The Challenge of Keeping Score in Distributed Epistemic Games

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# ABSTRACT

Most research on knowledge construction focuses on an individual learner. The objective of my work is to take the theory and methods developed to understand an individual’s knowledge construction and apply them to collective knowledge construction. Towards this objective, I’ve created a framework called distributed epistemic games (DEGs). Having built descriptive lists of DEG moves with earlier work, I am now focusing on expanding this framework to address the goal of evaluating a group’s progress with respect to knowledge construction.

## Author Keywords

Collective Intelligence; Distributed Epistemic Games; Knowledge Analysis

# CSS Concepts

• **Human-centered computing~Collaborative and social computing**; *Collaborative and social computing theory, concepts and paradigms*; Computer supported cooperative work

# INTRODUCTION

## Motivation

In Prelude to Foundation, Asimov proposes a thought experiment asking whether a certain block of platinum would be too heavy for the unaided strength of those who could surround it [2]. This corresponds to a class of problems, which I call cubic meter (m3) problems, which are unsolvable not in theory, but because there is no way to get enough people around the problem to solve it.

In God's Debris, Adams introduces a claim that humanity is using the internet and other tools to build an omniscient super-being by creating a system in which any human has access to the knowledge of any other human [1].

These two books inspired my work, with Asimov leading me to look for ways to lift the cubic meter by solving problems which are only unsolvable as a technicality because they need more minds than can currently fit; and Adams leading me to study how humanity is building a collective omniscience by working together to construct knowledge and preserve it in the form of artifacts, including blogs, papers, and other repositories.

I view this collective knowledge-building work as a distributed epistemic game (DEG) which integrates the theoretical lenses of *epistemic forms and games* [3] and *distributed cognition* [9, 10].

## Theoretical Background

*Epistemic forms and games*, introduced by Collins & Ferguson, views the knowledge construction of scholars as the result of an epistemic game, guided by a form, which is selected based on a question [3]. For example, a scientist might start with a question, such as ‘How can I distinguish between two plants?’ Using the question as a guide, they next select the form which is a template that - when completed - will answer the question. In this example, the form could be a list or a compare & contrast table which would store the characteristics of the plants, or a dichotomous key which would present a series of binary choices to guide the decision. Finally, the learner plays the game by completing the form. The theoretical framework of epistemic forms & games, while elegant, doesn’t account for knowledge construction of a group.

To handle group or collective knowledge construction, I add Hutchins’ framework of *distributed cognition* [9, 10]. Hutchins asserts that knowledge is highly influenced by the environment - including tools, artifacts, and other individuals - and that the interactions between an individual and the environment are the thinking process itself, not merely the evidence thereof [10]. I also draw a connection, based on the significant and causal importance of interactions to the knowledge construction process, to the *doer effect* as studied by Van Campenhout and others [16]. Like *epistemic forms and games* the *doer effect* focuses on the individual learner, but I use the lens of *distributed cognition* to look at the learning of a group instead.

## Methodological Background

Characterizing the knowledge construction of a group, rather than an individual, has required an open approach, largely using the methods of *grounded theory* building [6, 8, 14]. Some of the key characteristics of this method are an iterative and recursive qualitative coding process in which data are evaluated in an open-ended manner to identify codes for each data point. The data set for grounded theory building need not be tied to knowledge construction specifically, grounded theory is open-ended enough to work with any type of qualitative data source.

I have also drawn methodological inspiration from *knowledge analysis* (KA), especially the distinction between *microanalytic* and *microgenetic* analysis goals and structure [5]. In their work, diSessa, Sherin, & Levin distinguish between describing specific moments (*microanalytic*) and describing the change over time (*microgenetic*) [5]. While *knowledge analysis* specifically focuses on changes at the grain of an individual learner, I have found these distinctions helpful in providing scaffolding around the goals for my *grounded theory* approach.

# EXISTING WORK

## Preliminary Work & Findings

In my work to this point, I have focused on completing an epistemic form of a list of elements by describing various moves in a distributed epistemic game.

### Published Work

I have focused on a specific instance of collective knowledge construction, the first Polymath project. This project is described in detail in other work, including several of my own publications, so will only be described briefly here [4, 11, 12, 13]. The first Polymath project was introduced by Tim Gowers on his blog [7] and carried out over the course of several weeks on his and Terence Tao’s blog [15]. The goal of the Polymath project was to evaluate whether it was possible to create a mathematical proof through a broad and voluntary collaboration [7]. My own goal in preliminary work has been to identify and describe moves within the distributed epistemic game. The moves of interest represent interactions between players, artifacts, and tools as the players work together to complete multiple concurrent forms (including lookup tables and mathematical proofs) and complete the game. In some instances, collections of moves were identified which form a tactic by influencing each other and progressing the game. One such tactic was key to the development of the *distributed epistemic games* theoretical framework [12] as well as a metric to track changes in interactions among players as the result of a single move [11].

