would claim that the thinking is "in the interaction." But what does it mean to claim that "thinking is in the interaction?" So either there is no method linking theory and data, or else the theory and method pass the object of study by. On the analytical side, you have already mentioned that the problem is that theory and method do not directly address *meaning-making*. A common method here is content analysis (Krippendorff 1980) involving the application of detailed coding schemes (that meet standards of interrater reliability) with the codes aggregated to present frequencies and

distributions of various qualities of the interaction. Codes applied independently to individual utterances are fundamentally problematic as a route to studying meaning-making, as the comments are produced in an interactive situation and thus their meaning resides in their relation to the context of the other messages. It is not possible to distinguish "pure individual cognition" from the social dimension of action (Perret-Clermont et al. 1991). If coding schemes cannot describe individual cognition in interaction, they are also not able to describe shared cognition. This is because an interaction is a process, which continually redefines its own context, not a bundle of unrelated individual events. Thus, currently, neither approach gets us closer to understanding collaborative processes of meaning-making. I should add as well that we must also be concerned that each tradition continues to be up-to-date on the latest methodological developments of the original traditions from which they derive (e.g., anthropology, psychology, et cetera). If we are not able to communicate back to these disciplines about the kinds of problems we want to address, we may not be aware of the latest methods available, and rather than conducting state-of-the-art research, we languish in a time-capsule of outdated approaches.

P: You have expanded my initial critique of a gap in CSCL to a judgement of the entire field. So what exactly do you propose to resolve this rather dire situation?

C: The solution is perhaps found in the very problem itself; conversation across the approaches is exactly what is necessary to fill the internal gaps. This an exciting research agenda to *together* develop a theory and model that address both the processes of communicative interaction *and* the processes of co-elaboration of thinking. This seems to me to be a very stimulating project and future for the field.

P: That is a beautiful idealistic vision, but in practice it is not what happens at all. Researchers entrench themselves in their theories and bend the types of questions to be asked, the type of participants to be studied, the way data will be collected, how the data will be analyzed, and how results should be presented to these views. At the same time, they lack an appreciation for the other way of doing things, seeming to question the fundamental value and validity of research following the contrasting approach. For example, it is quite common to see critiques of interpretive research as "a product of the researcher's or informant's manipulation, selection, or reconstruction of preconceived notions of what is probable or important" (ten Have 1990, p. 2). In addition, interpretive approaches are accused of analyzing in minute detail very small collaborative exchanges without being clear about why they were selected, and obtaining results that are not generalizable beyond the very specific situation in which they were generated. Conversely, we hear less often, but there are complementary critiques to be made of analytical approaches. First, since theoretical assumptions about what constitutes a collaborative process of good quality must be made before gathering the data that will be used to test them, other important aspects of the collaboration that are not anticipated will be missed. In addition, a theory used in this sense of the term is a general proposition, which establishes a relationship between variables independently of time and place, and thus analytical researchers are reproached for not being sensitive to important contextual differences. For example, a prototypical question might be "To what extent are specific epistemic activities (e.g., relating conceptual and problem space) associated with improved domain knowledge among participating individuals?" (Stegmann and Fischer 2011). In addition to the generality, here learning is defined in terms of individual acquisition of knowledge; the compatibility of this definition with the cornerstone of collaborative learning–collective meaning-making — is highly questionable to some. To add one more point, analytical approaches also often employ experimental designs in very controlled classroom or laboratory situations, leading to questions about

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whether we can learn very much about the autonomous efforts of students engaged in meaning-making.

C: Yes there are great differences, but that does not mean that they cannot be bridged. I will give you some examples that show nascent efforts of what is possible. In the first one, the researchers initially focused on restricted aspects of the phenomena of interest, but they were subsequently able to explore other aspects that allowed them to more fully explain the phenomena. This research originated within the European project SCALE where Baker and colleagues elaborated a coding scheme called Rainbow for analyzing online pedagogical debates during which students could both chat and draw argument diagrams (Baker et al. 2007). After a rich theoretically informed development process and refinement in confrontation with part of their own corpus, the researchers applied the scheme with satisfactory inter-rater reliability. The researchers obtained results relating characteristics of specific online distance pedagogical situations and an outcome measure of argumentation (e.g., Lund et al. 2007). But this French team was also a victim of its own pre-conceived view of what was important. For example, the researchers attributed the most importance to "opinions," "argumentation," "exploration," and "deepening" categories because these were the conceptual notions under debate that were being delineated, disentangled, and deepened. However, other types of interaction that were not immediately focused on turned out to also be important for the way argumentation unfolded. For example, the dynamics of power and influence between group members explained to what extent some members admitted publicly to being influenced by other members into changing their opinions. In Baker and Andriessen (2009), they explore extending the socio-cognitive paradigm to include how the dynamic interplay of emotions relates to processes of knowledge co-elaboration. Finally, even a phenomenon specifically judged as initially uninteresting by the theoretical framework was revealed to be interesting later on. We originally saw the arranging of elements of an argumentation graph spatially (as opposed to arranging them logically or thematically) as a waste of time, but actually it allowed students to easily review the arguments as they were discussed during the interaction and therefore increase the quality of their argumentative texts written afterwards (Baker et al. 2003). Recent studies confirm the importance of the students' spatial arrangement of arguments in an argumentative map as a way to contrast a private space and a public space in discussions (see Slakmon and Schwarz 2017). This example shows how suppositions about theoretical constructs orient the gaze of researchers. The first studies may be represented by the old adage of looking for your keys where the light is good (e.g., conceptual aspects of argumentation) whereas during the further analyses, the researchers turned on other lights (e.g., highlighting social relations and emotion during argumentation and spatial organization of arguments) and looked under those. The idea is to link up all the different light sources and build a coherent narrative.

The second example I offer is of the ambitious Productive Multivocality Project (Suthers et al. 2013), which developed a new form of joint engagement as an alternative to in-depth collaboration. Over a series of many workshops, this group developed an approach that allowed researchers to unpack and explore their epistemological assumptions about learning and group work through analysis of shared data (Lund et al. 2013). In this approach, researchers not only analyzed the same corpus (sharing the context for analysis), but did so using the boundary concept of looking for "pivotal moments" (sharing the problem to be solved). This approach was designed to focus analytical attention on a phenomenon that was sufficiently stable to be comparable between analysts, but also sufficiently flexible to fit into each analyst's particular theoretical and methodological framework. In addition, the corpus had

to be parsed in a way that was compatible with the different analytical constructs used to understand it. When this occurred — in varying degrees for five different corpora — the researchers were able to cross paradigm boundaries while making coherent analytical progress on better understanding learning and group work. In many cases, differences were hashed out, consensus was reached, and analytical claims became much stronger because they were multifaceted. Many tensions remain regarding how different paradigms conceptualize the place of the individual in relation to the group, and work is still needed to determine whether these tensions are fruitful or hinder scientific progress. The most important thing this example shows though is that with a deep commitment to understand and challenge each other, such conversations are indeed possible. In addition, we see that the epistemological encounters that researchers from different traditions may experience may be leveraged in order to explore the extent to which approaches can be integrated (Lund et al. 2013).

P: I admit that these stories are beautiful but unfinished and very much exceptions to the rule. So far, efforts in filling the gap have led in some cases to different perspectives that lack an integrative move, and in others to a deadlock rather than synthesis. Saying that the CSCL community should redouble efforts to determine whether this deadlock can be overcome or not sounds empty. *While you see glimmers of promise in select conversation across the two camps, I see that what happens most often between them is, in the best case, a "dialogue" in which people talk but do not listen, and in the worst case, a situation of mutual disdain.* As long as attempts to deconstruct central ideas such as meaning-making in terms of individual actions are not seriously undertaken (or, contrarily, the reconstruction of individual actions in terms of group meaning-making), the field will not progress. I am uncertain about whether this de/re-construction is currently within reach, but the recent emergence of a new class of computational methods for analysis might provide some clues on this issue. I know that what I say might sound unrealistic to many, but I would like to discuss more broadly the adoption of computational approaches to understand collaborative learning.

Provocation 5: vigorously pursue computational approaches to understanding collaborative learning

P: Manual examination of collaborative learning through the analysis of language, gesture, gaze, and other forms and artifacts of interaction has been a valuable approach in CSCL that has provided some insights; however, the laborious nature of the task (whether done quantitatively or qualitatively) dramatically limits our progress. At the same time, the emergence of new and larger datasets (more people, more types of data, more temporal resolution) in combination with the increased accessibility of computational analytic techniques (for example data mining methods, social network analysis, and natural language processing) offers a new and exciting world of possibilities for CSCL methods. We should vigorously pursue computational methods as an extremely promising means to rapidly advance our understanding of collaborative learning.

