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ABSTRACT

Teachers often maintain that there is very little classroom time available for student inquiry which leads to in-depth questioning of subject matter, and improves performance levels. In addition, teachers often assert that there is little time for unit planning. To examine these problems, a group of teachers (n=24) were involved in a study designed to obtain insight regarding the following questions: (1) how do teachers who use the instructional process model understand a generative learning model (a form of inquiry teaching) when presented as the preferred model for teaching science in the elementary school?; (2) what are specific points of conflict between the two models?; (3) what are points where the models are complementary?; and (4) how can generative learning model be communicated effectively to a broader range of teachers? The results indicated that these teachers felt that it was easier to teach using the traditional instructional process model largely because of the added skills and attitudes that must be considered in generative teaching. Also included in the article are points of conflict and similarity of the two models and implications for teacher education. (ZWH)

Understanding Generative Learning Models of Instruction by Elementary Teachers Trained in a Linear Instructional Process

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The Problem

Generative learning models of teaching (Lawson, et al., 1989; Osborne & Freyberg, 1985; Bybee et al., 1989; Barman, 1989) share a common ancestry in the Learning Cycle (Karplus & Thier, 1967) and generally articulate the kind of instruction envisioned for systemic reform in mathematics and science education (NCTM, 1989; Ahlgren, 1993). However, generative learning models have not enjoyed wide acceptance in the educational community. General books and articles on teaching contain references to instructional process models of teaching whose lineage derives from explicit teaching research (Hunter, 1976; Hunter, 1982; Strong, et al., 1985; Rosenshine, 1986), but few reference generative learning strategies. Even the practice of science teaching show that fewer than 25% of teachers use the learning cycle or related forms of inquiry strategies (Hurd, Bybee, Kahle, & Yeager, 1980).

Reasons for not using inquiry strategies include that it takes too much time to develop appropriate materials and the instructional pace is too slow to incorporate the prescribe curriculum (Hurd, et al.,1980). Yet inquiry-oriented instruction in general and the learning cycle in particular has been shown to motivate students, improve attitudes, and increase the cognitive level of student responses while maintaining levels of knowledge learning comparable with more explicit approaches (Lawson et al., 1989; Shymansky et al., 1990). One explanation is that instruction is rarely presented in a pure form. Teachers must modify and modulate instruction in reaction to a constant barrage of stimuli. Brophy and Good (1978) cite studies demonstrating that teachers may engage in more than a thousand interpersonal exchanges with students everyday and may initiate on the average 80 contacts an hour. Studies that focus on inquiry teaching may de-emphasize forms of teaching that are more direct and explicit but which integrated inquiry teaching. Conversely, studies of explicit teaching may de-emphasize forms of teaching that allow students to follow-up their own ideas by inquiring into a problem or skill.

If teaching is an eclectic process, then why doesn't the mix of instructional strategies involve more opportunities for students to inquire through tasks that develop performance skills and lead to in-depth questioning of subject matter? If teachers shift their instructional approach to adjust to circumstances and student behavior, then why aren't students allowed to adjust their involvement to a more personal interaction with content? It may be that teachers inadvertently limit students to a few types of classroom "moves" such as responding while maintaining control over the more inquiry-oriented moves of initiating, evaluating, and elaborating (Rowe, 1973) in response to the complex environment.

One approach to examining the problem is to enter into the planning time of teachers preparing instruction in science. This study observed a series of release days that focused on unit planning in science. Among the many types of planning in which teachers engage throughout the year, teachers cite unit planning as most important followed by weekly and daily planning (Clark & Yinger, 1979). Unit planning allows teachers to envision the scope of learning that they hope to achieve before it has to be broken into chunks to fit the structure of the school and accommodate students. Through unit planning, teachers confront the tension between broader goals that motivate the unit and shorter-term objectives of daily lessons. Observations during this study attempted to capture moments of conflict and decision making as teachers were asked to specifically consider the use of a generative learning model in contrast to the district prescribed instructional process model. For the purpose of this discussion, GLM will refer to generative learning model as a form of inquiry teaching and IPM will refer to instructional process model as a form of explicit or mastery teaching.

The questions for this study were:

- How do teachers who use IPM understand GLM when presented as the preferred model for teaching science in the elementary school?
- What are specific points of conflict between the two models?
- What are points where the models are complementary?
- How can GLM be communicated effectively to a broader range of teachers?

Background

In the science education literature, GLM strategies have been sharply contrasted with IPM strategies. Lawson et al. (1989) criticizes Hunter's (1982) basic elements of teaching which specify that one objective be taught at a time and that teachers explicitly tell students what they are to learn beforehand. Lawson et al. argue instead for the importance of dual objectives in learning cycle lessons which are to teach concepts and improve thinking skills. Calling her approach "simplistic and misguided" (p. 87), they point out the importance of maintaining an inquiry stance that promotes curiosity and the integration of knowledge into meaningful generalizations. Bybee et al. (1989) also singled out Hunter (1982) by saying "The panel believes that the ITIP model contradicts what is known about how learners develop new conceptual understandings in science" (p. 86).

