Knowledge Construction Patterns in Online Conversation: A Statistical Discourse Analysis of a Role-Based Discussion Forum

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Abstract: Assigning roles to individual students can influence the group's knowledge construction (KC) process during online discussions. Twenty-one students were divided into two groups and assigned rotating roles for eight one-week asynchronous online discussions. The KC contributions of all 252 posts in the discussion were coded using a five phase scheme; then statistical discourse analysis was applied to identify segments of discussion characterized by particular aspects of KC and "pivotal posts"—those posts which initiated new segments of discussion. Finally, the influences of assigned student roles on pivotal posts and KC were modeled. The results indicate that most online discussions had a single pivotal post separating the discussion into two distinct segments: the first dominated by a lower KC phase; the second dominated by a higher KC phase. The pivotal posts that initiated later segments were often contributed mid-discussion by students playing one of two summarizing roles (Synthesizer and Wrapper).

Introduction

Small group interactions in discussion forums are increasingly common during online learning and blended (face-to-face plus online) instruction. These discussions provide opportunities for negotiating meaning and co-constructing knowledge (Boulos & Wheeler, 2007). Like their face-to-face counterparts, online discussions can help learners participate in different aspects of the knowledge construction (KC) process: they can articulate their ideas and hear alternative points of view; debate and probe different ideas more deeply; synthesize and negotiate compromises in their positions; and test, modify and apply their newly-constructed knowledge (Stacey, 1999). However, simply putting students together in a computer-supported environment does not necessarily lead to knowledge construction (Fischer et al., 2002). Online conversations often remain exercises in listing ideas rather than engaging in rich interactions to construct shared understandings (Thomas, 2002). To support KC, online discussion environments must structure interactions to encourage productive collaboration (Dillenbourg, 2002).

We investigate one technique for supporting productive collaboration and KC during online discussions: assigning conversational roles (e.g., "Questioner") to script the process by which students interact (Hare, 1994). Specifically we use both content analysis and statistical discourse analysis (Chiu, 2008) to examine how: (a) the process of KC proceeds in an online discussion with assigned roles; and (b) a "summarizing" role in the middle of a discussion affects subsequent KC.

The Process of Knowledge Construction (KC)

The five-phase Interaction Analysis Model for Examining Social Construction of Knowledge developed by Gunawardena et al. (1997) is a tool for conceptualizing and assessing the process of KC during asynchronous discussions. The theoretical model was developed using a grounded theory approach and attempts to represent "the complete process of negotiation" involved in KC (p. 413). The model is presented in enough detail to guide empirical coding of the KC process and has been used extensively in studies involving roles.

In Gunawardena et al.'s (1997) model, KC occurs in a series of successive (though not necessarily strictly sequential) phases that can be viewed as moving generally from lower to higher mental functions. In the model, learners begin by sharing, clarifying, and elaborating ideas (Phase 1: *Sharing Information*). Then, conflicts among them are explored (Phase 2: *Exploring Dissonance*). Next, learners reconcile conflicting ideas by negotiating their meanings and co-constructing new knowledge propositions (Phase 3: *Negotiating Meaning*). Learners may then test and revise their synthesized ideas (Phase 4: *Testing and Modifying*). Finally, they can state and apply their new knowledge (Phase 5: *Agreeing and Applying*). The drive is to achieve higher phases of KC; however, successive phases build on each other. Hence, *all* phases contribute to the KC process (Gunawardena et al., 1997).

While Gunawardena et al.'s (1997) model conceptualizes knowledge construction as a process which occurs though learners' interactions (via their posts), previous work has not capitalized on its capacity to examine this process by analyzing *patterns* of KC. Past studies have often evaluated discussion quality by counting the posts in each KC phase (e.g., Schellens et al., 2007) or by computing each discussion's average KC phase (e.g., Schellens et al., 2005). These compiled measures treat KC as an outcome variable where more posts in higher KC phases indicate better learning, though the scheme was designed as a model of the *process* of constructing knowledge. Importantly, two discussions can proceed quite differently, while having the same KC phase counts (e.g., a sequence of posts with KC phases 1212312123 vs. 1111222233). By treating KC as an

aggregate outcome of individual contributions, prior studies failed to test a central underlying premise of the model: groups construct knowledge through a specific sequence of phases. In this study we address this issue by analyzing how the group proceeds through the phases of the KC process.

