Listening to Our Students

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For many people working intimately with mathematics there is a tension between mathematics and one's "real self" or one's "own personality." The tension seems to include a fear of being *too* close to the mathematics; of being drawn into the mathematics TO THE EXCLUSION OF other areas of life. One part of the tension is the pull that the mathematics has for the mathematician. There is a strong belief that in order for one to do mathematics successfully, one must devote all one's energies to mathematics as if insights gained might slip out of one's mind were they not held there with constant will and attention. One must become immersed in the mathematics; and in fact, anyone doing mathematics *will* become immersed in it whether he or she wishes to be or not. It is as if the mathematics and the mathematician are becoming so close they are becoming as one. Further elaboration of this view of mathematics constitutes Part II of this paper. Part I of this paper details the method of investigation that has proven successful in illuminating some of the feelings associated with mathematics.

Part I

INTEGRATION OF THOUGHT, FEELINGS, ACTIONS

Mathematics is often viewed as a cold, indifferent, logical discipline; yet probably more intense emotion surrounds mathematics than any other subject. I have observed students react with delight when they suddenly saw meaning that they hadn't seen before in some mathematics. Those who acknowledged feelings of elation when something "clicked" often used that high as inspiration to keep on with their work. I have watched students cry, shake or shout when fears came up for them while they were trying to think about some mathematics. Those who ignored or did not pay attention to what they were feeling, sometimes found that it was possible for negative feelings to overwhelm then and leave them nearly paralyzed in ability to think about mathematics. (Having feelings, even negative ones, is not the cause of the difficulty. The difficulty comes with not acknowledging the feelings. Those students who paused to consider their feelings were very ingenious in taking power over or using their feelings in constructive ways.) Feelings, thoughts and actions are all part of learning anything, so it is expected that feelings similar to those encountered when learning mathematics are encountered in other areas. Yet the feelings around mathematics seem particularly intense. Also there is less inhibition, it is almost an accepted practice, to discuss feelings about mathematics explicitly and openly. Therefore an investigation of the nature of feelings in learning might well begin with the nature of feelings in learning mathematics.

Most of us have ample opportunity to listen to people describe how they feel or have felt about mathematics. In addition, sometimes we can observe directly the person at the same time that the person is actually having the feelings that she/he may later describe. This kind of observation is a basis of my method of inquiry which will be discussed later. There are important features in this method of inquiry that are not present in questionnaires or even in clinical interviews. The clinical interview has use as a tool for evaluation as well as a means by which to elicit information [Confrey, 1978; Easley, 1980; Pines, et al., 1978]. It may, however, seek answers to questions not previously contemplated by the interviewer or it may evoke general descriptions of remembered thoughts and feelings of past events. Each example in this paper came from observations of an individual who was in the midst of feeling and deliberation on mathematical issues which that person brought up because they were of importance to that person. One result of this method of research is a rich collection of unexpected concerns that students expressed about their mathematical experience [Rosamond, 1981]. I had the unique opportunity to interact with students as they expressed unsolicted concerns during my work in the Mathematics Support Center at Cornell University.

THE CORNELL MATHEMATICS SUPPORT CENTER

The Mathematics Support Center (MSC) at Cornell University was established in December, 1979 as a support service for students. The Center supports people to become more comfortable with mathematics and encourages them to take more mathematics courses and to consider mathematics-related careers. The MSC attempts to appeal to and support at least three parts of the population: those students who need extra support in order to do well in mathematics courses; those students who do well in mathematics but feel their self-confidence eroding or see mathematics as not fun any more and are uncertain about continuing to take mathematics; those students who have little anxiety and do well in mathematics but who feel isolated and need encouragement to persevere.

The intention is that the MSC be a small in-house operation, intimately part of the Department of Mathematics, where any student can receive help to think about and do mathematics. Thus, although some course-tutoring is

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available for any student, the large majority of students who visit the MSC are regular students in regular courses.

The students who come to the MSC are a self-selected, relatively small number of all the students taking mathematics courses at Cornell. In one sense each student is unique, representing only that sudent. Yet in another sense that which stands out most from the many visits by students to the MSC is that they are all really seeking the same thing: (1) to make personal sense out of the mathematics; (2) to see the mathematics in the light of their own past experience; and (3) to find ways of relating this to what they are hearing.

