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ABSTRACT

Teacher Education for Arizona Mathematics and Science (TEAMS) is a technology-based program for preparing scientists and mathematicians for a career in middle school teaching. The metaphor of "reflective practitioner" guided the design and delivery of this program. Students did not respond well to journal keeping and many failed to comply with the requirement. Because of opposition to journaling, the requirement was modified. At the same time, faculty, staff, and students enrolled in a listserv called "Edteams." The listserv has generated an increasing volume of correspondence on a wide variety of topics, some relevant to the program and others not. Some students have recognized the interaction as a type of journaling. Listserv dialog has characteristics that are very different from typical classroom language. The roles of teachers and students are reversed, with students initiating conversations, teachers answering questions, and students reacting. Long and complex conversations develop on listservs, as students explore their developing understandings of both content and pedagogy. Most important, students find that listservs are fun, and they participate in them with enthusiasm. Contains nine references. (Author/ND)

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LISTSERV AS JOURNAL:
Computer-based reflection in a program for pre-service mathematics and science teachers

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ABSTRACT

Teacher Education for Arizona Mathematics and Science (TEAMS) is a technology-based program for preparing scientists and mathematicians for a career in middle school teaching. The metaphor of 'reflective practitioner' guided the design and delivery of this program. Students were required to maintain reflective journals. They did not respond well, and many failed to comply with the requirement. Because of opposition to journaling, the requirement was modified.

At the same time, faculty, staff and students enrolled in a listserve called edteams. Opposition to journaling was evidenced by an abundance of email under the subject heading "That #*@!! Journal!!!" When talking about the relative merits of journaling versus email, one student wrote that "I ended up responding ... via email and found this type of faculty interaction MUCH MORE SATISFYING!"!!!!!!" Since then, the listserve has generated an increasing volume of correspondence on a wide variety of topics, some relevant to the program and others not. One participant summed the new interaction up with the observation that "Hey I think you were journaling!"

Listserve dialog has characteristics that are very different from typical classroom language. The roles of teachers and students are reversed, with students initiating conversations, teachers answering questions, and students reacting. Long and complex conversations develop on listserves, as students explore their developing understandings of both content and pedagogy. Most important, listserves are fun, and students participate in them with enthusiasm.

The Importance of Reflection

> Teacher reflection has been on the minds and in the writings of teacher educators for the last decade.
> (Ducharme & Ducharme, 1996, pg. 83)

The constructivist revolution has spread widely throughout all areas of education, and is alive and well in teacher education. Just as students have to construct their own knowledge of science, prospective teachers have to construct their knowledge of teaching. The challenge to teacher educators has become one of facilitating this process of knowledge growth.

This shift in emphasis away from the process/product approach to teacher education that dominated the field until recently reflects a consensus that "efforts in the area of thinking that focus primarily on 'how to' instructional strategies and that minimize opportunities for teachers to reflect upon and conceptualize facets of their teaching are unlikely to produce significant, long-term change (Onosko, 1992, p. 43)." In short, emphasis on teaching specific skills to prospective teachers has largely been a failure.

Most models of constructivism assume that the way knowledge is organized develops through a sequence of increasingly sophisticated schemata. This often represents the path from novice to expert. Studies of teachers suggest that "expert teachers possess knowledge that is more thoroughly integrated--in the form of scripts, propositional structures, and schemata--than is the knowledge of novice teachers (Sternberg & Horvath, 1995 pg. 11)."

Another difference between novices and experts is the degree to which they are able to think about their own thought. The ability to engage in such *metacognitive* activity is described as one of the major characteristics of those who are good problem solvers. Expert teachers appear to be more self-aware and reflective than novices, less likely to search for simple solutions to complex problems, and are more creative.

Engaging prospective and practicing teachers in the act of reflection is one way to facilitate the process of knowledge construction. It is a strategy that attempts to engage participants directly in an analysis of their own thought. At one end of the continuum, it assists in identifying explicitly that teacher knowledge with the most value, and helps to make it explicit and part of second nature. At the other, where conflict is encountered, it has the purpose of inducing dissonance, or disequilibrium, and the concomitant need for conceptual change.

The contemporary literature of teacher education emphasizes the importance of metacognitive, or 'executive', processes for teachers. "The current popularity of 'reflective practice' as a touchstone for teacher excellence suggests that, in the minds of many, the disposition toward reflection is central to expert teaching (Sternberg & Horvath, 1965, p. 15)." To learn to be reflective is to learn to be an expert.

The Conditions for Reflection

> Learning mediated through an exploratory writing process
> that requires intellectual confrontation among members of
> a group creates a collaborative context for reflection,
> a condition that enhances conceptual change.
> (Audet, Hickman & Dobrynina, 1996, p. 205)

It is common in teacher education programs for students to be required to maintain a self-reflection notebook, or journal (Raymond & Santos, 1995). This serves a number of functions. It maintains a line of communication between student and teacher, it serves as a record for the evaluation of progress, and it allows the student to practice metacognitive processes. Journals are often included in student portfolios.