Possible Patterns of KC Phases

Gunawardena et al.'s (1997) model suggests two possible KC patterns, but others are also theoretically possible. By identifying these patterns' characteristics, we can empirically test for them. These patterns are currently descriptive; future work will evaluate their benefits, drawbacks and relationship to KC outcomes.

Theoretically Predicted Pattern 1a: Strictly Progressive Segments for Each KC Phase

One interpretation of Gunawardena et al. (1997) views the KC phases as a strictly increasing sequence. Viewing KC as an interdependent process and a cumulative group effort, an individual's progress through the phases depends on and influences other group members, stimulating them to proceed through the phases more-or-less together. Transitions between the phases can thus be viewed as initiated by a "pivotal post," a contribution by a student (or the instructor) which changes the mode of discussion from one phase to another. This perspective aligns with other recent work on "pivotal moments" in the CSCL community (e.g. Lund et al., 2009).

A discussion that follows a strictly progressive sequence of the KC phases might proceed as follows. Initially, learners share ideas (a series of KC Phase 1 posts, e.g., 111). When a learner disagrees with another group member's idea (KC Phase 2), others may not always engage. Instead, they might continue proposing new ideas (e.g. KC phases 111211). In this case, the discussion continues in a sharing mode, identified by the dominance of posts in KC Phase 1 (with occasional posts in other phases). In contrast, a disagreement can act as a *pivotal post* that radically changes the mode of discussion. In this case because the pivotal post is a disagreement, the new mode of discussion becomes that of exploring disagreements (e.g. 11211→**2**22, the pivotal post is indicated in **bold**). At some point, a learner may attempt to reconcile views presented in different posts (KC Phase 3). This can provide a more cohesive view of disparate ideas—a common base around which group members can negotiate shared understandings. If others follow suit, the post serves as another pivotal post, and the group transitions from debating to reconciling ideas (e.g., 222→**3**3233). Next, a learner may start to test the negotiated idea(s) (KC Phase 4) which can stimulate more testing and revision of the idea(s), creating another higher phase discussion segment (e.g., 33233→**4**454344). Finally, if a learner formalizes and applies the revised idea(s), this can spark other applications in a KC Phase 5 discussion segment (e.g., 4454344→**5**5545). This hypothetical discussion follows Gunawardena et al.'s model of a "complete" knowledge construction process; it consists of five distinct, segments of progressively increasing KC phases with changes initiated by four pivotal posts (11211→**2**22→**3**3233→**4**454344→ **5**5545).

Theoretically Predicted Pattern 1b: Progressive and Regressive Segments for each KC Phase

Knowledge construction is not always a strictly linear process (Paavola et al., 2004). Thus another interpretation of Gunawardena et al. (1997) recognizes earlier phases as logically prior to later phases, but also allows regressive segments: segments dominated by lower KC phases than the previous segment. For example, a tentatively shared synthesis (KC Phase 3) might break down when a learner returns to debating the merits of a particular idea (KC Phase 2) and others follow suit (e.g., 11211→**2**22 →**3**3233→**2**212). In this pattern, any number of segments can occur, and the return to a "lower" phase as part of the KC process is not necessarily negative for the discussion.

