Literacy Lessons and Mathematics Learning *

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August 8, 1994

1 Background notes

The bulk of the following essay was written in 1989. The previous year I had stopped teaching K-12 language arts and began writing computer programs and documentation. I worked alone, linked electronically to my employer two time zones away. I had to learn several programming languages and a considerable amount of mathematics and computer science to do my work. As a teacher, I had been a strong proponent of the notion of "writing-to-learn across the curriculum" which espouses the use of writing to promote thinking and learning in any discipline. It was time for me to put the theories I supported to the test. If I approached my own technical learning as a language acquisition process and used the methods I espoused as an English teacher, would the results be as good as all the literature claimed? or would it just be another example of practitioners in one discipline (Language Arts Education) insisting that their methods should work in any discipline.

It turned out that what I had learned about language acquisition to support my teaching of reading and writing served me well as a neophyte programmer and a beginner in computer science.

During the same period, I was making regular visits to my children's classrooms, observing how much their beginning mathematics education differed from their indoctrination into language arts. This is when I met Mike Fellows, a mathematician and computer scientist,

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then at the University of Idaho, who was puzzling over the same issues from a mathematician's perspective. The first draft of this essay was attempt to synthesize for Mike the connections that I saw at the time between language arts education and mathematics.

The question posed in this essay which continues to fascinate me is, "How do you create a mathematically rich environment?" More daunting than simply creating such an environment, is the prospect of trying to do that *and* teach the existing mathematics curriculum. Eventually, I think the school mathematics text will go the way of the phonics book—not disappear entirely, but re-emerge as one element in a wide variety of mathematical literature available to students. But the shift is slow, and teachers are really caught—the demands come from all sides and their job is simply to make it wonderful for everyone concerned. Teachers are the ones whose voices need to be heard the most. After all, anything works in theory!

I am especially indebted to Marcia Anderson and Prudy Heimsch of the Moscow (Idaho) School District, two dedicated, gifted, and experienced teachers. Observing them taught me more about teaching than I ever learned elsewhere. Mike Fellows (`mfellows@csr.uvic.ca`) is currently at the University of Victoria, British Columbia and our collaboration continues.

2 The nature of language learning

Language is a beautiful, complex, all-encompassing human activity that requires no special gifts. We all do it. Language is not taught to people, it develops within them. Barring brain damage, human children learn whatever language or languages they are exposed to.

The richness of a child's linguistic comprehension and expression is directly related to the richness of the linguistic environment. Children learn the languages that they hear. If, in addition to conversation, they are read a wide variety of literary forms—stories, poetry, nonfiction—they learn the language of those forms, as well. When children are exposed to the ways that others express themselves in writing, they become familiar with those forms as frameworks for telling a story or conveying and idea. Hand in hand with the development of an understanding of how written forms can be used to communicate meanings, come children's attempts to express themselves in similar forms. Their expression and comprehension is creative, not strictly imitative. The will not simply reproduce the forms and vocabulary to which they are exposed, rather they adapt them for their own communicative needs.

3 Extending language: Reading, writing, thinking and mathematics

In the mid 1970's research in congnitive and developmental psychology and linguistics was brought to bear on the issue of children's learning to read and write. Written language is a communicative form unto itself and not simply an encoding of the spoken word. As is the case when children learn spoken language, the learning process for written language is part of a child's inherent movivation to make sense of the world and to communicate. This process is best enhanced by rich exposure to written language in meaningful contexts. Clearly, approaches to teaching reading and writing that rely solely on mastering rules of sound-letter correspendence are too narrow in focus. For nearly 20 years, teachers and researchers have been seeking to understand how reading and writing operate within the language-learning processes that are already very active for young children.

Reading was recognized as a psycholinguistic process in which a person's knowledge of the world, understanding of language, and expectations for a text are all engaged in the process of deriving meaning from the printed page. Knowledge of phonics, sentence structure and rhetoric compose only a small part of the psycholinguistic awareness which makes the written word meaningful to the reader. A child who grows as a reader is developing a broader ability to make predictions about the meaning of the writing and either confirm or refine these predictions with information they obtain from the page.