Students don't always like writing. In fact, many find it distasteful. Some teachers have reported that paper and pencil journals produced few noteworthy results, and have

turned away from them. As an alternative, some educators have turned to electronic journaling (Audet, Hickman & Dobrynina, 1996) or communications (Thomas, Clift & Sugimoto, 1996) as a means to facilitate self-reflection.

We encountered similar difficulties, to be described shortly, in a program for the preparation of mathematics and science teachers. For the reasons given above, we encouraged students to engage in self-reflection by maintaining journals. We found that they disliked the process and that we were not achieving the desired end. As a result we turned to electronic communication as an alternative.

Little is known about the dialogue that takes place via computer. Thus we were unable to predict whether it would serve as a useful substitute for journaling. In this paper we attempt a description of a computer-assisted dialogue between participants in a teacher education program.

The questions are, "Is the type of reflection found on the TEAMS listserve worthwhile? In the place of journals, what kind of conversations are facilitated through this new medium? " This paper is an exploration of these two questions.

The Setting

Teacher Education for Arizona Mathematics and Science (TEAMS) is a fast-track post-baccalaureate program designed to prepare scientists and mathematicians for a career in middle school teaching. It is funded through a National Science Foundation project called the Arizona Collaborative for Excellence in the Preparation of Teachers (ACEPT). ACEPT is one of only thirteen Collaboratives currently in operation throughout the United States.

Through its connection with the Collaborative, TEAMS is partnered with the Phoenix Urban Systemic Initiative (USI), a coalition of eight high schools, and the eight inner-city school districts that feed into them. A total of 85 schools in the urban corridor

are involved. Teacher leaders from the USI serve on TEAMS committees and assist in placing TEAMS students in USI schools.

The core of the TEAMS program is a sequence of experiences that integrate science, mathematics and technology with pedagogy and field experience. The first centers around tool use, focusing on the types of technological and pedagogical tools that fundamentally alter what science and mathematics can be taught, and how science and mathematics concepts can be represented. Applications taught include three primary types: Communications and presentations (the Internet, World Wide Web, Microsoft Powerpoint); Mathematical content (Logo, the Geometer's Sketch-Pad, Measurement in Motion); and Data tools (Graphing calculators, Calculator-Based and Microcomputer-Based Laboratory data-probes).

The second experience focuses on pedagogy, emphasizing lesson design and delivery, adolescent development and field experience. The third is the student teaching practicum. The fourth examines national trends, including assessment and standards. The entire sequence, which leads to secondary certification with a middle school endorsement, and a Masters Degree in Education, can be completed in one year.

A guiding metaphor of TEAMS is that of *reflective practitioner.* Two components of the program were explicitly designed to encourage reflection. The first was a pair of courses designed to help students conduct classroom research. An initial course focused on research methods, while another at the end of the program helped them conduct and organize their own research. This research is presented at the end of the program in fulfillment of the requirements of the M.Ed. degree.

The second formal component of the program that was designed to encourage reflection was a requirement that students maintain a journal. Journals were described as a form of diary that recorded their observations, feelings and needs as their experience in the program unfolded. This was to be a personal document that was shared only with the

instructor(s). Journals were collected weekly, read and responded to by one instructor, and returned to the students.

This paper is based upon an analysis of journals and electronic messages collected between September 6 and November 29, 1996. All TEAMS participants have agreed to share this information, but have provided aliases known only to them and the authors of this paper.

The Trouble With Journals

Trouble with journals originated early in the program. Students were not used to recording their thoughts, didn't like journals very much, and resisted completing them. By the end of the first course several were no longer turning their journals in.

At the same time, a listserve had been created to allow communication between students and faculty. Within five weeks the issue was joined through a message from Lightning titled That #*@!! Journal. The author felt stymied by the need for "metacognitive reflection." In particular, since only one instructor was reading and responding to journals, she felt that there wasn't enough feedback and the activity wasn't being taken seriously. Moreover, since she felt that email communication was "MUCH MORE SATISFYING!!!!!!!" (emphasis hers), she began to question the pedagogical reasons for journaling. "Why do you guys want us to journal? Is it really that important? I mean REALLY? (Colleague to Colleague, you know)?" The parenthetical comment referred to the fact that we had all been struggling with the concept of collegiality and its meaning to a group like this one.

Buffy agreed with the criticism of journals. She confided:

> "I have on occasions tried to start a diary, only to find the desire to last a few days. I have taken notes in other classes, but never seem to go back into them to find the information. I try to make myself see the importance of journaling and sometimes convince myself that I should really make it a daily practice. *But, thinking is a lot easier than doing...*

> "I seem to get more satisfaction out of the discussions I have with TEAMmates. In these open discussions, we share, compare, and discuss our ideas, observations, viewpoints...it is also very useful when someone has a differing viewpoint. It would seem more beneficial to share in this manner..."