Proponents of direct teaching have leveled criticism at more open ended strategies. Englemann & Carnine (1982) argue that proponents of what they call the "humanistic position" teach by "natural-learning or general-stimulation" which suggests a serendipitous or accidental approach to teaching (p. 376). Likening humanistic teaching practices to "the practice of using leeches to bleed diseased patients", the authors say humanistic teachers abdicate their responsibility by settling for students progressing at their own rates and in their own style. This leads to a self-fulfilling prophesy that some children are slow and "would have been slow now matter what type of instruction had been provided". They state that teachers should learn to control the variables that are controllable and proceed in a deliberate manner to present the content and its structure in its clearest format.

In a more conciliatory tone, Lawson et al. (1989) suggested "Perhaps a closer look is in order as it may be possible to go beyond these apparent contradictions to find some common ground to strengthen both approaches" (p.

87). This paper will first examine each model and sketch apparent contradictions as well as common ground. Next, discourse from several teacher planning sessions will develop the meaning teachers give to these two models. Finally, the paper will discuss possible approaches for strengthening each model.

Instructional Process Models

Two decades of research on effective teaching produced a set of instructional principles that have been shown to be useful in teaching specific concepts or skills. The essence of the research establishes that the components of effective teaching "include teaching in small steps with student practice after each step, guiding students during initial practice, and providing all students with a high level of successful practice" (Rosenshine, 1986, p. 62). Rosenshine (1986) carefully points out that these principles of explicit teaching are "most important for young learners, slow learners, and for all learners when the material is new, difficult, or hierarchical" (p. 62). For older and more capable students or when the foundations for the instructional unit have been established, instructional steps become larger and students can be expected to engage in more independent practice.

Rosenshine (1986) uses three findings from information processing research as a theoretical basis for assumptions that IPM makes about the cognitive capabilities of students. First, students are limited to about seven pieces of new information that can be meaningfully processed at any given time. Second, students must review, summarize, and elaborate material in order for it to reach long-term memory. Attempting to process too much information leads to confusion or omission of material and ineffective processing. Finally, frequent practice in rehearsal and recall speeds information access time which facilitates application of the skills or concepts at more integrated levels of cognitive activity. IPM monitors students as information processors so that their capacities do not become over loaded.

IPM makes few assumptions about cognitive capabilities for slower students or for most students when learning new and well-structured information. Englemann and Carnine (1982) postulate that the most effective way to design instruction and analyze its effects is to minimize assumptions about cognitive capabilities of students and maximize assumptions about the completeness of instructional communication to students. The general approach is that by assuming minimal cognitive capabilities, any errors in learning can be traced to the way the lesson was communicated. Englemann and Carnine (1982) suggest a minimal set of assumptions about the student to be (a) the capacity to learn any quality, no matter how subtle, that is presented by examples and (b) the capacity to generalize on the basis of sameness, and only on the basis of sameness to new examples. The analysis of the information to be learned involves identifying critical qualities and organizing examples to carefully regulate the presentation of these qualities in the presence and absence of non-critical qualities.

Hunter (1982) also presents IPM with an emphasis on analysis of the target information. The approach requires that the teacher examine the information for its "basic structure" and present it to students in "some organized way". The goal is that students will glimpse the whole before seeing all the parts in detail. The teacher next presents the information "in the simplest, clearest, and most understandable form". To do this the teacher selects appropriate terms and examples that are unambiguous and which present the most critical qualities of the concept or skill. Where possible, the teacher should model the information through concepts and experiences that the students already have. The goal of the model is to produce insight in students based on connections they make with current knowledge. Finally, Hunter (1982) advises that examples and models should avoid controversial issues that distract students from focusing on the critical qualities.

The essence of IPM is to (a) select information that is clear and unambiguous, (b) analyze its basic structure and give students a sense of what this looks like, (c) present new information in small steps using concrete models from students' past experience where possible, and (d) provide students with practice after each step to insure high levels of success.

The model for instruction used by the district in this study is described as mastery learning. According to district handouts, IPM is "supported by Teacher Expectations and Student Achievement (TESA), Cooperative Learning, Instructional Theory Into Practice (ITIP), and others as appropriate." The lesson planning format used by the teachers is patterned after ITIP categories (see Figure 1).

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insert Figure 1 about here

Generative Learning Models

Within the science education community, GLM has its origins in Piagetian psychology and observations about the nature of science and scientific attitudes. Scientists seek understanding of the world by raising questions and searching for verifiable evidence that will help answer those questions. Cumulative evidence leads to the construction of theories from which consequences can be deduced that raise other questions. Lawson, et al. (1989) point out two problems that are particularly interesting to instruction in science. First, scientists often form concepts based upon evidence where the defining attributes are not directly observable. Second, the results of scientific investigations occasionally produce theories that contradict what is currently understood. While the authors do not propose that professional science mirrors learning, GLM exploits certain critical parallels. The instructional analog includes the following elements (a) students raise or teachers pose questions that require students to investigate using their existing understandings, (b) results of these investigations are ambiguous and perhaps contradictory and force students to reflect on their understandings, (c) teachers pose concepts accepted by science, and (d) students apply the scientific concepts which challenge original understandings and promote construction of new understandings.

