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ABSTRACT

          This paper argues that the goals of education,
whether in university or kindergarten, are not achieved by the
one-way transmission of knowledge, but through a dialogue between
teacher and learner which has as its aim the co-construction of
meaning in relation to tasks and topics of mutual interest and
concern. The paper first addresses how the ideal educational
environment casts learners as participants rather than spectators
because the making of meaning is always part of a larger activity,
and it is the purpose of this activity that provides the motivation
for the meaning-making and for the framework of relevance within
which the meanings can be evaluated for their validity and utility.
How understanding starts with a real question which does not
necessarily include a clearly formulated statement of the problem,
but nevertheless transforms the manner in which new information is
dealt with is next considered, and a workable model for an
inquiry-oriented classroom is presented. It is proposed that
schooling amounts to a cultural apprenticeship in which students
learn about ways of acting and thinking that constitute the
intellectual resources of the culture of which they are a part; in
this context the role of discourse in inquiry and the role of the
teacher in an inquiry-oriented classroom are also discussed. The
paper concludes by considering how the model of inquiry-based
learning can be applied to a variety of subjects and grade levels.
Two figures and one table are included. (Contains 33 references.)
(SAM)

LANGUAGE AND THE INQUIRY-ORIENTED CURRICULUM

Gordon Wells

Ontario Institute for Studies in Education

[Presented at the Annual Conference of the National Council of Teachers of English, Louisville, Kentucky, November 1992]

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LANGUAGE AND THE INQUIRY-ORIENTED CURRICULUM

Gordon Wells

Ontario Institute for Studies in Education

A few days ago, I received a copy of the Newsletter of our Provincial University Teachers'
Association. I don't usually make the time to read this particular broadsheet but, disturbed
by the title of the leading article and noticing that it was written by no less a person than
the President of the Association, I decided to read on. "Great Teaching", announced the
title, "Means Mastery of Subject Matter and Transmission of Knowledge."

The article was as disturbing as the title suggested. Let me quote a few short excerpts.

> Knowledge needs to be transmitted in an effective and cogent manner for learning to take
> place. ...

> One factor influencing teaching styles is the distinction between data transmission and
> advanced learning. At the elementary and secondary schools the emphasis in teaching is
> placed on transmitting facts. Children need this information as the basic elements in the
> development of knowledge. A subtle but very important change occurs at the university
> level. Facts and data still remain important but the emphasis now begins to shift towards
> the integration of knowledge and the attainment of understanding. ...

> Another shift occurs at the university level with regard to responsibility for knowledge
> acquisition. During the pupil's first 12 or 13 years of schooling the major share of
> responsibility for knowledge acquisition rests with the teacher. ... At the university level
> the student is expected to assume responsibility for knowledge acquisition. ... It is at the
> university that the student is transformed into a self-educator.

I find almost everything about this view of education deeply disturbing - from the arrogant
implication that it is only in universities that great teaching can be found, to the abysmal
ignorance that the author displays about what is actually achieved by so many dedicated
elementary and secondary school teachers, despite the enormous difficulties with which
they have to contend. But perhaps the most disturbing feature of this characterization of
teaching is its complete disregard of the active and constructive part that the learner plays
in the teaching-learning transaction. The goals of education, I suggest, whether in
university or kindergarten, are not achieved by the one-way transmission of knowledge, be

it ever so cogently expressed, but through a dialogue between teacher and learner which has as its aim the co-construction of meaning in relation to tasks and topics of mutual interest and concern.

My purpose in this paper is to expand this latter claim and to describe and illustrate one way in which it can be put into practice.

Learning and Teaching for Understanding

What are the goals of education? In the debate that rages around this question, two very general concerns are regularly heard: first, that education should ensure the continuity of the culture through the socialization of the young into the knowledge and practices that have been built up and refined by past generations; and secondly that it should provide the opportunities necessary for each individual student to realize his or her full potential. Often, however, these concerns are treated as if they were in conflict: each can only be achieved at the expense of the other. What I shall try to show, however, is that if learning is properly understood, both these concerns can be met through transactions that have the potential to renew and enrich the culture whilst at the same time empowering its individual members.

