Intern. J. Comput.-Support. Collab. Learn (2023) 18:457–464
https://doi.org/10.1007/s11412-023-09415-y

Reflecting on what counts as collaboration: Reaching forward without losing what is behind

Sanna Järvelä[1] · **Carolyn P. Rosé**[2]

Published online: 6 December 2023

In this final issue of our co-editor-in-chiefship, we take the opportunity to reflect, both on the past four years and on the road ahead. Thinking back to the time when we were just starting to imagine what our experience would be taking on this task, we had no idea what was in store for us, our community, our nations, and the world. It has been four years filled with challenges and big questions. With the backdrop of COVID accompanied by waves of political and economic turmoil, we find ourselves at a crossroads in terms of our own identity as a research community. At the heart of all of this, we arrive at a focal question: What is the essence of collaboration? As we reach out in openness to new ideas, how do we maintain our identity? What defines the frontiers of what we embrace as a community? In short, how do we emerge from this period of uncertainty and instability to move forward in strength as a cutting edge research community.

In the time since the inception of the CSCL community, we have observed transformations in how computers are conceived and what they are capable of, what kinds of support are desirable, possible, and efficacious, and what there is to learn, how we learn, and where we learn. But in all this, perhaps we have taken for granted the definition of the part of CSCL that is most core to its essence, the definition of collaboration itself. Though a major thrust of this community's research in the past two decades has focused on illumination of collaborative processes, perhaps we have still not fully grasped what counts as collaboration in the first place.

Collaboration involves individuals or groups working together to achieve common goals, share ideas, and contribute their efforts toward a collective objective or joint goal (Dillenbourg, 1999). It can take various forms and occur in a wide range of contexts, but it is active, intentional, shared, and effective communication and participation. We also know that it can be scripted, intentionally designed for ready support using the gamut of technologies available to us. Therefore, for more than three decades CSCL has been a powerful field, with research that advances theory guided and empirically grounded collaborative

✉ Carolyn P. Rosé
cp3a@andrew.cmu.edu

Sanna Järvelä
sanna.jarvela@oulu.fi

[1] University of Oulu, Oulu, Finland

[2] Carnegie Mellon University Language Technologies Institute and HCI Institute, Pittsburgh, PA, USA

learning (Cress et al., 2021). In our own work as co-editors-in-chief, we are called upon to judge each submission in terms of whether it is in scope. Not infrequently do submitted articles challenge our notions of what should be in scope. For example, if a group is working on a problem and talking together, are they necessarily collaborating? If the discussion is not centered on a set learning objective, might they still be learning together? If a group is learning together while performing a task without learning as the primary goal, might they still be engaged in collaborative learning? If a human is performing a task with one or more computer agents, can it still be a collaboration? What does it mean to build knowledge collaboratively when a human is interacting with agents that do not have their own mind and their own thoughts? What is required of the beings engaged in an interaction in order for intersubjectivity to be achieved?

The fundamental question "What counts as collaboration" has helped us keep the journal on track during the past four years as we have seen CSCL competing with other new emerging themes and concepts, for example, from learning analytics (LA), to augmented reality (AR) and virtual reality (VR), to chatbots and generative artificial intelligence (GenAI) more generally. These ideas and new "vocabulary" have clearly challenged us to defend our concepts and terms, which have grown from the strength of our theory grounding. On the other hand, these emerging paradigms and ideas have also invited us to be more open to new things. Now we begin to see a new and revitalized CSCL on the horizon, just about to emerge, but currently we stand in a place where we must elaborate what the concepts and methods mean for us so that we can integrate them with accumulating scientific knowledge.

We have identified four themes from the four past years of ijCSCL issues, which we see pushing the discussion forward. We have seen new technologies, such as human–robot interaction or virtual reality, which have extended human ways of collaboration. Digitalization and technology development has offered new ways to collect data from these interactions, thus bringing new methods and means of analysis to the field. Perhaps this is why there has been an emergence of new terms and concepts to explain CSCL. We have also noticed that our community is alert to societal changes and brings new phenomena into CSCL to discuss.

