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Toward an Understanding of How Threads Die in Asynchronous Computer Conferences

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Previous computer conferencing research has been concerned with the organizational, technical, social, and motivational factors that support and sustain online interaction. This article studies online interaction from a different perspective. Rather than analyze the processes that sustain discourse, the following research examines how and why discussions shut down. A computer simulation of asynchronous threaded interaction suggests that certain common online habits, when practiced by many people, can adversely affect the lifespan of some threads. Specifically, the widespread practice of focusing attention on unread notes during computer conferencing sessions can produce a starvation condition that hastens the death of some threads and reduces the likelihood that inactive threads will become active again. The longevity of a thread, therefore, is partially affected by the kinds of routines that online participants follow when they use a computer conferencing interface. The educational implications of this finding are discussed, and strategies are presented for limiting adverse educational effects.

The rapid growth and widespread accessibility of the World Wide Web (WWW) is providing educational institutions with new instructional possibilities. In recent years, it has become increasingly feasible to establish virtual learning communities to supplement or replace traditional face-to-face classroom meetings. Many different kinds of online communities have been established, but most of them currently employ some form of asynchronous, text-based, computer-mediated communication (CMC). CMC environments are available 24 hr a day, allowing learners to work at times and places of their own choosing (Harasim, 1987, 1989; Kaye, 1989). Un-

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like face-to-face interaction, there is no need for turntaking. Everyone can effectively "talk" at once and simultaneously participate in multiple discussions without fear of interruption (Hammond, 1999; Kaye, 1989); an arrangement that theoretically permits higher levels of peer discourse than in traditional face-to-face courses (Hiltz, 1986). In addition, the asynchronous nature of the interaction allows learners to reflect in greater depth before they share their ideas publicly. These logistical and educational advantages have inspired many post-secondary institutions to augment their conventional course offerings with Internet-based programs of study.

The educational value of computer conferencing is perhaps best understood from a social constructivist perspective. Online interaction supports learning by exposing students to other people's ideas, and by providing them with an opportunity to articulate their own ideas and receive peer feedback. Given the educational importance of these processes, much of the existing CMC research has focused on the organizational, technical, social, and motivational factors that appear to promote sustained, educationally productive discourse (e.g., Bullen, 1998; Gunawardena, 1995; Gunawardena & Zittle, 1997; McDonald & Gibson, 1998; Ross, 1996; Vrasidas & McIsaac, 1999). This article is similarly concerned with the challenge of sustaining CMC discourse, but it explores the problem from a different angle. Rather than identifying the factors that support electronic interaction, the following study instead examines how and why online discussions shut down. Of particular interest are the subtle processes that can cause a productive discussion to stop growing—often without people noticing. It is hoped that by improving our understanding of how these processes work, it ultimately may be possible to develop new pedagogical models that better support online learning.

SUSTAINING DISCUSSIONS IN ONLINE COURSES

Most CMC environments use a process called "threading" to impose structure on electronic exchanges. A thread is a hierarchically organized collection of notes in which all notes but one (the note that started the thread) are written as "replies" to earlier notes. Indented text is often used to depict the "reply" relationships (e.g., in Figure 1, Notes 126, 134, and 135 were written as replies to Note 125; and Note 132 was written as a reply to Note 126). These kinds of representations make it easier for people to trace the evolution of the discourse. Threads are arguably the most visible manifestation of an online discussion. Because a thread is fundamentally a mechanistic construct (Herring, 1999), it is technically possible for consecutive online notes to have little or no bearing on one another. Nevertheless, threads are well-defined, easily identifiable artifacts; and the reply protocol roughly aligns with the notion of conversational turntaking. Accordingly, for the sake of simplicity, this study examines the growth and death of threads, and the words *thread* and *discussion* are used interchangeably in this article.

Note 125. The double edged sword? by Eli
    Note 126. Self-actualization vs. social needs by Zoe
        Note 132. Yes and no by Marj
    Note 134. Constructionist personalized by David
    Note 135. Learning how to learn by Zoe

FIGURE 1 A computer conferencing thread.

The notion that educational online discussions should be *sustained* is a reoccurring theme in the literature (e.g., Guzdial & Turns, 2000; Jaffee,1997; Vrasidas & McIsaac, 1999). Learning is thought to emerge out of efforts to construct shared meanings (Roschelle, 1992); a process that typically requires many conversational exchanges. As Guzdial and Turns pointed out, it takes time for learners to collaboratively develop and explore hypotheses, negotiate differing perspectives, and work toward common understandings. Extended online dialogue should ideally be the norm. Yet, discussions in online courses are often surprisingly brief. Guzdial (1997), in his study of 18 classes at Georgia Tech, found that the average thread contained only 2.2 notes (essentially a single note and a response to that note). Similarly, Hewitt and Teplovs (1999) reported a mean thread size of 2.69 notes across seven graduate courses at the University of Toronto. Moreover, one of the striking characteristics of the computer conferencing literature is the sheer number of studies (many of which are cited in this manuscript) that are concerned, in one way or another, with promoting longer, more educationally worthwhile online discussions. Limited thread growth appears to be a persistent and widespread problem.