In order to provide a basis for my argument, let me propose a schematic way of looking at the meanings that are constructed through learning. First, I want to make a distinction with respect to the learner's mode of involvement, which may be either as participant in ongoing action that is of considerable personal significance, or as spectator on the actions of others, that may be distant both in time/space and also in their perceived relevance to the learner. Cross-classifying this is a second distinction which has to do with the degree of inter-relatedness among the meanings made, which may be either unconnected and inconsistent, or highly integrated and coherent. In both cases, of course, we are dealing with continuous dimensions rather than with dichotomies. But, for the moment, I should like to explore a little further the four categories of meaning that result from the

intersection of these two dimensions. These are shown in figure 1.

ACTION/PARTICIPANT

EXPERIENCE	UNDERSTANDING
INFORMATION	KNOWLEDGE

UNCONNECTED &
INCONSISTENT
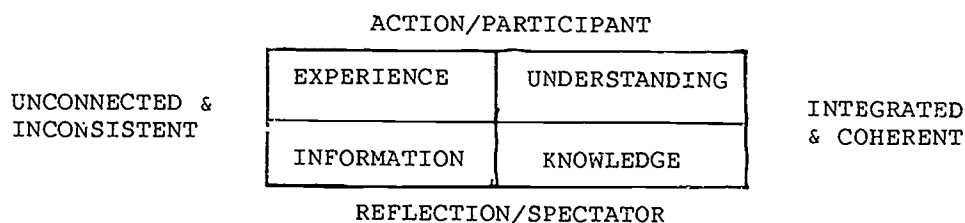
INTEGRATED
& COHERENT

REFLECTION/SPECTATOR

Figure 1. Dimensions of meaning

In the ideal educational environment, I want to suggest, all four quadrants are involved. Personal experience, the meanings derived from participation in the ongoing stream of action that we call living, is supplemented by information derived from accounts of the world as experienced by others; over time, both personal experience and impersonal information are gradually integrated and organized within the prevailing structures of cultural knowledge and, as this knowledge is brought to bear in further situations of action, the learner gradually constructs a personal understanding of the relevant structures of meaning, as they relate to his or her being and acting in the world.

All too often, unfortunately, learners do not have the opportunity to work in all four quadrants. In societies that do not have a system of formal education, learning takes place very largely through action and, although a degree of understanding is certainly developed on the basis of experience, it may not be enriched by the more systematic and integrated knowledge that has been built up in the wider culture beyond the immediate extended family. This may also be the outcome for learners whose schooling is governed by an ideology that places an almost exclusive emphasis on discovery-learning in a child-centered curriculum. By contrast, in schools where the ideology emphasizes cultural reproduction, and the definition of teaching is of the kind quoted above, the learner's attention is focused almost exclusively in the lower two quadrants. Information is delivered, often in a highly systematic, preorganized sequence and, through reception of, and reflection on, this information, the learner is expected to acquire the same knowledge as that of the 'experts' who were involved in designing the curriculum. In such schools, very little value is accorded

to learners' personal experiences in the planning and enactment of the curriculum and, if understanding is considered as a goal at all, it is almost always postponed to a later stage, when the learners will have amassed all the information and skills that are believed to be necessary for understanding to be an achievable goal.

What this brief analysis reveals is the unfortunate consequences of an unbalanced emphasis on either of the two overarching educational goals that I identified earlier. In both cases, I would suggest, this imbalance results from a fundamental misunderstanding of the nature of learning. However, since it is the ideology represented by the quotations on great teaching quoted above that tends to dominate public debate, it is with the misconceptions underlying this ideology that I shall attempt to deal.