The faculty wanted the students to journal for good reasons based on research: Reflection of the type required improves students' metacognitive skills, helps the faculty assess understanding in a more natural, "conversational" manner than testing, and allows students to communicate their frustrations more readily to the faculty.

Lancer defended Lightning's unwillingness to journal with an argument that the faculty found difficult to counter...

> "My own take on this is that perhaps it's time for a customized approach. I have no problem that Lightning has developed her metacognitive and writing skills to a sufficient degree. I also believe that if she has a criticism of the program, she won't be shy about sharing it. I think she has also demonstrated a willingness...to tackle truly large and worthwhile projects. I therefore submit that Lightning has demonstrated that she can make better use of her time, and should therefore be excused from journaling."

The faculty's problem, from Lancer's perspective, was:

> "How do we get these bozos to keep on journaling while convincing them that we are remaining sensitive to their needs?"

The instructors resolved the problem by taking Lancer's advice and making journals optional. Lightning ended the matter with a final message titled Journaling :)):

> "I think that you guys are way cool.....Thanks for making journaling optional. I'm feeling like a weight (small but there nevertheless) has been lifted. Now, I can go back to concentrating on having some fun."

Only two students continued journaling after that. However, in the two months that followed nearly 300 messages were recorded by students and faculty on the listserve, a significantly larger number of entries than were forthcoming from the journaling.

Listserve as Journal

Although they are relatively new, computer applications are viewed with some favor by many teacher educators. A quick introduction to this topic can be gained by

reviewing the May-June 1996 issue of Journal of Teacher Education, which is devoted to the topic of Technology and Teacher Education.

One of the most widely available applications is an electronic communication system called a listserve. Briefly, a listserve is a way to automatically direct a message to a *list* of individuals simultaneously. Everyone on the list receives every message sent to the listserve. Some major examples of listserves are those operated by the National Council of Teachers of Mathematics, the National Council of Teachers of English, and PRESTO. All link in-service and prospective teachers in an ongoing conversation about what it means to teach (Thomas, Clift & Sugimoto, 1996).

Listserves are obviously very different from journals in many crucial respects. For example, they are public, whereas journals are private. The teams faculty did not include the listserve as a legitimate journaling forum for this very reason. On the other hand, TEAMS students saw them as equivalent in major ways. On at least two occasions students' messages generated the response "Hey, I think you were journaling." While these were partly in jest, they illustrate the changing definitions both faculty and students were constructing about the nature and functions of journals.

Listserve Characteristics

General Characteristics

Some general characteristics of listserve dialog became evident early. Messages varied tremendously in length, from one line to several pages. The average message length, however, was about 15 lines of text.

Listserve communication was also episodic and was often related to specific topics of conversation. For example, a participant may have remained silent for days or weeks, and then posted a number of messages within a few minutes or hours.

Just as in spoken conversation, some people are quiet and others loquacious. The most talkative person posted 51 messages with 790 lines. Another posted only one message consisting of one line of text during the during the entire time being considered. Some of the differences in verbosity were due to familiarity with the computer medium. Participants with high computer access and a high degree of experience with email communications tended to post more messages than individuals with lower computer access or experience.

Our first analysis of the listserve was based upon a modified set of categories based upon the work of Thomas, Clift and Sugimoto (1996). These categories attempt to parse the subject of conversations into five general foci. All entries were coded as one of the following:

> Non-academic - Messages that do not relate to the TEAMS project. Includes introductions, jokes, parties, personal statements, etc.
>
> Procedural - Scheduling, announcements, logistics, listserve membership.
>
> Technical - Computer related messages. Getting on the listserve, web page addresses and construction.
>
> Content - Asking for or giving specific content in science and mathematics.
>
> Pedagogy - References to teaching strategies and personal responses. Includes both TEAMS instruction and field experiences.

The results (Table 1) indicate that the contents of the TEAMS listserve have been quite businesslike. The most common category of message concerned some aspect of teaching (pedagogy). This is not particularly surprising, since the students were preparing to enter their student teaching placement shortly, and this subject was the primary focus of their course experiences. Three other categories, content, procedural and non-academic, occurred with similar frequencies. The latter two are not surprising. The listserve was used by faculty and students to coordinate schedules, relay news and interesting tidbits, and to plan social events. Content, however was a surprise. As stated earlier, all of the TEAMS participants had degrees in mathematics, science, or technology-related fields. We

had not anticipated that concerns about mathematical and scientific content would be so prominent.

TABLE 1. LISTSERVE PARTICIPATION OF TEAMS MEMBERS. Total number of messages sent by each participant.