THE METHOD OF INQUIRY

My practice is listening. I focus my complete attention on the person while the person is talking. By this I mean I do not allow my mind to wander to my other work nor to anticipate the next thing the person is going to say nor indulge in memories or reactions to what the person is saying. My reason for this view is that something in what the person is saying of in how they say it may give me a clue as to how I may be helpful. As important, however, is my belief that a person is intelligent enough to find a solution to the person's own difficulties and the very act of thinking aloud about a situation to another human being who at the same time is thinking and caring is beneficial in resolving difficulties.

I do whatever I can to let the students know that I care about them. This means that I view the students as being of primary importance, more than the mathematics. Caring for the students means allowing the student to express any feelings the student needs or wants to express. Feelings of isolation, powerlessness, panic or anger block clear thinking. Often students express these feelings when they perceive that the listener cares about them and understands that these are feelings and the reality of feelings is not the reality of the situation. Once bottled-up feelings like these are expressed, the student is able to think more rationally about the situation and about the mathematics. In the MSC, I allow students to express their feelings. It's not just a place to share their thinking.

Caring means esteeming the students and respecting their intelligence and thinking about how to help them recognize and accept their own intelligence. Many students are afraid to take charge of their learning or have lost confidence in their ability to learn. Many students have become accustomed to feeling that knowledge they learn on their own is not as worthwhile as that which they can find in a book or hear in a lecture. I look for ways to help students value what they already know as a basis from which to learn the new. The above is consistent with some of the findings of Paulo Freire in his work with oppressed peoples. One of the characteristics Freire describes is a feeling by people that they don't know things, accompanied with much self depreciation [Freire, 1978]. This feeling of not knowing, or of not knowing enough, is often expressed by students. The MSC's basic assumptions are similar to Freire's admonition that the most important thing for allies to do is *trust* the people and to be a partner with them. Also, we in the MSC concur that the learner must not be passive [Freire, 1982]; learning (liberation) includes action, reflection and dialogue.

Perhaps I should mention that there are some students that I like better than others but this never interferes with my being able to care about and pay attention to a student. I try to see that student in another dimension. I ask the student to tell me more, often about early years. I might ask a question such as, "Tell me about when you first learned about numbers." This almost always elicits fascinating mathematical as well as childhood memories that help me see the richness in the person (and contributes to the person sensing validity in their own knowledge.)

The MSC office is a rather narrow room and I arranged the chairs and desk so that sitting nearly knee to knee or working shoulder to shoulder can almost be construed as a function of the room size (see Brooks [1969] for study of physical distance and student acceptance). My purpose is to get as physically close as I possibly can get and still have the student be comfortable. The amount and kind of physical closeness varies with each individual, with the particular reason for their visit, and with what is happening during the visit. People who are crying often receive hugs or I hold their hand or arm. If a person is angry about something I might suggest a punch at my hand (or a pillow I have in the room). Sometimes I reach out and touch a person's shoulder in encouragement. Almost always I shake hands or hold my hand out to the student in some way. My goal is to suggest neither motherly nor sexual tone to my actions, but rather to convey respect and liking for the other person as a comrade human being. Again, focus is on the student and not on my own desire for distance or closeness.

I try to make the MSC a place where the student feels safe and comfortable. Often the student or I close the door during our conservation. Some students especially older students returning to school, feel acutely embarrassed that they didn't know some elementary mathematics. I insist that these students sit in my chair (giving the reason that I am left-handed and this favor will make it easier for me to see them work). I reason that a person who feels dignity will express concerns of substance.

Typically students walk right into the MSC (sometimes asking first if I am available just then) and rush to show me the mathematics exercise they have brought as if to legitimatize their presence. I work to slow down this nervous rushing by smiling at them, shaking hands and asking them about themselves, all the while clearly ignoring the math book or paper they have placed on my desk. I want to convey that I am interested in them before I am interested in the mathematics they have brought.