1. The first, and perhaps most serious, misconception is to be seen in the separation of knowledge from action. This occurs at two levels, both based in the image of a learner as an empty vessel, or uninformed mind, who receives and amasses knowledge as a passive spectator. However, there is now ample evidence to show that, as in the particular case of acquiring information through reading, meanings are not simply absorbed from the information that is presented but have to be actively constructed as the learner brings his or her existing knowledge into a transaction with the cues provided by the information source (Bruner, 1966, 1986; Piaget, 1967; Rosenblatt, 1988;) Meanings are made, not found.

But action is also involved at a second level. The making of meaning is always part of a larger activity, and it is the purpose of this activity that provides the motivation for the meaning-making and for the framework of relevance within which the meanings made can be evaluated for their validity and utility (Dewey, 1938).[1] Information that is not

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[1] As Dewey remarks: "In actual experience, there is never any .. isolated singular object or event; 'an' object or event is always a special part, phase, or aspect, of an environing experienced world - a situation. The singular object stands out conspicuously because of its especially focal and crucial position at a given time <u>in determination of some problem of use or enjoyment</u> which the 'total' complex environment presents. There <u>is always a 'field' in which observation of 'this' or 'that' object or . Observation of the latter is made for the sake of finding out what that 'field' is <u>with reference to some active adaptive response to be made in carrying forward a 'course' of behavior."</u> (p.65) (emphases added)

transformed by being brought to bear on some action beyond that of attempting to comprehend and retain it, is unlikely to be remembered (Bereiter and Scardamalia, 1987); and knowledge that is constructed without a concern for its consequences for action is unlikely to empower the learner in his or her dealings with the problems and predicaments of life outside the classroom. This is what Barnes (1976) had in mind when emphasizing 'action-knowledge' as the goal of school learning. It is also what I intend when speaking of the goal of understanding.

2. It follows from this constructivist view, that learning can never be the direct outcome of the attempt to transmit knowledge by a teacher or text. On the one hand, the words spoken or written do not carry ideas and concepts in the way that railway trucks carry coal (Rorty, 1979); as symbols, they represent the meanings of their originator in the form of cues, which have to be interpreted by those who attempt to reconstruct them. Furthermore, meanings are always constructed in the making of speech acts (Lyons, 1981; Searle, 1969); they are, therefore, not neutral expressions of detached, immaterial thought, but strategic actions intended to have an impact on the beliefs and actions of their recipients. Likewise, every act of reception and interpretation is shaped by the existing knowledge that the interpreter brings to bear on it, as well as by his or her current purpose. The meanings that are constructed by both speaker/writer and hearer/reader are therefore always occasion-specific, differing from one individual to another in ways that are systematically related to interest, level of familiarity with the subject, cultural background, the purpose of the ongoing activity, and so on. The same is true of information that is received more directly through observation.

3. It further follows, therefore, that the ideal input for the learner will not be the carefully organized structure of information devised by the expert, but distant, textbook writer or curriculum planner. Although this expert's knowledge can be analysed into its constituent components of skills, facts and organizing concepts, simply to present these components in what is judged to be their optimal sequence takes no account of the learners' contribution to the transaction. This is not to argue that coherence and systematicity have no value in the

construction of knowledge, but rather to emphasize that these qualities must be built on particular learners' existing knowledge and be the outcome of their purposeful and constructive effort.

4. The final misconception that I want to address concerns the highly individualistic concept of the learner that undergirds the 'transmissionary' ideology, as Lemke (1992) so aptly terms it. Simply put, learning, according to this view, is an activity that takes place entirely within the individual, as a result of input from the outside world. How successful the learning is depends on the personal efforts and abilities of the individual, which, although affected in a quantitative way by individual differences and sociocultural factors such as class, gender or ethnicity, are assumed to be universal and genetically determined. By contrast, as soon as the situated and transactional nature of the learning and teaching encounter is recognized, it becomes clear that learning is as much a social as an individual endeavour and that the meanings that are constructed occur, not within, but between individuals; furthermore, these meanings, far from being neutral and value-free, are shaped by the social activities from which they arise and towards which they are directed. In simpler terms, what we learn depends crucially on the company we keep, on what activities we engage in together, and on how we do and talk about these activities.