	Non-Academic	Procedural	Technical	Content	Pedagogy	TOTAL
FACULTY						
Coyote	1	0	0	1	1	3
Elmer	2	5	0	6	9	22
Frankie	0	1	0	0	0	1
Jimbo	1	7	2	7	12	29
Jonboy	3	9	6	3	9	30
Rose	1	0	0	1	3	5
Pescador	1	6	1	8	3	19
STUDENTS						
Brenda	0	4	0	0	2	6
Buffy	10	1	0	1	6	18
Doe	1	1	1	1	2	6
Flincher	2	2	0	1	2	7
Lancer	12	7	3	11	18	51
Lightning	3	3	3	6	16	31
Lobo	3	4	1	4	9	21
Max	6	5	3	5	15	34
Pooh	0	2	1	3	7	13
TOTAL	46	57	21	58	114	296

A further analysis compares listserve use by faculty and students. A chi-square test (Table 2) reveals significant differences between the types of messages sent by faculty and students ($X^2 = 12.5$, $df = 4$, $p = 0.014$). Comparing expected and observed frequencies reveals the areas of difference. Faculty messages focus more on procedural and less on non-academic content than those of students. In terms of the content/pedagogy duality, faculty messages are skewed in favor of science and mathematical content, and student messages in favor of pedagogy.

TABLE 2. CHI-SQUARE ANALYSIS OF LISTSERVE PARTICIPATION OF TEAMS FACULTY AND STUDENTS

	Non- academic	Procedural	Technical	Content	Pedagogy

Faculty	9 (16.9)	28 (21.0)	9 (7.7)	26 (21.4)	37 (42.0)
Students	37 (29.1)	29 (36.0)	12 (13.3)	32 (36.6)	77 (72.0)

(expected frequency)

There are large individual differences in the content of listserve contributions. Among the students, Moose and Lancer are particularly prominent in the non-academic category. Moose is noted for the number of jokes she has posted on the listserve. Lancer, Lightning and Max were heavily involved in discussions of pedagogy. On the faculty side, Jonboy is primarily responsible for field assignments, and accordingly posted the largest number of procedural messages. Among faculty, Elmer, Jimbo and Jonboy posted a substantial number of messages regarding both content and pedagogy. In general, students participated more heavily than faculty, and three faculty rarely contributed to the listserve.

Listserve Dialog

One of the important characteristics of the listserve has been the conversations that have developed on it. The most extended of these are summarized in Table 3. The longest conversation so far was initiated by a request for more information about a classroom activity involving the diameter and circumference of a circle inscribed on a sphere. The most recent and least easily categorized discussion stems from the students' field experiences and centers on their fears, misgivings and experiences in classrooms.

TABLE 3. SUMMARY OF LISTSERVE CONVERSATIONS WITH THE MOST EXTENDED DISCOURSE

Subject	Summary
That #*@!! Journal	10/14/96 - 10/22/96 Began with the line, "Lets discuss this journaling business." Ended with the line, "You have been caught red-handed--JOURNALING!"

	Discussion centered on the function of journals and the costs vs. benefits of writing in journals. The nature of the listserve as a journaling activity evolved into the primary focus. **9 messages**
More Blah	10/24/96-10/29/96 Pooh described some reading he had done about Piagetian descriptions of children's' difficulties reproducing geometric figures such as squares, triangles, and circles. "Even Johnny Cochran couldn't convince the 3 year old a triangle and circle are not equivalent." Many listserve participants found this analysis unlikely to be true and challenged Piaget's interpretation. Faculty presented their views on children's understanding of shape. **16 messages**
That Crazy Ball	10/22/96-11/5/96 Did you know that the ratio of the circumference to the diameter of a circle drawn on the surface of a sphere is not pi? Max, a student, initiated a discussion of the differences in spherical measure and planar measure. She stated, "I visit unbalanced land (a reference to cognitive dissonance) frequently and enjoy it more and more." One of the faculty, Pescador , challenged participants to extend the reasoning of curved surfaces to curved space. The discussion evolved into an ongoing argument about the nature of space-time. **30 messages**
The Floating-Sinking Tube	11/8/96-11/25/96 Lobo posted a request for information on a class she had missed. The activity done in class was an inquiry into the operation of a Cartesian diver. Lightning introduced a "science game" to stimulate discussion... "Note: Only people who don't know the answer get to play. I really hope no one has posted an explanation before we get to play the game. I find it is like somebody telling you the end of a really great book that you only just got started reading." The game continued to be monitored by Lightning, and everybody followed the rules except Lancer, was eventually unable to tolerate the ambiguity. "You guys are driving me nuts with this," he said, and proceeded to give a number of "Physical Science 101" answers. **15 messages**
Rock 'n' Roll	11/25/96-continuing

Lightning initiated this conversation on 11/25/96, with a message about teaching your first lesson: "...I finally got to a point in my head that I have come to call rock 'n' roll. I was as prepared as I could be. I had no way of telling what was going to happen. It was time to rock...I haven't had an experience like this in a long time...so new, challenging, and exciting...that it brought me to this rock 'n' roll attitude. Not exactly comfortable. But it does fall in an odd category of fun."