The underlying theory postulates that students are motivated to reexamine their current ideas when results from their own actions or from the comments of others contradicts what they expect (Piaget, 1964). Students attempt to resolve this cognitive disequilibrium by looking for more effective ideas or procedures. This search often involves dialogue and argumentation with peers or the teacher. Lawson et al. (1989) review literature that describes these verbal interactions as precursors to the internalized formal thought of adults. Younger students use the dialogue as a means of working out their own reasoning that will resolve the problem causing cognitive disequilibrium. They progressively internalize patterns of argument which lead to progressively more reflection. As a result students become better able to carry on these arguments in their own thinking.

Osborne and Freyberg (1985) describe several GLM versions before outline their own version. Bybee et al. (1989; 1990) include GLM in the context of a general framework for curriculum and instruction at the elementary and middle levels. The model presented to the teachers in this study is outlined by Bybee et al. (1990 p. 67-68) and shown in Figure 2.

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insert Figure 2 about here

A Comparison of IPM and GLM

The models differ with respect to three components of instructional design and two dimensions of learning.

Dimensions of Learning. The models differ with respect to the assumed capacities and motivations of the learner. The IPM teacher initially assumes the learner has few capacities and requires external motivation. Only through repeated success in practicing a specific outcome will the learner be motivated and able to access higher learning capabilities. The GLM teacher assumes the learner will be motivated by an unresolved or contradictory problem. The teacher assumes the learner has the ability and motivation to communicate and compare ideas given a sufficiently engaging problem and materials to work with.

The models differ with respect to the mechanisms that drive learning. The IPM learners are driven to find patterns of similar qualities among disparate items. These patterns of similarity lead to concepts. The GLM learners are driven to resolve contradictions between what they experience and what they understand. The resolution of this disequilibrium is necessary for long-term learning.

Instructional Design. The models differ with respect to the specificity of the concept or procedure being presented. The IPM teacher focuses each lesson on one objective that can be unambiguously presented to students. The GLM teacher has at least two objectives in mind for each lesson. One addresses concepts or procedures to be learned and one addresses the thinking skills or scientific attitudes that are being emphasized.

The models differ with respect to the remedies for learning failure. The IPM teacher accepts learning failure as an error in how the lesson communicated the concept. Corrections are made in examples and their presentation. The GLM teacher assumes that the student is progressing if the incorrect ideas are based on reasoning with the information generated by experiences or discourse in the lesson.

The models differ with respect to the purpose of assessment. The IPM teacher bases assessment on how closely the student approximates the specified objective. The GLM teacher bases assessment on how consistently the student engages with the problem and materials and how much of the information the student is able to apply to a new problem.

Similarities. Both models aim to make the student an independent learner. Both models advocate using concrete materials where appropriate to demonstrate the concept or procedure. Both models emphasize the importance of connecting new ideas to what students already know. Ideally the teacher is thoroughly knowledgeable about the subject matter so that in IPM it can be organized in its clearest form and in GLM the most important and engaging problems and materials can be selected.

Research Context and Methods

All 24 teachers in an elementary school in south central Washington state engaged in a curriculum design project to integrate math and science. The district is located in a community whose population is 130,000 and where the agriculture supports a large number of Hispanic migrant farm workers. The student population of the school is 77% minority, where 49% have limited English proficiency, and 70% are low income based on eligibility for free or reduced lunch. The students are expected to meet specific learning objectives established by the district and these objectives are measured through annual, standardized testing at every grade level. Instructional leadership in the district emphasizes the importance of making a measurable difference in literacy skills each year through an IPM mode of instruction. The school was selected because the principal and staff were actively working on ways to make educational theory and practice respond to the significant social, economic, and cultural issues facing its students. This educational context served as a severe test of the comprehensibility of GLM instruction.

The principal of the school strongly supported the project which was made possible by a grant from the Department of Energy written by one of the second grade teachers. The grant provided release time for all-day, curriculum planning sessions where teachers at a given grade level worked together to design a unit that integrated math and science. The author was an instructional consultant and evaluator for the project.

Each curriculum planning session was attended by the four teachers at a given grade level. Meetings were held in a work room off the library from about 8:30 a.m. to 3:30 p.m. with the goal of designing a unit of instruction. The goal was to integrate math and science but in practice the sessions focused on science because a majority of the teachers felt that they were doing a poor job of teaching science. The format for each planning session was to (a) introduce a contemporary view of inquiry-oriented science and math teaching (Bybee et al., 1989; NCTM, 1989), (b) initiate a critical discussion of a generative learning model in relation to their instructional process model, and (c) design a unit of instruction.

The opening discussion of about 90 minutes of each planning session was tape recorded. The grant supported a second round of all-day planning sessions held about 10 weeks later. The format was similar but the introduction was replaced by prompted reflection on inquiry-oriented instruction and the science and math teaching which transpired over the previous two months. The opening 90 minutes of half of these sessions was also tape recorded. In addition to these recordings, teachers turned in copies of their notes and drafts of unit plans. Visits were made to selected classrooms to observe science lessons to improve the researcher's understanding of planning documents and the context of teacher discourse.

The instructional framework for the district reflected a philosophy of education based on promoting self-esteem and concern for others. It is based on a belief system outlined in three statements:

- All students can learn.
- Success causes further success.
- Schools control the conditions of success.

In addition, students are expected to exit the district schools showing evidence of growth in learning basic literacy skills, process skills for problem-solving and decision-making, and skills for becoming a self-direct learner.