C: I am skeptical about the potential of computational approaches to contribute substantially to our understanding of collaborative learning. There is a history of hype about what seemingly sophisticated methods imported from other domains can offer that has proven disappointing in the past. For instance, social network analysis (SNA) has been useful in a variety of areas of the social sciences, but repeated attempts to apply it to collaborative learning in small groups have not resulted in significant insight into the nature of collaborative learning. This may be in part because of the particular ways in which it was applied, but I think it is also

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due to its inherent orientation towards structure instead of process and its corresponding lack of sensitivity to the sequentiality of interaction in the specific, unique, and evolving context of the discourse. Similarly it provides no window into participants' tacit but subtle understanding of linguistic fine-points. Such important characteristics of collaboration preclude replacing the generation of understanding by human intellect with automated algorithms based on unsituated generalities that must be known and programmed in advance.

P: Computational methods have already entered CSCL's repertoire (e.g., Dascalu et al. 2015; Erkens et al. 2016; Gweon et al. 2013; Schneider and Pea 2014; Wise et al. 2017), thus the substantive question is not *if* we should embrace computational approaches to understanding collaborative learning, but *how* to develop practices and norms around their use that maintain the community's commitment to theory and situational context. It is true that the unthoughtful application of automated algorithms offers little to our understanding of collaborative learning, but the same statement could be made about the poor application of any analysis method, quantitative or qualitative. In fact, even when appropriate analytic methods are applied, it is questionable whether the accumulation of case studies leads to clear progress in our field. Moreover, it is a false conclusion to say that the use of computational methods seeks to supersede human intellect in the generation of understanding. With data science, as with traditional statistical methods, there are numerous decisions that go into how one collects, processes, and interprets the data. In fact, given the diversity of computational methods available and the potential sensitivity of results to the particular algorithm chosen and how it is implemented, it can be argued that transparency around analytical decision-making is more critical than ever. Equally important, interpreting what the results mean in the context of the existing knowledge base requires human-sensemaking. Thus computational approaches to studying CSCL should be thought of as a way to create new aides for human understanding rather than be seen as an attempt to replace or automate it.

C: While it is true that human intelligence is involved in computational analyses, it is not to interpret the processes of meaning-making that occurred but to make high-level methodological choices. At their core, the new contribution of computational methods is the ability to discover regularities in the data; this is inherently a structural approach. But structures of participation alone, without an empirical account of the meaning-making that emerges through the participation, cannot further advance our understanding of what collaborative effort means for students and participants in specific settings.

P: My argument is not that computational approaches should constitute the entirety of CSCL methods; it is that they have a particularly valuable and unique contribution to make, and that they can also enhance the capabilities of our existing analytic tools. Computational methods allow us to look for complex and fine-grained patterns that might never be detected by hand because the grain-size at which we are looking to generate explanations is substantially larger than that at which the data is collected. Even if we knew where to look, a manual point-by-point examination of the data is unlikely to produce useful insights of these higher level phenomena. Computational approaches can also extend manual analyses by allowing us to look for the presence of detailed patterns previously identified by hand across many more instances and contexts. Returning to your earlier example, SNA has been helpful in showing patterns of distributed versus dominated communication (Brooks et al. 2014), the uptake of ideas across a distributed community over time (Suthers 2015), and finding noteworthy collections of interactions within a large network that merit the intensive time needed to study meaning-making activities in-depth via qualitative approaches (Wise and Cui in review). As language is often a central (though not necessarily the only) mechanism through which

learners communicate, the use of natural language processing (NLP) technologies is of particular interest to the CSCL community. For example, it can be used to scale up (and speed up) the process of content analysis by letting the machine "learn" from a sample set of human coded messages (Rosé et al. 2008; Mu et al. 2012). Computational approaches can both be applied to the kinds of data long-used in CSCL research (e.g., the content of student utterances as they collaborate in a face-to-face or textually mediated environment) and also allow for new forms of data (e.g., eye gaze, gesture, location, biosensors). One area in which computational methods offer a particular advantage is in the study of self−/co−/socially shared regulated learning in collaborative contexts. Regulated learning is a complex metacognitive and social process that is cyclical and involves adapting thinking, motivation, emotion, and behavior (Järvelä and Hadwin 2013). Currently, limited methods exist for making these processes and accompanying social and contextual reactions visible, and those that do are time-consuming, expensive, and often reliant on subjective self-reports. New physiological and technology-assisted data collection can simultaneously trace a range of parallel and overlapping cognitive and non-cognitive processes. These multimodal data can be used to identify markers that characterize successful SRL and learning progress. This, in turn, can help us to better understand the interactions between different facets of regulation and how small-scale situated adaptations and regulation of situated challenges contribute to large-scale adaptation during collaborative learning tasks (Järvelä et al. in review).

C: The examples you give suggest that one of the main driving reasons to adopt computational approaches is as an answer to the challenges presented by the vast quantities of data that are becoming available. But the critical problem in CSCL with big data, and fine-grained data (which tend to get big), is not to document empirical patterns. It is to develop and test concepts and theories that make sense of patterns in the data as a representation of collaborative learning processes. Data are descriptions, based on a vocabulary that researchers make up based on existing knowledge; something new that is not describable in patterns of the already known will not appear to algorithms as a pattern, no matter how much data, nor how clever the algorithm. For example, one could look for patterns in an infinite number of descriptions of chemical experiments, without ever finding the idea of a molecule or atom. Thus there is a danger that we become infatuated with new analytics methods at the expense of the important task of theorization. I am concerned that the introduction of computational methods will result in the documentation of empirical patterns and predictions for large quantities of data without building on or contributing to a growing understanding and knowledge base about collaborative learning.

P: I agree with you that "flat ontology" data mining has little to offer our understanding of collaborative learning. Approaches that provide explanations of actions by referring solely to other actions do not generate new theory and are limited in what they can offer. But computational methods are not limited to dustbowl empiricism; they can also be used to generate and test theory (Wise and Shaffer 2015), particularly when applied to systems that have been carefully designed. For example Schneider and Pea (2013, 2015) designed a system that used eye-tracking technology to allow two distributed learners to monitor each other's gaze (both learners saw the same computer screen with their partner's gaze indicated as a glowing area). They found that the percentage of time that learners had their gaze aligned to the same part of the screen was highly correlated with human-made judgements about the quality of their collaboration and automated measures of the coherence of their talk. This provided empirical support for the notion of joint attention as important in collaborative learning, an extension of the work originally conducted in the context of language

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development in young children (Tomasello 1995). In addition, computational methods offer particular promise for the theorization of the ways in which collaboration unfolds over time (Reimann 2009), which could dramatically advance our understanding of CSCL. Collaborative learning is inherently defined as a process that occurs over time, yet traditionally quantitative research has ignored this character, choosing instead to examine relationships between relatively static input and outcome variables. In contrast, qualitative research has examined learning as a dynamic process, but interpretative methods attend to time as a general idea rather than a precise concept. Computational methods that identify common and consequential sequences of events (Wise and Chiu 2011) thus offer the potential to generate new, precise theories of collaborative processes. Furthermore there is an opportunity with computational methods to move beyond questions of induction and deduction to engage in abductive reasoning that offer explanations to "how" kinds of questions such as "how is the pattern observed brought about?" This requires developing theory that can form the basis for *generative models* that use a set of rules to produce the phenomenon (pattern) as a way of developing an explanation of it. Such a trend of research is still very rare in CSCL, but one good example is the explanation of the emergence of stratified zones of learning in group work by Abrahamson et al. (2007), where the explanation takes the form of an agent-based model.

C: What you describe, in-depth theorization along with the use of advanced computational methods, asks a great deal of CSCL researchers. It also raises the issue that most CSCL researchers were not trained in these computational approaches, so that when they use them they run the danger of doing so naïvely or choosing the simplest version of a technique when complex ones would be more appropriate. Returning to the case of SNA, while a basic network approach produces a descriptive analysis of connections aggregated across time, more sophisticated techniques such as ERGM (exponential random graph models) and dSNA (dynamic social network analysis) allow for inference testing and the study of network evolution over time, respectively. Such methods are rarely used in CSCL, however, where the majority of SNA work employs the most basic set of approaches.