This approach tends to encourage students to express their feelings. When I ask for example, "What is going on for you right now?" the student might hesitantly begin to talk about some worry. As students begin to trust that I am not going to abandon them either mentally or physically they allow more feelings to surface. I try to work with the student's anxieties first but often we go into the mathematics and something there will stimulate an expression of feelings. Often we work on mathematics and feelings simultaneously. It is an "in and out" sort of thing,

with the student and me sharing the direction the visit takes I am not a psychiatrist and the visitors to the MSC are healthy, intelligent, reasonable Cornell people. The feelings that are talked about here are feelings that concern teaching and learning mathematics (not the whole wide range of feelings). Often a student talks the entire time or most of the time in the MSC. A couple of times a student cried the entire visit.

Virtually all visitors to the Mathematics Support Center come to ask for help with mathematics. (A fair number come to discuss ideas they have about some mathematics that is not related to course work.) The requests may be general, as for help with trigonometry or algebra, or specific, as for help with a particular homework problem. Frequently in the context of discussing a particular mathematics problem the student will bring up other issues that the student feels influence present learning. If these issues involve the current situation, they may be mitigated immediately with a phone call, a change of section or some arrangement.

Sometimes students recall confusion they have about some elementary or high school mathematics they have learned. Sometimes they say they visualize what is going on in their class in a way different from what is being presented. (For Davidson [1973], having students work in small groups provides an opportunity for listening. He observes that "the curriculum writer and the students might have drastically different notions about the meaning of a concept.") Students want to see the mathematics the way the professor does or confirm that their interpretation is correct. The student is encouraged to expand on the student's own interpretation so that the specific nature of the confusion may come to light. It is not assumed that the student would not misconstrue the meaning if only correct information were given. The probability is high that the student already has been given good advice and correct information.

What is important in the relationship between the student and the MSC is that in the MSC the student is the real focus of attention and the understanding that the student has about the mathematics is as important as the mathematics itself [Perry, 1973]. Therefore, it is not embarrassing to the student when a problem turns out to be trivial, because it is the student and the student's understanding of the problem that is important in the MSC. I do not allow a student to bluff that some mathematics is understood. The student must answer, "What do *you* mean by this? How do *you* see it?" I help students make connections between what they know already and what they want to learn.

Out of my experience and the experiences of the other MSC staff there has evolved a basic working rule of thumb, a fundamental assumption. It is this: *assume that the student is asking a genuine question*. If the question sounds like gibberish then keep trying to draw out more from the student until finally you both see where the confusion lies. There are many techniques for this; concept maps [Novak, 1977], the methodological "V" [Gowin, 1981], working specific problems. Also, it may turn out that the student's confusion lies in an area of legitimate mathematical mystery (rules for multiplication of negative numbers, concepts of limits, assumptions about equations, etc.) that has been glossed over in the student's mathematical experience.

At the end of a visit I ask the student if what we have done has been helpful. Also, I ask the student to voice whatever difficulty was or is getting in the way of learning and I press for specific steps the student sees to take to overcome the difficulty.

One of the people who came to the MSC on a fairly regular basis was a woman who has been a practicing psychiatrist for over twelve years. She was in a graduate program now in another field and was trying to prepare herself for the required statistics course. She made a remark about my methodology so I asked her if she would describe my methodology as she sees it. The following long quotation is her description.

Student: If I were to say, "How does Fran teach?" I'd say first of all that she provides a very warm, secure environment. Secondly, she starts at the level of the student. Thirdly, at every step of way it's always extremely positive rather than any form of introducing negativity. Because the student who has already failed already has such superabundance of negativity that anything coming from you would just reinforce that and create a bigger block. So that there is an extreme exaggeration of positivity.

Fran: It's real.

Student: Yes, which works. You know, to enhance the confidence. I mean, the student will say, "Gee I just added two and two, why is she making such a fuss? Maybe it's good." and then the student says, "Let's keep on doing it." The student feels good because it's praise.

Student: Then, also, you encourage the student to bring whatever props the student needs. For example, with me; I come with food all the time and I walk out with food.

And you use visual... you find out the method from which the student learns best and you pick up on that. In my situation it happens to be visual; something concrete that I can see rather than abstract.

And the expectations are very limited initially so that the student gets her feet wet in order to get over that block at her own pace. There is time for "revving up" once that's gotten over. Anyway, I would see that as a methodology.