Efforts to sustain online discourse have taken a number of different paths. One important strand of research focuses on strategies the course instructor can employ as a moderator of online discussion. Over the years, a set of generally accepted moderating practices has been established in the literature. For example, moderators are advised to encourage broad student participation (Lai, 1997), keep discussions on track (Eastmond, 1992), and periodically generate summaries that weave together ideas from different learners (Feenburg, 1989). These kinds of operations are thought to foster higher levels of student–student interaction, increase the connections between participants' ideas, and reduce the likelihood that discussions will become sidetracked or terminate prematurely. In short, good moderating is popularly viewed as one way to improve the quantity, quality, and depth of online discussion.

Other researchers, while acknowledging the importance of effective moderating, suggest that the instructor's broader challenge is to nurture a sense of community. This involves fostering a class-wide commitment to shared goals, building trust among participants, and establishing productive norms of peer interaction (Rovai, 2000). Part of community building also involves the development of online "social presence" (Gunawardena & Zittle, 1997). Short, Williams, and Christie (1976) defined *social presence* as the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships" (as cited in Gunawardena, 1995, p. 65). Many traditional carriers of social presence such as eye contact, vocal intonations, physical distance, and facial expressions are missing in online environments (Gunawardena & Zittle, 1997). This can make it difficult to build a sense of community. However, these limitations can be partially overcome by skillful instructors who find ways to express missing social information in written form (Gunawardena, 1995). Research suggests that higher levels of social presence are associated with increased levels of interactivity among participants (Tu & McIsaac, 2002).

Other efforts to sustain interaction have focused on ways in which specially designed software can improve the quality and depth of learner discussions. As Kear (2001) demonstrated, even small changes in the way that discussion threads are visually represented can affect the structure and nature of online interaction. Accordingly, in recent years, a variety of experimental conferencing tools have been developed. Some of the more innovative supports for discourse include textual prompts or sentence openers to scaffold inquiry (e.g., Guzdial & Turns, 2000; Hoadley & Linn, 2000; O'Neill & Gomez, 1994; Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989), discussion visualization tools (e.g., Reyes & Tchounikine, 2003; Suthers, 2003), and facilities that allow learners to arrange discourse elements in different configurations (e.g., Scardamalia, 2003; Stahl, 1999). Innovative tools like these are often designed to work in conjunction with pedagogical approaches that focus learners on the ways in which student contributions interrelate and build on each other.

Thanks to the impressive body of research that has been conducted over the past decade, both in the areas of distance education pedagogies and interface design, researchers now have a better sense of how to promote and sustain discourse in online courses. However, although there appears to be a wealth of strategies for sustaining thread development, fundamental questions remain unanswered. What causes threads to stop growing? Why are moderators often needed to keep discussions moving forward? Why do threads sometimes end prematurely, even in apparently ideal situations—situations in which students are using sophisticated conferencing software and the instructor is following all the recommended practices? This study begins an investigation of these questions. Much has been written about how to sustain discourse and prevent threads from dying; the goal of this research is to uncover the factors and conditions that cause threads to die in the first place.

METHOD

The research focused on the life and death of threads in a master's-level distance education course at the University of Toronto. The class, which was comprised of 14 graduate students and 1 course instructor, used a conventional Web-based threaded conferencing environment to engage in issue-based discussions over a 13-week period. Online interaction took place in five separate conference areas (i.e., discussion spaces), each dealing with a different topic. These conferences were introduced, one at a time, at roughly 2-week intervals over the 13 weeks of the course. The instructor started each conference by suggesting issues to discuss, but the students were free to raise their own issues and frequently initiated new threads.

Three studies were conducted. First, the discussions were examined for evidence of a causal link between conference transitions and the death of threads. It was hypothesized that students may abandon some threads when they move from one conference to another. The second study focused on learner perspectives. Distance education students were asked, through an online questionnaire, to share their explanations of the thread death phenomenon. Finally, in the third study, patterns of online activity were examined to better identify what students actually do during their computer conferencing sessions and how their actions affect thread development. Data for this analysis were drawn from conference log files, which preserved time-stamped records of all student actions (e.g., logging in, reading a note, saving a note to the conference).

STUDY 1: THREAD DEATH AND CONFERENCE TRANSITIONS

The first study searched for a relationship between thread death and conference transitions. Figure 2 provides a longevity chart of the 105 threads (517 notes in total) generated in the course. The lower end of each vertical line represents the date that the thread was created, whereas the upper end of the line represents the date that the last note in the thread was saved. The instructor introduced the five conferences on Day 1, Day 19, Day 33, Day 48, and Day 64, respectively; the course ended on Day 85. As might be expected, many threads stopped growing around these dates as course participants shifted their attention from one conference to another. Students were allowed to continue working on old discussions if they chose to do so, but a disproportionately high percentage of threads (54%) ended within 3 days of a conference transition or at the conclusion of the course. Of course, some of these deaths may have been caused by other factors, but it seems reasonably safe to assume that conference transitions reduced the lifespans of at least some threads. If transitions had occurred even more frequently (e.g., once a week), it is possible that an even larger number of threads would have been affected.