***P*:** Your argument that applying computational methods well is difficult is not a justification to reject them. To the contrary, it is all the more reason why CSCL needs to begin the process of adoption and training sooner rather than later. Returning to my original point, it is in our hands to establish practices and norms around *how* computational methods are used in CSCL. I see this as an opportunity for innovation to develop novel ways that computational approaches can be applied with delicate attention to situational context. For example, we can set standards in our community for the ground-truthing of claims made based on computational analyses that require going back to specific episodes of collaborative activities to examine if the experiential trace bears out our interpretation of the analytics. Furthermore we can require the inclusion of representative examples from the underlying data to help draw connections between the collaborative event and its computational representation. An example of this can be found in Wise and Cui (in review), which traced high node degree and edge weights in a sub-community detected by SNA back to a subset of MOOC forum discussions characterized by expansive questions and peer-coaching activities. Such use of qualitative methods to complement computational approaches might additionally serve as a lever in addressing the current theoretical and methodological gaps in the field (see Provocation 4). CSCL cares deeply about the context in which collaboration occurs. Thus we can also establish best practices for paying close attention to the context(s) of collaboration involved (Herring 2007) in computational analyses such that researchers are able to make principled decisions about what data to combine (see Gašević et al. 2016 for an empirical examination of

the dangers of over-aggregating) and that results can be generalized appropriately. But for these activities to be successful, we need your participation. *Thus my invitation to you is to put aside your well-explicated doubts about the limited insight provided by computational approaches* ***as they are currently used****, to help us explore the uncharted space of* ***how they could be used*** *in ways that you would find valuable.* In addition, I would like to open a discussion with you about the usefulness of computational methods for enabling adaptive support and providing learners with feedback on their collaborative processes using learning analytics.

Provocation 6: learning analytics and adaptive support should be a top priority for CSCL

P: The advent of fine-grained and/or large-scale near-real-time data and computational analysis methods offer benefits not only for our *understanding* of collaboration (see Provocation 5) but also the ways in which we can *support* it. Collaborative learning analytics (metrics, indices, and visualizations of collaborative processes) can be devised to be used as real-time diagnostic aids to support students' self–/co–/socially shared regulation as well as teachers' orchestration. In addition, the results of computational analyses can be used to automatically adapt support for CSCL based on the activity that has occurred and/or characteristics of the individuals involved. Learning analytics and adaptive support have the potential to dramatically advance our capabilities for supporting collaboration by driving human and machine-based adjustments to collaboration-in-progress that are tailored to the collaborating group. It should be a top research priority for the CSCL community in the next five to ten years.

C: While it is true that the opportunities here are great, the move from computational metrics of collaborative learning as research tools to their application in practical contexts with teachers and students is not as straightforward as you suggest (Wise et al. 2015). The threshold of certainty for making recommendations is a high one and we are still early on in understanding how data traces can most usefully serve as indices of productive or problematic collaboration. Even if we were to agree on data-based operationalization of constructs, it can be quite challenging to usefully translate sophisticated models based on clickstream data and eye-gaze saccades to a form that is useful to teachers and students in terms of classroom practices and vocabulary. In the case of learning analytics, "useful" means that teachers and students are able to make sense of the analytics (interpret their meaning in the context of a specific learning context and goals), evaluate the information they provide, and make an informed decision about how to take action based on them. In the case of adaptive support, "useful" means translating diagnostic information into a prescription or recommendation, i.e., creating a pre-determined logic of either how the system will change in response to particular circumstances or how it will suggest that the teacher or students change. Problems in any of these elements will make the tools useless (or potentially harmful), thus it remains to be seen whether these new technologies will live up to the promise you describe.

P: The issues your raise are indeed important to address, this is exactly why learning analytics and adaptive systems for collaboration are critical research agendas to devote our energies to immediately. Furthermore, such practical application of computational methods provides us with a new tool for conceptualizing, studying, and supporting CSCL that is generative in opening up novel and exciting avenues for investigation. For years, the design of (relatively static) CSCL tools has been the field's preferred way to think and led to claims that *globally* some design factor (e.g., assignment of roles) supports some situational characteristics (e.g., positive interdependence) that makes it more likely for a desired collaborative process (e.g., negotiation) to occur. The opportunity to tailor support for particular groups of

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learners creates the potential for much more precise and nuanced claims (e.g., in groups that have previously had an imbalance in the degree of group member's engagement, negotiation by all members can be encouraged by inducing positive interdependence via role assignment).

C: The idea of data traces as a new tool with which to conceptualize CSCL research is intriguing. But there must be a research program aimed at understanding before we attempt to act on these traces. Otherwise we risk having unintended detrimental effects on collaboration, which would be irresponsible. We have not yet answered the question of what are good measures of collaboration and there is a huge repository of possibilities to explore (see Provocations 1 and 5). Beyond agreeing on what constitutes productive collaboration (and there may be multiple models appropriate for different learning contexts), even with the same definition there are many ways to operationalize it in different technical environments. For example, conceptually we may care about learners maintaining joint understanding of a shared problem space, but what is a measure of this on which we would be willing to take action: Would a lack of synchrony in EEGs be satisfying? Would poor coherence in talk as measured by low word overlap? Through asking these hard questions and trying to operationalize our definitions, we will come to conceptualize collaboration better and be forced to be more specific in our claims. It is premature to make recommendations to learners or changes to a system before this occurs.

P: But it is exactly through design that we will come to identify what are good indicators and models of collaboration. Collaborative learning analytics and adaptive systems are new technological innovations that pave the road for new learning interactions. As has happened previously in the field (for example, with tangibles, augmented reality, et cetera) we must design environments for these new types of collaborative interactions to occur in order for them to be studied. For example, adaptive systems can be built to diagnose ineffective peer tutoring approaches (Walker et al. 2014), use individual knowledge profiles as a basis for suggesting peers to help each other with specific kinds of needs (Rosé and Ferschke 2016), analyze group knowledge profiles to select or generate tasks to optimally challenge a group (Hoppe and Ploetzner 1999), and support intelligent group formation to induce particular kinds of collaborative interactions (Konert et al. 2014). Furthermore, analytics can be developed to provide automated feedback to students and teachers on various qualities of collaborative dialogues such as the degree of agreement/disagreement or the mention of task-related concepts (van Leeuwen 2015). They have also been used to alert teachers about critical moments for groups of students working on geometry problems to help them orchestrate students' progression in solving problems (Schwarz et al. under review). Thinking about the future of physical classrooms, learning analytics could be shown to students and teachers through ongoing ambient displays and adaptive support could be enacted through the use of robotic furniture to create an entirely new, responsive, and heretofore impossible kind of collaborative environment (Dillenbourg et al. 2008).

C: I think you underestimate the extent to which such endeavors require an additional knowledge base, beyond that traditionally drawn upon and generated in CSCL work, to be successful. Yes it is a research agenda to pursue, but as a yet-unproven technology, it would be foolish to privilege it above all others; there have been many other seemingly promising technologies that have failed to yield the expected benefits. In particular, this area requires many elements that the field of CSCL has previously not addressed, thus there is a high degree of uncertainty as to what will result. For example, to create learning analytics, first a decision must be made about what metrics to visualize. Here there is a tension between constructs/concepts we define as researchers (and which we show to be related to learning) and the ideas

teachers and students (the end users) have about what is important for effective collaborative learning. There is also the question of which information should be given to students and which should be given to teachers and for what purposes. For example, a teacher may benefit from a dashboard showing a detailed comparison of the depth of negotiation of each group, while students might be better off seeing how their group is progressing with respect to the teacher's expectations. The question of the information provided to students and teachers is not one of either/or, but how it can be best provided to enable "distributed scaffolding" (Tabak 2004) that manages the teacher's load while offering maximum support to collaborating groups. Here we must also be careful that the analytics intended as a form of support do not unproductively distract from engagement in the collaboration itself. In addition, there are important decisions about how to visualize the data. Insights from the fields of information visualization and multimedia learning can provide a foundation, but there is much work to be done to determine what designs are clear, comprehensible, and motivating for learners. It is important to consider both cognitive and non-cognitive components. For example when does awareness of the skills in which you are lacking or how far behind/ahead you are from others cause anxiety or depression and when does it create the desire to improve? (see, for example, Wise et al. 2016). We need to conduct studies in authentic contexts that use think-aloud protocols and interviews to enable us to systematically investigate how students and teachers respond to learning analytics visualizations and adaptive system recommendations and what kinds of reasoning and emotional processes they engage in when provided with them.