Many fears about actually teaching are presenting themselves in this conversation.

3 messages

Excerpts from "That Crazy Ball!" illustrate typical interaction between students and faculty on a content- or pedagogical-related theme. First, the theme is introduced by Max. This introduction begins with a description of the student's metacognitive dilemma, struggling with visualizing the circle scribed on the surface of a sphere, and her disappointment in discovering that the formulas presented in her Geometry texts did not present the information in a form she could readily translate...

> I am looking at this sphere and wondering "what did I want to know?"
> Well some time passed and still nothing.
> Went and looked at the formulas of spherical volume and surface area.
> The R used is from the middle of the sphere.
> I am learning something knew all the time and just do not know what to do. I feel in a state of unbalance, trying to get back to that place of balance... Although, in reflection it is much more exciting trying to catch my balance, staying in balance or even avoid becoming unbalanced!
>
> One problem of unbalancedness (if that is a word) is that it is hard to stay focused. Not being focused for something seems like a bad thing. Not being focused implies not caring about what is going on or you do have enough intelligence to follow. I wonder if that is how kids feel a lot of the time.
>
> I visit unbalanced land frequently and enjoy it more and more.

Lightning joins the conversation a short time later, providing her own insight into the problem...

> I've been thinking about this some more....
>
> If you used the circumference and diameter, you would not get to see both arcs at the same time on the same circle, right?
>
> It is necessary (to build the picture I'm wanting) to be able to see both of these arcs change at the same time on the same circle.

Lightning's response validates Max's struggle, and provides deeper insight into the reasons the problem causes such difficulty...

> I am somewhat amused at my reasoning about this issue. Pooh was the first one to suggest this course. Now, this is the reason that I like to work with Pooh. He asks great questions from a point of view very different from my own. I learn a lot about things that way.
>
> Now, I felt very strongly about using the radius. But I didn't know why. I looked at several of my books and I found this kind of diagram over and over again. Oh, I say to myself, that must be what I was thinking about. I am building a foundation for these concepts. It sounded good. I kind of bought into it. And I guess it is a better answer than "I don't know". But when I stopped to picture this alternative method (using the circumference), I suddenly realized my partial circles went away and the picture I was trying to paint disappeared.
>
> Such a simple thing ... but powerful in my mind.
>
> BTW, I'm glad this pi thing didn't work out perfectly. I learned a great thing. And I'm very glad to have learned it with you guys, instead a room full of rowdy eighth graders. It was a very positive learning experience for me. Making mistakes that aren't too painful is the way I learn best. AND having a new little door of awareness open in my head always makes me feel really good.

This represents a significant change in the conversation from one primarily concerned with learning content, to one concerned with *understanding how one goes about learning content*--fusing content understanding with students burgeoning knowledge of pedagogy. This fusion of content and pedagogy is typical of our listserve conversations. It served a number of functions, primarily as a springboard for other conversations. For example, Elmer, a faculty member, took the opportunity to respond to Max regarding her development of content understanding:

> We live on the surface of a sphere, not inside. If you restrict yourself to a small part, it looks pretty flat. If you trace a circle with a radius of 10 km on the surface, you will still pretty much get a value that is close to pi if you divide the circumference by the diameter. However if you trace a really big circle the ratio will be smaller than pi. That is one way to prove that the Earth is not flat.
> I liked your metaphor of the "unbalanced land". Piaget also uses the term balance when children have experiences that contradict their inner schemas and have to reconfigure those.
>
> I used Plato's metaphor of the cave to convey how hard it is for people to change from one mode of learning to a different one (see "The shadows of mathematics" *Arithmetic Teacher*, v.40 (1993), p.428-429). Yes, it takes time and effort to "get used" to live with this sense of unbalance all the time, but it makes learning so much more alive.

and to Lightning, who was developing a micro lesson on the nature of pi:

> I liked your lesson a lot. I had never seen pi presented this way, by comparing the circumference (or half of it) to an arc that has the same

length as the radius (I had only seen activities where the circumference was compared to the radius). Of course this lesson would also be a great introduction to radians. If you measure the angle formed by that arc you will get about 57.3 degrees. If you divide 180/57.3 you get pi again.

I think we all learned a lot from the activity, both from a mathematical point of view and from the teaching aspect.

These responses were posted within 2 hours of each other, and were followed by a description of Elmer's first experience teaching a mathematics lesson, which sparked another conversation on the experiences faculty had when they began teaching oh so many years ago...

