Embedding CSCL in classrooms: conceptual and methodological challenges of research on new learning spaces

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Embedding CSCL in Classrooms: Conceptual and Methodological Challenges of Research on New Learning Spaces

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Abstract: This symposium brings together a panel of five groups who are leveraging new technologies to embed CSCL within classrooms. The goal of the symposium is to enter into a conversation with the audience about issues relating to methods and analysis of computer-supported collaboration within formal and informal learning contexts, exploring the future of classroom-based learning, and how technologies will give rise to new kinds of inquiry and collaboration. Our discussions will center on video of collaborative learning provided by each group and commentary from the panel. The symposium will be divided equally between short presentations of the panelists and discussion. The discussion will consist of responses from the audience to the videos, as well as panelists commenting on the data, and expanding or reflecting on comments from the audience in reference to their own work.

Introduction and Proposed Format

New technologies like multi-touch surfaces, location-sensitive devices and physical computing provide opportunities for transforming classrooms into innovative learning spaces. However, we still have much to understand about how such technologies can be used to transform the physical space and promote new forms of learning and instruction. To make effective use of these new tools, we need to understand how to design learning environments and pedagogical approaches that take full advantage of what they have to offer. Thus, we require research concerning how these new technologies influence the individual learner, group collaboration and whole-classroom in the course of complex collaborative inquiry. This symposium brings together a set of international projects that are exploring the integration of new technologies into classrooms. We seek to broaden the conversation about how to design, evaluate and understand the influence of these technologies.

As the primary goal of this symposium is to generate discussion about the study of new forms of collaborative learning in technology enhanced classrooms, panelists will show a short video clip of classroom activities, accompanied by slides that describe the research design and data collected. The audience will be asked to respond to each clip, commenting on initial interpretations of what is occurring, research questions that they find compelling, and methodological or analytic approaches they would like to consider. Members of the panel will also contribute at this stage, adding perspectives from their own work. We anticipate discussion amongst the audience and panel, with topics related to new learning spaces, such as the nature of collective knowledge, the role of the duration of activities, the physical environment, the pedagogical affordances of multi-touch surfaces, and the nature of participatory simulations. In addition, we expect to discuss common methodological challenges and appropriate research approaches with respect to these new learning spaces.

SynergyNet: Exploring Design and Pedagogy in a Multi-touch Classroom

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Description

The SynergyNet classroom was designed to integrate multi-touch tables into a typical classroom environment. The data to be presented in this symposium are concerned with how students working on a collaborative mathematics task, collaborated within and between groups to find solutions to problems, and how the orientation of the room influenced the teacher's apparent or actual control and the collaboration between students.

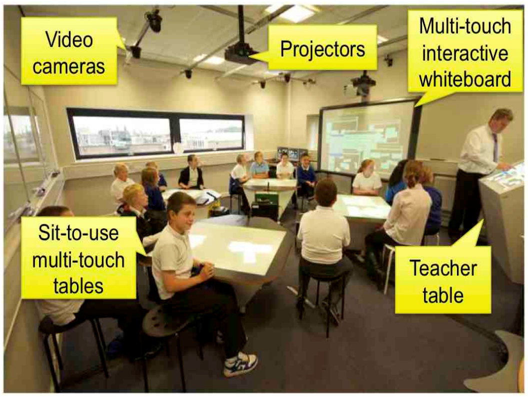

Figure 1. The SynergyNet Multi-touch Classroom.

Theoretical Perspectives

We approached the design of a multi-touch classrooms recognizing the importance of peer-support and authentic experiences for learning, while also paying attention to the role of the teacher in orchestrating learning opportunities (Dillenbourg & Jermann, 2010). While classrooms are traditionally designed to privilege teacher-led discussions, and teacher-pupil interactions, orchestrating collaborative learning within classrooms requires a pedagogy that promotes pupil-pupil interaction (Blatchford, Kutnick, Baines, & Glaton, 2003). We focus on understanding how to design and develop classroom activities and pedagogy in a multi-touch integrated space and the role that the teacher and students must take to take advantage of the possible learning opportunities.