There is another important level that needs to be mentioned. Namely, that the persona or the role that you transmit is one of equality rather than "teacher/student" which would further impair the learning experience for people who are anxious. And then the student doesn't have the association with a negative role. The student already has "math-negative role." So it is important to provide a different role model that doesn't associate previous anxieties but attempts to do it in a relaxed, informal normal fashion.

Fran: Human, in a human fashion.

Student: Yes, yes. But it's beyond that. If you are dealing with someone who has a block then it has to be

above and beyond the human element. It has to include that but it has to address itself to the nature of the block. So I would say the the exertion has to be (given to maintaining a) directed, sensitive role rather than just the human interaction that occurs.

Fran: I am not a psychiatrist. I am not a psychologist. I do mathematics. I don't talk about sex problems. I don't talk about family problems. I talk about mathematics. It's all in this context. Is that what you are saying?

Student: No, but you do that too. You do that too. What I am saying is that a person who comes in for help with math, who has math anxiety, usually has blocks which they've created with impair learning.

Student: One has to be extremely sensitive to this excessive anxiety and whatever else is impairing the learning. By bringing the type of atmosphere that you create you diminish that. In other words, you slowly chip away at it. And so that is why when you said; "Human or human interaction" I said "No." It's a directed, extra-sensitive interaction which is human plus. Because you are dealing with what is not a normal situation. You are dealing with a situation that has problems.

Fran: We are not dealing with the "normal". We are dealing with something that has happened that shouldn't have happened.

Student: Yes. The symbol that I usually like to use is that a person comes in with cabbages on their back. They are not coming in unencumbered. They are coming in encumbered. They are carrying stuff they don't need.

Good listening is a demanding activity. For the most part it would have taken much less time and energy for me to say, "Here, this is how you do this problem," but students resisted this. They had heard that already and came to the MSC for something else. They wanted support for their own efforts to make meaning in the mathematics. The act of listening communicated to students that they were considered valid makers of mathematical meaning. It encouraged them to accept their knowledge and take charge of their learning. This sort of listening is more than a means of acquiring information; it is more than a diagnostic tool. As Easley and Zwoyer [1975] claim in the title of their fine article, there is teaching by listening.

Part II

Listening to students revealed commonalities in concerns they have, concerns that hinge on feelings and on the desire to make and share mathematical meaning. The importance of the integration of thoughts, feelings and actions is given special attention in the philosophy of education of D. Bob Gowin. Gowin stresses the power feelings have to impede or to drive clear thinking and his model acknowledges student claims to what they can bring to the educating episode. An especial strength of Gowin's theory lies in its articulation of educational events in the four commonplaces of teacher, student, curriculum and governance. These commonplaces were used as a framework by which to organize the variety of student concerns. Under each commonplace, student concerns were grouped into three broad and overlapping categories: closeness and isolation, context and meaning, power and powerlessness.

An explanation of each of these categories is beyond the scope of this paper. However, I would like to share here a section from "Closeness and Isolation: Curriculum" from my Ph.D. thesis. I chose this section because the feelings reported were delivered with such great intensity and with a tinge of hopelessness demanding attention. Also, the phenomenon is not one which is apprehended readily. I would appreciate personal correspondence and reactions from the readers so that together we may see the reality beyond the words.

CLOSENESS AND ISOLATION: CURRICULUM

There is an isolation between the mathematical self and the real that, at least for the visitors to the MSC, had not been reconciled. This produced a felt need for the mathematician to exert an effort to preserve himself or herself as bigger or more than the mathematics. Examples of language of visitors to the MSC may shed light on the nature of the separation people seem to feel.

Example: "A" came to the MSC in early May looking for advice. She had been a mathematics major at Cornell three years ago but had not finished and now needed three more semesters to complete the degree. She lived in the Boston area but had come to Ithaca for a few days to seek advice and to find someone to tutor her during the summertime. The plan that she was seriously contemplating was to leave her home area to live in isolation in this semi-strange town to "work like a dog all summer and be tutored to see if I'm math material."

The thought behind "A's" plan of action is reflected in the question posed by a senior mathematics major, "Do you think that if I eat, sleep and breathe mathematics that I will become a mathematician?" The idea is that one must give up oneself in order to do mathematics, it is an all or nothing endeavor. The following example illustrates the resistance to this consumption by mathematics.