Social Semiotic Analysis

Studying the planning processes of teachers is an appropriate application of social semiotic analysis. Social semiotic analysis is an approach for systematically examining various forms of communication for the purpose of understanding how people make meaning (Lemke, 1990). The emphasis is on social construction of meaning by people as contrasted with the view that meaning is vested in the words or actions themselves and interpreted by individuals. Social semiotics is concerned with the contexts in which socially meaningful acts take place. It is also concerned with the relationships among practices, processes, and themes that emerge from an analysis of social activity. This type of analysis has been made of classroom discourse of students and teachers (Cazden, 1988; Pimm, 1987) and in studies of a variety of adult activities (Resnick, 1991).

The goal of social semiotics is to identify major themes or unifying concepts that tie otherwise disparate chunks of discourse together into a coherent whole. Where this holistic picture is understood to be coherent by other individuals equally informed on the subject of interest, then the interpretation is considered meaningful (Lemke, 1990). Further, the social discourse makes available to members of the group, ideas that are otherwise less accessible to the individuals, for example, relationships among pieces of information that were not seen to be related before. The construction of meaning by social discourse encompasses more information, feelings, and ideas than would be available to the individuals by themselves (Rogoff, 1990).

Halliday (1973) identified three major "macro-functions" of language: ideational, interpersonal, and textual. The ideational function of language conveys information about the world and is the most conscious aspect of adult language. Halliday points out that nearly all utterances have an ideational component, but with the developed language of adult discourse the other language functions are also represented. The interpersonal function expresses social and personal relations and provides the means for the speaker to express judgments (modality) and the factuality or likelihood of an action (mood). The third macro-function Halliday calls textual and essentially underlies the other two. It provides speakers with the assumption that language is relevant and therefore conveys meaning.

Our analysis focused on the ideational and interpersonal functions. The analysis involved a systematic examination of teacher discourse in terms of three functions subordinate to Halliday's categories and identified by Lemke (1990) as the functions of representation, relation, and orientation. First, the function of making representations was examined through words, actions, and document structures as they related to understandings of planning, teaching, learning, inquiry, and assessment. Second, the function of making relations was examined in terms of connections the teachers made among inquiry, teaching, learning, objectives, and activities. Third, the function of establishing an orientation was examined in terms of how teachers expressed a point of view concerning, for example, the value of science, importance of GLM instruction, and importance of IPM.

Data and Analysis

Analysis proceeded through an iterative process of linguistic coding and the production of narrative interpretations. The steps involved were roughly (a) computer-aided search and marking of key words, (b) writing narrative summaries at points drawn to attention by key words, (c) linguistic coding by clause of logical relations, juxtapositions, analogies, and glossings, and (d) iterations of a, b, and c.

The following is a sample piece of transcript with notations in boxes. The single box denotes narrative summaries while the double box denotes linguistic coding. The first step in preparing the text for analysis was to separate each clause (Halliday, 1973). The following conventions were used for coding the text: {analogies in curly brackets} with explanations following, rewordings or glossings were underlined, juxtaposed words were double underlined, and (parentheses denoted interpretive comments). Boldface words denote the results of computer search text for key words. Ellipsis are used to abbreviate this sample data.

> Karl recalled a TV commercial for Wonder Years that presented a dull classroom with a nerdish, male science **teach**er droning in a nasal tone "Mars, a great red planet. Many volcanoes scatter the landscape of Mars."

Terry	it was almost that bad because I remember getting out the book and reading about Mars.
Karl	The funnest (sic) part I had was getting my globe... and spinning that sucker... and walking... and showing... and showing... and giving the globe to someone and saying... kids would have {To cause to, as by persuasion or compulsion} to think kid would really have {To cause to, as by persuasion or compulsion} to think about it It (student interaction) was cool that kind of thing was fun, the free discussion

Student involvement was described in terms of how they interacted with his **activ**ities. Questions were based on his understandings and sample **student** responses were based on his thinking about the concepts. He alludes to but does not elaborate on the nature of the "free discussion".

Key pieces of data and the analysis are reported for each category to reconstruct the meaning expressed during planning sessions. The language functions presented here are Representations, Relations, and Orientations. Elements of both GLM and IPM are capitalized to highlight their use in teacher discourse.

Representation of GLM & IPM

Teachers viewed GLM as an activity-driven model of instruction which contrasted with their perception of IPM as an objective or outcome-driven model. Within IPM the teachers were expected to focus on the objectives of instruction while their perception of GLM shifted attention to the actions of teacher and students.

Katie: So we are going to develop this unit by activity-basing it
and we've been taught not to do it that.
It is supposed to be objectives and then activities.
You're kind of going the other approach, you're starting at the backdoor.

Key terms 'activity' and 'objective' are juxtaposed in this excerpt highlighting a central conflict. The phrase containing 'activity-basing' was reworded three clauses later with the term 'starting at the backdoor' meaning GLM is putting IPM instruction out of order. In terms of IPM, these teachers are saying that GLM seems to start instruction with Practice, a step normally preceded by Input and Sharing the Objective (see Figure 1). This way of representing GLM could mean that these teachers have a limited view of the use of activities in instruction. However, other statements suggested that this was not the case.

Karen: I feel like
we don't need to spend too much time trying to convince us to
go with the hands on experience approach,
we're {sold }on that...

Mary: No, no I'm sitting here thinking,
it's hard for me to imagine...
that we've always, that we've been so driven by the text
because of lack of resources...
but in my mind, this is the way we should always do science...