Listening to students present lessons is one of the parts of teacher preparation that I like the most. I always learn something.

I remember vividly the first time I gave a lecture in math, more than 20 years ago (in those days, lecturing was synonymous with teaching). I prepared carefully one 60 minute lesson. I decided to prepare a second lesson too in case my estimate of the time was not exact. I went in and delivered the first lesson. I still had time so I delivered the second lesson. I was done with that too, and I noticed that I had only used 20 minutes for both lessons. No need to say that I had to improvise for the next 40 minutes. I don't think 40 minutes ever lasted so long.

Pescador closed out this portion of the conversation and opened up another content investigation with the following query...

I've been reading your most recent correspondence on pi, and it makes me sorry I'm not spending time with all of you any more. I miss those kinds of experiences and conversations.

Elmer's message about circles on spheres reminds me of a chapter from George Gamow's book 1,2,3, infinity (I don't have it handy, so I can't actually confirm this reference) where he raises the question of how a two-dimensional being that lives on the surface of a sphere could prove that its universe (the sphere) was three-dimensional. There are a lot of ways. For example, the sum of the internal angles of a triangle wouldn't be 180 degrees. But I was interested to learn that the relationship between circumference and diameter of circles wouldn't be pi.

So then the question is, how would three-dimensional beings (us) prove that they lived in a four-dimensional universe?

Conversations like this one seem to be typical of the listserve. Each was initiated by a single member, and if the subject struck the fancy of others, grew in largely unpredictable ways.

It is apparent from our analyses that the conversations that have sparked the most reflection for the longest period of time are centered around content and pedagogy.

Procedural queries are short, to the point, and limited to a specific event or activity. Technical conversations are also short, focusing on how to do a particular thing with technology. Non-academic contributions are most often one-time postings, most often with no reply. Content and pedagogy, on the other hand, usually involve a larger number of participants, continue for an extended period of time, and often transform into even deeper conversations. This characteristic of our listserve dialogue addresses the fundamental reasons that we required TEAMS students to journal in the first place--to engage in reflection about the ways in which they think about science and mathematics content and teaching so that faculty could assess students' understanding and growth. The major difference between the listserve as "cyber journal" and our original notions of journaling center on the public nature of the listserve where a multitude of voices can be heard sharing their understanding of a topic, and the dramatic shift in the role of the student and the role of the instructor in this medium over traditional journaling.

The Language of the Listserve

Language is one of the most powerful forces in any classroom, and it is expressed primarily through dialog. Who speaks and who listens, who asks and who answers, has served to define the power structures and relationships between teacher and students. Because much of the listserve has taken the form of a set of discussions, it is as subject to this kind of interpretation as the more traditional language of the classroom.

We have chosen to use, as a vehicle for the analysis of this set of conversations, the methodology first developed by Bellack and his colleagues at Columbia University (Bellack, A., Kliebard, H., Hyman, R. & Smith, F., 1966). The reason for this is that body of research has yielded a description of the language of classrooms that seems almost universal. It is against this that we wish to describe the conversations of our listserve.

Bellack saw classroom dialog as consisting of four types of "moves." A cycle begins with the initiating moves of structuring or soliciting. These are followed by the reflexive moves of responding and reacting. These are defined in the following way:

> Structuring. Focus attention on a topic and launch the conversation. Teachers frequently begin a class period with a structuring move.
>
> Soliciting. Elicit a verbal response or attention to something. All genuine questions are solicitations, as are commands, imperatives and requests.
>
> Responding. Answers to questions, commands or requests are responding moves.
>
> Reacting. Occasioned by structuring, soliciting, responding or another reacting move, but not directly elicited by them. Evaluation of another person's response, for example, is designated a reacting move.

The conversational pattern that has been observed most commonly in classrooms has been one of solicitation by the teacher, response by a pupil, and reaction by the teacher. The ratio of teacher to student moves is about 3/2, and the average ratio of teacher to student talk is about 3/1. This pattern has been called the **SUPER-STAR** by some, after its primary characteristic; all dialogue must pass through the teacher as intermediary. Such a cycle is characterized by the absence of student to student interaction.

Here is an example of this analysis applied to the listserve conversation about the nature and need for journals. We have only included the definitive statements for classifying the type of move for each participant:

			Lines
Lightning	Structure	Let's discuss this journaling business.	29
	Solicit	Is it really that important?	2
Buffy	React	I too have a negative reaction to the journal.	13
	Respond	It would seem more beneficial to share in this manner	5
Max	Respond	Using this listserve should be enough.	12
	Solicit	More reflection is needed on the instructors' part.	3
Lancer	React	A truly interesting dynamic....	20
	Respond	It's time for a customized approach.	8
	Solicit	Can the rest of us meet this standard?	5
	React	I prefer not to keep on...	5
Lobo	Respond	I find the journaling valuable.	10
Lancer	React	Sorry for any confusion....	8
Max	Structure	Maybe the faculty would consider...	9
Lightning	React	You guys are way cool.	6
Jimbo	React	You have been caught red handed--JOURNALING	7

This conversation is different from the traditional teacher/student discourse structure in two fundamental ways.