Technology Environment, Curriculum Materials and Approach

As can be seen in figure 1, the classroom contains four large student multi-touch tables. The multi-touch tables can detect multiple touches, allowing for joint control of the table and simultaneous manipulation of content (like large iPads). The tables are networked, allowing for movement of content between the tables. There is also a multi-touch orchestration desk, which the teacher can use to send content to the student tables or monitor the content on the tables. The multi-touch interactive whiteboard can be used to project content from the student tables or orchestration desk, to support whole-class conversation about the small group work.

A recent study of this classroom consisted of six groups of 16 ten-year olds from local schools. Two configurations of the classrooms were compared in this study. Three classes were taught with the tables positioned facing center, while three classes were taught in a more typical configuration, with the tables facing towards the large interactive whiteboard. We hypothesized that the second configuration would privilege the teacher's position, while the first configuration would promote between-group conversation. The task that was used for this study was a mathematics 'mystery' in which students receive pieces of information that they need to sort through in order to solve the problem. Mysteries are a pedagogical strategy created for the development and assessment of complex thinking. Each piece of information was written in text on a digital piece of paper. The clues could be moved around the table, reoriented and made bigger or smaller to aid reading or indicate relative importance. For each task there was a single right answer that the groups were trying to reach, and sufficient pieces of information to overload most children's cognitive load, encouraging joint work. The teacher's goals were to foster within and between group collaboration, encouraging groups to solve the problem themselves, then share their strategies with the class. The content on the tables was projected at various points during the task, so that a particularly useful strategy from one group could be shared with the whole class.

Methodological or Analytical Challenges

Exploring the simultaneous between and within group collaboration, and the whole-classroom conversation leads to difficulty defining a unit of analysis and moving between levels of analysis. While traditionally we would focus on either the group or the whole class and teacher led discussion, moving between these results in multiple challenges. These include the need for complex transcription protocols (e.g. a single teacher transcript which is integrated into each group's transcript, which identifies when discussion is between group members, other class members, or aimed at the whole class), and coding in layers to attend to the different interaction levels. Additionally, we are exploring how the teacher's behavior changes under different configurations, how that relates to the students' collaborations and whether and how it has an impact on the students' learning.

SAIL Smart Space: Orchestrating Collective Inquiry for Knowledge Communities

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Description

New forms of knowledge media and data repositories offer opportunities for researchers and curriculum designers to take advantage of the varying contexts (i.e., in the classroom, in field activities) and devices (e.g., smart phones, interactive tabletops, large format displays). This functionality allows for new forms of instruction where students collaborate across contexts, dynamically generate knowledge, build on peers' ideas, and investigate questions as a knowledge community. Our research recognizes the potential of technology enhanced learning environments to support such pedagogical models through physical and semantic coordination. We advance the notion of a "smart classroom," which employs a range of technologies to support our investigations of a spectrum of collaborative inquiry and knowledge construction activities.

Theoretical Perspectives

A research tradition with relevance to the present study is that of the "knowledge community approach" – where students collaborate with peers to develop their own learning goals and approaches for achieving them (e.g. Scardamalia & Bereiter, 1992). The notion of knowledge communities is an ideal complement to the emergence of "Web 2.0" technologies, where knowledge is also seen as an emerging, collaborative product of all users (e.g., Wikipedia; YouTube) rather than a static source provided for consumption. An emphasis on collaborative knowledge creation, coupled with the recognized efficacy of scaffolded inquiry (Slotta & Linn, 2009), raises unique opportunities for curriculum that leverages these information and technology affordances for purposes of deep conceptual understanding within a knowledge community of peers and teachers (Slotta and Peters, 2009). Rich technology environments can be developed to support such a knowledge community and inquiry approach.

Technology Environment and Curriculum Materials

Recent advances in CSCL have emphasized technology frameworks where learning content is added and refined by users dynamically during learning activities, with some learning objects gaining content and definition only through patterns of access and use by students. Such content has been referred to as "Emerging Learning Objects," and often include a versioning system (i.e., to allow all student changes to be tracked) as well as powerful data mining performed by intelligent software agents (e.g. Slotta & Aleahmad, 2009).