P: Yes, this is a wonderful research agenda you have laid out and CSCL is a field well-versed in interdisciplinary collaboration. The concerns you raise are all issues for learning analytics in general, and in fact our field's diverse and deep understanding of learning might allow us to come up with solutions that could inform that field (which has focused primarily on the individual to this point) more broadly. For example, a CSCL approach to learning analytics might highlight effort and improvement at both the group and individual level and draw attention to the ways students improve collectively. For example, following traditions of intentional knowledge-building, analytics are already being designed to help students evaluate promising ideas by letting them use interactive visualizations to explore similarities between ideas and monitor the collective landscape of emergent strands of inquiry (see Chen and Zhang 2016 for a description of these and several other knowledge-building learning analytics in development). Additionally, adopting processes of co-design with teachers and students may be a useful strategy to construct tools that are likely to be adopted in classrooms. Put together, all of this is to say that our field has both the computational and pedagogical expertise (and experience in combining them) to develop the necessary tools.

C: You are very optimistic in your estimation of our abilities. But even if we are successful, such success creates new dangers. For one, there is a serious concern that the operationalized measures become targets in and of themselves, rather than being treated as indices of the actual construct we care about. To give a basic example, higher-quality collaboration is more likely to have extended (longer) turns of talk because this is required for the well-supported articulation of ideas. However, telling a group of students that productive collaborating groups tend to have longer turns of talk than their own is unlikely to produce better collaboration (it may, however, produce longer turns of talk). This is because the length of comment is an epiphenomenon of making a complex and well-justified point — it is thus useful as a measurement proxy for identification, but not causally related and thus an inappropriate basis for action. Even when a metric is more centrally connected to the core phenomenon, rote adherence to behaviors that serve to increase the metric is a potential danger. We must also be concerned with the

unintended consequences of creating these tools. For example, we may create metrics as formative learning assessments to help students improve collaborative interactions over time. However, that does not mean such tools could not be misused, misappropriated, or misunderstood; for example, to make high-stakes summative judgements. Perhaps most importantly, there are serious concerns about data privacy and a potential loss of student agency. Important questions arise here not simply about what kinds of support *can* we provide, but what kinds *should* we provide. With the notion that CSCL often seeks to build not only students' (individual and collective) understanding of specific ideas/content areas but also their ability to learn in collaboration, there is a concern that too much automated adaptation might rob students of the opportunity to self-regulate and learn skills for future collaboration.

P: Yes, questions of privacy and agency must be addressed. One possible answer would be to open up the data/analysis to the learners and to establish a sense of (individual and joint) ownership of the digital traces and their use. In the fields of AIED and ITS, this direction has a long tradition under the name of "open learner modeling" (Bull and Pain 1995; Bull and Kay 2005; Kay 2001). It is also important to remember that if done well, these systems can be used to foster, not supplant self-regulation. It is easy to cynically imagine a dystopian future in which adaptive support for collaboration prescribes actions to be taken without explanation, nuance or flexibility; however, a more progressive vision is also possible in which the system is based on a transparent model of collaboration, offers alternatives rather than dictum, and the teacher is empowered to select or reject the system's recommendations (Rummel et al. 2016).

C: You seem to want both the benefits of artificial intelligence and the ability to disregard it. But this is not possible. We think that if we know something is good for us we'll do it, but research on health, exercise, and eating habits all suggest otherwise. If students and teachers are given license to just ignore the information of recommendations provided, then why bother to provide them in the first place? Either we develop systems that reliably guide collaboration or we should scrap the whole enterprise.

P: The world is not as black and white as you would have it. We can develop systems that are quite good most of the time, but there will still be situations where unanticipated factors come into play or the information we have to draw on is incomplete. A system does not need to be perfect for it to be useful, and in fact the recognition that a system is not perfect should support more thoughtful use. The expertise of the teacher is thus a critical resource in making the necessary judgements and they take on the responsibility as a collaboration engineer, with the analytics or adaptive system as an aid. While you seem concerned that the tools will have too great an effect on teachers and students, the more likely problem is the reverse. We know that students already have difficulties regulating their collaborative processes and teachers are often challenged by the heavy load required to orchestrate collaborative classroom activities. To actually change behaviors, students and teachers need to be able to not only understand why patterns in the data are there and what is causing them but also be emotionally invested to put forth the effort to change and feel the change will make a difference. They also need to have trust in the system yet be aware of the limits of the information it provides and the potential fallibility of its recommendations so that they can intelligently appraise how to act rather than following it slavishly. This becomes a "didactic contract" around the role of the tools; one that needs to be investigated in-situ through ethnographic studies that describe the uptake of this new class of technology into the culture of the classroom and document how they act as an artifact that is used by teachers and students to support group work and make meaning. *In the end, the reason we do not see eye-to-eye is not a question about the possible value of learning analytics and adaptive systems to support collaboration (I think you agree*

that the potential here is great), but rather the path by which such a vision should be pursued. You cautiously recommend that we focus first on increasing our foundational knowledge about computational approaches, while I suggest that we must build support-oriented systems in order to study and understand them. In particular, I feel very strongly about the exciting possibilities for applying computational methods to practical issues such as orchestration. This direction brings CSCL research back to the classroom, making it relevant to educational practice. However, I should confess that I am worried that attention to formal schooling is not enough. Thus I now raise a new concern for us to consider: that CSCL research risks becoming irrelevant because it does not sufficiently address the deep technological/cultural changes that society is undergoing and the corresponding expansion of venues in which collaborative learning occurs.

Provocation 7: evolve or become irrelevant

P: The field of CSCL has been too restricted in the collaborative learning environments that we investigate. While other research communities have begun to investigate learning among people in various social networking and large-scale learning environments, CSCL has largely eschewed these sites as data sources for our research, focusing instead on tools of our own design. While principled in theory, this choice leads us towards being an insular community on the outside of important debates about learning with others in the digital age. Our field must expand the scope of its investigations to include social media and large-scale learning environments or we will become provincial, and others will reinvent methods and ideas without us to study one of most central and revolutionary changes in human communication — the change towards a collaborative mode.

C: I am not convinced that social networks and large-scale environments are always sites of collaborative learning. For many years, the CSCL community has held a high standard for what can be considered collaboration; if we expand our study to environments that were not designed with any vision of collaboration in mind and there is not necessarily a meaningful persistent "group" to talk about, you are implicitly suggesting that we loosen the criteria for considering something as collaborative activity. This creates a risk of eviscerating the core that binds us together in a joint endeavor: that of trying to understand the phenomenon of collaborative learning as a scientific object of study about which we can build an increasingly informed knowledge base.

P: Here you rely on the exact point I made earlier when I criticized research in CSCL in which tools are designed for collaboration but the actual presence of collaborative processes is often not checked (see Provocation 3). The difference is that I did not eliminate any environments as inherently incapable of being sites of collaboration, but argued for precision in defining collaboration and empirically verifying that is has occurred. I concede that social networks are different from tools specially designed for collaborative learning. But we have mentioned earlier that a plurality of tools opens the door to a plurality of forms of collaborative learning (Stahl et al. 2014; see Provocation 1). One form is *knowledge-building*. It has generated over a decade of study of students' small group collaborative interactions; however, it was grounded primarily in theories about *individual* expertise and how *communities* develop collective knowledge. Intersubjective meaning-making in *small groups* is another form. CSCL tools have also afforded more specialized classes of collaboration; for example, in the forms of argumentation or of shared inquiry. The question is not whether we should include social networks in our research. Of course, we should. The issue is to identify and characterize cases

of collaborative processes within them that might look different than a small group intensely working on a joint task. For example, affordances of social network platforms such as iconic (re)presentation and negotiation across distributed interactions support the exploration and performance of identity as part of a process of learning through becoming (boyd 2014; Davies 2007). Schwarz and Caduri (2016) studied this in an educational context as students progressively developed identities through the enactment of disciplinary practices in the roles of scientists or historians on Facebook. Other forms of collaboration can be seen in the interactions of large-scale publics in which the players may change but collective narratives are developed. For example, Ziegler et al. (2015) documented the ways in which tensions between competing values of an online hiking community ("be prepared" versus "travel light") were negotiated through forum dialogue. Similarly, Introne et al. (2017) explored how pseudo-knowledge was collaboratively constructed over time as a process of participatory storytelling. Another form of activity seen in both social networks and large-scale learning environments is sharing practices. Asterhan and Bouton (2016) observed that school-related knowledge sharing is widespread across peer-networks (motivated by prosocial motives and expectations of future reciprocation) and question-asking and -answering are a common practice in MOOC discussion forums (Rosé and Ferschke 2016).

