Uncovering Features of Discourse that Increase Interactions

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ABSTRACT: Isaac Asimov discussed *the parable of the cubic meter*, in which a group of individuals are unable, through their own unaided strength, to lift a cubic meter of platinum due to its weight. He compares this to a problem that cannot be solved because it isn't possible to get enough people around it (Asimov, 1989, p.62). Some problems are larger than what a single mind can solve alone; these problems require collaboration or collective intelligence to arrive at a solution. As learning scientists, improving our understanding of collaborative problem solving – and what makes that problem solving effective – can help us design collaborative processes that more effectively lead to solutions. In this paper, we introduce a technique for automating the identification of a key moment in group discourse (an interruption) that leads to an increase in interactions among group members, thus enriching the group's thinking.

Keywords: Interactions; Automation; Text Analysis; Collective Intelligence; Collaboration

1 WHY INTERACTIONS MATTER

Interactions have been shown to have a powerful and causal relationship with what is learned and retained (Koedinger et al., 2018; Van Campenhout et al., 2021). In theories of distributed cognition (i.e., the idea that intelligence is distributed across people, tools, and contexts), these interactions are regarded not as evidence of thinking, but as thinking itself (Hutchins, 2008). Building on these concepts, it seems reasonable to expect that increasing interactions increases the thinking that occurs in the group, which can have a positive effect on learning. To help learning communities become more interactive we need to better understand what factors lead to a change – especially an increase – in interactions. By describing key changes in interactional patterns, we can lay the groundwork to develop computational methods for analyzing larger data sets of group interactions.

1.1 The Polymath Project

In prior research, we analyzed data from the first Polymath Project (Cranshaw & Kittur, 2011) to understand productive moves in distributed knowledge-construction activities (Matthews & Swanson, in review). In the Polymath project, a group of individuals with a range of mathematical expertise was able to solve, within a few months, a problem that had remained unsolved for some time (Polymath, 2012). A proof that seemed an impossible target was created by this group in a relatively short time. This collaborative work was facilitated by technological tools and artifacts - from computers connected through the internet to a blog facilitating discussion threads. In our prior work, we evaluated this robust data set (consisting of blog posts and response threads) to better understand the processes involved in distributed knowledge construction.

2 THE INTERRUPTION AND ITS IMPACT ON GROUP INTERACTIONS

Through a qualitative coding process, we identified a key moment where a question served as an interruption that changed the interactional pattern of the group. Recalling from Hutchins (2008) that interactions are the thinking process itself, we interpret a change in interactional patterns as a change in thinking. In our data, the group went from a monologue (i.e., a large word count with a single, distinct speaker) to a conversation (i.e., additional speakers with smaller individual word counts), following the interruption. Figure 1 represents the change in the group's interactions from left to right. Each circle represents a speaker's contribution; its radius represents the word count per comment. The single grey circle represents a lengthy contribution made by a single speaker. The smaller multi-colored circles represent the shorter contributions of seven speakers, including the speaker from before the *interruption*~~.~~ Our qualitative examination revealed that the post-interruption comments addressed the interrupting question in relevant and diverse ways. This is most noticeable in the way that the interrupting question challenged assumptions from earlier in the conversation. Indeed, many post-interruption comments reconsider these earlier assumptions. Recognizing the importance of interruptions, we examine automatic ways to detect these moments in this paper.

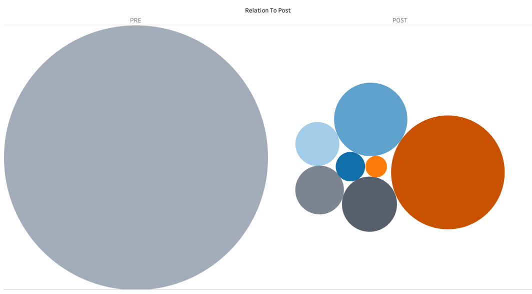

Figure 1: The impact of interruption – more speakers with fewer words per speaker

3 DETECTING INTERRUPTIONS

3.1 Manual Process

3.1.1 Data Set

We started with a data set of 765 comments posted on the blog of a leading mathematician near the beginning of the first Polymath project. We selected this data set to investigate the nature of distributed knowledge-construction in the early phase of the Polymath project. Furthermore, the data set provided multiple interesting interactions between individual mathematicians, as revealed by our pilot analyses. We removed comments that happened well after the initial set of interactions. This left us with a subset of 552 comments, all of which happened between January 27, 2009 at 4:47 pm and February 15, 2009 at 10:59 pm (times are taken from blog post data).

For each remaining post, we calculated the word count, then a running total of the word counts and speakers for the previous 10 posts. These running totals were used to create a ratio of words to speaker. For each post that ratio was compared to the ratio for the next 10 posts (placing the post in the center of a before-after picture). A decrease in ratio (before - after > 0) means that there were more interactions after the post (more speakers, lower word:speaker ratio) than before. Because we are comparing the 10 posts before with the 10 posts following, the first and final 10 posts in the data set are not included in the analysis. We are therefore working with a data set of 532 comments.

3.1.2 Posts Increasing Interactions

Out of the 532 comments from the previous step, we were left with 289 posts which led to a decrease in the word:speaker ratio, meaning those which led to an increase in interactions. These decreases in ratio varied significantly, from 3.05 to 17,638.67. Sorting from largest to smallest variation can allow us to focus our time on the most impactful interruptions, or those which change the word:speaker ratio - and therefore the number of interactions - the most.

4 NEXT STEPS – AUTOMATING THE DETECTION OF INTERRUPTIONS

By automating this process – detecting those moments where *something* happens to cause an increase in interactions – we can focus our time as researchers on understanding what it is that increases the interactions and the discourse that follows. We agree with Hutchins (2008) that these interactions *are* the thinking process, and with Koedinger et al., (2016) and Van Campenhout et al., (2021) that the interactions increase understanding and retention. It follows that any automation that helps researchers understand how to increase interactions allows us to better design the collaborative work around our difficult problems - our cubic meters - to increase a group's thinking and their progress toward a solution.

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