New technologies enabling collaborative interactions

Since COVID, there has been an intensification of interest in technology mediated togetherness, which creates the time and place for Virtual Reality (VR) and Extended Reality (XR) technologies to be used as a platform for such experiences. In the past years continuously developing technologies have offered new possibilities for collaborative learning experiences, enabling students to engage, interact, and learn together. This trend is documented among other places in national policy reports (e.g., Tuomi et al., 2023). Most recently we discussed in our June special issue how XR environments open up tremendous opportunities for learners to connect new representational forms and modes of interaction to prior knowledge and experiences through embodiment (Fortman & Quintana, 2023). In contrast to work in other communities focusing specifically on technology advances, the CSCL community is interested in the ways groups experience these environments and how affordances can be created within them to foster productive learning processes.

As collaborative interactions are mediated by technology in richer ways than before, new kinds of evidence and data are available from collaborative interactions. For example,

CSCL environments can be enriched by enabling learners to utilize movement, gesture, and gaze to support collaborative learning for groups co-located within virtual learning environments. CSCL in particular pushes the VR and XR research to address questions related to new challenges connected with the distributed nature of the human–human interaction within these environments.

Expanding the scope of modalities where collaboration occurs, is studied, and is supported

As the field of multimodal machine learning has substantially advanced in the recent decade (Baltrušaitis et al., 2018), the CSCL community has adopted a unique stance within that space (Ochoa et al., 2017), focusing on how to instrument collaborative spaces to collect needed data (Yan et al., 2022) and refashion existing collaborative support in the gamut of environments and spaces where collaboration occurs (Vitiello et al., 2023; Wang et al., 2020). Our journal submissions have exhibited growing interest in methodological solutions that utilize technological tools and multimodal methods to understand learning processes and to collect data about the temporal process of collaborative learning (Wise et al., 2023). Many of the factors affecting learning are invisible to the outside observer, and sometimes to the learner as well. For example, certain processes occur at the metacognitive level, such as Socially Shared Regulation of Learning (SSRL). On the other hand, there may be a strong emotional reaction inhibiting learning that the learners themselves are not even aware of.

With these developments rich multimodal data have been collected to investigate the cognitive, metacognitive, emotional, and social processes related to CSCL at both individual and group levels. These data include, e.g., tracking logs, video, audio, eye-tracking and physiological data such as electrodermal activity (EDA) and heart rate. Interdisciplinary efforts have investigated the alignment between theoretical notions, data structures, and methodological assumptions underlying data analysis. CSCL researchers have started to collaborate with the learning analytics (LA) community (Chen & Teasley, 2022). Recent work has focused on how to detect key learning processes, such as SSRL (Nguyen et al., 2023), using machine learning models that may eventually be deployed in real time during collaboration. However, without sufficient constructive critique, such as provided by Wise et al. (2023) in our June Editorial, these efforts have room to grow in terms of contribution to the needed multidisciplinary discussion.

New phenomena in CSCL addressing evolving societal needs

In past years we have seen that globally changing landscapes, societal tensions and technological opportunities contribute to forms of collaboration and highlight the extent to which it matters. While CSCL may be a more powerful way of learning and educating than ever, there have been new phenomena we have discussed in our journal. For example, in our journal we have raised discussion that CSCL should contribute to educational change and in particular must be responsive to the epistemic diversity of learners. Uttamchandani et al. (2020) called upon researchers to focus on equity in CSCL practices to promote educational change. Isohätälä et al. (2021) call for actions in CSCL research that ultimately contribute to more democratic and equitable collaborations. They bring forward a manifesto

of social sensitivity: increasing interdisciplinary efforts to enhance constructively critical, respectful, and cohesive collaborations in technology-supported environments. What societal themes we need to know in CSCL and how much we do need these themes in CSCL is not yet clear and more discussion is needed.

Emerging generative artificial intelligence technologies

For decades, researchers have argued that tools change how we think, act, and learn (Lajoie & Derry, 1993). Now we are living in the age of artificial intelligence (AI) and entering into the discussion of "new wave of AI in education" and CSCL in specific. For example, Generative AI (GenAI) (Rosé, 2023) has recently grown into a term known not only in technical circles but in virtually every sector. As highlighted in this issue's squib (Cress & Kimmerle, this volume), GenAI technologies, such as ChatGPT, are capable of generating human-like text based on context, prompts, and past conversations. Considering the rate at which AI is evolving, the CSCL field is challenged to participate in it with its strong understanding about human–computer interaction, leverage earlier theories and develop new concepts to bring AI to CSCL research. Currently, the field of CSCL has a lot to learn in terms of understanding AI beyond just using it as a tool in simple ways through a public interface. Questions must be addressed, such as: What would it mean to collaborate with a GenAI agent? What new skills are needed from the learner side? How do we participate in developing hybrid human-AI systems for humans to learn, interact, work and collaborate?