Alternative Patterns

There are other theoretical alternatives to the ones Gunawardena et al. (1997) suggest. One possibility is that groups might skip one or more KC phases. For example, learners might share their ideas (e.g., 111211) and then propose a compromise among them (111211→**3**333) without exploring differences or disagreements (skipping KC Phase 2). Then, they might conclude their discussion without testing or applying it (Phases 4 and 5). Here, the discussion has only two segments (111211→**3**333), though each segment is dominated primarily by posts in one KC phase. This pattern of segments with skipped KC phases can be strictly progressive (Pattern 2a) or include regressive segments (Pattern 2b; e.g. 111211→**3**333→**2**2122). In both cases the patterns do not require passing through all earlier phases to reach later ones. Other alternatives are that the KC phases of posts increases through progressive segments that are not clearly defined by a single phase (Pattern 3: e.g. 111→**2**21312132) or that no distinct segments of KC phases exists (Pattern 4: e.g. 15314215). Next, we discuss how assigned student roles and the functions they ask learners to perform align with the KC phases and might influence the above KC patterns.

Supporting KC in Online Discussions with Assigned Student Roles

Online learning conversations often do not realize their potential as sites of rich KC. One way to increase the likelihood of valuable learning interactions is by assigning roles to students to script their collaboration (Dillenbourg & Hong, 2008). Roles give students guidance about how to interact with one another productively

in ways that promote desired cognitive, metacognitive and socio-cognitive processes (King 2007). Common assigned roles include moderator, starter, wrapper, planner, theoretician, source searcher, responder and summarizer (e.g., Schellens et al., 2005; Strijbos et al., 2004).

Roles can support collaborative KC in online discussions by creating positive interdependence and mutual accountability among students (Schellens et al., 2007; Strijbos et al., 2004), leading to increased interaction (Hara et al., 2000; Seo, 2007) and integration of discourse (Persell, 2004). Roles can also support students' metacognitive awareness of their contributions to the group's KC (Persell, 2004; Strijbos et al., 2004), helping them to self-moderate discussions and increase their autonomy, ownership, motivation and responsibility for learning (Seo, 2007). However, not all roles influence posts' KC, and specific assigned roles can have different influences (for example, contrast the positive effects of the "Wrapper" role with the negative effects of the "Source Searcher" role in De Wever et al., 2007 and Schellens et al., 2005; 2007).

While past research suggests that some particular roles can have a positive impact on KC during online discussions, research gaps remain. In particular, researchers have not examined the interdependent nature of the group processes underlying KC, in which each learner's posts help build the context for others' future posts. Specifically, work is needed to investigate how role-based posts influence other participant's postings and overall group KC patterns. To consider how specific roles may interact with the KC process, we can examine the alignment between the KC phases and the specific functions that each role asks a learner to enact. If a role asks a learner to perform a function that aligns with a KC phase different from the KC phase of the group members' current posts, that contribution could act as a pivotal post that initiates discussion in a new KC phase. Building on De Wever et al.'s (2007) efforts to assess role enactment, Wise et al., 2009) analyzed assigned roles in the literature and identified six core conversational functions that they ask learners to perform: Introduce New Idea, Bring in Source, Use Theory, Respond, Give Direction, and Summarize. We propose that some of these functions conceptually align with specific KC phases. Specifically, we focus our attention on the Summarize function and its associated roles because it theoretically aligns with advanced phases of knowledge construction (De Wever et al., 2007; Schellens et al., 2005; 2007).

Learners in Summarizing Roles May Create Pivotal Posts That Advance KC

Summarize is a synthetic function that asks a learner to organize and integrate different ideas in the discussion (Wise et al., 2009). For example, in a discussion on math lesson planning, a learner can describe how several different suggested activities for teaching parallel lines could be combined. Cognitively this helps the summarizing learner (and potentially those who read the post) to consolidate their understanding of different ideas. From a socio-cognitive perspective, summarizing posts can support the group in building on the existing discussion, maintaining joint attention and coordinating their activity.