STUDY 2: STUDENT EXPLANATIONS FOR THREAD DEATH

Although conference transitions could explain the deaths of perhaps one half of the threads, the deaths of others remained a mystery. A large number of discussions

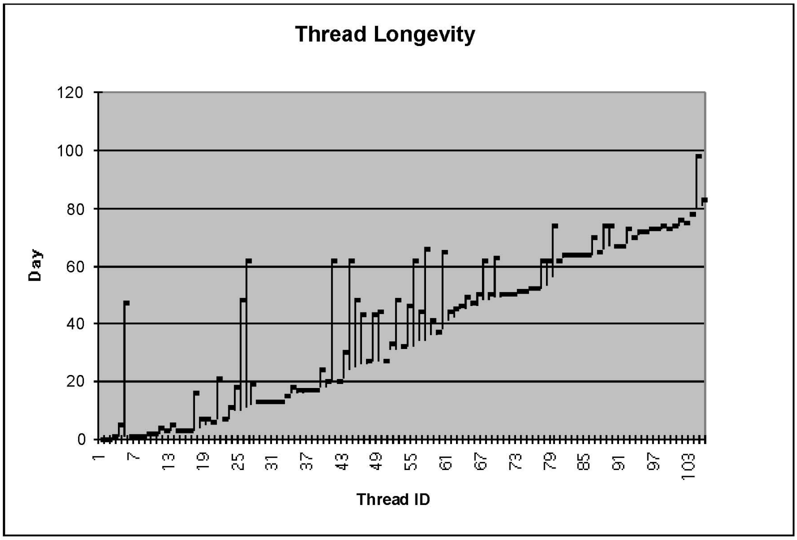

FIGURE 2 The lifespan of threads.

seemed to shut down in the middle of a conference, even though they contained unresolved questions and issues. What caused the death of these threads?

It is posited that many of the reasons for a thread's death may be invisible to outside observers. For example, some students may avoid a particular thread because they dislike the topic being discussed. Others may stop working on a thread if they become upset by something somebody has written. In other cases, boredom, time constraints, or loss of interest may reduce student involvement. People may abandon discussions for many reasons that are not apparent in the text of the discourse. Therefore, to understand how threads die, it is important to tap into the students' own first-hand experiences. From a learner's point of view, what are the processes and conditions that cause discussions to stop growing?

To collect a range of learner perspectives, a brief questionnaire[1] was administered in which students were asked to explain why threads sometimes stopped growing between conference transition periods. Students were presented with the following open-ended question:

> Sometimes discussion threads seem to stop growing prematurely (i.e., the thread dies despite the availability of time and opportunity for further development). What factors do you think cause a thread to stop growing?

[1]The questionnaire was administered by Vanessa Peters as part of a study of computer conferencing practices.

To gather a wide range of responses, students in seven distance education classes (in addition to the original class of 14 students) were invited to complete the questionnaire. To encourage candid responses, learners were asked to respond anonymously using a form on the WWW. Thirty-six responses were received. The contents of these responses were analyzed and classified into the following seven themes by two researchers[2]:

1. Discussion is exhausted (11 respondents): Many students hypothesized that a discussion may die if a point is reached in which people feel they have nothing left to say.
2. Discussion is too confrontational or threatening (7 respondents): Some people reported that they leave discussions if they feel threatened or if the tone of the discussion becomes too emotional. For example, Respondent 24 wrote, "[I abandon a thread] if the topic gets too hot or if people are beginning to move it to a personal level."
3. Loss of interest (8 respondents): Eight individuals suggested that a thread's development, or lack thereof, might be a function of personal interests. If many students lose interest in a thread, the thread is likely to stop growing.
4. Competition between threads (6 respondents): Some students offered a competition hypothesis. They suggested that a popular thread could suddenly become unpopular if "another more interesting topic or discussion appears" (Respondent 17).
5. Clunkers (5 respondents): A number of respondents raised the possibility that a thread's development could be adversely affected by "clunkers"—notes that shut down communication. For example, a note in which someone simply agrees with an earlier viewpoint may be considered a clunker because it leaves little room for further discussion. Several different phrases were used to refer to these notes, such as "dead-end comments" (Respondent 13) and "superficial comments" (Respondent 5). Clunkers appear to come in different varieties. One person (Respondent 13) claimed that "pontificating on the part of some participants" could shut down discourse. It is interesting to note that in the eyes of some people, a note may be considered a clunker because of its form rather than its content. Two students felt that personalized responses (e.g., "Dear Zoe:") were exclusionary: "I think that threads can die prematurely when contributors close off the contributions to others by opening posts with salutations to each other rather than the group" (Respondent 1).
6. Discussion is off topic (5 respondents): Consistent with research that suggests online conversations can drift (Herring, 1999; Hewitt, 2001), some students remarked that they had abandoned discussions that had strayed too far off topic.

[2]Some students offered several hypotheses. Therefore, the sum of the responses is greater than 36.

7. Death due to moderator influences (5 respondents): Five people suggested that threads can die if the moderator does not show interest in a discussion or does not properly support it. Respondent 14 suggested that instructors who "post a note that is seen as the final answer" could kill discussions.

A review of the seven themes suggests that several items may be related. For example, people may lose interest if the discussion goes off topic or if it appears to be exhausted. Similarly, loss of interest may be related to competition between threads, because the appearance of a new and exciting thread may cause people to lose interest in older threads. Therefore, although the seven themes represent different reasons for abandoning a thread, they are also interconnected.