What emerges from the discussion so far, then, is an image of learners actively engaged in constructing meanings from their personal experience and from the information that is made available to them in the interest of effective participation in social activities to achieve goals that are individually chosen or mutually agreed. And the outcome of such learning is the gradual construction of more systematic knowledge which can and should inform both present and future action. That is to say, it leads to the development of understanding.

This image applies both to learning in school and learning in the community. However, what distinguishes the two settings, I suggest, is that, ideally, in school, learners are assisted by teachers who, through education and experience, have developed their own

understanding of how to create the situations in which this sort of learning for understanding can occur, and who are able to engage in the co-construction of meanings with individual learners in ways that are responsive both to the particular meanings they are currently making and to the larger vision of the meanings they need to be able to make to become productive and creative members of the wider culture.

What sort of curriculum is implied by this emphasis on understanding - on knowledge that grows out of, and feeds back into, action? The answer, I want to suggest, is a curriculum organized in terms of inquiry.

The Driving Force of Inquiry

'Understanding starts with a question,' says Bettencourt (1991); 'not any question, but a real question.' And, explaining what he means by a real question, he continues:

> Said in another way, a real question expresses a desire to understand. This desire is what moves the questioner to pursue the question until an answer has been made. Desiring to understand opens ourselves to experiencing what is new as new, and the already known under new aspects.

All of us know from our own experience how much we can learn when we have a real question to answer - a practical problem to solve or an intellectual puzzle to which we are driven to find a solution. But perhaps the most energizing and productive inquiries are those that are motivated by problems that are both practical *and* intellectual. The same can be true for learners in the classroom, as I have witnessed on numerous occasions. On this occasion, I should like to quote an example from a grade six class that I observed this year, in which the students were making a study of time (Wells, in press a).[2]

One afternoon, at the end of school, Nir, an Israeli student spending a year in Canada with his parents, came to ask me to help him figure out a puzzle he had. He was trying to explain the relationship between the earth's rotation on its axis and the organization of the

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[2]This and all the other classrooms to which I shall refer are in urban schools in Metro Toronto; the communities they serve are, in every case, culturally diverse, and many of the students have a language other than English as their first language.

time zones in terms of the 24 hour day. If, he asked, at a spot just west of the international date line, it is five minutes past midnight on the 13th April, and at the same moment it is already 6 a.m. in Canada, midday in Europe and almost midnight in Asia - all on the 13th April - how does it ever get to be the 14th April - anywhere?. We struggled with this problem for quite a while, marking points on a circular table to represent places on the earth's surface and taking it in turns to represent the sun. First, the sun moved round the table, as it appears to do when viewed from any position on earth; then the sun remained fixed while one or other of us rotated the table. Eventually, we worked out that the best way to think about the problem was by adding one day to the date each time one's location on the earth's surface passed an imaginary point in space diametrically opposite the position of the sun. However, this still left unresolved the problem of how at midday today, it could already be tomorrow at other places on the earth's surface or, in yet other places, still yesterday. Nir went off to see if he could find something to read that would help him solve this problem.

When he came to make his presentation to the class a week or two later, it was obvious that he had been successful. First he demonstrated how a sundial works, shining a flashlight (the sun) from a position several feet above the floor towards a circular piece of wood (the earth) lying flat on the floor, which had a pointer projecting at an angle of 45 degrees from its centre, representing the location of Toronto. As Nir turned the earth anti-clockwise, the sun's light on the pointer cast a shadow which, as it moved round the circumference of the circle, traversed the hours from 6 a.m. to 6 p.m., which were marked by radii spanning an arc of 180 degrees. Here I recognized an imaginative extension of the solution we had arrived at to the problem we had been struggling with a few days earlier. However, as he went on to explain the difference in time between places in different time zones, he made use of a novel and even more effective demonstration.

