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Quantity and quality: A model of how linguistic input drives lexical and cognitive Development

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Scientific Reasoning in Day-to-Day Research

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Introduction

Klahr and Simon (1999) identified four approaches to scientific studies of science emerging in recent decades: (a) Historical accounts of scientific advances, (b) psychological experiments of non-scientists on structured and ill-structured problems, (c) observations of researchers' daily work in science, and (d) computational modeling of scientific discovery processes. Our study fits as (c) observations of daily work in organic synthesis laboratories as others have done in biomechanical engineering (Nersessian, et al, 2002) and molecular biology (Dunbar, 1995). We expect to develop a grounded theory (Glaser & Strauss, 1967) of scientific reasoning within a community of practice (COP).

Theoretical Framework & Methodology

Cognitive apprenticeship is situated learning within a proficient COP through each participant's immersion with frequent opportunities for practice, reflection and discussion while pursuing goals (Lave & Wenger, 1991). When Dunbar studied four different laboratories, all four COPs practicing molecular biology reasoned very similarly, i.e., similar experimental heuristics, mental representations, and problem solving heuristics, and differed only in their own combinations of these features. He noted that researchers interacted with the COP's domain knowledge and fellow researchers to reduce reasoning errors. Logic in scientific reasoning requires *substantial leaps* from the data to infer conclusions (Toulmin, 1977). Toulmin explains that each field (COP) has different things to reason about, different consequences to gauge, and thus, different criteria for justifying inferred conclusions. Thus, apprentices must learn COP-specific standards of justifiable reasoning.

Video data collected included 80 hours of researchers working in the lab, gathering and interpreting data, interacting with mentors, and attending group meetings. Semi-structured interviews, field notes, and laboratory notebook pages supplemented video data. All COP data were analyzed for norms, practices and reasoning.

Results & Conclusions

We asked how scientific reasoning, is instantiated when apprentice researchers pursue their daily work towards Ph.D. "certification" as scientists. This organic COP synthesizes compounds for potential in treatment of diseases, e.g., HIV. The research director determines norms of distributed work from success in funding proposals**;** each project proceeds from a different foundational molecule, however uses similar techniques, equipment, and instruments to perform chemical reactions. Long series of reactions and what makes them work (a mechanical system) lead to a molecule engineered to possess specific and valuable properties.

Problems punctuate researchers' progress. We define a problem as a *difficulty* when the issue shows a basic lack of understanding of the process or inability to get the mechanical system working whereas an *anomaly* is an unexpected and therefore, problematic, piece of evidence. Experience with COP problems inspires integration of explicit declarative knowledge of chemical properties and mechanisms with functional procedural knowledge, whose product is often tacit expertise.

Scientific reasoning is instantiated as "street smarts" developed in a specific research COP where reasoning: (a) Is guided by expectations of the organic synthesis COP's norms and standards (constraints) while researchers do valued COP work. (b) Leads to and develops further apprentices' learning in what to notice, understand, and take advantage of in terms of physical, human, and disciplinary COP resources (affordances). (c) Determines causal interactions of relevant variables in a mechanical system causing difficulties. (d) Is *learning how* to interpret the COP's typical kinds of evidentiary formats in feedback because evidence is often evident only to COP members. (e) Recognizes anomalies in feedback. (f) Deciphers and explains anomalies.

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