First, this conversation is almost completely between students. Of course, some part of it took place off the listserve, and cannot be analyzed. Nevertheless, the only message from a faculty member comes after the matter has been resolved. Second, three separate people performed the traditional teacher's role of soliciting, and two of structuring. There does not seem to be a dominant individual in this conversation.

A similar analysis was applied to the four other conversations mentioned in Table 3, and the results are found in Table 4. We give only brief analyses of each of these conversations.

'Blah' is an interesting conversation. The students have discovered Piaget and are trying to decide what they make of his work. Pooh is structuring the discussion by making some assertions, and the other students are asking questions. Most of their solicitations are addressed to faculty, who initially fail to respond. Finally three faculty provide alternative interpretations based on other understandings of how children organize spatial information. Interestingly, topics initiated in this conversation, dealing with how children think and how we can find this our, became woven throughout many other discussions dealing with assessment and pedagogy.

TABLE 3. THE NUMBER OF LINES IN LISTSERVE MESSAGES THAT ARE PART OF FIVE CONVERSATIONS.

	FACULTY				STUDENTS			
	STR	SOL	RES	REA	STR	SOL	RES	REA
Journal	0	0	0	7	38	10	35	54
Blah	0	0	37	41	56	33	19	31
Ball	0	16	161	28	15	23	50	126
Tube	0	7	4	0	7	36	141	55
Rock 'n' Roll	0	0	0	0	18	1	0	37

The content of 'Ball' was much more difficult, dealing with everything from multidimensional universes to space-time continuums. All those participating found it fascinating, and faculty entered in to a much greater extent. The contributions of faculty in this conversation crossed over lines of expertise. For example the participating mathematics faculty responded more as physicists, describing space and time, while the participating science faculty responded more as mathematicians, asking questions dealing with dimensionality and proof. To some degree they functioned as the experts and responded frequently. But everyone began to play the 'science game' and Lightning congratulated Max. "Kudos on getting into this conversation."

Lobo began 'Tube' by asking "what happened in class yesterday." It was the first conversation deliberately structured around the 'science game'. It became pretty much a question and answer session, with a lot of attention paid to the behavior of the Cartesian diver. Almost all of the entries are solicitations and responses from students.

'Rock 'n' Roll' is a little too young to do much with in this analysis, but it does have one element that is worth noting. It is a conversation by students and about their feelings about teaching. Since it has no factual content, it is more appropriate for structuring and reaction than for solicitation and response. It looks like it will have a structure that is almost the mirror image of 'Tube'.

The hazards of aggregating these data are apparent from the analyses given above. Each is very different, and seems to have its own structure. Nevertheless, we would like to compare the listserve with the conversation so commonly observed (Bellack, Kliebard, Hyman & Smith, 1966) in more traditional classrooms (Table 5).

TABLE 5. PERCENTAGE OF MOVES BY TEACHERS AND STUDENTS ON LISTSERVE AND IN TRADITIONAL CLASSROOMS.

	TEACHERS				STUDENTS			
	STR	SOL	RES	REA	STR	SOL	RES	REA
TEAMS LISTSERVE	0	3.6	15.2	10.9	7.6	23.9	15.2	23.9
TRADITIONAL	4.8	22.8	3.5	22.6	0.4	4.4	25.0	5.7

An immediate observation from this table is that the two conversations are different in many respects. The ratio of teacher to student contributions on the listserve is 3/7. Students make approximately twice as many moves as teachers. In traditional classrooms, teachers usually talk more than students.

The pattern of talk is also different. In fact, it is almost reversed. In traditional classrooms, teachers solicit and react. On the listserve, teachers respond to solicitations generated by the students. Responding, however, is the traditional student role, but the teachers adopt it here. On the listserve, students react more often than any other type of move. This essentially evaluative role is reserved for teachers in traditional classrooms.

Journals as Private Conversations

Journals in the traditional sense might be characterized as a conversation with oneself. A teacher may view a journal, write comments or queries, or speak to the student about what he or she wrote, but for the most part, the content of a journal is developed by the student in isolation to structure their experience and to make meaning from the experiences they are struggling through.

Journals lack most of the characteristics of true conversation, and thus proved impossible to analyze in a manner comparable to the listserve. Instead, we would like to focus on some elements of journaling that make that process unique, or at least very different from listserves.

Whereas listserve contributions are short and choppy, journal entries can be long and introspective. While listserve conversations often take abrupt turns and changes in topic and focus, journals often follow a single thread to its conclusion. But, most important, journals are private and listserves are not.