Mary: See, I look at this (GLM)
and I'm going down the list and saying
This is the Instructional Process.
This is exactly what we've been, are trying to move our
instruction model.

They implied a positive orientation toward active instruction and an indication that they were trying to implement more of it in their classrooms. The fact that GLM represents an inside-out or upside-down version of IPM implies a more fundamental difference between GLM and the representation these teachers have of instruction.

For these teachers, GLM represents a more passive mode of teaching than IPM. In IPM, Best Shot clearly identifies where teachers apply specific procedures to get the objective across. In GLM, there is no comparable step. Teachers introduce new information in the Explanation phase (see Figure 2) but it is done in the context of the preceding student ideas and does not appear as explicit.

Bill and Karen: (speaking together) To me the Best Shot is doing the
activity.

Bill: There is no real stand up teach a concept or teach a skill type
thing
the way I understand it.
And that's what I was saying,
maybe we need to reorganize the order (of IPM).

Teachers often used the term 'activity' as a referent for GLM. In an over simplified sense, GLM is doing the activity. In the above excerpt from the fifth grade team, activity is juxtaposed with and subsumed by the direct teaching step in IPM, called "Best Shot". The joint statement is reworded, as indicated by the underlines, in Bill's next statement where he clarifies what Best Shot means. GLM proponents describe Bill's statements as a linear transmission mode of instruction which does not provide the cognitive conflict necessary for student learning. This standard contrast does not capture the dilemma these teachers were expressing. One way of restating the problem is contained in this statement by a fourth grade teacher.

> Vy: We are sometimes pre-requiring our kids right back to birth. We spend a lot of time developing their background.

GLM makes more generous assumptions about the capabilities of the learner than does IPM. GLM rests on such implicit assumptions as, (a) Well-designed activities will engage students, (b) Interesting ideas will motivate students (c) Appropriate materials will be persuasive in student thinking. The experiences of these teachers suggest that many of their students can not attend long enough to get engaged. Students are often absent for several days as a result of disrupted family life or simply neglect. They miss key segments of instruction and find it difficult to catch up.

Assessment is another specific line item in the IPM instructional budget and is part of how the teachers represent instruction. The unit outline from the third grade team included over ten activities some of which were indicated as demonstrations involving only a few students. Each activity was tied to a specific objective for that day. An example objective was "Students will define precipitation in its various forms: snow, rain, hail, and sleet, and explain how it is measured." The activity for that day was to make a rain gauge and learn how to read its scale. Assessments in the unit ranged from evaluation of student products to answering questions from the text. At issue was how to conduct assessments from activities where students were expected to do some exploring and where the outcomes were not explicit statements. A first grade teacher expressed it this way:

> Karen: I am struggling...
> You just made the statement...
> the outcome... may not be well-defined
> the district is outcome-based
>
> we are {looking at} (responsible for) outcomes
> we are obligated {to see} (to insure) that we assess these outcomes
>
> how do you start (planning) with that (non-explicit outcomes) perspective (of teaching)?
> start planning activity?

In the first segment, Karen contrasted "not well-defined" and "outcome-based". The second segment is rewording that says responsibility means assessing outcomes. The teacher is saying in effect, If I don't know exactly what the outcome is going into the lesson, how am I going to assess it? The last segment is a reworded question which seems to ask, Do I start planning by finding an activity first? These statements followed from discussions about the processes of inquiry and the importance of assessing these processes.

Karen: we have in mind this (outcomes)
but as you say what we may {come out with}...
I {see} the process {in there}
Investigation, Exploration, is valuable
people are uneasy (about), how do you assess just process?

"Just process", as a rewording of the GLM components Investigation and Exploration, denotes their fuzzy understanding of how student activity and discourse can become a part of instruction and assessment. Later, the problem seemed to clear up a little. They began thinking of student behaviors that represented processes of inquiry and attitudes of science. Michael made obvious connections between observations and classroom experiences.

Cheryl: That (asking questions based on data) is interesting...
we could actually assess that
I never thought of that
Michael would be wonderful
I could assess that (asking questions based on data)
and know exactly (if the questions were based on data)...
and if he didn't, I'd be surprised
and then I'd wonder why
because it would be so out of character for him.

Teachers heard GLM presented through the metaphor of a cycle that was contrasted with IPM as being linear. In their attempts to construct a representation of GLM, these metaphors become useful in the fifth grade team. Note that the discourse was carried out in IPM terms but they were trying to describe GLM principles. They were designing a unit around the question "What makes things gooey."

Karen: You might not need to have Guided or Independent Practice.

Bill: It's Independent Practice is what they are doing (during activities).

Karen: We see the instructional process (IPM) as being {linear},
we have to go here then here.
I don't think so,
I think it is {circular}.
Your Best Shot includes Guided and Independent Practice.

Bill: You may decide to do the Best Shot
when we start talking about what we saw,
or when we are talking about what is a compound.
Maybe that is when the Best Shot would happen.

These teachers were beginning to take the first steps in forming a new representation of instruction out of their IPM representation. "Your Best Shot includes Guided and Independent Practice" shows a fundamental difference in the two models. In IPM, the Best Shot contains the information or skills to be Practiced. To say that the former contains the latter does not make sense in IPM. However, in GLM part of the teacher's Best Shot is to engage students to Explore their own thinking which means jumping directly into the activities that embody the new information. No other team of teachers expressed this kind of synthesis.