The development of individual children's ability to express themselves, communicate, and understand others via writing is, on the one hand, unique for every child, and on the other, tends to follow a general progression for all children. At the core of understanding and using written language is the notion that marks on paper make sense or carry meaning. As children develop cognitively, so do the depth and complexity of the meanings they can associate with the marks. In addition, the child gradually internalizes concepts about how writing is organized: reading from left to right, page ordering, chapters, poetry versus prose, the way ideas progress in a story, etc.

Just as speaking and understanding are interconnected and learned together, so too are reading and writing. A child who knows that meaning can be taken off of a page will attempt to put meaning on a page with writing. Writing emerges from drawing as a child draws letters as pictures, engages in "pretend writing", and puts ideas on a page with letters and pictures. Gradually, sound-letter correspondences and other spelling conventions internalized from reading are actively used in writing with increasing accuracy. When freed to do so, children's motivation and desire to write are fueled by their drive to communicate.

Of greatest importance, all children, when given an opportunity to express themselves creatively in such an environment, reveal themselves to be deep and creative thinkers. Their meaning-making activities with words on a page are but a subset of their continuous endeavors to make meaning of everything they see and know. They are curious, fresh, and ruthless observers of their environment. They seek patterns and make generalizations, and just as eagerly delve for exceptions and counterexamples. Opening the door to writing has provided children with many opportunities to analyze their world, and to ask questions, and communicate with others about what they are thinking. The door to mathematics can be opened for them in the same way with equally exciting possibilities.

Mathematicians describe and recognize patterns, make abstractions about those patterns, drawing conclusions about the natural world, or manipulating pure abstractions out of sheer joy. Drawing upon a common vocabulary, notation, traditions, and body of knowledge, mathematicians communicate with one another about their perceptions and insights. The language they use is mathematics. Children who are invited to use that language to communicate in meaningful ways about their perceptions of the world will blossom as young mathematicians, just as they blossom as readers and writers when the full communicative power of written language is made available to them.

Many of the marks that children make on paper, are marks that they see. What if they are exposed to mathematical symbols to the same extent that they are exposed to letters? And what if someone talked to them in the language that those symbols represent, and read to them from texts that contain those symbols, and used the language (the words, the concepts, the symbols) to talk about the concrete world around them and to share abstractions? Wouldn't children discover in mathematics a language for exploration, play, and communication that opens otherwise unaccessable doors to insight and discovery? Might not this language also provide them with facilities to describe ideas they already have for which the language of ordinary conversation and literature are found wanting? Wouldn't we discover that the line that divides mathematics from language arts is a language barrier? If so, extending children's range of expressive and comprehensive abilities to include the things that mathematicians talk about will dissolve that barrier.

4 Classroom practice: Encouraging language development in a language-rich environment

The matter of teaching reading and writing is that of enhancing language development, and the most effective way to do this is to enrich the environment linguistically. This is not done haphazardly. The teacher's responsibilities in the "whole language" curriculum are to command a deep knowledge of the subject matter, understand the child's learning process, provide a language-rich environment, and invite children to participate in a larger community of literate people. The result is a student-centered orientation to teaching and learning. The teacher's focus is each student's development; the student's motivation for learning comes from within.

The teacher's depth of knowledge provides the flexibility that student-centered learning requires. A language arts teacher is well-read across many genres, forms, time periods and themes, and can frame a concept, not in a single, heirarchical manner, but in whatever manner the situation, a question, or a student's receptivity requires. The teacher is a wealth of suggestions, encouraging students individually and collectively to follow tangents: a similar form, another slant on the subject, a view from a different century, an invitation to creative expression. The direction that students' learning takes is never limited to the ordering imposed by a textbook sequence of exercises and activities.

The structure of the learning is rooted in the teacher's understanding of the learning process—for the group of children as a whole, and each child individually. The teacher decides how to proceed, what questions to ask, and what enouragement to offer by communicating with students about what they are learning. The teacher tries to understand where the students are and to bring them forward.

The "language-rich environment" is the framework within which the teacher can do all of this. The children have much to talk and think about, interesting and stimulating things to read, meaningful and authentic contexts for writing, and the freedom to develop. Available or close at hand are books, posters, pictures, anthologies, fiction, non-fiction, poetry, reference materials, a wide variety of writing and book-making materials, film, videotape, tape recorders... The classroom walls are a mosaic of the creativity and inquisitiveness of the collective mind of the group—artwork, posters, writing, questions.