Thus far we have seen promising ways to implement AI capabilities for CSCL research in terms of extracting properties of collaboration and detecting collaboration patterns, automating tasks for efficiency and granularity and operating complex and sophisticated analyses (Rosé, 2018; Fiacco et al., 2023; Järvelä et al., 2023). More is needed to know how AI can support teacher orchestration in CSCL or how AI can become a potential partner in collaboration.

A Squib in this issue written by Ulrike Cress and Joachim Kimmerle takes part in this theme and challenges us to ask to what extent these tools can be employed by users for individual learning as well as for knowledge construction to spark a collective new insight. Cress and Kimmerle remind us that Generative AI tools do not have any conceptual knowledge or conscious understanding. Therefore, there is a critical role for the field of CSCL to play in contributing technologies and approaches, such as new prompting techniques, to create theory-grounded interventions in this new technology space. They outline future CSCL research paths and challenge the field to leverage our theories, such as collective notion of knowledge or argumentation, as a basis to establish a dialog that goes beyond knowledge telling and stimulates knowledge transformation. We see this squib as just the beginning of the conversation and invite subsequent squibs to continue from here.

Highlighting the research articles of this edition

This issue comprises five full articles and a squib. The full articles can be organized into two distinct themes, namely collaborative problem-solving and interaction competencies and characteristics influencing CSCL. These topics contribute to our understanding of how individual characteristics, such as prior knowledge, motivational components or group composition contributes to group interactions and collaborative learning gains.

The first article by Yue Ma, Huilin Zhang, Li Ni and Da Zhou, entitled "Identifying collaborative problem solver profiles based on collaborative processing time, actions and skills on a computer-based task", reports about distinct collaborative problem-solver profiles of Chinese 15-year-old students on a CPS task. The process indicators they used for problem-solver profiles were time-on-task, actions-on-task, and three specific CPS process skills, namely establish and maintain shared understanding, take appropriate action to solve the problem, and establish and maintain team organization. Based on a large data set (N = 1,677) from the 2015 PISA Assessment they further examine how these profiles may relate to student demographics, motivational characteristics, as well as CPS performance. The results of latent profile analysis indicate four collaborative problem-solver profiles: Disengaged, Struggling, Adaptive, and Excellent. These findings may contribute to better understanding of the way students interact with computer-based CPS tasks and inform educators of individualized and adaptive instructions to support student collaborative problem-solving.

The second CPS article, by Jiun-Wei Guo, Hsiao-Ching She, Meng-Jun Chen and Pei-Yi Tsai, presents a study to answer the question "Can CPS better prepare 8th graders for problem-solving in electromagnetism and bridge the gap between high- and low-achievers better than IPS?" It especially focuses on studying whether CPS and individual problem-solving (IPS) are equally effective in improving students' understanding of physics concepts, problem-solving abilities, and minimizing achievement gaps. They developed two types of online electromagnetism problem solving programs with simulations, contrasting IPS and CPS for 8th grade students over five class sessions. The results show that students in the CPS group significantly outperformed those in the IPS group on their performance of physics problem solving and online problem-solving (PS), while IPS and CPS both affected their physics concept test performance to the same degree. While Both CPS and IPS affected high-achievers' problem-solving performance to the same extent, the researchers found differences in favor of CPS, for example, in maximizing low-achievers' problem solving performance and minimizing the discrepancy between high- and low-achievers.