Relationship of GLM to IPM

Halliday (1973) emphasized that adult language is often functioning on several levels. This is particularly true in this case, where teachers are expressing their representation of instruction by actively constructing relationships between the familiar IPM and the unfamiliar GLM. The data in the previous section, therefore, revealed at least three points about the way teachers related the two models. These points are summarized here: (a) GLM emphasizes activity-based instruction more than IPM, (b) GLM is an upside-down or backward version of IPM, and (c) assessment in GLM significantly emphasizes process over content whereas IPM emphasizes content over process. With the exception of the fifth grade team, the teachers generally expressed the relationship as one of two extremes. One view was that the models are one and the same: "See, I look at this and I'm going down the list and saying, this is the Instructional Process. This is exactly what we've been, are trying move our instruction model." The other implies a relationship of mutual exclusion. Teachers perceived GLM as requiring activities-first planning with vague process-oriented objectives for which they were "taken to task" or "taught not to do" by the principal.

This section will examine two additional details that impacted how the teachers related the two models. One concerns their understanding of student outcomes and the other concerns the knowledge necessary to teach science. The terms activity, objective, and outcome were regularly juxtaposed as teachers struggled to put them in a meaningful relationship. This district prescribes detailed outcomes in math and reading stated as "critical learnings" that students are to achieve at each grade level. The teachers are guided to write specific objectives to meet these outcomes. Teachers perceive unit and lesson objectives to be short term outcomes. Using GLM, teachers select activities ostensibly to facilitate exploring a science concept but the activity begins to look like an outcome (or objective) itself. An example of the resulting discourse follows from this third grade planning session. Planning proceeded around a unit on weather.

Lupe: Some of these are outcomes
and some are activities, I think.
Like generating a weather report.

Lonnie: See, I see that as an objective.
This is where we started to write (an objective for skepticism as science attitude)
"Given a weather prediction, students would be skeptical"
but we didn't finish that.
That sounds like an objective too, though.

Karl: I have a hard time differentiating them (outcomes and objectives) also.

Activities become objectives and objectives become outcomes. The discourse in planning becomes muddled as teachers try to express a relationship between instruction (the means) and outcomes (the ends). They wrote an outcome: "The student will understand general weather patterns in the mid-Columbia River valley". It provided little specific direction for designing a unit of instruction. They wrote specific objectives for reading weather devices, but when considering prerequisite knowledge, vocabulary, and skills, it seemed to lead to an entire unit devoted to reading instruments. The above third grade team went through seven iterations of objectives and activities trying to decide how to incorporate an objective on how to read weather instruments. An operational understanding of instructional models must resolve this problem.

An concurrent issue was teacher understanding of subject matter to be taught. The relationship between most of these teachers and their science subject matter was tenuous. It appeared that the introduction of GLM may have exaggerated this problem. Many teams expressed guilt and regret concerning how little science they had taught by the time the planning sessions began in November and December. This was not for lack of planning and intention. The fourth and fifth grade teams described having blocked out science instruction for the whole year. However, their lack of knowledge about science and the uninspiring and uninformative nature of the textbook resulted in science being put off. However, GLM's reliance on activities designed to promote student inquiry through teacher questioning and observation was a significant challenge.

Bill: I guess the first thing that comes to mind is
the background knowledge you need {to pull these things out of the air}.
And I don't personally feel
that I have the resources or the background knowledge to
{come up} with these engaging activities.
That scares us
so our first instinct is okay,
here we go
this (text) will help.

Bill used the metaphor "pulling these things out of the air" to present the view that skilled GLM teachers have a facility with activities that he does not.

Observations in his classroom revealed that he did use hands-on activities in science, but both observed lessons involved one-shot projects. One involved building a model of a planet and the other involved building a bridge out of pasta and glue. In both cases, students were given instructions based on a teacher resource and provided time over two or three days to complete the project. While Bill conducted follow-up discussions, the projects themselves were not an interactive part of instruction in the sense implied by GLM.

Other teachers expressed similar concerns about their relationship with science content and activities, such as, "Learning just ahead of the kids. That's how I feel." Most teachers have experienced the need to increase their learning curve to out pace their students, but another teacher said "I am not comfortable with science. So I would be more comfortable if I knew what the kids needed to know before this would be successful." The statement was made in spite of the fact that the school had purchased new science resources and her team had made plans to teach science earlier this fall. The meaning of her comment might have been that given GLM, she was not sure what students were supposed to learn, whereas, given IPM she was more sure.

Orientation toward science teaching, GLM, and IPM

The orientation of an individual toward teaching a subject can be estimated from language use in several ways. One can be positively or negatively disposed toward engaging with the subject. One can be enthusiastic or indifferent. One can actively contribute to a product or passively mark time until the product is done. None of the teachers were hostile or unconstructive. In fact, the general attitude of all 24 teachers was somewhere in the range of moderate to highly enthusiastic. They engaged in spirited discussions about science content and sought to clarify their own thinking while trying to understand how to teach science.