With respect to the KC process, a summarizing post can identify areas of agreement and aid compromises between contested ideas (which aligns theoretically with KC Phase 3, Negotiation of Shared Meaning). Or, it can help group members reach a final agreement and recognize changes in their ideas (which aligns with KC Phase 5, Statement/ Application). While empirical studies show that summarizing *posts* consistently contribute at a high KC phase (De Wever et al., 2007; Schellens et al., 2005; 2007), *groups* assigned roles with a summarizing function have not consistently outperformed those without one (e.g., compare Schellens et al., 2005 and 2007). One reason other group members may not realize the benefits of summarizing posts is that the Summarize function is often assigned to a Wrapper role asked to conclude a discussion. (Schellens et al., 2005; 2007; see also Hara, et al., 2000). Since a Wrapper generally summarizes at the end of a discussion, other group members are unlikely to make subsequent posts and thus realize the coordination benefits described above.

We propose using the Summarize function in the middle of a discussion to synthesize discussion strands, maintain joint attention and ground subsequent discussion. While few students are likely to post after the Wrapper at the end of a discussion, many more are likely to build on a midway summary that helps them integrate their understanding of the various ideas. Reading a summarizing post can prompt them to join the synthetic effort to co-construct shared understandings with their groupmates. As more students do this, they create more posts in higher KC phases, compounding these processes until the whole group collectively climbs to a higher phase of KC. In this way, a midway summarizing post is potentially a pivotal post that can elevate a group to a higher KC phase, helping to solve the insidious problem of online discussions stuck in the rut of simply listing ideas without developing them collaboratively (Thomas, 2002).

Research Questions

Past work has looked at KC in aggregate, losing important information about patterns of KC and how they may be influenced by the assignment of student roles. In addition, the beneficial Summarize function has been primarily assigned to roles that post summaries at the end of discussions, limiting its potential to elevate group KC processes. In this study, we used a temporal analysis to examine KC as a process in a series of role-based discussions. One particular role ("Synthesizer") was used to elicit a Summary midway through each discussion.

We asked the following questions:

1. What pattern(s) characterize KC processes during an online, asynchronous discussion with assigned roles?
2. Does a summary midway through the discussion affect subsequent KC?

Methods

Participants

Twenty-one students (8 women, 13 men) taking a blended (face-to-face and online) Educational Technology course. Seven of the 21 participants were of Asian descent. There were 10 undergraduate students, 8 graduate students, and 3 practicing teachers. Class members formed two discussion groups: (a) undergraduates and (b) graduate students and teachers.

Learning Context & Procedure

For each of the eight weeks of online asynchronous discussion, groups were asked to collectively create a solution to an authentic instructional design challenge (e.g. in one week they were asked to design a set of activities to help 10 year-olds become "experts" in the Chinese Zodiac). Each week, students were given one of 10 functionally-aligned roles to play: Starter (New Idea, Give Direction), Inventor (New Idea), Importer (New Idea, Bring in Source), Mini-me (Use Theory), Elaborator (Respond), Questioner (Respond), Devil's Advocate (Respond), Traffic Director (Given Direction), Synthesizer (Summarize, Give Direction), Wrapper (Summarize). These were randomly assigned and rotated so that each student played a different role in each of the eight weeks. Roles were introduced to students via a role description guide and modeled by the instructor in an earlier practice discussion. Students were required to post twice (first five weeks) or once (final three weeks) each week in the LMS Moodle discussion tool (http://moodle.org/); discussion participation was 15% of the course grade. A total of 252 posts were created and collected for content analysis.

Content Analysis

Function enactment and KC were evaluated at the level of the individual post by two independent coders for all posts in the data set. Krippendorff's α (Krippendorff, 2004) was used to assess inter-rater reliability.

Enactment of Functions

The Analysis Scheme Identifying Message Characteristics-Functional (Wise et al., 2010) has six dimensions corresponding to the six conversational functions. Krippendorff's α was: New Idea (.65), Bring in Source (.92), Use Theory (.73), Respond (.98), Give Direction (.76), and Summarize (.88). New Idea was coded as Absent or Present; other dimensions were coded as Absent, Minorly Present, or Extensively Present.