To summarize, the findings from Study 2 suggest that students stop working on threads that they feel are uninteresting, threatening, off topic, or when they cannot think of anything else to say. They tend to gravitate to those threads that both interest them and offer them opportunities to make worthwhile contributions. To some extent, different threads in a conference compete for student attention. If many learners are suddenly drawn to an exciting new thread, this may result in the abandonment of other older threads.

STUDY 3: THREAD DEATH AND PATTERNS OF ONLINE ACTIVITY

In an attempt to probe the phenomenon of thread death even more deeply, a study of tracking data was conducted to determine what students typically do during their online sessions. How do students' online behaviors affect the growth and death of threads? It was discovered that the students collectively logged into the online environment on 601 occasions. Analysis of the session logs yielded the following information:

- On average, students logged into the conference 3.08 times per week.
- Students almost always read notes before they wrote notes (98.5% of the time, their first action was to read 1 or more notes).
- The notes that students read were usually ones that they had not read before (i.e., they were marked as "unread" in the computer conferencing environment). Approximately 83% of the notes that they accessed were notes that they had not examined in a previous session.
- Students wrote a note in most of their sessions. On average, they started a new thread in 17% of their sessions. In 69% of their sessions, they extended an existing thread by responding to someone else's note.

Using these findings, it was possible to develop a profile of student online behavior. Learners typically logged on to the conference, read notes that recently had been added (notes they previously had not seen), after which they usually responded to some of these notes. There was some variation in this practice. Sometimes people would read several notes, write a response, then read more notes. On other occasions, people would read many notes all at once and then decide which notes to respond to. However, the general tendency was to read new contributions, identify notes that were of interest, and then formulate one or more replies. This approach might be best described as a "single-pass" strategy for computer conferencing because people typically did not reread notes they had viewed in an earlier session. Nine of the 14 students in particular regularly practiced a single-pass strategy. Over 90% of the notes that these learners accessed were ones that they previously had not examined.

From these observations, a new theory was developed to explain why threads stop growing. It was hypothesized that thread death may be partially a product of the habitual, single-pass routines that people follow during their computer conferencing sessions. Specifically, a thread's longevity may be affected by the common practice of reading unread notes, followed by the construction of responses to some of these notes. At first glance, such an online practice seems natural and benign. However, deeper analysis suggests that it can adversely affect thread development in some situations.

THREAD DEATH AS A PRODUCT OF SINGLE-PASS PRACTICES

It is proposed that thread death can be attributed, in part, to the way that people typically work during their computer conferencing sessions. Many online participants develop a habit of reading unread notes every time they access the course conference, while largely ignoring notes that they have previously examined. This is not a universal practice, but it is a common one. Studies by Brett, Woodruff, and Nason (1999), Burge (1994), and Hewitt (2003) also reported that students focus most of their attention on new notes. This tendency may unintentionally contribute to the death of threads, as the following hypothetical situation illustrates.

Scenario

The threads in Figure 3 represent three discussions taking place simultaneously in a computer conferencing class. During their online sessions, students read those notes that were marked with an unread flag. Old notes were ignored. This practice unintentionally contributed to the death of the first thread. Once the class had read all the notes in the first thread, it stopped growing. Whenever students logged on, their habit of reading new notes focused their attention on the unread notes in other threads. Because the original thread no longer contained any unread notes to attract people, it was forgotten.

Note 659. Situated learning - by Don
    Note 666. Help! I need somebody…- by Julie
        Note 677. A reflection of initial comments - by Kelly
        Note 683. Another skill of expert learners - by Lynne
        Note 783. The value of extended B.Ed. programs - by Don

Note 669. The high attrition rate of new teachers - by Jim
    Note 682. … and in the business world too - by Doug
U   Note 753. Adult ed and new teachers - by Lynne

Note 661. Re. waste - by Jim
    Note 664. Redirection: Relevance / Mentorship - by Julie
    Note 690. Balance - by Doug
U   Note 691. Model class - by Jim
U   Note 693. A helpful source - by Esther

FIGURE 3 Three threads with three notes marked as unread.

This scenario highlights several important ideas. First, it suggests that the death of a thread can be unintentionally brought about by learners' single-pass practices. The effects of these practices are subtle. None of the students in the preceding scenario may have wanted the first thread to stop growing. In fact, the discussion may have contained a number of unresolved issues that arguably would have been valuable to pursue. However, once a thread is cleared of its unread flags, the well-rehearsed routine of reading unread notes focuses people's attention on other parts of the conference. This can cause a thread to stop growing, and the online participants may not even realize that it is in jeopardy.

The preceding scenario also demonstrates how single-pass practices can create a self-reinforcing dynamic in thread development. Because learners focus primarily on recent (unread) notes, threads that contain a higher number of these notes (e.g., the third thread in Figure 3) tend to receive more attention; thus increasing the chance that they will grow even larger (which, in turn, adds more new notes to these threads). On the other hand, threads that contain no recent notes (e.g., the first thread) are less likely to be noticed; thus reinforcing their inactive state. In this fashion, single-pass practices foster a rich-get-richer pattern of thread development (for a more detailed analysis of how threads tend to evolve in CMC courses, see Hewitt, 2003).