From the discussion so far we can infer that these teachers felt that science was important and deserved more instructional time than they had given it. Further, their goal before entering the planning sessions was to use more participatory, hands-on science activities. They felt it worthwhile to discuss all these topics in the context of GLM as part of a planning day in science.

The most telling aspect of how teacher language expressed orientation toward science instruction came through the frequency with which their discussion lapsed into lengthy inquiry into science topics. The third grade team while planning a weather unit became curious about the distribution of heat by ceiling fans, the operation of convection ovens, and why one's nose runs in cold weather. The fourth grade team spent over an hour doing a self-study of simple machines with a video disk and make-shift materials hustled out of classrooms. The fifth grade team dropped the textbook topic of states of matter and became fascinated with the idea of teaching material science and designed a unit around the question, What makes things gooey? This resulted in numerous questions about polymers and colloidal suspensions.

Results and Implications

The elementary teachers in this study were predisposed to work on teaching more and better science. Their jobs were complicated by a student population where half have limited English proficiency and where seven out of ten come from low income families. They enthusiastically participated in two full days of planning for science instruction based on GLM, an instructional model that differed significantly from IPM, the model they used daily. The results shed light on the problem of understanding GLM and the research questions of this study. Each of the question is discussed below.

Understanding GLM

Their representation of GLM identified it as activity-based even though many of them used activities regularly. Increased emphasis on planning activities generated the view that the activities were more important than the objectives of instruction or at least needed to be identified first. They spent considerable time thinking about activities in part because they lacked sufficient knowledge in science or lacked confidence in the knowledge they had. Understanding GLM meant using activities as a central component of instruction made meaningful to students through teacher questions and the use of inquiry processes. This representation of GLM resulted in several teachers commenting that GLM was an inverted version of IPM. They saw the activities coming first and attention to objectives of instruction being postponed. The inquiry or process side of GLM implied fuzzy objectives which went counter to how they were taught to plan instruction.

Adding skills and attitudes to the already familiar knowledge objectives led teachers to feel that GLM was harder to teach than IPM. Specific points made about inquiry during the planning sessions included that students must be engaged in organizing information and solving problems. Teachers should help foster science attitudes such as being skeptical and basing ideas on data. They were going to have to exercise their generally limited amount of science knowledge in ways that increased student interaction with themselves and the materials.

Points of Conflict Between the Two Models

Of the five points of conflict between GLM and IPM predicted by theory, three showed up in teacher discourse. The first concerns the specificity of the concept or procedure being presented. These teachers had typically used knowledge statements from the text or from district critical learnings as a source of objectives. In addition to knowledge, GLM emphasized inquiry and thinking skills and scientific attitudes. The teachers had difficulty understanding these in operational terms. As a result, many felt that these objectives were too vague and ones for which they would be criticized by their principal. After hearing several examples during their planning sessions, teachers expressed confusion and concerns and a few began to reexamine their experience with students in a new light. The data summarized above cited first grade and fifth grade teachers who were able to use classroom experience to operationalize an understanding of inquiry.

The models differ theoretically with respect to means of assessment. With the general difficulty of writing clear objectives concerning the processes of inquiry, the teachers found it doubly difficult to see the various ways assessment can take place in the classroom to capture student inquiry. Their discourse suggested that they make numerous observational judgments about the social behavior of students which would be similar to judgments made about students operating in groups during science activities or during science discussions. These skills would be applicable to broadening assessment techniques once inquiry and skills objectives became clearer.

The third predicted conflict represented in the discourse concerned the assumed capacities and motivations of the learner. Teachers talked in various ways about prerequisite knowledge and the need to build background in these students. Where a good 50% of the students face obstacles of race, culture, language, and money, the teachers find it more difficult to establish common experiences upon which to build class discussions and upon which to base activities. GLM expects students to be able and willing to wrestle with cognitive conflicts created by well chosen activities. The school principal made the point repeatedly that school is often the most stable influence many of these students have. IPM was seen as a way of providing stability and predictability.

The other two predicted differences, remedies for learning failure and mechanisms driving learning, were not in evidence in teacher discourse. It was not clear what role learning theory plays in team planning sessions and faculty meetings. Teachers did not talk about how students learn. They did talk about the need to build skills for paying attention and for carrying on social interactions. Tying instructional practice to learning theory in clear operational terms would be an appropriate step in addressing all of the above differences.

Points of Similarity

Of the predicted similarities between GLM and IPM, teacher discourse touched on two, the use of concrete materials and teacher knowledge of subject matter. Teachers were very clear about their preference for the use of concrete materials. However in science, their ability or inclination to use hands-on materials was influenced by both their marginal knowledge of subject matter and the nature of the students. Teachers spent a large amount of time discussing activities and materials in what they described as an upside-down process of selecting activities before objectives. Dispite what teachers claim, McCutcheon (1980) reports that 81% of teacher planning decisions concern activities rather than following an "objecitves first" model promoted by administration and teacher education courses. When asked why, McCutcheon's teachers said "Objectives are implicit in the activities ..." and "The objectives are in the manuals; they're done for us ...". Teachers in the current study typically relied on detailed curriculum guides from the district office in reading and math to plan instruction. They had no curriculum guides for science outside of the text. Their experience told them that the texts were not effective, but their background knowledge was not sufficient to generate objectives and identify activities.