Example: "B" was a mathematics graduate student in his last year. He was waiting outside the MSC door when I came in one day and when we went in and closed the door he sat down and immediately began to talk. He talked almost without stopping or without comments from me for about two and one-half hours. While he talked he sat rather stiffly in his chair and kept his head turned to stare across the room toward the window, not directly in front of himself at me.

B: I hate mathematics!

MSC: Why did you go into mathematics?

B: Well, no particular reason except that I was good at it. It was something I did well.

MSC: You must also have been good in English. ("B" is extremely articulate.)

B: I like the clever twists of logic that could turn a two page proof into a one-half page proof. There are lots of clever little insights. There's something

very satisfying about a nice tight argument that no one can doubt is correct. Mathematics seems to tie together in a bundle.

When I got to college I found that my education had been very diffuse while many of the other students had specialized even in high school and been in programs affiliated with area colleges. Mathematics came at me so thick and fast that I didn't think of it as disconnected pieces of information of theorems here and there in isolation. Well, maybe I did at first, but at first (first two years) there was so much novelty that I enjoyed that and then later (about junior year) the ideas would fold in on each other.

I've worked on a research problem for over six months with no results and it's hard for me to go on with a different problem because I keep going back to that same problem. Now I'm starting to dream about it and that's too much. the mathematics is taking too much control over me. (Angrily.)

This is the second time "B" has talked to me about how angry he was to be dreaming about mathematics. Later "B" talks about discussing mathematics with fellow graduate students and his identification with mathematics.

B: We talk about the mathematics we are doing more here than we used to. I think if you identify yourself with mathematics and see mathematics as part of your identify, then you will talk about mathematics with other people.

The reification of mathematics and personal identification with it was brought up by several advanced mathematics graduate students. Most often the feeling of identity with mathematics brought a painful sense of isolation from others or from one's own total personality.

Example: "C" is an advanced mathematics graduate student who is considered by his peers as one of the finest, if not the very finest, in the department. Yet "C" was very troubled this semester and confided that it was the worst semester he ever had experienced. Part of what he was troubled about was confusion about his mathematical talent and doubts that he could ever be creative enough to be a good research mathematician. He says with great distress, "It takes years to get to the forefront of an area in mathematics. Only a few are creative enough to do good research in mathematics." Another part of his distress (and he used that word himself) had to do with identification with mathematics. "C" stood in front of me with tears in his eyes and said, "What do you do if you are 80 – 90% mathematics? If you've let yourself become consumed by mathematics so that that is what you are. And then you want to let someone get to know you. What do you do when you can't explain that much of yourself to them? How can they get to know you when they can't understand that much of you?"

Example: "D" is an advanced mathematics graduate student.

D: Mathematics takes up so much of my life that if I had it to do over again I'd never be in mathematics. It takes all one's time and I fight that. There are some people who allow the mathematics to be everything and it takes away their personality.

Example: "E" is an advanced mathematics graduate student who was also present during the above conversation with "C" and "D". Here we are discussing schooling in general.

E: So much is psychological pain that is unnecessary. It makes you not want to learn anymore. There's really something wrong with the system. Like "F" (another graduate student), "F" said he used to love to do problems and now he doesn't want to do problems. It makes him feel really threatened and unhappy. That's how I felt too, shame, you know.

MSC: (I mentioned the conversation with student "C" and how he felt that mathematics consumed so much of him.)

E: (Flatly) Give up math. (Without discussing it further E goes on to talk about being a TA.)

MSC: (I mentioned "D's" comment that mathematics ruined the personality because it seemed that one had to do math solely and nothing else.)

E: I just can't believe that! That must be wrong! I can't believe that that's what you have to do to do mathematics. I just can't believe that! There must be a way of doing both. The whole way of approaching things must be wrong. There must be a way that you can do both.

The entire tone of "E's" protest was less one of denial than it was a plea that such a thing not be true. His accusation "The whole way of approaching things must be wrong" as well as other conversations with him reveal the fear that indeed it might be the case that to do mathematics successfully one must do mathematics solely and nothing else, even if it ruins one's personality.