A COMPUTER SIMULATION OF SINGLE-PASS ACTIVITY PATTERNS IN A COMPUTER CONFERENCE

In an effort to explore the extent to which single-pass practices may affect thread growth, a computer simulation was developed that mimicked the general behavior patterns of students. In the simulation[3], virtual participants were programmed to read new notes each session and ignore older notes. A four-step routine served as the algorithm that each virtual participant followed:

1. Login and read all the notes that are marked as unread (i.e., all the notes that were added since the virtual user last logged in).
2. Write new notes that respond to some of the unread notes (the number of responses is determined by a preset probability factor).
3. Write new notes that start new threads (the number of new threads is determined by a preset probability factor).
4. Logoff.

The idea behind the simulation was to define simple rules that roughly reflect how students tend to work online, and then observe the larger scale threaded patterns that subsequently emerge. This technique is sometimes referred to as *exploratory modeling,* and it is commonly used to study the ways in which complex phenomena develop out of simple interactions in decentralized systems (Resnick & Wilensky, 1998).

No text was written to any of the notes produced in the simulation because note content was not important. Rather, the goal was to determine the degree to which threads can stop growing as a result of single-pass practices alone. The simulation's preset values were derived from data collected from the online course. On average, students wrote 0.69 responses per session and started 0.17 new threads per session. These values were used in Steps 2 and 3 of the algorithm. A random number generator was used to determine which unread notes each virtual user would respond to. Like the actual course, the simulation involved 14 (virtual) students, each of whom logged in on 43 different occasions (601 sessions total divided by 14 students).

It is important to emphasize that the purpose of the simulation was not to replicate genuine computer conferencing interaction. In real life, students do not respond to each other's notes randomly, and the contents of notes influence how discussions evolve. Rather, the goal of the simulation was to narrowly focus on the effects of single-pass practices. Can single-pass practices alone bring about the death of threads?

The threaded patterns that emerged from the simulation (Figure 4) were strikingly similar to the ones that developed during the actual course. Large and small threads were scattered throughout the virtual conference. The simulation was run 100,000 times. At the end of each run, the threads were automatically analyzed to