Concerning the last two predicted similarities, district philosophy explicitly stated that the goal of instruction was to make students independent learners. There was no discourse on the long-term effects of instruction during the observations of this study. When teachers talked of students' current knowledge, it was usually in the context of deficits. As one teacher said "We are sometimes pre-requiring our kids right back to birth. We spend a lot of time developing their background." An improved applicaiton of both IPM and GLM would need to demonstrate more clearly the relationship between the background knowledge of economically and socially disadvantaged students and goals of instruction.

Implications for Teacher Education

The examination of teacher discourse during instructional planning sessions has implications for going beyond the "apparent contradictions (between IPM and GLM) to find some common ground to strengthen both approaches" (Lawson et al., 1989). To the teacher with unmotivated or disadvantaged students who does not have a wealth of science knowledge or materials, GLM appears complicated, demanding, and poorly focused. On the other hand, IPM appears to these same teachers as leading to overly narrow instruction that does not address topics of interest to students. To draw useful implications from these results, we must emphasize three elements of previous work. First, the challenge is to strengthen both models and not to create some hybrid unacceptable to either supporting theory. Second, the resulting implications must recognize that both theoretical positions have merit under different assumptions about the capabilities of the learner. Third, the implications must exploit and clarify the theoretical significance in both models of the importance of concrete materials and students' prior knowledge.

A good starting point is to note that Lawson et al. (1989) described three forms of learning cycle (GLM) models. The authors call them descriptive, empirical-abductive, and hypothetical-deductive learning cycles. For the purpose of this discussion and for most pre-college applications, this discussion will focus on the first two forms. A descriptive learning cycle helps students discover patterns by interacting with some part of the environment and look for that pattern elsewhere. The empirical-abductive learning cycle leads students to discover patterns and then generate explanations for the pattern. This form is a bridge to the third, hypothetical-deductive learning cycle, where students engage in testing hypotheses. The descriptive (GLM) form would be valuable for young learners, slow learners, and for all learners when the material is new. Note that this is almost exactly what Rosenshine (1986) said about explicit teaching practice. The theoretical connection is that teachers need not make generous assumptions about the capabilities of the students using the GLM descriptive form. By focusing on description, teachers may design IPM lessons to teach specific descriptive vocabulary or the recognition of specific sensory features. For example the fifth grade teachers in this study were interested getting their students to distinguish between substances that were sticky, gooey, or slimy. There could be a constructive interplay between GLM and IPM lessons. Students might be introduced to a problem such as "What makes things gooey?" through a GLM lesson that motivates description based on students' prior knowledge. This could be followed by an IPM sequence that teaches explicit vocabulary and manipulative skills in preparation for other GLM lessons that explores a wider variety of materials leading to more subtle discriminations.

The empirical-abductive GLM form engages older, more capable, or more experienced students in generating explanations. To apply this model, teachers must distinguish between traditional scientific explanations and explanations people give to one another. Martin (1970) emphasized that the former must adhere to more rigorous truth standards than does the latter. The explanation given by a teacher to students is intended to incrementally increase understanding and of necessity the explanation "may properly abridge, omit or otherwise falsify the account in order to make the explanation accessible..." (Horwood, 1988, p. 43). These allowable inaccuracies relax the knowledge requirements on teachers as long as the explanation does not inhibit the learner from later accepting better explanations (Horwood, 1988). The teacher using the empirical-abductive form would mediate student discourse so that all would be able to develop explanatory skills. IPM instruction may be used to teach explicit explanatory skills such as using direct observations from an activity rather than hearsay or opinion. IPM may also be used to teach explicit discourse or social skills for carrying on a discussion or debate.

This discussion has broken GLM into three forms in order to address the varying capabilities of students. This allows teachers to increase the focus of a GLM lesson while still adhering to its theoretical foundations in promoting student thinking and inquiry. The sharper focus allows the teacher to design IPM instruction to teach selected verbal or procedural skills that are supportive of more general inquiry.

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- Motivation and Cue (ITIP phrase is Mental Set and Sharing Objectives, where the teacher establishes a connection to something the student already knows.)
- Best Shot (ITIP phrase is Input, where the teacher presents new material)
- Guided Pra tice and Independent Practice (ITIP phrase meaning the place in the lesson where students use the information from the Input)
- Formative Assessment and Corrective Teaching (Where student mistakes are corrected before moving on to the next lesson)
- Enrichment (Plans for students who do not need re-teaching)
- Closure (Lesson is brought to an end while preparation is made to move to next lesson)
- Summative Assessment (Evaluative activity based on the objectives)

Figure 1. Mastery learning model based on ITIP principles used by the teachers in this study.

Engagement. Activities in this phase mentally engage the student with an event or question. Engagement activities help the students make connections with what they know and can do.

Exploration. The students work with each other to explore ideas through hands-on activities. Under the guidance of the teacher, they clarify their own understanding of major concepts and skills.

Explanation. The students explain their understanding of the concepts and processes they are learning. The teacher clarifies the students' understanding and introduces new concepts and skills.

Elaboration. Activities in this phase challenge the students to apply what they have learned, to build on their understanding of concepts, and to extend their knowledge and skills.

Evaluation. The students assess their knowledge, skills, and abilities. These activities also allow teachers to evaluate student progress.

Figure 2. Generative learning model presented to teachers during science planning sessions. The sources of this model is Bybee et al. (1990, p. 67-68).