We will describe our development of a flexible open source platform called SAIL Smart Space (S3), which in turn builds on the rich framework of SAIL (Scalable Architecture for Interactive Learning – Slotta & Aleahmad, 2009). S3 specifies a framework in which devices and displays are configured, building on a set of core underlying technologies: (1) a portal for student registration and software application management; (2) an intelligent agent framework for data mining and tracking of student interactions in real time; (3) a central database that houses the designed curriculums and the products of student interactions; and (4) a visualization layer that controls how materials are presented to students on various devices and displays (Slotta, 2010). Our current S3 smart classroom implementation involves four large projected displays in each corner of a classroom, a fifth, larger, multi-touch display on the front wall, and twenty laptops – all interconnected via high-speed wireless network (Figure 2).

Figure 2. S3 Smart Classroom Setup.

One recent implementation of S3 involved two grade 12 Physics classes, where students were sorted into four groups, with each student in the group assigned four out of sixteen total multiple-choice conceptual physics problems to individually solve and tag (using a set of keywords chosen to represent 12 different physics elements, such as "constant acceleration," "conservation of momentum," etc.). Once the first solving and tagging phase was completed, students remained in their groups where they were shown four of the questions along with the aggregate of the all answers that had been posted (from the wider class) to those problems. They were then asked to form a consensus concerning a "final answer," a final set of tags, and a rationale for their choices.

To investigate the role of large displays, two conditions were enacted. In the first, students used only laptops (and not the large displays) for all steps in the intervention; in the second condition, all group work was projected from the group laptop onto the group's corresponding large display. There was a significant difference between these two conditions, in terms of the group's problem solving and tagging success, with the shared display groups showing higher gains in their correct answers (from 50% to 81.25%) as compared with the group who used only laptops (from 60.38% to 69.23%). One possible explanation is that the large format displays provided the teacher with the ability to see what students were writing in their summary responses, and engage them in meaningful interactions. For example, in one episode, the teacher was watching one group discussing the aggregated answers of the class and saw that *no* students from the individual phase had approached the problem correctly. In other words, the aggregate data was completely incorrect! The teacher was able to intervene, advising students (in this case) not to listen to "the wisdom of the crowd."

Methodological or Analytical Challenges

Several challenges arise in this work concerning the "collective knowledge", artifacts, and complex forms of discourse generated by the various configurations of students and groups. From the problem solving results, it is possible to show that students are gaining a better understanding of the content (i.e., beyond that which they would get from normal class activity). What can the large set of individual student reflections stored over the curriculum reveal about students' progress, and the role of the wider knowledge community? When the response of the group to the short answer problems is different from that of individual students, what happens to the individuals' conceptualization? How can such questions be addressed using the data from student reflections? How does the teacher contribute to a knowledge community through his engagement with the students' aggregated responses and reflections? How can the teacher's actions be interpreted based on data logs, and their impact on student ideas? We will present video from a recent adaptation of this approach, and discuss our current analytic approach and several directions for future research.

Identifying Effective Collaboration Scripts for Orchestrating Technology-supported Learning in Innovative Learning Spaces

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Description

The data presented and discussed were collected in a series of three studies that were conducted in an innnovative learning space that included mobile furniture and digital technologies. The studies focused on the question how innovative furniture and CSCL technologies affect learning and how they can be used to better orchestrate and foster student learning. Study 1 investigated in what way students already have access to internal scripts to use innovative furniture and CSCL technologies if confronted with them without having received instructions on how to use them. This was compared to a condition in which students received minimal instruction on the tools' functionalities. Study 2 looked at whether marginal changes in the physical lay-out of an innovative learning space has effects on group performance, individual learning outcomes and emotional well-being. For that sake, students in one condition worked on two tasks while standing at lifted desks, while students in the other condition worked while being seated at a normal desk. Study 3 investigated whether highly structured external scripts are needed in innovative learning spaces to help students produce better group output and reach higher levels of emotional well-being.

Figure 3. University Students Rather Sit on the Floor than Re-arrange the Physical Environment.

Theoretical Perspectives

The project has been guided by a scripting approach (Kollar, Fischer & Hesse, 2006), assuming that powerful and widely shared (internal, i.e. cognitive) classroom scripts (e.g., teacher as expert and evaluator, students as participants with knowledge deficits, in a teacher-led activity ending with the evaluation of the students' performance by the teacher) may impede innovative uses of classroom technology. According to this approach, externally provided scripts may provide students with guidance for effective use of technology and furniture.

