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# Socio-technical configurations for productive talk

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The four papers in this issue cover most of the pedagogical concepts and computer tools that CSCL research so far has provided to education: Collaboration scripts, prompting, group and task awareness, orchestration, and knowledge building. The contributions make it very clear why we develop these concepts and tools: to foster productive talk and productive interaction. These are the mechanisms that bring about learning and knowledge advancement in dyads and groups. However, this issue is not only representative of the state of the art of CSCL technologies, it is also a testimony to the methodological maturity of the field. The four papers can be seen as each demonstrating productive ways of overcoming the epistemic divide between quantitative and qualitative approaches, which separate much of educational research into two camps (Jacobson et al., 2016). Importantly, in these studies methods of the quantitative and qualitative kind do not just get "mixed" with the main concern being their sequencing (Creswell, 2014), but are combined in a genuinely synergistic manner. While "coding and counting" has for good reasons been criticised as too simplistic for capturing human collaboration (e.g., Csanadi et al., 2018), it has provided a baseline for advancing the field such that it now combines interpretation with quantification in a more sophisticated manner. A prominent example in CSCL for this combination is Epistemic Network Analysis (Shaffer, 2017). Another example is Social Network Analysis in combination with qualitative analysis. We find examples for both in this issue.

As a research field, from its beginnings CSCL has been aware of the many challenges that collaborative learning constitutes, not only for the learners, but also for those who design and manage group learning activities. Collaboration scripts (Fischer et al., 2013), group awareness technologies (Schnaubert & Bodemer, 2019) and technologies for classroom orchestration (Dillenbourg, 2013) have been intensively developed and studied as approaches for making group learning scalable and widely used. In their paper *Deconstructing Orchestration Load*, Ishari Amarasinghe, Davinia Hernández-Leo, and Ulrich Hoppe provide a powerful example for how far we have come in supporting students, learning designers, and teachers in the planning and conduct of collaborative learning.

Amarasinghe and colleagues' focus is on supporting teachers in the classroom where synchronous group work is conducted. The challenges for teachers have been discussed under the label of classroom orchestration (Dillenbourg, 2013), which focusses on the cognitive resources required. Teachers face these challenges in the face-to-face classroom as well as while using web-conferencing tools. Building on Cognitive Load Theory (Sweller,

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2010), Amarasinghe and colleagues suggest distinguishing content load (such as interpreting a group's contribution), orchestration load (such as making decisions about when to move to the next activity) and cognitive load (the effort needed to process all other relevant information, such as for using a learning analytics dashboard). A quasi-experimental comparison is performed between a teacher-facing dashboard that provides mirroring information and one that provides guidance information. The expectation was that the guidance dashboard would free up comparatively more resources for teachers to adapt transitions between activities to student performance and to interact more with the students. This is tested with six teachers in real face-to-face university classes, varying in size from 12 to 51 students. In the classes, a variant of the pyramid collaboration script is enacted on three levels: individual, group and class. Students worked on programming exercises and voted on group and class level on the quality of solutions developed in the individual phase. Using a within-subjects design with a counter-balanced sequence, each teacher worked under the conditions No dashboard, Mirroring dashboard, and Guiding dashboard. Teacher actions were coded with respect to interaction with students and use of the dashboard. Then Epistemic Network Analysis (ENA, Shaffer & Ruis, 2017) was employed to identify sequential patterns and set them in relation to the experimental condition.

While the data support the general expectation that the mirroring and guiding dashboard lead to more awareness amongst the teachers, and to more and more targeted interventions, they also reveal an interesting tension between attending to the epistemic and social aspects of the learning situation. Because in this study the epistemic artefacts were not simple yes/no answers, but rather solutions to programming problems, teachers had to invest considerable effort in appraising them. Particularly in the mirroring condition, this led to relatively more attention given by the teachers to the epistemic than the social aspects of learning. In the guiding dashboard condition, teachers' interventions were more equally divided. Amarasinghe and colleagues interpret this as a benefit of the guidance condition, but this conclusion is tentative because of the small sample in this study and the absence of learning outcome measures.