[3]The simulation was written in the computer language C. A Web-based version of the simulation, and the corresponding source code, can be found at http://research.oise.utoronto.ca/~software/threads/ThreadSimulation.html

```
Virtual Note 99 by user 2
    Virtual Note 114 by user 13

Virtual Note 100 by user 3
    Virtual Note 103 by user 5
    Virtual Note 116 by user 1
        Virtual Note 122 by user 8
    Virtual Note 124 by user 9

Virtual Note 102 by user 4

Virtual Note 104 by user 5

Virtual Note 131 by user 6
    Virtual Note 141 by user 3
        Virtual Note 147 by user 5
        Virtual Note 158 by user 1
            Virtual Note 165 by user 9
        Virtual Note 167 by user 12

Virtual Note 107 by user 6
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FIGURE 4 Sample of thread printout generated by simulation software.

determine which were still active and which were dead. “Dead threads” were easily identified because they had reached a state in which everyone in the virtual class had read all of the thread’s constituent notes. Given the first step of the algorithm (i.e., users only read unread notes), these threads could not grow any larger regardless of how long the simulation ran. Surprisingly, 95% of the threads died, on average, during each trial. In other words, the shared practice of reading exclusively unread notes led to the eventual death of almost all of the threads. The 5% of the threads (on average) that survived were usually threads that were introduced just before the trial ended. Had the trial run longer, it is likely that they too would have died.

One conclusion that can be drawn from the simulation is that it may be overly simplistic to attribute the death of a thread to individual interests or clunkers. Although such factors undoubtedly play a role, the preceding simulation demonstrates that single-pass practices can also cause threads to die.

It is interesting to note that the distribution of thread sizes in the simulation closely resembled the observed distributions in the actual class conference. The frequencies of the simulation’s thread sizes were averaged across the 100,000 trials, yielding the following mean values: 40.9 threads of size one, 15.3 threads of size two, 8.4 threads of size three, and so forth. These values closely matched the frequencies of observed thread sizes in the actual course (Table 1).

TABLE 1
A Comparison of the Frequency of Thread Sizes Predicted by a Computer Simulation to the Frequency of Thread Sizes Observed in an Actual Computer Conference

Thread Size	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Computer conference: Actual	42	17	9	6	7	1	5	1	2	1	2	1
Computer simulation: Average of 100,000 trials	40.9	15.3	8.4	5.4	3.8	2.9	2.3	1.8	1.5	1.3	1.1	1.0
	13	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*
Computer conference: Actual	1	2	0	2	1	0	0	0	0	0	2	0
Computer simulation: Average of 100,000 trials	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3
	25	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*
Computer conference: Actual	0	0	0	0	0	1	0	0	0	0	0	0
Computer simulation: Average of 100,000 trials	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	37	*38*	*39*	*40*	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48+*
Computer conference: Actual	1	0	0	0	1	0	0	0	0	0	0	0
Computer simulation: Average of 100,000 trials	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1

The simulated conference also resembled the real conference in terms of the distribution of notes across small and large threads. For example, after 100,000 trials, the simulation predicted that 44.4% of all of the notes in the computer conference would be located in threads that contain 10 notes or fewer. This was close to the observed figure of 46.2% in the actual course. Table 2 shows the predicted and actual values for other ranges of thread sizes. The one notable discrepancy is that the simulation predicts the existence of at least one thread containing more than 50 notes. In the actual course, the largest thread held only 41 notes.[4]

[4]This discrepancy may be partially explained by periodic interruptions in the online course caused by conference transitions (see Study 1). These transitions may have made it more difficult for extremely large threads to become established. Conference transitions were not programmed into the simulation.

TABLE 2
Percentage of Total Notes in Threads of Different Sizes: Values Predicted by Computer Simulation and Actual Values

Thread Size (in Notes)	*1–10*	*11–20*	*21–30*	*31–40*	*41–50*	*> 50 Notes*
Computer conference: Actual	46.2	24.0	14.7	7.2	7.9	0.0
Computer simulation: Average of 100,000 trials	44.4	20.6	13.2	8.6	5.4	7.8

The preceding analysis raises the possibility that single-pass practices may partially account for the distribution of small and large threads in computer conferencing courses. Further research is needed to see if the algorithm is equally effective at predicting threaded distributions in other courses. However, the more important finding, for the purposes of this study, is the discovery that randomly reading and responding to unread notes can, by itself, stop the growth of threads. Of course, in real conferences, other factors (e.g., the content of notes, learner interest, the instructor's directives) also play a role. However, the simulation shows that single-pass practices alone can explain how threads grow and die.

TOWARD AN UNDERSTANDING OF THREAD GROWTH AND DEATH

By observing how threads evolved in the simulation, it becomes possible to develop a working model of how threads died in the online course. Specifically, the tendency among computer conference users to focus on unread notes introduced a rich-get-richer dynamic. Threads containing many new notes were the targets of attention in the online community, thus increasing the likelihood that they would continue to grow. Threads that contained few unread notes, or no unread notes, received comparatively less attention, which further reduced their chances of development. This lack of attention was not intentional, but was rather a byproduct of people's single-pass tendencies. As a result, once a thread slipped out of the communal spotlight, it was unlikely to return.

One implication of the rich-get-richer dynamic is that the quality and value of a given thread, as a whole, is not necessarily a good predictor of future growth. Rather, the key to a thread's prospects lies in the quantity and quality of its unread contributions because these are the notes that are under heaviest scrutiny (Hewitt, 2003). It is at this level—the level of unread notes—that individual interest, competition between threads, and clunkers (see Study 2) may have their greatest impact. If people feel that a thread's newest contributions are compelling, the thread is likely to continue growing. If, on the other hand, the recent contributions are clunkers, or if they are less interesting than the unread notes in other discussions, the thread's long-term chances of survival are diminished—regardless of how important the thread is or whether the issues it raises have been fully explored.

Although the simulation demonstrates that single-pass practices can cause threads to shut down, the death of a thread in a real conference is likely the product of many different variables working in combination. For example, research on human memory suggests that recency of exposure to an item is a predictor of recall and recognition (Anderson, Bothell, Lebiere, & Matessa, 1998). This means that if students visit a particular thread on Monday, it increases the likelihood that they will recall and revisit the thread when they login on Tuesday. Conversely, if students have not recently visited the thread, there is a corresponding drop in the likelihood that it will be revisited during subsequent sessions (Hewitt & Teplovs, 1999; Recker & Pitkow, 1996). Therefore, psychological factors may contribute to the explanation of why some threads undergo rapid growth over a series of days, while other threads stagnate. "Recency effects" may also reinforce single-pass tendencies by focusing students on highly active threads that contain many unread notes while reducing the likelihood that students will revisit older inactive threads.