Knowledge Construction (KC)

Gunawardena et al.'s (1997) scheme was used to code the highest KC phase achieved in each post (α= .84).

Statistical Analysis

The KC in each group's weekly online discussions was modeled at the micro- and meso-levels using Statistical Discourse Analysis (SDA) (Chiu, 2008). As described below, SDA first statistically determined pivotal posts ("breakpoints" in statistical terminology) and discussion segments based on the KC phase exhibited in posts, then tested explanatory models for these pivotal posts, and finally tested explanatory models for the KC phase of an individual post. Several levels of variables were used in the explanatory models to capture the characteristics of student demographics, learning activities, roles and posts. The statistical power of any regression (including SDA) for this sample size of 252 posts is .99 for an effect size of .30 (α = .05; Cohen et al., 2003).

In the initial phase of analysis, for each week of each group, we statistically identified pivotal posts that divided discussions into segments by using regression analysis to model different possible numbers and locations of pivotal posts and finding the model that best fit the data (Chiu & Khoo, 2005). First, we modeled the KC phase of each post in a discussion under the assumption of no pivotal posts. Next, we assumed one pivotal post and tested all possible locations of the pivotal post. Then, we assumed two pivotal posts and tested all possible pairs of locations of two pivotal posts, and so on up to all possible location combinations for six pivotal posts. The best model of pivotal posts had the smallest Bayesian information criterion (BIC, also known as Schwarz information criteria, Kennedy, 2004).

In the second phase of analysis we created an explanatory model (a multilevel, binary logit regression) to identify characteristics associated with pivotal posts and the posts preceding them. We entered variables at multiple levels (e.g., activities, student characteristics, and post characteristics) in sets according to time constraints, expected causal relationships, and likely association with pivotal posts. If the variable Summarize was significant, we tested whether the effects differed across the type of summarizing by replacing the Summarize variable with Minor Summary and Extensive Summary. We then used lag variables to model the

characteristics of the preceding posts. We first entered a set of post characteristics for the previous post (lag 1), then added the same explanatory variables for the post before that (lag 2). No variables were significant at lags greater than 2. To test for moderation effects by discussion segment, we added terms for the interaction of the above variables with a variable indicating posts after the first pivotal post. A nested hypothesis test (χ^2 log likelihood test, Kennedy, 2004) with an alpha level of .05 was used to test whether each set of explanatory variables was significant. Multi-level mediation tests were used to test if a variable M mediated an X→Y relationship: X→M→Y (Krull & MacKinnon, 2001).

Finally, in the third phase of analysis we created an explanatory model for the KC phase of an individual post. As above, we entered factors at multiple levels (e.g., activities, student characteristics, and post characteristics). The procedure was the same as that of modeling pivotal posts with the following exceptions. First, KC has 5 ordered values (1, 2, 3, 4, 5), so multilevel, ordered logit was used rather than multilevel, binary logit. Second, to examine differences in KC across discussion segments we added a variable that indicated posts created After the 1st Pivotal Post. Third, in the Current Post Characteristics variable set, we did not include KC since it is the outcome variable.

Results

Descriptive Statistics

Results confirmed that discussions were enacted without overrepresentations of posts from specific roles, from specific students or in particular weeks. The ten assigned roles yielded equal numbers of posts, except for the Starter and Wrapper roles which should and did make only one corresponding functional post per discussion. Over half the posts were in KC Phase 1 (Sharing Information), with substantial numbers in KC Phase 3 (Negotiating Meaning) and KC Phase 5 (Agreeing and Applying). Few focused on discrepancies or contradictions (KC Phase 2 [Exploring Dissonance] or KC Phase 4 [Testing and Modifying]).

Identifying Pivotal Posts

The discussions averaged one pivotal post each (two time segments) and most segments had a majority of posts in a single KC phase (see Figure 1). The Synthesizer and Wrapper roles contributed most of the pivotal posts, and these pivotal posts often were Extensive Summaries in KC phases 3 or 5. Other pivotal posts had varied characteristics.