For this, Nir had stuck two miniature sundials onto an actual globe, one at the location of Toronto and the other at Greenwich. With the room darkened, and using the same flashlight held several feet away from the globe and at a height appropriate to be 'over' the

equator, he demonstrated how, when the sun was due south of Greenwich, the sundial in Toronto showed 7 a.m. and when it was due south of Toronto, the time was already 5 p.m. in Greenwich. With this physical model and his accompanying explanation, Nir enabled many people in his audience, including his teacher, to understand these difficult concepts more clearly than they ever had before.

There are several important characteristics of inquiry to be seen in this example. First, the intense engagement shown by Nir. He cared enough about his question to stay after school to try to resolve his puzzlement and he subsequently spent considerable time and effort in further reading and in preparing a model that would enable him effectively to communicate what he had discovered to the rest of the class. So often, students are presented with questions that their teachers think are important to answer. And, at one level, the teachers may well be right. But that does not make them real questions. What makes a question real is the commitment of the questioner that energizes him or her to persist in efforts to make an answer to it, that he or she finds personally satisfying.

The second point to note is that questions do not necessarily start with a clearly formulated statement of the problem. The initial impetus is frequently a puzzlement or simply a wondering about something observed. But if this is pursued through a combination of further observation and the marshalling of what else is known that might be relevant, it is possible to develop the initial wondering into a question that can be addressed through systematic inquiry. For example, I remember recently noticing some sparrows hopping around the garden, and I idly began to wonder whether all birds hop. Then I recalled having seen both ducks and pigeons walking, one leg after the other, and so my unfocused wondering began to develop into a question: What determines whether a bird moves on the ground by hopping or by walking? Immediately, a number of hypotheses occurred to me, involving the body weight of the adult of the species and possibly the location of its centre of gravity. Perhaps habitat might also have something to do with it, and how it obtains its food. Next summer I shall be able to pursue my question in the form of field research by noting and identifying those birds that hop and those that walk and by obtaining more

information about their habitats and feeding habits.

A third characteristic of inquiry is the way in which a real question transforms the manner in which one deals with new information. For example, when engaging with a written text or other source of information, instead of attempting simply to comprehend and remember what the author said, the inquirer asks questions and critically evaluates the answers found for their relevance to the issue under investigation. The importance of the difference between these two ways of reading - which Lotman (1988) characterizes as 'univocal' and 'dialogic' - has been remarked on by several of my students who have begun to inquire into their own classroom practice. Striving to make sense of observations they have made, they find themselves rereading with critical appreciation papers which had before seemed boring or unintelligible, when read at somebody else's instigation. Even more striking was the discovery by a group of teachers, who were investigating the changing phases of the moon, that the information found in some of the books they consulted was proved inaccurate by their own careful and systematic observations (Wells, forthcoming). Understanding develops, not by taking information as true because it is pronounced by an authority, but by evaluating it in the light of one's own experience and of its relevance to one's own concerns.

The final characteristic that I wish to draw attention to is the important role of communication with others in the process of inquiry. This takes a variety of forms, from ongoing discussion with colleagues and consultation with those believed to be more knowledgeable about the issue, to sharing the results of the investigation with an interested audience. This latter type of communication is significant for two reasons. First, the natural impulse of someone who has discovered something of interest is to share the discovery with others, both to celebrate the achievement and to receive feedback in the form of further questions and constructive criticism. However, even more important is the motivation that the expectation of such critical attention gives to the presenter to clarify his or her own understanding so that the presentation will be complete and intelligible to others. As Britton et al. (1975) point out in their study of writing, in order to make the meaning in one's text clear to others, one must first get it right for oneself.

