

Collaborative Problem Solving with Linked Representational Tools

Tobin White and Kevin Lai

School of Education, University of California, Davis, USA
twhite@ucdavis.edu

Abstract: This paper presents a design for collaborative problem solving with networked representational tools, and reports on two studies—one with undergraduates in a laboratory setting and one in a high school algebra classroom. By equipping multiple participants with an array of representational resources linked through a device network, we sought to explore instances of distributed cognition through this design. Initial findings show different representational tool usage between students from the two settings.

Keywords: Collaboration, distributed cognition, technology

Introduction: Distributed Learning and Collaborative Design

Collaborative learning tasks are likely to be most effective when they are sufficiently complex to necessitate contributions from each member, and when participants engage the task and one another in ways that sustain that variety of contributions [1]. Distributed cognition, by taking the analytic unit of cognitive activity to be an aggregation of persons, tools, and task [2], provides a powerful framework for conceptualizing such collaboration. This paper describes a design for collaborative problem-solving, and examines the different forms of collaborative activity that emerge from different distributions of persons and tools and in different settings. In particular, we investigated two research questions: 1) How does the distributing of representations across devices support collaborative problem-solving? 2) How do participants in classroom and laboratory settings differently engage the distributed representational affordances of this system?

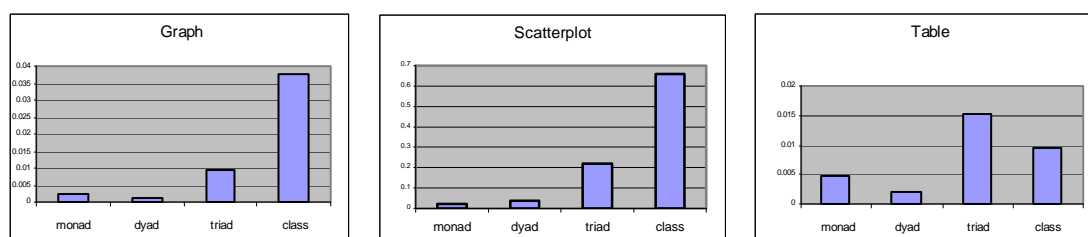
1. The Learning Environment: Collaborative Cryptography

Our design uses the NetLogo modeling environment and the TI-Navigator 3.0™ graphing calculator network [3]. A laptop placed at each group's table provided both a shared display for up to four students and a server for their network of calculators. Groups worked together on a series of open-ended mathematical problem-solving tasks set in the context of cryptography. Each task presented the group with a cipher text message that had been encrypted by assigning letters in the English alphabet to their ordinal values 1 through 26, and then mapping those values through a polynomial function. Breaking these codes involved finding this unknown function using three different representational tools, each controlled by a different calculator and displayed on the laptop screen: a graphing tool, a function table, and a scatterplot. Along with these tools, the cipher text and a table displaying the frequency of each distinct letter in the message were displayed on the server screen. Responsibility for these different representational tools could be consolidated to a single calculator and the server, or distributed among up to four participant roles, so that one student generated graphs of a candidate function, another toggled between tabular displays of her own and the grapher's candidate function, another manipulated plain-to-cipher text ordered pairs in the scatter plot, and another sought syntactical or syllabic patterns in the encrypted text and character frequency table.

2. Methodology

In the laboratory study, we recruited 24 volunteer undergraduates to participate in decryption. In the classroom study, we implemented the same series of decryption tasks with 26 ninth grade students during a four-day lesson sequence in a first-year high school Algebra class. In the laboratory trials, all problem-solving sessions were videotaped with two cameras, one focused on the participants and one on the computer screen. In the classroom implementation, three focus groups of four students each were videotaped during all decryption activities. Several key pieces of data related to the problem-solving process were logged on the server. In particular, each candidate function entered into the table and graph tools was recorded and time-stamped, as was each input of a letter-number ordered pair in the scatterplot tool.

3. Results



Figures 5a, b & c. Comparisons of Dynamic Representational Tool Use.

In our initial analysis, we focused on the representational usage by the various laboratory groups (monads, dyads, triads) and classroom groups. Figures 5a, b and c display use of the three dynamic representations—the graph, scatterplot and table—as measured in inputs per second through server log data. All three representations were used far more by the triads than either monads or dyads. Moreover, classroom groups used both the graph and scatterplot more frequently than the triads, while using the table somewhat less frequently than the triads, though still more than the monads and dyads.

The greater frequency of use of these representational tools is partly accounted for by the numbers of calculators and participants. But we note that particularly in the cases of the graph and scatterplot, use appears exponentially rather than linearly correlated with group size. We hypothesize that the interactive affordances of more visual representations (graph and scatterplot) may make them more appropriate in the larger groups. These trends might also reflect preferences for more visual representations among high school students and for more analytical approaches to problem solving among advanced students. In general, the classroom groups appeared to spend more time using the representational tools provided by the technology, while the laboratory groups were quicker to analyze patterns in the abstract. In subsequent analyses, we will examine relations between the groups' representational and their strategies and overall efficiency in breaking codes.

References

- [1] Cohen, E. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*, 64(1): 1-35.
- [2] Pea, R. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (ed.), *Distributed cognitions: psychological and educational considerations* (pp. 47-87). New York: Cambridge University Press.
- [3] Wilensky, U. & Stroup, W. (1999). HubNet. <http://ccl.northwestern.edu/netlogo/hubnet.html>. Center for Connected Learning and Computer-Based Modeling, Northwestern University. Evanston, IL.