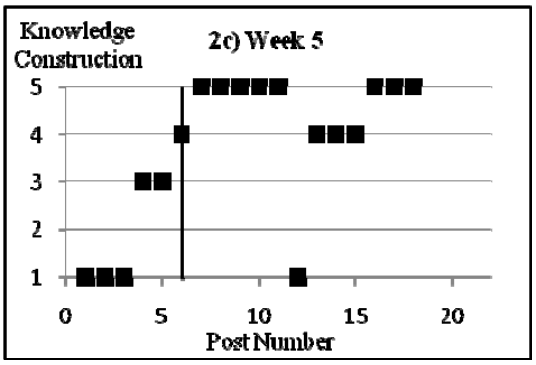

Figure 1. Example of a Discussions with 1 Pivotal Post (Yielding 2 Segments of Discussion).

Modeling Pivotal Posts

Assigned role and current post characteristics accounted for a substantial portion of the pivotal post variance (28%, see Figure 2). Compared to other roles, Synthesizers' and Wrappers' posts were more likely to be Extensive Summaries, and Extensive Summaries were more likely than other functions to be pivotal posts. Other variables (including discussion group and post order in the discussion) were not significant. Notably, Minor Summaries were not significantly more likely to be pivotal posts.

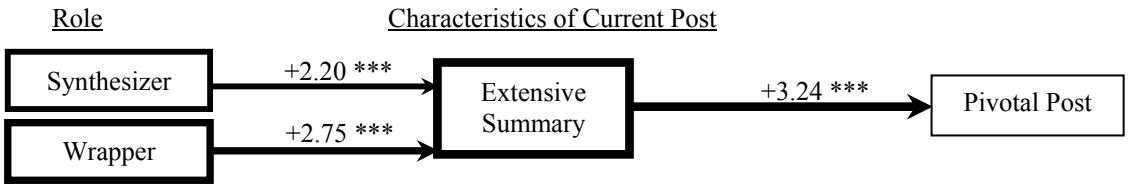

Figure 2. Path diagram of final model predicting pivotal posts. Numbers shown are regression coefficients. Solid lines indicate positive effects. Thicker lines indicate larger effect sizes. *p<.05, **p<.01, ***p<.001.

Modeling the KC Phase of Posts

Discussion segment, role, characteristics of the current post, and characteristics of the two prior posts accounted for much of the variance in the KC phase of a post (see Figure 3). Only 23% of the differences in KC phases occurred across discussions; 77% of the differences were within each discussion. Across all discussions, Synthesizers and Wrappers posted many more Summaries compared to other roles. Posts with Summaries (Minor or Extensive) exhibited a higher KC phase on average. Thus, Synthesizer and Wrapper posts averaged higher KC phases compared to other roles with the effect largely mediated by the Summary function.