We assumed that furniture and computer technology can be designed to support more innovative forms of collaboration between students and teachers, and among students. However, these more innovative classrooms would typically be incongruent with the learners' internal (cognitive) scripts (Schank, 1999) they have acquired in hundreds of hours of school lessons and university seminars. We therefore assume that if left with no instructional support (e.g., by external scripts) students don't use innovative classrooms effectively because of their inappropriate internal scripts and that this may also lead to lower emotional well-being.

Technology Environment, Curriculum Materials and Approach

262 students participated in three studies on the use of furniture and technology in university seminars in an experimental classroom. The furniture consisted of chairs with wheels, tables that can be easily stored away and lifted to a standing position in order to switch between social levels and postures. The digital technology included laptops with wireless Internet access, an interactive whiteboard, and several large, movable screens.

In the different studies the learners worked on tasks related to presentation techniques and working in groups. For example, they were supposed to learn how to create an effective presentation and to identify the best solution in a decision task in a group. In the former case, we used guidelines and examples for the design of presentations that have been used in regular tutorials at the university. In the latter case, we used standard material for the analysis and training of group decision making tasks (Stasser, & Titus, 1985).

Methodological or Analytical Challenges

Study 1 showed that if not, or only marginally, instructed, learners had difficulties in appropriately using the new environments for their tasks. Especially with respect to furniture, students seem to have few internal scripts available to guide them in how to create and use supportive environments. Even after being instructed to use the furniture as they need and in how to use the furniture, several groups chose to sit on the floor rather than take time to prepare their environments (Fig. 3). As expected, the acceptance of the innovative furniture and tools was rather low.

Slightly changing the affordances of the learning environment to a realization of a more unfamiliar situation (having to stand during task accomplishment) had negative effects on emotional well-being, but positive effects on group outputs (study 2). Thus, although learning in an unfamiliar environment may make learners feel uncomfortable, this unfamiliarity may sometimes lead to more effective collaboration.

Results of study 3 showed that with external collaboration scripts learning was to be more effective with respect to knowledge and with respect to collaboration in the new environments than without. Additionally, groups with an external script showed higher emotional well-being than groups who did not receive further support on how to collaborate with each other in this unfamiliar situation. Thus, the results indicate that students need external support to effectively use the advantages that innovative learning spaces offer.

Our current methodological challenges are to find ways to expand the idea of external scripts to whole classrooms, in which such scripts would specify and distribute learning activities and roles over the different social planes of the classroom (plenary, small group, individual; Dillenbourg & Jermann, 2007). Additionally more work needs to be done in the creation of effective classroom scripts to help teachers foster different types of social learning. Another challenge is to find technical solutions for good recordings of what goes on when students use new learning spaces without impeding the acceptance of the learners. Tightly connected to this we explore ways to synchronize data from different sources (logfiles, video data of small group discussions and classroom interaction) to be able to trace computer-supported processes of learning and collaboration through the different social levels.

Embodied Learning in Embedded Spaces

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Description

WallCology is an agent-based simulation of a small ecosystem (Moher, et al., 2008). The central conceit of WallCology is that the walls of a classroom contain a secret, controlled habitat housing a simple ecosystem of endangered flora and small fauna. The students are given collective responsibility for maintaining the viability of the resident species by monitoring those populations and adjusting the heating and lighting of the habitat. A small number of "WallScopes" (computer displays) on the walls around the room afford the visual access to small regions of dynamic behavior in the habitat at their respective locations (Figure 4). Much of the activity revolves around computing and tracking population estimates (typically a dozen times over a month) based on the samples observed through the WallScopes. The class is usually organized in groups of 3-6 students, depending on the number of available WallScopes and class size. The video here shows the work of one group of 10-11 year olds at three sequential points in their collaboration as they identify activity affordances and negotiate their respective roles in the group activity.

Figure 4. Students conduct sample surveys using WallScopes. Sample data are used to compute population estimates for the walls and room.