In the third article, Natalia Reich-Stiebert, an-Bennet Voltmer, Jennifer Raimann, and Stefan Stürmer report about a study where they investigated "The Role of First-Language Heterogeneity in the Acquisition of Online Interaction Self-Efficacy in CSCL". The acquisition of online interaction competencies is an important learning objective, and the way that relates to communicative preferences and abilities is critical and not heavily studied in this journal community. The present study explored the relationships between the first-language heterogeneity of computer-supported collaborative learning (CSCL) groups and the development of students' online interaction self-efficacy via a pretest–posttest design in the context of a nine-week CSCL course. The research participants were 1,525 freshmen receiving distance education who were randomly assigned to 343 CSCL groups. Independent of their own language status, students in CSCL groups featuring first-language heterogeneity exhibited lower precourse–postcourse gains in online interaction self-efficacy than students in groups without heterogeneity. Consistent with a theoretically derived moderation model, the relationships between first-language heterogeneity and self-efficacy gains were moderated by the amount of time that the groups spent on task-related communication during the initial collaboration phase (i.e., the relationships were significant when little time was spent on it but not when a great deal of time was spent on it). In contrast, the amount of time that groups spent on communication related to getting to know each other was ineffective as a significant moderator. Follow-up analyses indicated that time spent getting to know each other in first-language heterogeneous CSCL groups seems to have had the paradoxical effect of increasing rather than decreasing perceptions of heterogeneity

among group members. Apparently, this effect impaired online interaction self-efficacy gains.

In the fourth article, Sadhana Puntambekar, Dana Gnesdilow and Sinan Yavuz present a study that deals with the "Effect of Differences in Prior Knowledge on Middle School Students' Collaborative Interactions and Learning". They investigated how the level of variance in students' prior knowledge may have influenced their collaborative interactions and science learning in small groups in multiple compost simulations. They examined learning outcomes from 102 groups from one teacher's classes and discourse, contrasting homogeneous versus heterogeneous groups. Hierarchical linear modeling (HLM) was used to explore the effect of membership in a homogenous or heterogenous group on students' learning. Social network analyses (SNA) was used to identify differences in interaction patterns and discussion between the two contrasting groups. According to their results, students in homogenous groups made significantly greater learning gains than students in heterogeneous groups. The SNA and thematic analysis of the discussions identify details and explanations in interactions in these contrasting groups, for example, that the interactions in the homogenous group were more distributed, while the interactions in the heterogenous were more centralized around the member with the greatest prior knowledge. Their findings indicated that students in homogenous groups learned more and collaborated better; they discuss how some heterogeneity may be helpful for scaffolding collaboration.

In the fifth article, Reet Kasepalu, Pankaj Chejara, Luis Prieto and Tobias Ley report about a study entitled "Teacher Withitness in the Wild: Comparing a Mirroring and an Alerting & Guiding Dashboard for Collaborative Learning". They studied how teacher "withitness", both the situational awareness and interventions taken in collaborative learning class, can be helped with a guiding dashboard alerting the teacher to problems and providing suggestions for interventions. They argue that teachers in a collaborative learning environment have the demanding task of monitoring several groups of students at the same time and intervening when needed. The needed withitness of the teacher might be increased with the help of a guiding dashboard alerting the teacher of problems and providing suggestions for interventions. Kaasepalu et al. carried out a quasi- experiment in authentic classrooms where students worked in a face-to-face learning environment and used a collaborative writing tool. Teachers ($N = 24$) were observed, interviewed, and answered surveys in three different conditions: with no extra information about the learning situation, using a dashboard providing mirroring low-level data about the collaboration, and a guiding dashboard with an AI assistant and. The results show that a mirroring dashboard helped teachers the situational awareness and alerting dashboard dropped their workload and decreased frustration.

Some concluding remarks

Despite the challenges, this past four years working together as co-editors-in-chief has been an incredible experience from beginning to end. From our vantage point, we have experienced the privilege of viewing front lines research as it comes across our respective desks, and to see articles evolve and transform through the editorial process. Some of the most exciting experiences have been with respect to encountering thought provoking contributions that highlight the ways in which we see the field expanding in a multidisciplinary way. It has been a rewarding experience for us to communicate with authors, reviewers and editorial board members who have been so engaged, even in the

sometimes tumultuous times we have walked through. We warmly welcome our new chief editors, Michael Baker and Peter Reiman, to continue in 2024 to lead the journal, and invite colleagues to submit high quality research papers to the ijCSCL. We look forward to seeing the emergence of a new age of CSCL under the new leadership.

References

Baltrušaitis, T., Ahuja, C., & Morency, L. P. (2018). Multimodal machine learning: A survey and taxonomy. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 41*(2), 423–443.