### Ongoing Work

My ongoing, as yet unpublished, work has focused on (1) expanding the list of moves and tactics within this particular game as well as (2) evaluating additional analytical methods such as network analysis to understand which moves most often occur together and temporal decomposition to understand which order moves most often occur in.

### Summary

Both published and unpublished work up to this point has been primarily descriptive, what KA would call microanalytic work, as I have identified the individual moves made [5]. This work has laid a beneficial groundwork, identified moments of interest in the larger data set, and led to publishable results. At this stage, I am seeking to transition from this microanalytic focus to a *microgenetic* focus, where I step up from describing individual moves and tactics to showing the *progression of knowledge construction throughout the game*.

# PROPOSED WORK

## Microgenetic Analysis

Every action has an impact, but those impacts differ in both direction and magnitude. With sufficient expertise in both the method (KA) and the subject matter (such as mathematics or physics), researchers have been able to analyze moves not only in terms of separate, individual actions but also in terms of progress towards a goal. This is the concept of *microgenetic analysis* as described in [5].

Another way of understanding this type of analysis is as a qualitative temporal decomposition, showing changes in the character of knowledge over time. As mentioned above, this analysis requires expertise in the subject matter in order to characterize the knowledge at any one point, as well as the relative value of changes to that knowledge.

## Proposed Experiments

Using existing or new data, I want to extend the framework of a distributed epistemic game to include the vector (direction & magnitude) of individual moves and tactics, to describe the progress they make towards the overall game. This goal will require subject matter expertise in order to answer the questions: Does move x get us closer to the ultimate solution? How does path y towards the solution differ from path z?

In order to accomplish this, I expect that the data will need to be initially coded using a similar approach as I have done for the Polymath data. The challenge I am facing at this stage is a way to code moves and tactics not only for what they are but for how they change the game. The goal of future work is to measure the epistemic value of moves or tactics and the progress/regress effect on the larger game.

## Research Challenges

With the goal of understanding distributed epistemic games - knowledge construction as a group - across multiple disciplines (including math, engineering, physics, art, and others) there are definite challenges to adding the vector to moves and tactics. At this stage, I’ve identified three options, listed here with their corresponding challenges:

The first option is to create a generic method for evaluating distributed epistemic games. However, a method generic enough to avoid the requirement of subject matter expertise is unlikely to be interesting or valuable enough to make a contribution. Taking away the subject matter expertise requirement is like removing the coordinates of a goal - we can see movement but can’t determine progress.

The second option is to develop the necessary subject matter expertise. But, developing subject matter expertise across all these fields as an individual researcher adds an inordinate amount of time to changing fields of focus, making it more difficult to identify methods which will work for the study of distributed epistemic games regardless of field. While the value of subject matter expertise is understandable, for my goal of understanding the process of knowledge construction as a distributed epistemic game - across multiple fields of study - the requirement of this expertise within an individual researcher is unsustainable.

The final option is the development of a *collaborative protocol*. Developing a protocol for working with experts within the field to evaluate moves and tactics for their vector brings challenges of translation across fields (from learning science to engineering, for example) and the blind spot in which experts are unable to articulate the specifics of their own expertise and process. However, the development of a protocol for evaluating distributed epistemic games in collaboration with subject matter experts provides exciting possibilities to work across disciplines to describe moves and tactics not only in terms of their actions, but also in terms of their vector or how they change the knowledge construction of the group overall.

Eventually, this understanding of the impact of moves and tactics on the distributed epistemic game will inform the design of environments and games to address the cubic meter problems across disciplines.

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# SUPPLEMENTAL PARAGRAPH

## Why now?

I believe now is the most effective time to participate in a doctoral consortium to get feedback and guidance from more senior academics in the field. I have completed the coursework and will be defending my comprehensive exams in early September several months before the conference takes place. This means that I will attend the conference having completed my coursework and pilot/preliminary analyses and ready to design the work for my dissertation.

## Expected Benefit

I expect to gain perspective/insights/advice to help address the challenge of ‘scoring’ moves or tactics in terms of their contribution to the construction of knowledge. Earlier work in similar fields has suggested that researchers must have their own subject matter expertise, I am hoping to develop ways to instead work *with* experts in the field so that my research can cross boundaries beyond where I personally have expertise. My current work has several descriptive methods. I am hoping meeting with the doctoral consortium will help me add a new layer in which the move is not only described but also scored.

## Completion of Doctoral Studies

Based on my current plan with my chair, I expect to complete my doctoral studies in Spring of 2025.