In the second study, by Jessica Vandenberg, Zarifa Zakaria, Jennifer Tsan, Anna Iwanski, Collin Lynch, Kristy Elizabeth Boyer, and Eric Wiebe, we encounter the fourth main contribution of CSCL research to supporting productive collaboration for learning: prompting (Harney et al., 2015).

Vandenberg and colleagues use ENA to study the effects of prompting on students' conversations as they worked on a pair-programming task using Scratch. Building on Mercer's distinction of Cumulative, Disputational and Exploratory talk (Mercer, 2000), the authors created pre-written prompts aiming at increasing Exploratory talk: suggesting alternative ideas, challenging a partner with questions, disagreeing and justifying ideas. In a quasi-experimental study with 62 upper primary students (9–10 years old), half of them received the prompts, the other half acted as the control group. Verbal reinforcement was provided along with the prompts in the experimental group. Students' talk was coded with a modified version of Mercer's framework. Statistical analysis progressed from a comparison of code frequencies to identifying temporal patterns using ENA. The dyads in the experimental group produced statistically significantly more Justifications and Alternative ideas. In both groups, the Simple questions were significantly more frequent than Higher order questions. Applying ENA revealed that the control group used Simple questions mainly for domain learning whereas in the experimental condition they were mainly used for coordination purposes.

It is interesting to reflect on the use of Epistemic Network Analysis in these two studies. As described in detail in Shaffer (2017), ENA is an extension of those text-mining methods that build on the co-occurrence of words ("bag of words"). It goes beyond these by adding a sliding time "window" so that co-occurrences can be counted over meaningful parts of speech or text—what Shaffer calls "stanzas". Thus, ENA allows the researcher to reveal temporally ordered patterns in sequentially produced data. The data that form the input to ENA are typically coded in some high-level coding framework, such as teacher actions in Amarasinghe and colleagues' paper (7 codes) and student dyad interactions in Vandenberg and colleagues' paper (9 categories). Formally, the codes form the nodes of a transition graph, and the co-occurrences form the edges between these nodes. Using mathematical graph theory, numerous features for such graphs can be calculated (such as graph density), and computational methods for network visualisation help to make them visually inspectable. In Amarasignghe and colleagues' paper, ENA allowed the researchers to find nuanced differences between the mirroring and guidance condition, and in the Vandemberg and colleagues' paper it enabled a better understanding of the different roles that Simple questions played in students' conversations.

As with the Vandenberg paper, the main concern of the third paper, this time by Jesse Ha, Luis Péres Cortés, Man Su, Brian Nelson, Catherine Bowman, and Judd Bowman, is making collaborative talk productive. Ha and colleagues take the work into the museum. With apps on mobile devices now being almost a standard for the museum experience, it would be good if they add value. This is not a given because interacting with a mobile device may interfere with experiencing the museum artefacts and reduce social interaction (e.g., Kushley & Dunn, 2018). Individual technology may also interfere with the sharing the experience with others, in case where the museum is visited by a group (e.g., a family or a group of students). This study extends the work on CSCL in museum settings by focussing on collaborative question-crafting and group inquiry.

As part of a larger project, a database of more than 13,500 questions and 5000 answers was developed and made available to visitors in two forms: as a mobile app with a no-frills interface that allowed entering questions by speaking and typing, and as a mobile app with the same Q&A logic augmented by a touch of gamification (level awards based on number of questions asked). The basic and gamified versions were systematically compared on a huge sample of more than 5600 visitors to two museums, with 614 natural groups (e.g., families) randomly assigned to the basic and 925 groups to the gamified version. A post-visit questionnaire asked for the ways in which the groups generated the questions they entered in the app. The reason for comparing these two modes of question generation comes from the theoretical framework employed (ICAP taxonomy, Chi & Wylie, 2014); it suggests that interactive (that is, collaborative) question generation would lead to the highest learning gains, more so than the constructive mode of individual question generation and both better than active (i.e., attentive) and passive (i.e., not engaged) modes. Since these hypotheses are strongly supported by former research, this study primarily seeks to establish that gamification enhances collaborative question generation. It also distinguishes three types of questions (nonsense/incomplete, fact-oriented, and wonderment questions).