A Model of the Inquiry-Oriented Curriculum

So far, I have argued for the value of inquiry both as a powerful motivator of engagement with a topic and as a way of sustaining and structuring that engagement. Now I want to say something about the actual organization of inquiry-oriented learning, based on observations in classrooms in which this is being put into practice. What I shall offer is a rather schematic account. It is important to emphasize, therefore, that the diagram presented below (see figure 2) is not intended to be read as a prescription, to be followed rigidly on every occasion, but rather as a suggestive framework that will assist teachers in planning thematic topics for study and in thinking about the sorts of activities that will enable them to achieve the overall goals of inquiry with the particular students for whom they are responsible.

At the heart of the inquiry-oriented curriculum are the questions that individuals or small groups of students choose to investigate. Helping them to develop questions that are both real, in the sense of being personally significant, and also amenable to investigation in a worthwhile manner with the resources available, is one of the most challenging aspects of this mode of teaching. The choice of the overall theme is critical in this respect. Ideally, it will be based upon a topic in which the class is known to be interested; but it should also be one that challenges them to extend and develop their interests. In many cases, the teacher will be constrained by an externally mandated curriculum but, even when the choice is circumscribed in this way, the initial presentation of the topic can be made in a way that encourages students to find their own ways of approaching it.

In preparing to start on a new topic, therefore, it is important to think of an initial activity that will challenge students to generate a wide range of ideas that can act as potential starting points for inquiry. I have referred to this opening event as the 'launching' of the theme. It can take a wide variety of forms, such as the reading of a poem, a demonstration of a physical phenomenon, a viewing of a film, the introduction into the classroom of a brood of caterpillars or the hatching of a clutch of eggs (Wells and Chang-Wells, 1992 b).

From a somewhat different perspective, Scardamalia and Bereiter (in press), suggest that the most energizing and productive questions are those that arise from simply speculating about a theme, prior to any work on it. In whatever way the theme is launched, however, what is important at this stage is the awakening of a sense of curiosity and the creation of a forum in which students feel able to express their ideas and ask tentative questions without being ridiculed or negatively evaluated by either peers or teacher.

Following an initial brainstorming session after the reading of a poem, the teacher in one classroom I observed invited the students to talk with their friends about the questions they would like to investigate and, when they had decided, to write their names on the sign-up sheet, together with the topic they had selected. In another case, with quite young children, the teacher gave already established groups a choice of activities to start on, believing that they needed a more structured framework within which to develop independence in planning and conducting their own inquiries. Whether by student choice or by some form of negotiation, however, the outcome to be aimed for is that the students should have a feeling of commitment to, and ownership of, the inquiry so that they take responsibility for planning it and carrying it through to a successful conclusion.