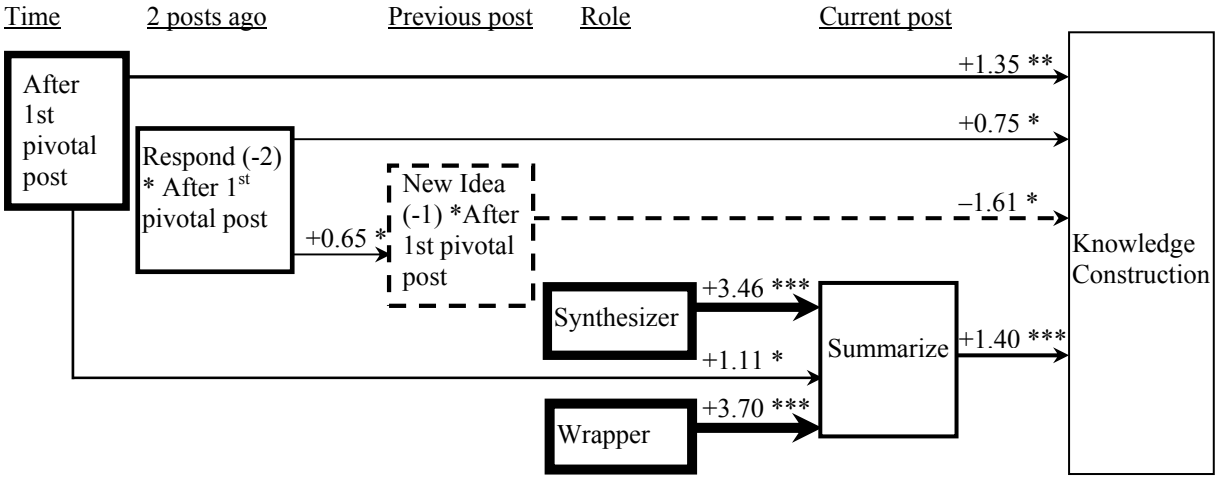

Figure 3. Path diagram of final model predicting knowledge construction. Numbers shown are regression coefficients. Solid lines indicate positive effects. Dashed lines indicate negative effects. Thicker lines indicate larger effect sizes.*p<.05, **p<.01, ***p<.001.

The results also show three time-specific relationships. First, the KC phase was substantially higher in posts after a pivotal post than before one. Second, Summaries were more likely to occur after a pivotal post. Third, there were two links between explanatory variables and KC phase that existed only after a pivotal post has occurred: one, if the previous post had a New Idea, the current post averaged a lower KC phase; and two, if a post was Responsive, the following post was more likely to be a New Idea and the KC phase was slightly lower two posts later (indirect and direct effects combined). All other variables were not significant. Notably, the order of a post in the discussion did not affect the KC phase of a post, showing that later posts did not necessarily show more advanced phases of KC. Furthermore, neither discussion group nor week explained a significant amount of variance in the KC phase of post.

Discussion

The study revealed a distinct KC pattern that emphasized sharing (Phase 1), negotiating (Phase 3) and summarizing (Phase 5) ideas, but not dissonance (Phase 2) or testing tentative syntheses (Phase 4). A pivotal post divided most discussions into two distinct segments. Segments were generally characterized by a majority of posts in a single KC phase with later segments showing higher KC than earlier segments. The pivotal posts that initiated later segments were typically contributed by students assigned the Synthesizer or Wrapper roles and contained Extensive Summaries that elevated KC both immediately and in subsequent posts. Below we discuss these results with respect to our research questions and the previous literature.

Research Question 1: What Pattern(s) Characterize the KC Process During An Online Asynchronous Discussion with Assigned Roles?

Like previous studies of online discussions with assigned roles, our analysis allowed us to examine the proportions of posts in each KC phase. As in prior work (Gunawardena et al., 1997; Schellens et al., 2005), most posts in this study were in KC Phase 1 (Sharing Information) showing that students produced new ideas much more often than they considered existing ideas. In addition, similar to some prior findings (Schellens et al. 2007), this study also showed a greater proportion of posts in KC Phase 3 (Negotiating Meaning) than in Phase 2 (Exploring Dissonance). This is different from a pattern in which the proportion of posts decreases for each successive KC phase (e.g. De Wever et al., 2007). In comparison with past studies, the learners in this study had many more posts in KC Phase 5 (Agreeing and Applying), though still few posts in KC Phase 4 (Testing and Modifying). The preponderance of posts in the initial (1) and convergent (3 and 5) phases and lack of posts in judgmental KC phases (2 and 4) suggest that these groups were focused on reaching consensus.