Significant differences in types of questions were found, with game mode eliciting more basic information questions and fewer off-topic, incomplete or nonsense questions than the basic version. With the game version, children and teens or the whole group were more often mentioned as the question generators than was the case for the basic version, but this difference did not reach statistical significance.

For us, two points stand out in this paper: The first one is that it is CSCL research "at scale"; rarely have we seen studies of this size conducted in authentic settings. The second point is conceptual: ICAP (Chi & Wylie, 2014; Chi et al., 2018) has so far hardly been used in CSCL research even though it provides conceptual and evidential support for the benefits of collaborative learning over and above all other modes of learning. While not specific to computer-supported collaboration, it might well serve as a conceptual pillar for our field and advance still further through closer attention to the role of technology in learning and collaboration.

Fostering productive, generative discourse is also at the heart of the fourth contribution to this issue, by Dan Tao and Jianwei Zhang. At the same time, it is an example for research on the fifth genuine contribution of CSCL to education: Knowledge building pedagogy and its technical support through Knowledge Forum (Scardamalia & Bereiter, 2006). What sets this paper apart is the duration of the study: A whole school year that about 20 students in a Grade 5 class spent on a project on the human body. The Knowledge Forum software was used throughout the year, extended by a tool called the Idea Thread Mapper, which visualises temporal information about the interaction. In addition to the information that Knowledge Forum log files provide, data gathering includes classroom observations of all lessons and video recordings of the reflective meetings ("metacognitive meetings"). A main analytical focus is on the way the students work on "big questions" as they evolve and how the work of the population is distributed and coordinated over student groups. Formation of groups was dynamic and left to the students; group membership changed dependent on which of the "big questions" was in focus. A combination of qualitative content analysis and quantitative analyses, including social network analysis, allows the authors to provide a rich picture of how ideas and collaborations evolve over time.

It is hard to overstate how important analysis of long-term group learning is. Too often learning (technology) innovations are only studied during early take-up, when practice is immature. It is remarkable that students so young can maintain productive collaboration over such an extended period, with the teacher remaining in a facilitative rather than guiding role. Interesting questions arise from comparison with scripting- and prompting-based studies, such as Amarasinghe and colleague or Vandenberg and colleagues in this issue. Obviously, such structuring of collaboration is needed when collaboration is of short duration and groups are formed in an ad-hoc fashion, just for the duration of a collaboration activity. Structure also helps in the early stages of teamwork, but then the question arises how students themselves can move into a position of agency. Long-term studies such as this one will be needed to study processes of social change that take forms such as structuration (Archer, 2003) and appropriation of (collaboration) technology (Lonchamp, 2012).

In summary, the four contributions of this edition cover the sample size range from "small N" to (very) "large N" research, and the time range from short-term collaborative activities to long-term collaborative learning projects. They reflect very well the state of the art of CSCL research as regards concepts, technology, and methodology. What do they tell us about potential directions future research might take? We certainly would like to see more instances of CSCL studies "at scale": studies involving many participants in authentic settings and studies that follow collaborative learning over longer periods of time. As regards methodology, the emerging trend in CSCL research to employ methods for analysing social, temporal, and spatial *configurations*—in their role as cause and effect—is worth reinforcing. Examples of these methods are SNA and ENA, both employed in the studies that contribute to this issue. Both are based on the graph-theoretical concepts, and both are more than formal techniques when applied to explain learning, development and collaboration. When used for explaining and theory building, they are part of a bigger conceptual framework, namely structuralism: "[The] belief that phenomena of human life are not intelligible except through the interrelations" (Blackburn, 2008). Sociologists have argued that SNA can be more than a mathematical and statistical technique; it can be part of a meta-theory of social causation, "a comprehensive paradigmatic way of taking social structure seriously by studying directly how patterns of ties allocate resources in a social system" (Wellman, 1988, p. 20). David Shaffer argues similarly when grounding ENA in linguistic structures (Shaffer, 2017). There are important lessons here for the use of structural-configurational methods such as SNA and ENA in CSCL research: They can be used not only for the purpose of describing data (statistical modelling) but also for explanatory purposes. This ontological shift from *patterns* in data structures to *real mechanisms* necessitates a corresponding epistemic move: From data description to theory/model testing. Therefore, we encourage CSCL researchers to advance the use of methods such as SNA and ENA so that they lead to empirically testable models.