Personal choice also plays an important role in the death of discussions. Some students may review a thread and make a conscious decision not to pursue it. Others may choose not to read the thread at all because of time constraints. These and other factors can undoubtedly contribute to a thread's demise. What single-pass explanations offer, however, is a way to tie the death of threads to common, everyday activity patterns. Even if only a few students in a class are single-pass practitioners, these individuals are essentially removing themselves as potential contributors from those discussions that do not contain unread entries. This reduces the likelihood that those discussions will continue to grow.

DECENTRALIZED SYSTEMS AND THE DEATH OF THREADS

The notion that online activity patterns can contribute to a thread's death is counterintuitive in some respects. None of the students proposed the idea in their responses to the questionnaire. Resnick and Wilensky (1998), in their studies of decentralized systems, found that people often focus on the short-term, local effects of their actions and do not always recognize the larger scale systemic implications. This may explain why the single-pass explanation for thread death did not occur to the students. Resnick and Wilensky also discovered that people sometimes reject models of collective behavior in which actions of individuals are described using a few simple rules. For example, CMC students undoubtedly see themselves as free agents who could theoretically contribute to any thread during a given online session. They probably do not see themselves as following rules. Of course, freedom of action does not preclude the possibility that their online behaviors follow somewhat predictable patterns, and these patterns have an impact on thread growth.

To further explore the phenomenon of thread death, it is instructive to compare computer conferences to other kinds of decentralized systems, like those found in natural-world settings. In his article, “Beyond the Centralized Mindset,” Resnick (1996) described how many real-world processes (e.g., stacking behavior of termites, traffic jams, the tendency for birds to fly in V-shaped formations) can be explained as the product of many individuals following a few simple rules. A careful study of these systems suggests that they share a number of important properties with the threads simulation. Consider, for example, Resnick’s termites model. A colony of termites can eventually gather scattered wood chips into a pile if each individual termite obeys the following algorithm:

Rule 1: If you do not have a wood chip, pick up the first wood chip that you encounter (and then walk in a random direction).
Rule 2: If you have a wood chip, put it down beside the first wood chip that you encounter.

To understand why this algorithm works, consider an initial configuration in which there are many wood chips strewn randomly. Some wood chips may already be in small piles, whereas others are by themselves (i.e., a pile of size 1). A study of the algorithm reveals why the number of piles must decrease with time. According to Rule 2, no new piles can be created—termites can only drop a wood chip onto an existing pile. However, piles can disappear. Once the last wood chip is removed from a pile, a point of no return is reached because that pile cannot be resurrected. In a similar fashion, a point of no return can occur during thread development. The threads in the simulation reached such a point after all of their constituent notes had been read by everyone. Because the virtual users only read those notes marked as unread, it was impossible for a thread to grow once all the participants had read it in its entirety.

Thread death is similar to the wood chip algorithm in other ways as well. Although it may appear to an outside observer that Resnick’s (1996) termites are collectively attempting to create a pile of wood chips, the individual insects are not necessarily aware of what the group as a whole is doing. The termites do not see themselves as part of a larger pile-building effort—they are just instinctively following a few simple rules. In a similar sense, CMC participants are not necessarily aware that their online habits may be affecting the lifespan of threads. In both cases, a set of simple, shared behaviors can yield outcomes that the individual participants may not anticipate or even recognize.

This latter point deserves particular attention. The problem with a single-pass routine is not simply that it can contribute to the death of threads. Intrinsically, a thread’s demise is not a good or bad event. In many cases, the abandonment of an unproductive line of inquiry may allow people to channel intellectual resources in more promising directions. Rather, the problem is the participants' lack of awareness concerning the state of online discussions. A focus on unread notes makes it difficult to keep track of how threads, as a whole, are developing. Learners may have little sense of whether a particular discussion has drifted off topic, whether it has unresolved issues that merit further analysis, or whether it is in danger of dying. In the next section, these concerns are examined in greater detail.

EDUCATIONAL IMPLICATIONS

Why are single-pass routines educationally problematic? In some respects, it seems unusual to even question the common practice of reading unread notes and writing responses—perhaps because it mirrors the way that people usually handle their e-mail. However, from an educational point of view, routines of this sort raise concerns because they can interfere with knowledge-advancing discourse. To make disciplined progress on a line of inquiry, learners must be aware of the issues and problems that the group is pursuing and tailor their actions accordingly (Guzdial & Turns, 2000). The trouble with single-pass routines is that people can easily lose sight of these core concerns. If new notes are all that a learner sees, the content of these notes—rather than communal problems—will tend to drive the discourse agenda.

For many students, a single-pass routine must appear to be a logical and appealing way to work in a CMC environment. It is a routine that requires relatively little thinking or decision making; learners simply read all of the notes that are flagged as unread. In addition, if a conference contains many notes, then reading each note only once will minimize workload while keeping the learner up to date with course developments. A single-pass approach is intellectually economical in other ways as well. By reading unread notes and responding to some of them, learners can seem actively involved in real discussions, but without the need to think about how the discussion has developed over time or the directions that it might most profitably take in the future. To an outside observer, students who use single-pass strategies appear to be deeply engaged in peer interaction. It is only when one closely analyzes the situation that a number of problems become apparent:

1. Learners may not be aware that important discussions have stopped growing. As discussed earlier, a focus on new notes may prevent learners from noticing that previously active discussions are no longer active. Whenever an individual starts an online session, his or her attention is immediately drawn to notes that are marked with an unread flag. Threads that do not contain unread flags are not examined and are easily forgotten. Consequently, discussions that are important to the online community can be unintentionally neglected.

2. Learners may not engage in synthesis and summarizing operations. The habit of reading a note only once reduces the likelihood that people will engage in synthesizing or summarizing operations, which typically require learners to revisit messages that they have already read. Hewitt (2001), in a study of three distance education classes, found that only 2% of the notes written by students could be characterized as efforts to synthesize or summarize findings from previous notes.