C: It is one thing to say that collaborative learning can exist at multiple levels, but quite another to say that the extremely various forms of social interaction that occur in digital environments should all be considered as collaboration. I agree that it is important to be inclusive of other contexts and widen the scope of CSCL research, but if collaboration is to mean anything, we cannot water down or abandon the definitions we have created. Instead, we should ask *if* there is collaboration (based on current definitions) in these contexts. If so, we can then characterize if it occurs only in small groups within the larger whole or across a larger scale. We can also ask if learning in these contexts is a weaker level of collaboration or if it exists with the same strength (or stronger) than we have seen in small groups. For example, I might accept social identification as a new aspect of collaborative learning, but I do not think that information sharing meets the threshold for what can be considered as collaboration. As for large public construction of collective narratives, I wonder if we can consider them as collaborative when the "group," which is so central in CSCL, cannot be defined.

P: I agree that we should not simply discard our current definitions, theories, and frameworks, but we also must be open to the presence of *new* phenomena. The existence of social media and large-scale interaction environments create the potential for forms of collaboration, which were not possible previously and go beyond the traditional model of well-formed small groups. It is true that in many of these open contexts people not only communicate with others they do not know but do not necessarily know with whom they are communicating. However, what is fascinating is that even in the context of these unknown and undefined others to whom one's senses of responsibility may be limited, rich and varied dialogue can indeed occur. New theory and constructs are needed to understand these new mass forms of collaborative learning. For example, one concept used in social media research to consider who is being talked with when the group is not fully known or defined is that of "imagined audience" (Marwick and boyd 2011). We might theorize and test the value of similar constructions from a collaborative perspective; for example, the notion of "projected uptake" (Rathnayake and Suthers 2017). Similarly, while a single person sharing information with another may not merit our attention, understanding how information flows and evolves across a distributed network and how groups come to construct this information as fact or fiction are complex and highly relevant questions. These environments also allow us to study constructs we

already know are important but have been limited in our ability to study empirically; for example, people's changing participation in the changing practices of a community over extended periods of time.

C: It seems you are arguing that our field should expand its considerations to informal learning environments as a new area of study, but research has already been going on in this area for many years. There have been extensive studies of environments such as Math Forum (Stahl 2009), Scratch (Kafai et al. 2009), and TappedIn (Schlager et al. 2002), which were designed to support precisely this end. The designed nature of these environments is important because collaboration includes a level of intentionality that is either defined by participants themselves or by the tasks that are set to them.

P: It is true that these environments offer space and tools for collaboration, rather than imposing it on people. But they still operate very much as school-like contexts in which there is clear, pre-determined content to be learned. Studies of truly informal environments, in which what is learned is determined by the participants themselves, are rare in CSCL. However, they are being extensively researched in neighboring communities such as Computer Supported Cooperative Work, Association of Internet Researchers, Social Media and Society, Learning Analytics, Educational Data Mining, and Learning at Scale. In addition to the examples given above, there is work that seems highly relevant to the concerns of CSCL; for example, on what qualities of messages are likely to bring new participants into a microblogging discussion space about policy issues (Hemsley et al. 2017) and how expressions of agreement and disagreement affect people's re-evaluation of opinions during democratic deliberation (Stromer-Galley and Muhlberger 2009).

C: There are good reasons that our community has generally not studied what goes on in these "truly informal" environments. First, there are challenges in studying learning when what exactly is to be learned is not (explicitly) known or stated ahead of time. In particular, there is a danger of assuming that *something* must be learned in these environments, and then setting out to document what it might be (see Provocation 3). Second, our community has had a strong focus on understanding collaboration through its design. These are environments that often fall completely outside of our control and to which we can only gain access post-hoc, which imposes limits on the data we can collect, the methods we can apply and, critically, the kinds of inferences and claims we can make. I am not convinced that expanding our focus to make descriptive claims about environments we did not create (and for which we may not know the full set of factors involved) will make a substantive contribution to our understanding of collaborative learning. Even if it could, we would need to find a way to draw conceptual connections between designed and purely analytic accounts; without this, we may develop a schism and the cumulativeness of the field could be lost.

P: You attempt to draw a clear distinction between formal and informal learning, but the omnipresent use of social media has blurred this distinction (Schwarz et al. 2017). Students discuss homework on Facebook and bring ideas they learn on Twitter into the classroom. This is the new world in which the CSCL community needs to redefine itself, even if we were to still take "school learning" as our focus. I am sincerely afraid that we are isolating ourselves. Of course, your concerns about losing the center of our field are understandable; clearly defining our scope and major objectives is important in retaining a sense of what is special and unique about CSCL. I have heard it argued in recent years that there is little to differentiate CSCL from LS more generally. Yet CSCL is distinct in its attention to the *processes* of meaning-making in contexts of *joint activity* as mediated by *available artifacts* and its overarching concern with drawing connections *across levels* from *small group* interactions

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up to *community* practices and down to *individual* phenomena (Stahl et al. 2014). Our decisions about the range of phenomena we consider and focus on should reflect these traditions. Traditions are important but they also need to be reconsidered in light of deep societal changes. I think that one tradition should be revisited — the primacy of tool design as a route to understanding collaborative learning. We should seek to understand collaboration both in the context of tools that were designed for this purpose as well as those that were not. In addition, although much of the research focusing on social media and large-scale learning environments does not currently engage in design-based work, there are signs that this may change. In his discussion of the future of MOOC research, Reich (2015) points out the need to nurture experimentation with domain-specific designs. Similarly, the well-documented challenges in social media of uncivil interactions, harassment, confusion, and mistrust (e.g., Duggan 2017; Rainie et al. 2017) have led to attempts to devise socio-technical tools to address these issues (e.g., Wang et al. 2013). If we feel that many of the interactions that occur "in the wild" could be improved then this is a call to build better tools. Questions about how we can design these large-scale contexts such that we can nurture collaboration represents an opportunity for us to bring our designer's toolkit to bear in a productive way in these spaces and have a powerful influence on society. Of course, while we can offer value to such environments, we must remember that their nature and attraction comes from being user-driven and open. Thus we must be careful not to impose such constraints on interaction that we destroy the very thing that makes these environments flourish.

C: Very well, I can agree that perhaps it may be time to expand our focus to consider collaboration in environments not specifically designed for this purpose. It may also be possible for us to stay relevant by sharing valuable ideas with other scholarly communities who study how people interact in these new spaces, without having to take them on as a focus of our own. This would mean both sharing our work with the communities discussed above and making it attractive for these researchers to share their learning-related work with our community.

P: Since you agree that it may be time to extend our focus, I will push a bit further. Beyond social media and large-scale learning, we should also include in our studies immersive games in which collaborative action occurs spontaneously and the workplace, where collaborative competencies are recognized as a necessity. There are also streams of work looking at collaboration with robots or agents that could be greatly extended. Furthermore, the emerging tools of virtual reality and augmented reality can inspire new genres of collaborative interactions and thus should be added to the list of environments that we should be researching. Additionally….

C: Stop already! I may accept your argument for why any one of these new technologies could be of interest to CSCL. But put them all together and you have a very scattered "field" in which little collective progress will be made. If we are to expand our scope, we need to reflect as a community on a constrained number of new directions that are coherent in some way and thus can constitute the major objectives of CSCL research. *In considering such choices I know that you see conducting research on social networking and large-scale learning environments as contributing to our relevance and impact, but I maintain that descriptive accounts of these informal environments over which we have limited control will not substantively contribute to our ability to understand and support collaborative learning.* I remind you that the CSCL community was initially committed to collaboration in group-work as a practice aimed at educational change. We should consider technologies only from the perspective of educational change.

Provocation 8: CSCL should give up on educational change

P: I am happy that you mention the initial commitment of the CSCL community to educational change. However, you should concede that issues of scalability and sustainability are far beyond the present scope of what is actually addressed in CSCL research. We should be upfront in acknowledging that the CSCL community no longer aims at educational change and has given up this initial ambition.