Moving beyond aggregate counts of posts, our analysis probed the process of knowledge construction by identifying segments of KC patterns. This let us empirically test the underlying premise that groups construct knowledge through a specific sequence of phases such as Gunawardena et al.'s (1997) theoretically proposed patterns of KC. Most of the online discussions studied had at least two distinct segments of discussion (one pivotal post), which rejects the KC Pattern 4 hypothesis (no distinct segments of KC). Segments were generally characterized by a majority of posts in a single KC phase, with later segments showing higher KC; this rejects the KC Patterns 1b and 2b hypotheses (which include regressive segments). In particular, the discussions often had an initial segment with mostly KC Phase 1 posts (Sharing Information) followed by a statistically identified pivotal post which elevated the discussion to a segment with a majority of posts in KC phases 3 or 5. This rejects KC Pattern 1a (which requires a segment for each KC phase) and provides strong support for the KC Pattern 2a hypothesis (strictly progressive segments with some KC phases skipped). However, nearly a quarter of the later segments did not have a majority KC phase which also provides some support for the KC Pattern 3 hypothesis (mixed KC phase segments). These results differ from the two theoretically "complete" patterns suggested by Gunawardena et al. (1997; KC Patterns 1a and 1b), both which include segments for all five phases of KC. Notably, in the original conceptualization, exploration of dissonance and testing a proposed synthesis are important to KC, but these results show that in some cases, groups can engage in KC Phase 5 processes without KC Phases 2 or 4 in this context. Importantly, while some disagreeing posts in KC Phases 2 and 4 were made, these contributions did not propel the group into a critique-focused segment of discussion. The lack of disagreements in the discussions may be due to concerns about social relationships (Chiu, 2008b), inadequate concern for the quality of the solution, or a notion of agreement as an indicator of a quality solution.

Whether the absence of disagreements affects the quality of knowledge construction outcomes is an important question both empirically and theoretically and at both group and individual levels. At the group level, exploration of dissonance between ideas is thought to be important as a foundation for quality co-construction of knowledge. At the individual level, the cognitive dissonance caused by engaging with conflicting ideas is needed to trigger a learner to reconsider existing ideas and construct new understandings. In future work, we will explore these issues by empirically studying how characteristics of the discussion process (such as a lack of posts in Phases 2 and 4) influences independent learning outcome measures at both the group and individual level.

Research Question 2: Does a Summary Midway through the Discussion Affect Subsequent KC?

Like past studies, our results show that roles encouraging summarization (Synthesizer, Wrapper) yielded posts in significantly higher KC phases than posts by roles which did not (De Wever et al., 2007; Schellens et al., 2005; 2007;). More importantly, our temporal analysis allowed us to examine the effects of these summarizing posts on the group's patterns of collaborative KC. As hypothesized, mid-discussion extensive summaries created by students in the Synthesizer role were often pivotal posts that initiated new discussion segments with posts in elevated phases of KC. Due to a large number of late student posts, many Wrapper summaries inadvertently ended up mid-discussion and also acted as pivotal posts that advanced the KC phase of the discussion. Notably, only one post with a minor summary was a pivotal post, suggesting that minor summaries are qualitatively different from extensive summaries.

These results suggest that reading the extensive summaries facilitated learner contributions at higher KC phases on average, thus advancing the group's KC process. Particularly, the integrative value of extensive summaries (Hara et al., 2000) can help students consolidate their understanding of the different ideas contributed and draw on the previous discussion to negotiate shared understandings (KC Phase 3) or apply their newly-constructed knowledge (KC Phase 5). In this way, the extensive summary can coordinate group activity and ground subsequent discussion. This result illustrates the power of our temporal analysis to illuminate how individuals' posts in a discussion can influence group processes of knowledge construction.

Conclusion

This study showed differences in KC phases of posts across time in an asynchronous online discussion. Notably, most discussions had only two discussion phases, unlike Gunawardena, et al.'s (1997) 5-phase Interaction Analysis Model. While past studies have shown that students benefit from writing a summary and that this can be encouraged using assigned roles, this study used a temporal analysis to show that extensive summaries mid-discussion can also change the tenor of the group's conversation and elevate it to higher KC phases. Future work will examine how different KC discussion patterns can affect group and individual learning outcomes.

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