Example: "G" is a successful mathematician extremely highly regarded by her peers, and with a tenured position at a major university. She came to give a seminar in her area of expertise to the Cornell mathematics faculty and the MSC asked if she would give a talk about herself as a mathematician. She was more than pleased and repeated several times that she was grateful when someone proposed something for her to do outside of mathematics. She didn't initiate non-mathematical activities. She wanted to do other things but was drawn just to doing mathematics. In the notes for her talk and in her talk she stresses the importance of feelings and their relevance to her continuance in mathematics.

I was a graduate student in . . . . . , which was the most fashionable subject at that time. But my male peers were producing such an amount of anxiety-panic, that I was not able to make much progress in learning. I know it was entirely psychological, as of course I feel now able to learn any subject in a reasonable amount of time.

I was scared. If I was working in the library and if someone was approaching me and looking over my shoulder, I was immediately hiding my stupid calculations, my ears were buzzing. I was just unable to say something intelligible. I was panic-stricken. I was certainly having some more and more doubts about my abilities and my own reserves of self-esteem and arrogance, from my past as a bright undergraduate student, were going down very quickly with this total lack of support.

However, by chance, I met two people who were involved in research and who encouraged me. In a better psychological environment, I learned and started to produce some mathematical research work, with a greater ease. It has never been very easy to do mathematics. But I started to believe I could. I believe our abilities to do productive research depends very much on our psychological resources: self-confidence, ambition, patience and resistance, resources of joy and energy and love.

She goes on to say that if support hadn't come through, she has big doubts as to whether she would have become successful. She said that she has become aggressive in her work, effective, respected and that she is comfortable with her knowledge and opinions on her work. But she is not comfortable with having to give up so much to do mathematics and that men usually don't have to make that choice. When she was asked "How much of your personal life is mathematics?" The reply was "100%."

> Before, when I was unsure and scared of doing mathematics, it was easier to find time to do other things. Now I know that I will be successful. Now I have no control over the amount of time I spend doing mathematics. I am rewarded so I want to do it. Now I know that I can do it so it is good for my ego. It is like a drug and I am addicted.

In each of these examples the person feels consumed by the mathematics. Each resents feeling that the mathematics is too dominant. It is as if each were two people; one being consumed by the mathematics and the other looking on and resisting. Love for mathematics seems to divide the self. There is a longing for reconciliation, or better, an integration of the "mathematical self" and the "real self."

Ferenczi [1955] the psychoanalyist colleague of Freud, suggests that mathematical genius is a combination of strongly-developed introspection with strong instincts. In his notes he claims "the mathematician has a fine capacity for self-observation of the process of formation of conceptions, of memory images, of speculative processes." His brief notes carry this idea further.

> *Query: is mathematics abstraction from external experience? or: a priori knowledge?*
> *Solution of this problem perhaps: self-observation is in itself an inner 'experience', out of which mathematics is abstracted. That is, on both sides of the [consciousness] system mathematical abstractions do occur. In other words: is mathematics internal or external perception? (Up to the present mathematical knowledge has been considered as abstraction (induction?) from external experience.) Here the tracing back of mathematical knowledge and abstraction to internal (self-) observation is attempted.*

The notion of giving up oneself to mathematics is expressed by students who have little mathematics background as well as by advanced mathematics graduate students. Perhaps it comes from the realization that mathematics is not a book or a set of techniques but a way of seeing. The pain in these voices may come from the awareness that once one sees in this new way one will never be able to see in quite the old familiar way again. Perhaps the voices reflect that awful feeling of narrowing that comes in the early stages of commitment. Perhaps this perception of the consuming nature of mathematics is so widespread that it is a contributing factor in women's decisions about taking mathematics courses. The view that mathematics is all consuming was viewed almost as inevitable, not problematic. What is the reality that these private, individual perceptions were reflecting?

The act of knowing is not antiseptic; rather it is wrapped in feelings, it is the engagement of feelings. It is important for the researcher, the teacher and the learner to pay attention to these feelings. Still, it is difficult for the researcher or teacher to prearrange a situation in which to dialogue with the student about student-raised concerns at the time that they are concerns. This paper was meant to offer some insights into how we can pay attention when the student comes to us and how we can reflect with the student on these subtleties in mathematics.

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