C: You go too far. The first projects that inspired the CSCL community — ENFI, 5thD, and CSILE — aimed at countering models of direct instruction to better meet the socio-cognitive needs of students. For example, the ENFI project focused on finding new ways of teaching writing to deaf students, through the development of some of the earliest forms of chat and social networking capabilities while 5thD aimed at creating a rich collaborative environment to help develop cognitive and socio-emotional skills that could scale (Cole and The Distributive Literacy Consortium 2006). CSILE/Knowledge Forum also used technology to counter traditional instructional norms. It decentralized information and authority over learning by providing students with opportunities to share their own conceptualizations of learning topics in order to build new knowledge with others and take ownership over this process (Scardamalia 2002; Scardamalia and Bereiter 1993). These early projects lay the foundation for changes we see reflected in formal and informal learning today: a greater emphasis on peer-learning networks, learner-driven inquiry, and discussions among small and large groups. The same spirit that inspired our community 20 years ago is still present, but we are now in a different time and place, thus the projects now take on a new character. Still this spirit fuels our goal to promote educational change by bringing to the fore collaborative practices.

P: I think you are fooling yourself if you believe we have moved closer to this goal. To the contrary, we ourselves have charted a path away from it. As you remember, one of the first intentions of the CSCL community was to provide evidence for the effectiveness of a collaborative approach. However, the implementation of collaborative settings was disappointing, as it proved to be very often ineffective regarding learning domain content (Barron 2000, 2003; Hogan 1999a, b; Webb and Palincsar 1996). These problems led many researchers in CSCL to constrain and script collaborative activity so as to help students better engage in expert discourse practices and promote deeper learning of domain content. Scripting succeeded in supporting the learning of domain content but shifted the focus of CSCL from a group-centered knowledge creation approach to an individual-centered knowledge construction approach (in a collaborative setting) since scripting aims at supporting individual acquisition of uniform knowledge constructs (Kollar et al. 2006). Thus the remedy to the challenges of learning through collaborative activities created a gap from the ideological aspirations to counter traditionally, individually focused instruction.

C: Uncovering the difficulties that students have in collaborating and the elaboration of sophisticated instructions to overcome these difficulties is a fascinating enterprise at the very heart of CSCL. There is always a tension between idealistic educational visions and what students do, but this does not mean that we should alter the vision. Collaborative settings were not originally chosen because CSCL researchers hypothesized that they would always be superior for learning domain content but because of pedagogical and ideological considerations related to the emancipation of learners as agents of their own educational destiny (Schwartz 1999; see Provocation 2). Many of these aims, such as the capacity for self-directed learning, the ability to persuade others, and being open to changing one's mind, are now coming to be seen as valuable educational ends unto themselves (Collins 2017). Today,

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when twenty-first-century skills are a very high priority on the education policy agenda, we can design studies that show how such skills can be fostered and enhanced. Furthermore, in the age of the internet, it can be said that knowledge is constantly in development through dialogue in which there is uncertainty and multiplicity of perspectives (Wegerif 2013). Being able to listen and remain in a state of potential is crucial to good creative thinking. An emerging goal for CSCL then becomes how to help people effectively engage in the process of thinking and learning together in a way that opens and expands the dialogic space. This aim is more relevant than ever and could lead to impact of a different form: the collective worldwide intelligence that comes from global dialogue among participants. This is a dialogue among people who have a capacity to listen and be open to new ideas such that they are able to allow themselves to see things from other people's points of view and be led by the force of good arguments. As for the focus on the individual in the group, this is an acceptable approach within the pedagogical vision; although collaborative settings are implemented collectively, it is reasonable and important to also evaluate individual gains.

P: You describe a so-called increase in the "collaborative" character of formal and informal learning practices, but this is not a product of our own doing and in fact the character of the group-work that happens in schools and across social media is generally quite far from the ideals of collaborative learning as a process of inter-subjective meaning-making or dialogue. The CSCL community has mostly constrained its interest to relatively short-term implementations in small-scale and highly designed/constrained contexts with the assumption that this work could unproblematically be scaled. Instead of taking the complexity of the class as a given and focusing on ways to adapt the use of CSCL tools to this complexity, the contrary happens: researchers find ways to propose activities that interrupt what is generally done in educational institutions and that look like experiments rather than real forerunners of change. But the true relationship between research and practice is more indirect and complex. For this reason CSCL research has not been a major source of inspiration for the ways in which collaborative interactions have been introduced into classrooms and large-scale social media. Furthermore, experiments rarely take place in classrooms where 20–30 students are at the same place, and when they do, they are conducted with enthusiastic teacher partners who are far from the norm. Thus, CSCL has neglected to study collaborative learning in its most natural educational contexts.

C: This is not true. A new domain in CSCL research focuses on orchestration. This focus is the consequence of a growing awareness that teachers are indispensable for the effectiveness of the collaborating learning technologies. The evolution of our community produced new pedagogical scenarios (also called macro-scripts) that integrate team activities with individual activities and class-wide activities. Conducting such a scenario requires the teacher to be very active in running the class-wide activities, managing the transition between activities, and regulating the whole sequence. This classroom task, which led to the metaphor of orchestration, is very demanding. While daily classroom constraints (such as discipline, time management, or teacher energy) were at first viewed as mere implementation issues, recent work has begun to take these into account as the classroom is considered a system (Dillenbourg 2013). Theorizing orchestration of the classroom as a system takes into consideration authentic collaborative learning process challenges and their management by teachers. Another burgeoning direction in CSCL research that may influence educational practice concerns the domain of trajectories of participation and learning across consecutive activities and sites (Ludvigsen et al. 2011). In particular, we can point to the identification of key (or "pivotal") moments in interactions (Damşa and Ludvigsen 2016; Suthers et al. 2013). These are an

action, or sequence of actions, at the epistemic level that trigger subsequent actions and lead to a particular development regarding the shared object. Curiously enough, this complicated idea is easily translatable for practitioners as moments the teacher should recognize and attend to. CSCL tools (in particular those providing learning analytics; see Provocation 6) may enable teachers to peruse group-work to identify such moments and act on them in real-time or reflect on them with students after the fact.

P: The study of orchestration is certainly an interesting research path in the CSCL community. However, this path does not consider the classroom as a practical context. To the contrary, the complexity of the classroom is treated theoretically as edges and workflows, while orchestration graphs are defined to model the role of the teacher in changing settings in consecutive activities. As in the case of scaffolding collaborative learning with CSCL tools, the rare studies in which orchestration-in-practice is described constitute proof-of-concept systems. Similarly, your discussion of key moments is interesting but describes a potential application of our ideas, not one that is being actively pursued in classrooms with teachers. Simply put, the CSCL community leaves the job of scaling up and sustainability to other research communities. But the lack of attention in teacher preparation programs to both collaborative learning and technology somewhat dooms these prospects. In short, the CSCL community does not choose to undertake the actions that would aim its efforts directly at educational change.

C: To say this ignores several notable efforts in our community. First, there were large-scale case studies undertaken in Hong Kong and Singapore (Chan 2011; Law et al. 2013; Looi et al. 2011), though I concede that these studies are exceptions. However, the contribution of CSCL research to the educational realm is also to produce models and compelling examples that can create the foundation for development of practices that function as boundary objects and semiotic resources across levels and time. Indeed, according to the PDS (Professional Development School), model teachers learn across sites (in programs and in schools), as models presented in the program are capitalized on in classrooms and reflected on in the program (Darling-Hammond 1994). At an institutional level, collaboration is presented and recognized as an important twenty-first-century skill (Ludvigsen et al. 2011) and in 2015 the OECD (Organization for Economic Co-operation and Development) built a framework for evaluating students' collaborative problem-solving skills as part of PISA (Programme for International Student Assessment) that drew actively on the input of some of the leaders of our field (OECD 2016). Also, in many countries, collaborative problem-solving in digital environments has become part of the curriculum. In particular, design tasks have become popular in several countries. For such tasks, collaboration arises as a necessity in order to undertake the task, instead of coming from a script imposed by the teacher.

P: What you describe here are general recommendations about the importance of computer-supported collaborative learning rather than specific detailed impact about how it should be done. This means that the vast majority of our research is irrelevant to educational practice beyond providing broad support for policy. The end result is worse than simply being inconsequential, it means that "collaborative learning" grows in importance, but as a hollow term — a buzzword for good intentions on which everybody agrees — that is not backed with the necessary know-how to implement it in schools (see Provocation 3).