Theoretical Perspectives

WallCology utilizes the "embedded phenomena" design framework (Moher, 2006), "embedding" learners in the spatial and temporal frames of phenomena while they are positioned as investigators of those phenomena. The pedagogical basis for embedded phenomena derives broadly from theories of situated learning (e.g. Brown, et al., 1989). The embedded phenomena framework situates communities of practice (Wenger, 1998) (in our case, intact self-contained classes) within activity structures (scientific investigations) for the purpose of socially constructing knowledge of science concepts and the processes of science as a technical and human endeavor (Duschl, 2000). The extended duration characteristic of embedded phenomena learning units seeks to afford time for movement from the periphery of practice to more central roles within an apprenticeship context of emerging expertise among peers and teachers. The strategy of "immersing" learners within communities and within the physical and temporal bounds of the phenomena, is designed to raise salience through visual and temporal immediacy. We also seek to leverage potential benefits of embodiment, including the motivational value of a physical activity and positive outcomes associated with engaging in physical actions concurrent with skill development and cognitive offloading (Wilson, 2002) and conceptual learning (Antle, et al., 2009), particular for concepts related to spatial phenomena. By engaging students in authentic science practices, we hope to increase the intrinsic motivation to learn science. Research suggests that students are highly motivated by engaging in collaborative scientific practice, and that opportunities for both autonomy and challenge are the critical determinants that engagement (Dede, et al, 2005).

Technology Environment, Curriculum Materials and Approach

WallCology requires a set of computers—WallScopes—capable of running Flash, either from the Flash Viewer or a conventional browser. A "Phenomenon Server" housed in our laboratory runs the population simulation, and any registered client can act as a portal into the simulation. (Ideally, the computers should be used exclusively for this application, and run continuously whenever students are in the room.) Stylus or touch-based interfaces support a "tagging" operation for students to apply a small "dab of paint" to the backs of creatures to track their migratory patterns or use sophisticated "tag and recapture" population estimation techniques.

The population tracking and environmental control activities associated with WallCology are conducted within the context of a curriculum unit on plant and animal ecologies. Depending on the grade level and local curriculum, students may investigate life cycles, predator-prey relationships, food chains and webs, the cyclic nature of populations, population estimation methods, and other topics. (We have used WallCology with about 220 students in grades 3-5.) The population estimation activity is interleaved in time within the larger instructional unit, stretching over most of its length. Periodically throughout the unit, the teacher leads full-class discussions focusing on the interpretation of the accumulating data and the decision regarding whether, and if so how, to intervene. Students maintain personal "field guides" (records of their group's data as well as responses to prompts driven by the larger curriculum unit), and they use large paper sheets taped to the wall to plot population estimates over time.

Methodological or Analytical Challenges

In designing for collaborative activity, it is important that there are enough things for learners to *do*. Observation and reflection are ways of doing, but a design based around one active agent and four silent observers would not have much prima facie credibility as a collaborative and/or constructivist environment. WallCology was designed with a "suite" of *participation affordances*, including performing and averaging creature counts, determining area of vegetation growth, estimating population sizes from samples, aggregating data with other groups to develop "whole room" estimates, and others subtasks. We left the organization of teams to the teachers, who most often adopted a strategy of encouraging, but not enforcing, the use of roles within the team.

A time-based *activity record* of how work was distributed within groups could provide important empirical feedback on the adequacy of the activity affordance suite, the effectiveness of collaborative designs in promoting specific participation distribution outcomes, and the relationship between participation and learning. While such records are possible to obtain from video, they require extensive instrumentation (particularly as activity is spread throughout the room), and the viewing and coding of a time series of activity records for an entire class of students is highly labor-intensive. As the whole classroom replaces the desktop as the venue for interaction, the development of new monitoring and location tracking tools has enormous potential for impact on research in embodied learning.

Interactive Technologies for Embodied Mathematical Learning: Analysis of Group Cognition in PreK Students Exploring Informal Geometry

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Description

The video, observation, and interview data provided by the Interactive Technologies for Embodied Mathematical Learning (ITEML) project was collected in a classroom at the institution's Child Development Center for Research and Learning, which educates a PreK population. The data illustrates how children, ages 4-5, collaboratively explore mathematical ideas in geometry with virtual manipulatives on a multi-touch, multi-user SMART Table™. This will be presented in more detail in a forthcoming publication (Evans et al, 2011).

