

# Analysing Collaborative Problem-Solving From Students' Physical Interactions

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**Abstract:** Collaborative problem-solving (CPS) is a fundamental skill for success in modern societies, and part of the most common constructivist teaching approaches. However, its effective implementation and evaluation are challenging for educators. Current inquiries on the identification of the observable features and processes of CPS are progressing at a pace in digital learning environments. However, still, most learning and teaching occurs in physical environments. In my current research, I investigate differences in student behaviours when groups of students are solving problems collaboratively in face-to-face, practice-based learning (PBL) environments in high school and universities. My data is often based on students' hand position and head direction, which can be automated deploying existing learning analytics systems. Using nonverbal indexes of students' physical interactivity in PBL, I try to interpret the key parameters of CPS including synchrony, equality, individual accountability, and intra-individual variability. The ultimate aim of my research is to be able to continuously evaluate and support students' collaborative learning during their engagement with constructivist pedagogies.

## Introduction

Collaborative problem-solving (CPS) is a fundamental skill for modern societies to function and it should be supported and practiced in Education systems across the globe. Perhaps, as the significance of CPS is clear to most educators, it is part of many common constructivist teaching approaches including problem-based learning, inquiry-based learning, project-based learning, and practice-based learning. It is common to see situations in which learners work in unison to solve a problem during these teaching approaches, and often that is why these constructivist teaching approaches are considered to have the potential to help foster the 21st-century skills we require of young people. For some decades now, there have been strong advocates of these teaching approaches in Education, arguing their merits in achieving high-tier learning objectives. However, existing evidence on the effectiveness of these methods to satisfy their learning outcomes is rare, and they have been harshly criticised by some researchers as not being effective pedagogical approaches (Kirschner, Sweller, & Clark, 2006).

According to Blikstein and Worsley (2016), this lack of evidence may stem from these pedagogical approaches' notoriously dynamic and laborious structures and commonly used standardised measurement method's lack of ability to detect impacts on students' skill development. However, the most recent developments in sensor technologies and learning analytics methodologies can help generate unique information about what happens to groups of students are engaged in constructivist pedagogies. The distinctions between groups can be used to continuously evaluate and support students during their engagement with constructivist pedagogies. In my research, I focus on CPS in practice-based learning activities and investigate the potential of multimodal learning analytics research to generate and present salient features of effective CPS behaviours of students in these open-ended, small group learning environments.

## Theoretical framework

CPS is a complex process that requires implementation of multiple social and cognitive competencies. This makes its observation, to see whether the CPS is of quality or not, extremely challenging for educational researchers and practitioners. In the learning sciences literature, there have been certain mechanisms suggested through which collaboration and problem-solving may influence cognition and support deeper learning. They include students demonstrating an ability to:

1. articulate, clarify and explain their thinking;
2. re-structure, clarify and in the process strengthen their own understanding and ideas to develop their awareness of what they know and what they do not know;
3. adjust their explanations when presenting their thinking, which requires that they can also estimate others understandings;

4. elaborate and internalise their new understanding as they process the ideas they hear about from others;
5. establishing and maintaining shared understanding; taking appropriate action to solve the problem; establishing and maintaining team organisation.

Looking at the suggested mechanisms from the learning sciences above, it becomes clear that all the mechanisms presented above require investigation of complex verbal interactions of students and most of them require quality judgments from the observers. Therefore, the evidence related to the existence of these mechanisms and their quality is hard to generate and implement at a scale. Although there is promising research on investigating students verbal input in digital learning environments, including chat boxes, verbal interactions with online agents and mobile tools that collect students written reflections on their CPS practices, such investigations are far from being straightforward. The investigation of complex CPS mechanisms through verbal indexes often require qualitative value judgments that are hard to validate, automate, and rely on. In my research I investigate students' nonverbal indexes of their behaviours including synchrony, equality of physical participation, intra-individual variability and individual accountability. I argue that some of the key constructs that constitute complex learning processes such as collaborative problem-solving can be interpreted with the use of students' nonverbal behaviours. These indexes of behaviours have the potential to reflect genuine observations of students intentions and ideas and can be automated with the help of using multimodal learning analytics systems.

## Methods

In my current research, I use an analysis framework developed (Cukurova et al., 2016) based on the OECD's exhaustive work on CPS to create an independent variable of students' CPS competencies. I invite teachers and educators to categorise groups of students as high, medium, and low competence CPS groups using their expert opinion and the OECD based CPS framework. I, then, investigate how do behaviours of those groups who are categorized as high competence CPS group differ from Medium and Low competence groups in terms of machine observable nonverbal indexes of human behaviours such as synchrony, equality, individual accountability and intra-individual variability. In addition to these constructs, I compare high competence CPS groups' multimodal learning analytics data generated from their hand tracking, head direction, emotional feedback, and voice levels (Spikol et al., 2016).

## Future work

The simple coding scheme of students' active, semi-active and passive positions, we created (Spikol, Cukurova, Ruffaldi, 2017) is a practical and valuable approach that can inform the design of automated analysis systems. It can be used to interpret the key components of CPS including students' participation, responsiveness, perseverance, awareness, etc. It can be automated and applied to a real classroom environment by using a learning analytics system that has the potential to detect the head directions and hand position of students (using fiducial marks for instance) such as the one we developed in a recent EU-funded research ([www.pelars.eu](http://www.pelars.eu)). My future research will focus on attempts to expand the key constructs of CPS (and potentially other student skills) that can be interpreted through indexes of students' nonverbal behaviours. I will also work to automate this process of coding of nonverbal indexes of student interaction to be able to provide real-time feedback to students and teachers about their CPS patterns. These results would have significant implications both for the design and implementation of CPS activities in classrooms and they would increase the accuracy and timeliness of teacher interventions.

## References

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