C: I concede that the tangible impact of CSCL on educational practice is very small so far. But this suggests that we must realign our effort, not abandon our very raison-d'être. We also must recognize that this is a goal we cannot achieve alone and build partnerships accordingly. To palliate the weakness, we need four parallel efforts: 1) design-based research that

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investigates student learning through CSCL within and across domains for at least 3- to 6-month periods; 2) research that engages in meta-analysis that can provide the field of education with valid and well-supported recommendations about what works; 3) design-based implementation research (Fishman et al. 2013) that develops research–practice partnerships to investigate how to introduce and sustain CSCL practices in ways that address persistent problems of practice; and 4) longitudinal research on how sustainable and scalable practices of CSCL can transform the dynamic social and knowledge practices that define classroom life (Hakkarainen 2009). High-quality studies that use qualitative methods are equally as important as large-scale quantitative studies conducted from a policy perspective. The small-scale studies provide models for how and what to do in practice, while large-scale studies provide evidence of what works. Beyond these research agendas, we also need members of our community to act as liaisons to school systems, teacher preparation programs, and governments. There are isolated examples (illustrated above) that show the path by which solid conceptual and technical methods can get accumulated in meta-analyses and systematic reviews that then inform policy briefs. While it places an additional burden on our community, it is critical for more of this non-traditional academic work to occur if we are to have an impact in the world.

P: Your answer is quite embarrassing. It is directed to the future, to what should be done. It resembles the general discourse in the first days of the introduction of computers in the educational system. The CSCL community was established over two decades ago. I would have expected a more tangible impact on educational practice than general recommendations or what "should be done" research programs. Whether it is due to a failing on our part or the intractably conservative nature of public education (Collins and Halverson 2009), perhaps we should concede that CSCL is not likely to have the large impact that we envisioned.

C: The main contribution of the CSCL community to educational change so far is foundational. Our field's founders have replaced old metaphors (transmission, acquisition) with new ones (participation, co-construction, co-creation). This is a revolution in the world of learning. Beyond the replacement of the old metaphors, the CSCL community has brought new and forceful ideas into existence (Stahl et al. 2014). For example one powerful idea that helps to overcome the distinction between what is in the mind versus what is in the world is the notion of defining artifacts as physical objects created by people to embody human meaning. Another is the idea that meaning is not created only in the mental processes of an individual, but through joint activity, typically in accordance with established social practices. The centrality of design in meaning-making — how to design artifacts of collaboration media, representational guidance, group interaction, and pedagogical approaches to promote collaborative learning — is another revolutionary idea that our community elaborated. Yet another notable contribution is the identification of the different kinds of *learning communities* that have been envisioned (knowledge building communities, communities of practice, expansive learning community, et cetera). While these contributions might be dismissed as merely theoretical, the ideas and vocabulary we have to work with shape our cognition (Lakoff and Johnson 2008) and thus their impact on how practitioners (and researchers) think about learning should not be underestimated.

P: The new metaphors enable us to envision new ways of learning. This is very important but the reality in schools is largely unchanged. We should be honest with ourselves: if we have not managed to achieve any measurable impact by this point, why should we believe that we will be able to do so in the future?

C: Your framing of this question as one of our impact *on* schools reveals the hubris of researchers who believe they have all the answers to share with teachers and nothing to learn in

return. The history of educational technology has shown again and again that attempts to impose the ideas or tools of external experts on teachers and students rarely goes as planned and is often quite unwelcome (Cuban 1986, 2001). As a field we *should* care about stimulating change in educational practices, but we cannot achieve this ambitious goal only by ourselves; we need to work together with teachers and school systems. I have in mind the growing movement towards developing research–practice partnerships (RPPs) and especially design-centric research–practice partnerships (DC-RPPs). DC-RPPs are long term collaborations that aim to design resources for use in schools with the school systems as partners, while simultaneously advancing theoretical understandings (Coburn and Penuel 2016; Kali et al. in press). They offer an excellent way to enable CSCL innovations to be taken up at scale, while also assuring that we develop ecologically valid innovations. This involves a family of approaches that connect basic and applied educational research in, on, or through design, including design experiments, design-based research, design-based implementation research, and educational design research (Collins 1992; McKenney and Reeves 2012; Penuel et al. 2011; The Design-Based Research Collective 2003). Conducting such research within DC-RPPs is a challenging task. To help overcome typical challenges, Kali et al. (in press) articulate nine design principles that can support DC-RPPs. For instance, one of the design principles ("change laboratory habits-of-mind") guides DC-RPP leaders in how to carefully question accepted practices in schools and analyze problematic situations as a basis for cultivating the "revolutionary" stance required for leading profound changes within an educational system. Thus the question of the impact of CSCL on education is reconceptualized from a problem of how to scale-up pre-developed tools and practices to one of working systemically with educational institutions to develop scalable and sustainable approaches to collaborative learning.

P: This model of (design-centric) research–practice partnerships is a very interesting model for effecting systemic educational change. But in conducting our design work in the messy world of classrooms and school systems and entering into a true partnership of negotiation with these stakeholders, we sacrifice some degree of control over them. This can muddy the instantiation of theoretical ideas, making the kinds of knowledge claims that can be generated quite different than those currently pursued in the community. *Thus we are faced with a choice between continuing with theoretically sound studies controlled by CSCL scientists that do not lead to educational change and shifting our work to studies that aim at educational change, but in which CSCL scientists are not the only stakeholders.* The second alternative has hardly been explored and risks not leading to proper research. But the possibility for CSCL researchers to be part of an attempt at real educational change is worthwhile enough to justify the undertaking.

Conclusion: to where from here?

The conversation between the Provocateur/Provocatrice and the Conciliator has come to an end for the moment, but the issues they have raised about the future of CSCL are yet to be resolved. It is not our role to prescribe solutions to such complex issues, ones that speak to the core of our shared endeavor. We hope that the community will take up these provocations, questions, and tensions in conversation with each other and within themselves. We stress that during the writing process at different times we (Baruch and Alyssa) each identified with each of the protagonists (P and C), and that for each provocation both perspectives have valuable

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contributions to make. Importantly, while there were many moments in which we disagreed, each of us remained open to listen to the voice of the other as we tried clarify our thinking. We always attempted to keep in mind that the fundamental issue is not about one view or the other "winning" but figuring out the most reasonable and productive way for the community to move forward. We end by stressing the urgency and importance for the community to take immediate decisions and action on these questions, especially those concerning the two last provocations: our so-called insularity and relationship to educational change. Our future as a scientific community — our very existence and identity — depends on it.

Acknowledgements We are extremely grateful for the strong support and contributions of the CSCL community to this project. The following individuals all gave kindly and willingly of their time and thinking (though we alone take responsibility for the final product and ideas ultimately represented here): Michael Baker, Marcela Borge, Allan Collins, Ulrike Cress, Pierre Dillenbourg, Yannis Dimitriadis, Frank Fischer, Cindy Hmelo-Silver, Yotam Hod, Ulrich Hoppe, Sanna Järvelä, Heisawn Jeong, Yael Kali, Timothy Koschmann, Sten Ludvigsen, Kristine Lund, Miguel Nussbaum, Peter Reimann, Carolyn Rosé, Nikol Rummel, William Sandoval, James Slotta, Gerry Stahl, Daniel Suthers, Anouschka van Leeuwen, Rupert Wegerif, and Jianwei Zhang. In addition, we particularly wish to thank Carolyn Rosé and the CSCL Committee within ISLS for the initial idea and instigation of the work, Nikol Rummel for the opportunity to share and receive feedback on these provocations-in-progress at CSCL 2017, and Sten Ludvigsen for being open to this somewhat unconventional form of scholarship and facilitating its review.

Full list of the themes used as prompts in the email interviews

Theme 1: support tools

One of the most spectacular achievements of R&D programs aimed at facilitating Collaborative Learning is the elaboration of new practices that are difficult or impossible without the creation of dedicated technologies. CSCL tools enable the creation of shared spaces in which people inquire together. With these tools, our field's founders have envisioned the constitution of communities and have revolutionized the world or learning: old metaphors (transmission, acquisition) have been replaced by new metaphors (participation, co-construction, co-creation) and new practices have been enabled by CSCL tools. The kinds of learning communities that have been envisioned (knowledge building communities, communities of practice, expansive learning community, et cetera) are intimately linked with the promotion of CSCL tools. An evaluative appraisal of these notable achievements and areas for future work is needed.

Theme 2: (scripting of) collaboration and argumentation and learning gains

The promotion of CSCL tools has led to the enactment of a profusion of collaborative practices (collaborative inquiry, on-going planning, peer assessment, et cetera). Also, argumentation that had been often seen as a confrontation was conceptualized as a collaborative activity with the elaboration of CSCL tools since disagreements are eventually resolved in a shared space. Novel argumentative practices are also multiple (text-based argumentation, summarizing discussions, co-construction of arguments, et cetera). Participation in collaborative and/or argumentative activities is prompted by scripts. An abundant literature shows how scripts and ontologies entail collaboration and argumentation. However, researchers have questioned the productivity of these ontologies and scripts during and after interaction. An update and critical assessment of this exciting area of research is needed.