The order and organization in such a classroom exists at a level other than that of regimentation. It is the responsibility of the teacher to know what is going on, who is learning and working on what, and how it is going. To arrive at this point, the teacher must teach the children how to accept the responsibility for their own learning, how to behave, how to follow up on their own inquisitiveness, and how to learn from and help one another.

These classrooms are veritable beehives of activity and, depending on the moment, can seem chaotic and disorderly at first: students bustling, talking, discussing things; the teacher moving among groups and individuals, observing, listening, engaging in thoughtful communication them. When the teacher does move to the front of the classroom to command the attention of the group as a whole, it is to present something relevant to everyone—and it is not at all unusual for the "teacher" to be a student.

5 A community of learners that excludes no one

As users of language and wielders of pencils, all humans are writers. The most effective writing teachers see themselves as writers. Levels of skill and passion vary among writers as among human beings, but from anywhere on the continuum, writing teachers who are also writers can share with their students the joy and power of writing. They impart facts and teach skills that are useful to the child at the child's own point of development as a writer. As writers, they extend to a child a resonable and genuine invitation to join and and be active in a larger community of literate people.

As recognizers of patterns and manipulators of abstract concepts, are we not all mathematicians as well? Language arts teachers were sometimes appalled and daunted to discover that to teach writing they had to become writers. The seemingly insurmountable task became a joyful one when the real requirement turned out to be developing their writing ability in much the same way that they were guiding their students. The exhuberance of a child who is learning something new is not the exhuberance of children, it is the exhuberance of learning. It is time to begin encouraging mathematics teachers to accept themselves as mathematicians—to learn the language by using its vocabulary to name what they see and understand, to see the world through the lens of the new concepts that fluency in the language gradually opens. There should be no stigma attached to lack of exposure to mathematics. This is an almost universal condition among elementary school teachers. What should be decried is the notion that one lacks "aptitude" or that mathematics is inaccessible. These attitudes close the door on the joy of discovery in mathematics for students and teachers alike.

Language arts teachers are becoming more experienced and comfortable with dealing with writers block. It is never terminal. Find your voice, and it always has something to say. With guidance and encouragement, anyone can learn to free the writer within, a writer that has often been imprisoned by earlier failures to jump though the hoops of so-called writing instruction. Aren't similar failures the source of math anxiety, too? If so, the cure is in encouragement, guidance and success in using mathematics to communicate in a meaningful way with other mathematicians.

What are the elements of the math-rich environment? What do you add to the language-rich environment to include the language of mathematics? The answers to these questions will come from creative experimentation by teacher-mathematicians as they try new things and observe how their students respond to them. Some possibilities include:

- Make mathematical symbols accessible and available as models and inspiration for drawing, just as letters are.
- Discuss mathematical symbols as a shorthand and as codes for words and phrases.
- In an open-ended mannter, encourage children to name concepts and use symbols to represent them.
- Model and encourage writing about mathematics. Use journals or folders to store thoughts about mathematics, from theorems to playful whimsy, using words, symbols

and pictures. Create opportunities for children to share their mathematical writing with each other and respond to each other.

- Encourage, model, and create opportunities for students to share their work and ideas with mathematicians outside the classroom.
- Publish student mathematical writing in school publications for students, parents, and the community, and in special mathematics publications that grow out of this process. Make posters, handbills, video and audio tape.

6 The teacher is at the nexus of change

It is impossible to propose more than a framework for approaching mathematics learning as language learning. Like their counterparts in language arts teaching have done, mathematics teachers must elevate themselves and claim the titles of mathematician and researcher. (Interestingly, in the elementary classroom, the language arts teacher and the mathematics teachers is quite often one and the same person.) As mathematicians and researchers, teachers are guides for and observers of children's development as mathematicians. The mathematics community is relying on them to begin to systematically take risks with their mathematics teaching, observe the paths of students' learning, share their experiences with other teachers, and come into contact with the mathematics community at large—a community which must welcome and encourage their participation.