3. Discussions may drift off topic. Herring (1999) observed that electronic discussions often flow in unstructured ways, jumping from idea to idea much like a cocktail party conversation. It is proposed that this phenomenon may be partially caused by the practice of writing a response to a note without being fully cognizant of the larger discussion of which the note is part (Hewitt, 2001). Single-pass practices focus learners on the most recent notes in a thread, whereas the thread's earlier notes (ones that have already been read) tend to be out of view. This can lead to situations in which people unwittingly take discussions in unproductive directions. To make disciplined, on-topic progress, participants must maintain a sense of the entire thread and the goals of the discourse.

4. Difficult issues or questions may be neglected. Students who view computer conferencing as a process of reading unread notes and then responding to some of them may come to see the read-and-respond process as a kind of goal in and of itself. That is, rather than focusing on progressive, sustained knowledge advancement, learners may feel that their primary objective is to simply participate in the conference and to be seen participating. Grading schemes that require students to contribute a certain number of notes each week may reinforce this view. However, if participation itself becomes the goal, there is a risk that people will gravitate to those topics that are familiar and easy to talk about, while avoiding challenging problems. When this happens, difficult issues may be neglected.

A number of steps can be taken to reduce or counteract some of the preceding problems. For example, constraining the number of online discussions can help circumvent the problem of thread death. In many courses, it is a common practice for the moderator to post a small number of discussion-starter notes—notes that pose questions or issues for the online community to discuss. Students are then responsible for writing replies to these notes. This approach creates a small number of highly active threads and thus reduces the likelihood that threads will die accidentally, even if students are using single-pass strategies. The problem with this approach is that the scope of the class discourse is narrower, and the moderator has a heavy influence on deciding what issues the community will pursue.

Some of the other problems associated with single-pass practices can be reduced through effective moderating. Many researchers (e.g., Davie, 1988, 1989; Feenberg, 1989) feel that moderators can play a pivotal role by calling attention to discussions that are faltering, or periodically summarizing conference findings for the class. They can also highlight unanswered questions or channel discourse in more productive directions should it drift off topic. However, interventions of this kind are fundamentally after-the-fact repair strategies designed to keep problems in check. The bigger challenge is to address the single-pass practices that give rise to these problems in the first place.

A naive way of reducing single-pass practices would be to direct students to frequently revisit older notes in the conference. However, revisiting older notes does not, by itself, guarantee that people will attend to those notes or the key challenges facing the community. Rather, what is required is the creation of new cultures of computer conferencing—cultures that focus more directly on purposeful, progressive knowledge building.

Several promising research projects have already begun to explore alternatives to traditional CMC models. Guzdial and Turns (2000), for example, developed a software package called CaMILE that offers special supports for sustained, on-topic discussions. Some of the distinctive features of CaMILE include an anchoring utility that keeps learners focused on pressing communal problems and scaffolds that prompt engagement in certain knowledge-advancing operations (e.g., question, new idea, rebuttal, revision). Research suggests that these features promote longer, more focused discourse than conventional threaded discussion forums (Guzdial & Turns, 2000).

The Knowledge Forum project (Scardamalia & Bereiter, 1999) represents another promising effort to transform the way people work online. Knowledge Forum is a software program that supports a pedagogical model that Scardamalia and Bereiter (1994) referred to as a knowledge-building community (KBC). Participation in a KBC entails learner commitment to the progressive and persistent development of ideas over time (Scardamalia & Bereiter, 1999). Using specially designed Knowledge Forum tools called "views" and "rise aboves," learners are expected to periodically synthesize the progress that the online community has made, highlight unresolved issues, and suggest new directions. These kinds of metalevel operations are incompatible with single-pass practices because they demand a constant monitoring of how the discourse is progressing relative to group objectives.

Research initiatives like CaMILE and Knowledge Forum also propose fostering new cultures of computer conferencing in which learners do more than simply read and respond to new notes (Guzdial & Turns, 2000; Scardamalia & Bereiter, 1994). In both of these environments, threads are less likely to accidentally die because people are more aware of the ongoing discussions and can respond intelligently and appropriately if a thread's development slows or stops.

Single-pass strategies are not always problematic. A single-pass strategy may be useful in recreational Internet discussion forums, where the goal is to share news and socialize. However, it is arguably inadequate in educational contexts where student discourse should be more rigorous and sustained. The challenge facing researchers is to build on the successes of CaMILE and Knowledge Forum and uncover increasingly effective techniques for supporting online investigations in which learners make multiple passes over online content.

CONCLUSION

This article has explored an aspect of CMC that has been neglected in the literature: the manner in which discussions terminate. In the past, researchers have emphasized the importance of promoting and sustaining participation in CMC settings (e.g., Guzdial & Turns, 2000; Jaffee,1997; Vrasidas & McIsaac, 1999). However, there has been little examination of a fundamental issue: What causes online discourse to stop growing in the first place? A simulation of online behaviors suggests that thread development in computer conferences may be partially an artifact of single-pass online practices. Consequently, a thread's survival or demise is not always tied to the relevance or importance of the thread's content. Instead, threads can die unintentionally as a by-product of a seemingly unrelated activity: reading new notes and ignoring older notes.

It is hypothesized that the routine of reading and responding to new notes may be, in part, an adaptive response to information overload. The large size of many online conferences, coupled with psychological limits on people's capacity to process information (Miller, 1956), may lead some learners to use single-pass strategies as a coping mechanism. Single-pass strategies may also be legitimized, and possibly reinforced, by course-marking schemes that require students to write a certain number of notes each week. However, it is argued that such practices are inherently suboptimal because they focus learner attention on local, note-level concerns at the expense of overarching communal goals. By working to understand both the nature of single-pass strategies, and the conditions that give rise to them, it may be possible to invent new cultures of learning that foster truly sustained, educationally productive online discussions.

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