Theme 3: dialogism & democratic talk and equity

The enactment of collaborative and argumentative practices is a remarkable achievement in CSCL but the community is not always fully aware of the ideational repercussions of such a success. The CSCL community has first seen the beneficial role of collaboration from the point of view of preparation to adult life at the workplace, or from the point of view of learning gains. The ethical dimensions — dialogic and democratic, have not been brought to the forefront nearly as often. Terms such as "democracy," "dialogism," or "intersubjectivity" are borrowed perhaps too easily from the philosophical realm in our community without true alignment to the underlying principles. The idea of equity can be critiqued as mere lip service. The articulation [philosophy (of education) ➔ theory ➔ educational practice] can be crucial in the case of CSCL and this articulation should be highly critical and not only top-down.

Theme 4: scalability & sustainability in authentic environments

The successes in the enactment of novel CSCL practices have been found in contexts in which small groups of students interact often in highly designed/constrained learning environments. The orchestration of collaborative work by a teacher in real classes is quite rare. The impression is that the use of CSCL tools has not been studied sufficiently in authentic contexts. Instead of taking the complexity of the class as a given and focusing on ways to adapt the use of CSCL tools to this complexity, the contrary happens: researchers find ways to propose activities that interrupt what is generally done in educational institutions and that look like experiments rather than real forerunners of change in educational contexts. In this situation, issues of scalability or of sustainability are out of scope in CSCL studies. The issues of scalability, sustainability, and authenticity are critical for the CSCL community if it aims at being relevant to educational change. Here also, an appraisal of what has been done (regarding authenticity) and whether the issues of authenticity, scalability, and sustainability are in the scope or beyond the scope of CSCL needs to be addressed.

Theme 5: workplace learning

Although the terms CSCL and CSCW allude to germane fields, so far, the CSCL community has marginally inquired how CSCL tools can be capitalized in the workplace. This is quite surprising since, in contrast with the school context in which collaboration is proposed or imposed in order to provide a novel setting for learning tasks, collaboration at the workplace is recognized as a necessity. The field of vocational education, which could have represented a bridge between CSCL and CSCW, is underdeveloped too. Studies in CSCL in workplaces or in vocational education are rare. We need to reflect on what has been done so far, and on whether this direction should constitute a major objective to the CSCL community or if it is outside of our primary scope.

Theme 6: computational approaches to understanding collaborative learning

Manual examination of collaborative learning in the form of discourse analysis, content analysis, and the like has been a foundation of CSCL research for many years; however, the emergence of new (and larger) datasets in combination with the increased accessibility of sophisticated computational analytic techniques (for example, data mining methods, SNA, and

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NLP just to name a few) have opened a new world of possibilities for CSCL methods (both in terms of coding and modelling). Key questions to consider here include how and when such methods are warranted and how they can be applied in theoretically thoughtful ways, questions about the ground-truth of claims, and how such new methods can articulate with, and both inform and be informed by existing manual and qualitative approaches. There is great opportunity in our ability to look in fine-grained ways for complex patterns that might never be detected by hand. There is also danger that the power of computational methods used across large quantities of data without close attention to the context(s) of collaboration in which it was collected or purely atheoretical approaches that produce empirical predictions but are not able to build on or contribute to a growing understanding and knowledge base about collaborative learning. Attention must also be paid to collecting rich and robust data sources in both virtual and physical environments (e.g., via eye tracking, motion capture, et cetera). There is a need to consider where and when such computational approaches are appropriate and how they should articulate with the existing set of approaches used in the field.

Theme 7: moment-to-moment meaning-making (microgenesis) and multi-level temporality

A spectacular and now classical achievement CSCL researchers have undertaken is the fine-grained observation of moments of interaction to describe and define learning processes in collaboration as moments of meaning-making. These are usually moment-to-moment observations that lasted seconds, minutes, or hours. However, another scale of time is badly missing in most CSCL studies — to include observations that encompass weeks or months of use or activity (though there are a few notable exceptions). It seems, however, that since learning and collaboration occur over time, the very expensive microgenetic methods are difficult to apply when considering the intertwining of scales of time to understand learning and development through the use of CSCL tools. While in the past quantitative approaches in CSCL have overwhelmingly relied on aggregated analyses that ignore or smooth out the occurrence of patterns over time, a variety of new quantitative methods that are temporally aware are now available to researchers — examining both flow and sequence. While again this presents exciting opportunities to understanding critical and common patterns in collaborative learning, it also requires the use of sophisticated modelling methods that are new to many CSCL researchers. The relative value of the different approaches to studying collaborative learning over time needs to be assessed and priorities set.

Theme 8: collaborative learning analytics

Building on the sophisticated computational analysis approaches discussed above, this theme refers to the growing field of analytics for learning; that is, devising metrics, indices, and visualization of the learning process that are useful not only to researchers in understanding collaborative learning but can be shown back to learners (and teachers) as a real-time diagnostic aid to support that very collaborative learning activity itself. This can be used to support students' self−/co−/socially shared regulation and teacher's orchestration. While opportunities here are great, the translation of sophisticated models and metrics to a form that is useful to teachers and students in the classroom is non-trivial. Questions of how non-researchers can both make sense of the analytics (interpret their meaning in the context of a specific learning context and goals) and take action based on them require an additional

knowledge base beyond that traditionally generated in CSCL work. Goals and focus for the creation of CSCL analytics, and perhaps basic questions of if and how this is worth doing, need to be addressed.

Theme 9: adaptive support for CSCL

Similar to the prior theme, the results of computational analysis can be used to create automatic adaptations to CSCL based on the activity that has occurred. This can be thought of in terms of responsive scripting, et cetera. Important questions arise here not simply about what kinds of support *can* we provide, but what kinds *should* we provide. With the notion that CSCL often seeks to build not only students' (individual and collective) understanding of specific ideas/content areas but also their ability to learn in collaboration, there is a concern that too much automated adaptation might rob students of the opportunity to self-regulate and learn skills for future collaboration. In one sense this might lead us to ask whether we see the future of scripting as a scaffold to eventually be faded or a performance support tool to be used in perpetuity. When and how adaptive CSCL support should be given and what it should look like are open areas for debate.

Theme 10: expanding contexts and definitions for collaborative learning

While for many years the CSCL community has held a high standard for what can be considered collaboration (e.g., variations on the definition as a persistent attempt by a small group of learners to maintain a shared problem space), emerging work in the field has looked in more varied contexts and with a somewhat broader definition of collaborative learning; for example, large-scale learning environments such as MOOCs, social networking, gaming, and mobile contexts in which environments were not designed with any particular vision of collaboration in mind and there is not necessarily a meaningful persistent "group" to talk about per se. There are important questions to address here about whether such environments are of interest to our community and if so, does this carry implications for a loosening of the criteria for considering something a collaborative activity. Alternatively, perhaps our community might hold to the existing definition of collaboration but expand the framing of our interest to also include learning in such "social contexts" more broadly. A third option would be to not concern ourselves with these new environments, though this raises questions about our community's ability to impact the world.

Theme 11: methodological diversity in CSCL

CSCL research is methodologically diverse with techniques drawn from the domains of experimental psychology, computer science, and cultural anthropology, among others. Jeong et al. (2014) note that while the immense methodological diversity in CSCL research is exciting and gives the field richness, it does not facilitate the synthesis of findings into a coherent body of knowledge. Work from different methodological traditions co-exists, but the findings remain disjointed. The problem is compounded by the fact that different methodologies link to different research traditions and standards of evidence (Arnseth and Ludvigsen 2006; Cobb and Jackson 2008). Thus there are critical questions to address about whether (or when) multiple stories about the same collaborative event (which may produce

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incommensurate claims) are valuable and how (or even if) we can begin to combine these different kinds of knowledge products constructively.

Theme 12: CSCL as ideology

The charge has been made that, for some, the belief in collaborative learning at the heart of CSCL and the claim that it is occurring is not a consequence of analysis but an ideology of sorts. This raises the question of whether our research seeks to answer questions of *if* collaborative learning is occurring (and if so if it is better than some other alternative) or *how* collaborative learning can best be supported (presuming that it is a desirable goal). People who are co-present while learning together are not necessarily collaborating and groups of learners do not always comprise a community. More and more voices have begun to raise these questions. There is thus a need for CSCL researchers to become more critical of the foundational premise of collaboration and when it is an appropriate learning strategy. In this way, we can more clearly define the scope and limitations of our field.

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