What will emerge is not a methodology, rather an attitude about and approach to teaching that empowers students to take charge of their own learning. Young mathematicians who leave elementary schools taking this approach will enter high school and college mathematics programs as mathematicians. They will have insights into their own learning processes and mathematics courses, regardless of "quality", will be opportunities to enrich their own mathematical power.

7 Final thoughts on "whole language"

In the five years since this essay was written, I have watched the movement called "whole language" come under increasing attack. At the same time, the phrase "whole math" has come into vogue. Neither "whole language" nor "whole math" is succincly defined anywhere; it's hard to understand anything from what the two juxtaposed words tell you. In a squabble about whether these means are the "best" for teaching and learning math or language, it is hard to tell from the labels alone what one might be attacking or defending. I try to avoid the use of these terms anymore because of the danger of being pigeonholed, as a user of the term, into a place where I clearly do not belong. Instead I will invent a new term: Good Teaching, and try to explain what I think it means.

The theoretical and practical evidence that connect language learning to reading and writing is impossible to ignore. Individual children, their cultures and backgrounds, and the influences of their peers are so diverse that it will be forever impossible to discover any step-by-step methodology for all teachers to teach all children whatever it is they should know. It is silly to argue over what is best. Such arguments always come with examples of how whatever is being touted worked, and worked well, in some context. Irrefutable proof, in my opinion, that there is a place for everything. Good Teachers leave no stone unturned.

I remain convinced that a rich classroom environment is the foundation for Good Teaching. A rich environment where children have options, make decisions, collaborate, and work on projects is not to be confused with chaos, even though such classrooms may seem chaotic at times. Good Teaching requires that all students have a sense of purpose, and have been *taught* to accept the responsibility of the freedom which they have in the classroom. This is not easy to do. I have written elsewhere[1] about how one teacher accomplishes this in a second grade classroom.

The strongest (and most credible, given the circumstances) criticism about "whole language" claims that in whole language classrooms, teachers don't teach, students do whatever they feel like, and aren't required to learn anything, particularly spelling, grammar and mechanics. Stories abound of students who, after four or five years of "whole language" instruction still couldn't read, but when someone sat them down and taught them phonics they began to catch on and made progress by leaps and bounds.

It *is* true that a large number of children will learn to read and write on their own, simply with exposure and encouragement. Some, however, will not, and this has absolutely nothing to do with the power of their intellect or their ability to perform in school. Not everyone learns the same way, no matter how trendy it might be. It is also true, that many so-called "whole language" teachers credit themselves with "teaching" the former students to read and write, and subtly blame the latter for not learning.

In some "whole language" clasrooms phonics is taboo, and this is patently absurd. Our writing system is *founded* on sound-letter correspondence; it is foolish to keep it a secret. Good Teachers, however, will not require all students to spend all of their time mastering rules of phonics as a prerequisite to beginning to learn to read. They will, however, see to it that students who will benefit *do* spend extra time working on phonics. I have seen individual children grasp all of phonics in a single "aha!", then sit down and begin to read. Things like this happen when some Good Teacher is sufficiently aware of the path of each

[1]Casey, Nancy. (1991). Enhanced lives: Classroom structures for human development. Unpublished ethnographic report. Available via `http://www.cs.uidaho.edu/~casey931/mega-math/write.html` or via anonymous ftp to `ftp.cs.uidaho.edu` directory:`pub/mega-math/enhanced.ps`

child's development to make the information that they need available to them when they need it.

If the foundation of Good Teaching is a rich classroom environment, that is only the beginning. Inside this environment, students act and learn. It is the task of the Good Teacher to assess what their students can do, both socially and academically, and set goals for each child's progress that are consistent with the child's abilities and with the expectations for that child in the larger context of schooling. Then the Good Teacher must devise, teach, and maintain a classroom structure within which she can address all of these students' needs. This is no simple task; it takes perception, energy and experience, not to mention a deep understanding of how children learn and develop, as well as a willingness to be surprised. Students have choices, but only inside of the structure set up by the teacher. The teacher's job is to direct them, push them and challenge them to work hard. Students must *not* be left to flounder and play in this rich environment with the expectation that they will stumble upon the best things for themselves to do, and blossom and grow as a result. A Good Teacher knows what everyone is doing, and why. In these classrooms *all* students make progress.

8 For further reading

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