Theoretical Perspectives

Learners activate schemas or frameworks for building knowledge and appropriate new knowledge. This can be accomplished through "actions on cultures," or through collaborative activity. Co-constructive knowing, as it takes place in knowledge-building communities, has been defined so that "the classroom community works to produce knowledge – a collective product and not merely a summary report of what is in individual minds or a collection of outputs from group work" (Scardamalia & Bereiter, 1994, p. 270). Knowledge-building communities place value on what has collectively been learned and how the learning environments push the boundaries of learning further than ones that focus on individual work. These ideas lead to the following research priorities:

- *Inquiry*: provides an authentic context for exploring mathematical ideas as students identify potential solutions to validate amongst peers and experts (Brown, Collins, & Duguid, 1989);
- *Mediation*: learning is mediated by the use of psychological and instrumental tools. Instructional artifacts include both externally oriented technical tools and internally oriented psychological tools or signs (Ares, Stroup, & Schademan, 2009);
- *Collaboration*: mathematics instruction now advocates the facilitation of the co-construction of knowledge with peers (Enyedy, 2003). Students with similar levels of competence share their ideas to jointly solve a challenging mathematical task that is less likely to be accomplished without collaborative engagement;
- *Discourse*: collaboration is driven by discourse, and knowledge is the product of a process of inquiry. Negotiation as a form of discourse is collaboration, and it is in collaboration that the group becomes defined and thusly the individual finds identity within the group (Stahl, 2006).

Our research attempts to develop a framework for inquiry-based problem-solving activities that promote PreK-2 students' understanding of mathematical concepts in geometry. It proposes a plan to implement and assess the learning outcomes of these activities with a special focus on mathematical discourse and technologies to facilitate this discourse.

Technology Environment, Curriculum Materials and Approach

Figure 5. Left: 4-year Olds Solving "Fisherperson" Puzzle. Right: Top Down View of Same Puzzle.

Our initial research used physical manipulatives of plastic tangrams to compare to virtual manipulatives using preexisting applications on the multi-touch, multi-user SMART™ Table, utilizing three students and one instructor. While the application allowed for some research opportunities, it contained several features that caused unwanted behaviors hindering research: pieces could be randomly placed within the puzzle causing a mechanism to automatically position, rotate, and lock pieces within the puzzle. This caused students to rely more on the mechanism than on reasoning and collaboration. We designed and implemented a new application with the intent of making it easier to observe the behaviors and interactions of the students with the multi-touch table and each other.

The latest build supports three different scenarios for each puzzle: free, single and divided ownership, which provide the learner with experiences that promote cooperation to aid the development of social skills. In the free ownership mode, learners move any of the pieces in order to complete the puzzle. In divided ownership mode, the pieces are separated into three different colors, one for each learner. In the single ownership mode, one learner can move any of the pieces while the other two learners assist in moving the piece using gestures and dialog. Each of the implemented modes, especially single-ownership, relies on both speech and gesture in order to complete the puzzles. In all modes, we encourage learners to talk together to complete the puzzle.

Methodological or Analytical Challenges

Our analytic goal is to better understand pivotal moments within small group collaboration among PreK students as well as how particular educational setups (physical/virtual, free/divided/single-ownership, etc.) influenced group knowledge construction. Through coding and identifying patterns in nonverbal and verbal indices of cooperation and focus (including gaze, gesture, manipulation, and speech), we were able to identify moments of discursive cohesion that structure collaborative reasoning. We identify these cohesive points via "coreferences" after McNeill (2009). In its most basic sense, a coreference can be understood as the repeated expression of a single referent, either object, person, or meta-structure, which crosses over verbal and nonverbal deixis, referring to the phenomenon that the denotional meaning of utterances and words is contextually based. Although the field of coreferential and deictic analysis has focused on spoken deixis, we find that especially in the development of mathematical and picture-making skills, observing nonverbal communication is key to understanding how shared cognition facilitates knowledge construction. We have developed a method of multimodal coding, through similar work with data from second graders but with different modalities, to allow us to track nonverbal as well as verbal events over time. The result of our continuing work is an expansive rubric for classifying how action, gesture, and speech relate to and build upon one another during the problem-solving process. We have found that many utterances contain implicit references to geometric principles (e.g., fitting larger pieces in first, properties of the pieces) as well as implicit references to principles governing cooperative problem solving (e.g., turn-taking,). We are interested in how children manifest their understanding of these rules and principles in speech, gesture, and action. Additionally, we investigate how individual coreferences (i.e. with a single referent) constitute larger units of collaboration; that is, how the children form coalitions focusing on a single task, such as, fitting in a single piece, with the greater aim of solving the puzzle.

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