Starting from the initial question - or identification of a topic to explore, if a specific question still has to be identified - an inquiry consists of three major components: Research, Interpretation and Presentation, each of which involves the three phases of Planning, Acting and Reviewing (see Figure 2).
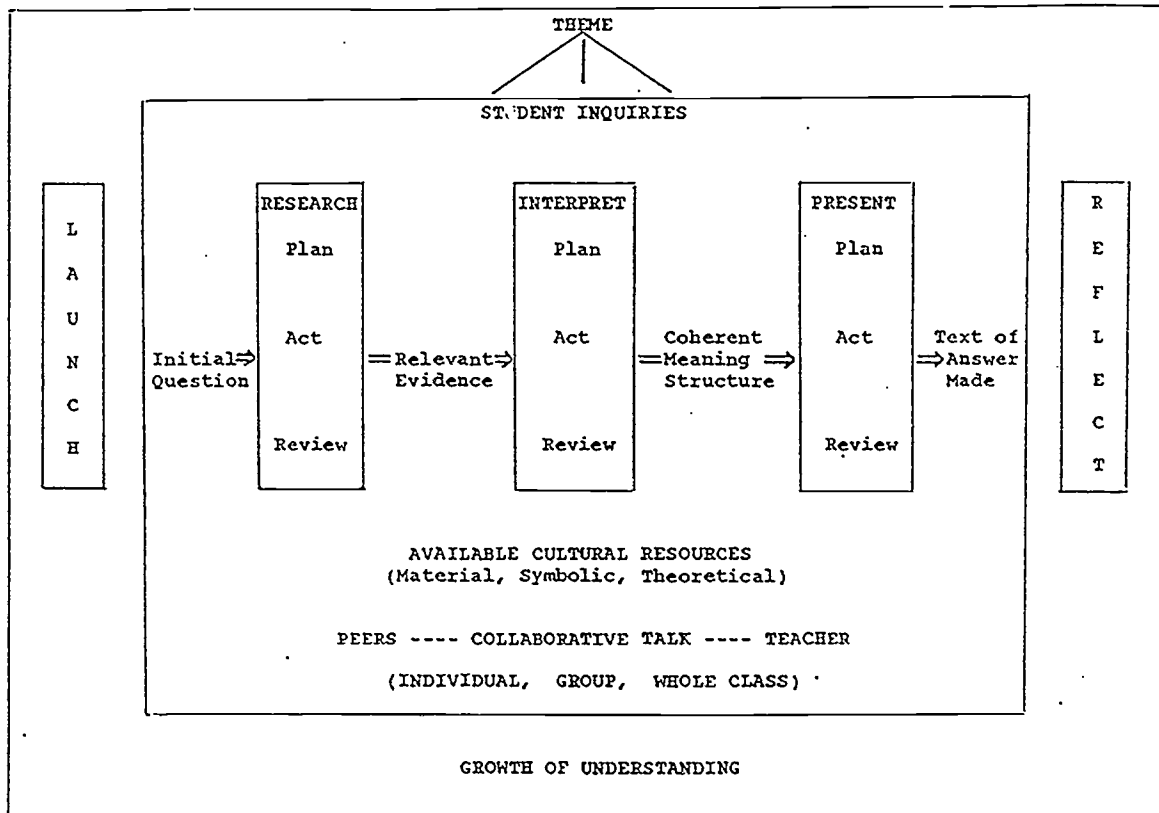
Figure 2.   An Interactive Inquiry Model of Learning and Teaching

The Research component is concerned with the gathering of evidence and information relevant to the question.   It will probably involve some combination of observation, experimentation and consulting of works of reference of various kinds.   This is the 'hands-on' component, in which students develop a sense of the empirical data that need to be taken into account in making an answer to their question.   It is in relation to this component, too, that they learn the importance of adopting systematic procedures of obtaining and recording evidence.

The following episode, from a grade three study of time (Wells and Chang-Wells, 1992 b),

illustrates some of these processes in action. Emily, Bianca, Jamilla, Veronica and Lily were testing the effect of changing the weight of a pendulum's bob. Their pendulum consisted of a length of string suspended from a pencil which had been firmly secured with adhesive tape so that it projected horizontally from the surface of a table. Over a period of about thirty minutes, they plan and construct their pendulum and proceed to carry out a number of trials, adding another washer to the end of the string for each trial and counting the number of complete swings made by the pendulum in thirty seconds. Having already discussed with the teacher the importance of making each trial a fair test, they are punctilious about ensuring that the length of the pendulum remains constant and that they release the bob from a horizontal position on each occasion.

When we join them, Lily has just added the fourth washer and Emily, who is responsible for timing each trial with the stopwatch, prepares to start.[3]

```
E:    OK, ready?

B:    No ..
      We've got to measure it to forty-four

      [B takes the tape-measure and, while V holds the pendulum
      horizontally, she measures its length in centimeters]

V:    Forty-four?

B:    Yes

E:    On your marks .. get set, go!

ALL:  One, two, three .... (continue counting)
      [V sways from side to side with the pendulum, making
      as if to push it on each swing]
      nineteen, twenty, twenty-one

E:                                        Stop!

B,V:  Twenty-one (laughing)

B:    Look, twenty-two, twenty-two, twenty-one, twenty-one
      (reading the results from the chart on which J is
      entering them after each trial)

E:    Five (instructing them to make the bob up to 5 washers)
```

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[3]In this and the following transcripts, . = 1 second of pause; < > enclose segments where the transcription is uncertain; * = a word that was inaudible; underlining indicates segments that were spoken simultaneously.