Chen, B., & Teasley, S. D. (2022). Learning Analytics for Understanding and Supporting Collaboration. In C. Lang, G. Siemens, A. F. Wise, D. Gašević, & A. Merceron (Eds.), *Handbook of learning analytics* (2nd ed., pp. 86–95). SoLAR.

Cress, U., Oshima, J., Rosé, C., & Wise, A. F. (2021). Foundations, Processes, Technologies, and Methods: An Overview of CSCL Through Its Handbook. In U. Cress, C. Rosé, A. F. Wise, & J. Oshima (Eds.), *International handbook of computer-supported collaborative learning. Computer-Supported Collaborative Learning Series.* (Vol. 19). Springer. https://doi.org/10.1007/978-3-030-65291-3_1

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and Computational Approaches* (pp. 1–19). Elsevier.

Fiacco, J., Jiang, S., Adamson, D., & Rosé, C. P. (2023). *Learning Analytics, International Encyclopedia of Education* (4th ed., pp. 75–82). Elsevier.

Fortman, J., & Quintana, R. (2023). Fostering collaborative and embodied learning with extended reality: Special issue introduction. *International Journal of Computer Supported Collaborative Learning, 18*, 145–152. https://doi.org/10.1007/s11412-023-09404-1

Isohätälä, J., Näykki, P., Järvelä, S., Baker, M., & Lund, K. (2021). Social sensitivity: A manifesto for CSCL research. *International Journal of Computer Supported Collaborative Learning, 16*, 289–299. https://doi.org/10.1007/s11412-021-09344-8

Järvelä, S., Nguyen, A., & Hadwin, A. F. (2023). Human and AI collaboration for socially shared regulation in learning. *British Journal of Educational Technology, 54*(5), 1057–1076. https://doi.org/10.1111/bjet.13325

Lajoie, S. P., & Derry, S. J. (Eds.). (1993). *Computers as cognitive tools* (pp. 289–317). Lawrence Erlbaum Associates, Inc.

Nguyen, A., Järvelä, S., Rosé, C., Järvenoja, H., & Malmberg, J. (2023). Examining socially shared regulation and shared physiological arousal events with multimodal learning analytics. *British Journal of Educational Technology, 54*(1), 293–312.

Ochoa, X., Lang, A. C., & Siemens, G. (2017). Multimodal learning analytics. *The Handbook of learning analytics, 1*, 129–141.

Rosé, C. P. (2018). Learning analytics in the learning sciences. In Fischer, Hmelo-SilverGoldman, & P. Reimann (Eds.), *International handbook of the learning sciences* (pp. 511–519). Routledge.

Rosé, C. P. (2023). The Generative AI Innovation Incubator, School of Computer Science, Carnegie Mellon University, https://www.cs.cmu.edu/generative-ai/

Tuomi, I., Cachia, R., & Villar-Onrubia, D. (2023). *On the Futures of Technology in Education: Emerging Trends and Policy Implications*. Publications Office of the European Union. https://doi.org/10.2760/079734

Uttamchandani, S., Bhimdiwala, A., & Hmelo-Silver, C. E. (2020). Finding a place for equity in CSCL: Ambitious learning practices as a lever for sustained educational change. *International Journal of Computer Supported Collaborative Learning, 15*, 373–382. https://doi.org/10.1007/s11412-020-09325-3

Vitiello, R., Tiwari, S. D., Murray, R. C., & Rosé, C. (2023). Traveling Bazaar: Portable Support for Face-to-Face Collaboration. In *Proceedings of 3rd Annual Meeting of the International Society of the Learning Sciences (ISLS)* (pp 59–60).

Wang, Y., Murray, R. C., Bao, H., & Rose, C. (2020, July). Agent-based dynamic collaboration support in a smart office space. In *Proceedings of the 21th annual meeting of the special interest group on discourse and dialogue* (pp. 257–260).

Wise, A. F., Rosé, C., & Järvelä, S. (2023). Nine elements for robust collaborative learning analytics: A constructive collaborative critique. *International Journal of Computer Supported Collaborative Learning, 18*, 1–9. https://doi.org/10.1007/s11412-023-09389-x

Yan, L., Zhao, L., Gasevic, D., & Martinez-Maldonado, R. (2022). Scalability, sustainability, and ethicality of multimodal learning analytics. *In LAK22: 12th international learning analytics and knowledge conference* (pp. 13–23).