## References


Archer, M. (2003). *Structure, agency and the internal conversation*. Cambridge University Press.

Blackburn, S. (2008). Structuralism. In *Oxford dictionary of philosophy* (2nd ed., pp. 353). Oxford: Oxford University Press.

Chi, M. T. H., Adams, J., Bogusch, E. B., Bruchok, C., Kang, S., Lancaster, M., … Yaghmourian, D. L. (2018). Translating the ICAP theory of cognitive engagement into practice. *Cognitive Science, 42*(6), 1777–1832. https://doi.org/10.1111/cogs.12626

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE Publications.

Csanadi, A., Eagan, B., Kollar, I., Shaffer, D. W., & Fischer, F. (2018). When coding-and-counting is not enough: Using epistemic network analysis (ENA) to analyze verbal data in CSCL research. *International Journal of Computer-Supported Collaborative Learning, 13*(4), 419–438. https://doi.org/10.1007/s11412-018-9292-z

Dillenbourg, P. (2013). Design for classroom orchestration. In *Computers and Education* (Vol. 69, pp. 485–492): Elsevier Ltd.

Fischer, F., Kollar, I., Stegmann, K., & Wecker, C. (2013). Toward a script theory of guidance in computer-supported collaborative learning. *Educational Psychologist, 48*(1), 56–66. https://doi.org/10.1080/00461520.2012.748005

Harney, O. M., Hogan, M. J., Broome, B., Hall, T., & Ryan, C. (2015). Investigating the effects of prompts on argumentation style, consensus and perceived efficacy in collaborative learning. *International Journal of Computer-Supported Collaborative Learning, 10*(4), 367–394. https://doi.org/10.1007/s11412-015-9223-1

Jacobson, M. J., Kapur, M., & Reimann, P. (2016). Conceptualizing debates in learning and educational research: Towards a complex systems conceptual framework of learning. *Educational Psychologist, 51*(2), 210–218.

Kushley, K., & Dunn, E. W. (2018). Smartphones distract parents from cultivating feelings of connection when spending time with their children. *Journal of Social and Personal Relationships, 36*, 1619–1639. https://doi.org/10.1177/0265407518769387

Lonchamp, J. (2012). An instrumental perspective on CSCL systems. *International Journal of Computer-Supported Collaborative Learning, 7*(2), 211–237. https://doi.org/10.1007/s11412-012-9141-4

Mercer, N. (2000). *Words and minds: How we use language to think together*. Routledge.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97–115). Cambride University Press.

Schnaubert, L., & Bodemer, D. (2019). Providing different kinds of group awareness information to guide collaborative learning. *International Journal of Computer-Supported Collaborative Learning, 14*, 7–51.

Shaffer, D. W. (2017). *Quantitative ethnography*. Cathcart Press.

Shaffer, D. W., & Ruis, A. R. (2017). Epistemic network analysis: A worked example of theory-based learning analytics. In *Handbook of learning analytics* (pp. 175–187).
Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. In *Educational Psychology Review* (Vol. 22, pp. 123–138).
Wellman, B. (1988). Structural analysis: From method and metaphor to theory and substance. In B. Wellman & D. Berkowitz (Eds.), *Social structures: A network approach* (pp. 19–61). Cambridge University Press.