In the best of circumstances, a sense of trust emerges between author and reader of a journal that allows the sharing of rather intimate ideas. The journals that we have

collected contain many rather specific, and sometimes highly critical, references to particular elements of the program that students are involved in. Often they include reference to individual teachers, classes, and lessons. At other times they concern other students. It is clear that the authors felt allowed to express such criticisms without fear of retribution, and they did so freely.

Very few entries of this sort have appeared on the listserve. However, we know that separate e-mail discussions have emerged between particular students and faculty, and that their content has been similar to the missing listserve contents. We are aware of at least three such instances, although there have probably been more. In each instance, students chose to communicate with a person who they felt might be sympathetic.

The absence of these kind of conversations on the listserve is unfortunate, for they may be among the more valuable for formative evaluation. In the hands of a sensitive teacher, such feedback can help correct problems before they become serious. In the best of all worlds, journals are vehicles for building trust between teacher and student.

Discussion

In his book, Talking science, Jay Lemke distinguishes between true dialogue and what he calls Triadic Dialogue. The latter is a type of conversation in which the teacher asks questions and the students answer them. The funny thing about those questions is that there is only one right answer, and the teacher already knows what it is.

Teachers engage in that kind of dialogue to project the image of good teaching and to maintain control of the classroom. This is essentially a power issue:

> "Teachers and students have grossly unequal power in the classroom...That difference in power extends to control of the dialogue itself, both in its form and its content...(Lemke, 1990, pg. 44)."

Teachers need to move along. They can't afford to waste time if they are going to finish the curriculum. Students want to take their time. They want to control the amount of

material that is covered, and thus to be learned, and they want to take their time and understand.

Electronic conversations seem to be different. Students take control, apparently with the permission of their teachers. This has been true in other settings than the one described here. It is possible that "shifting the accountability for making meaning to groups of students changed the authority structure of the class, creating an atmosphere of apprenticeship in which the lines of authority between teacher and student because blurred (Audet, Hickman & Dobrynina, 1996, pg. 220).

In part, this may reflect a very different role that teachers adopt in such conversations. Teachers in this study were mainly reacting, providing information where it was requested but not interfering in the conversation. The ratio of teacher to student talk was much lower than it is in typical classrooms. Both results have been found in other studies where free exchange with other students was encouraged (Audet, Hickman & Dobrynina, 1966), but not in those where students communicated directly with teachers (Thomas, Clift & Sugimoto, 1996).

Another possibility is that the pace of electronic communication is so different that it does not allow the traditional dialogue of the classroom. Mary Budd Rowe (1974) was able to show that increasing the wait-time of teachers could lead to a transition from Triadic Dialogue (which she called the interrogation) to true dialogue (which she called conversation). Wait-time isn't a relevant concept on a listserve. People come and go, often not having read their e-mail for some time. They come into the conversation at their own pace, and it is impossible to interrupt someone else, or to cut off the conversation. Perhaps that feature alone is enough to explain the observed differences.

The listserve is a conversation with others--i.e., discourse--as students are able to question, reflect, plan, and respond to topics of mutual interest. This, we feel, adds a sense of legitimacy to the "journal" entry. The students are not writing for the professor. They know their postings will be read (by multiple readers), and their writings have a

purpose: to find out an answer to an important question, to help a colleague in need, and to determine if their feelings and fears are warranted. This in part explains the motivation to write in the listserve format for the majority of TEAMS students over the more traditional journal format. It must be stated, however, that a few students, for one reason or another, still do not engage in written metacognitive reflection. It is unclear at this time what this signifies: whether writing is not a preferred mode of communication for these students, whether lack of technological experience hinders their "getting on-line", or whether the public nature of the listserve is seen as a threatening environment.

It is also clear that the listserve is inferior to more traditional journaling in a number of ways. First, the length of each posting on the listserve is significantly shorter than the typical journal entry. Students, in feeling comfortable to post a query and receive immediate feedback may not engage in the depth of individual reflection that they seem to do in their journals. It is unclear what this tradeoff may signify. On the one hand, the listserve-as-journal goes into greater depth in terms of content. On the other hand, the contributions of individuals at any given moment in time more terse. Is the shared understandings of a cohort as powerful as the more intimate understandings developed between a teacher and a student? In addition, students traditional journal entries contain "spur-of-the-moment" statements that pertain to what they are doing at the moment in their TEAMS experience. These types of statements are not as evident on the listserve since students are not on-line for much of their classroom and field experiences.

Whatever their relative strengths and weaknesses, our experience indicates that listserves are more fun than journals. Our students disliked journaling. They were bored with it, and did not see its value. On the other hand, they love the listserve. It is a playful medium, and they play with it. That alone suggests that, despite some inadequacies, listserves may be preferable to journals as devices to encourage communication and introspection.

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