While Lily is adding the next washer, Emily has nothing to do and she idly swings the stopwatch by its carrying strap. As she is watching it swing, she suddenly sees the significance of what she is doing and announces: 'I've got a pendulum'. Jamilla immediately picks this up and starts to swing the kiss-curl on her forehead, announcing that she too has a pendulum. This is followed by Bianca, who swings her pony-tail as a pendulum and finally by Veronica who, not to be outdone, shakes her whole head to make her loose hair swing. They all laugh with pleasure at the discovery of this extension of their understanding of what may function as a pendulum.

By now, the extra washer has been added and Emily is keen to proceed. But there is a problem. The knot is not secure.

```
V:    No wait

L:    Uh-oh . that not way to tie it on

V:    I started to hold them and they ***

B:    I'm wonderful at tying knots, I love them
      I mean I like tying them
```

While Bianca is retying the knot, the teacher approaches to check on how they are progressing.

```
T:    What did you get, guys?

B:    We got a pattern of twenty-two, twenty-
      two, twenty-one, twenty-one

J:    -two, twenty-one, twenty-one (chiming in)

B:    We want to see what it's going to be this time

E:    I predict the more washers there, the less * swing

B:    I think this time maybe we'll get something like
      nineteen, eighteen or twenty . something like that

J:    Maybe

B:    Maybe

E:    I predict twenty dead . Bet you have twenty
```

As the teacher walks away, they prepare to start the next trial. But first Bianca insists that they must measure the string again to make sure that it is still the right length. As

she does so, she notices that, with all the tying and untying, the string is fraying.

```
B:    Cos it's actually .. it's actually the string that's
      breaking .see

V:    Yeah, it's the string

B:    So what we have to do is- the string's probably getting
      shorter by the minute

E?:   I don't get it

B:    Because it's breaking, you know these things are
      getting heavy on the string and if they're all
      unpleating . next thing you know it'll be tearing off
```

Finally, the knot is firmly tied, the length of the pendulum checked, and the trial completed. The result is as before: twenty-one swings. After considerable further discussion, they decide that changing the weight of the bob does not systematically affect the period of swing. This is captured in the following extract from Emily's journal entry for this activity:

```
My Opservation
I learned that adding more washers make no difference.
Not even the count of swings.
I thought it would put more wight on the string so it
will go slower each time.
```

In this extract, we have caught a glimpse of all three phases of the research component, as they apply to this particular situation: preparing the pendulum for a trial (and making adjustments until it is accurate), carrying out a trial and recording the outcome, and reviewing the results so far. In passing, we have also seen how the experimental task is embedded in a nexus of interpersonal relationships which both facilitate the group endeavour and are further cemented by their shared interest in the task in hand.

With Emily's journal entry, however, we have already moved to the next component, that of Interpretation. Here the task is to make sense of the evidence that has been collected in terms of the question that is driving the inquiry. As this is reviewed, it may well be discovered that the question has not, in fact, been answered. If this is so, it may be necessary to engage in further research or, where this does not seem likely to be fruitful, to modify the initial question, the procedures used for obtaining evidence, or a combination of

the two. Sometimes, interpreting the evidence obtained towards answering the current question may lead to the asking of further questions which, in turn, require further research.

This was the experience of the group of teachers, referred to above, who were studying the moon. After the first few observations, they revised their question to: 'What patterns of change can we see in the moon's phases and in its movements?' Then, as one of them subsequently wrote:

> For the next three weeks our group lived 'moon'. With compasses and crude home-made sextants, we were up at all hours of the night taking measurements intended to locate the moon in a consistent way. Our findings were recorded and compared, often to our dismay. More questions were being generated than were being resolved. We were to move deeper into the layers of the moon study than we had ever intended, drawn in by discrepancies that begged for resolution.

There comes a point in all inquiries when either time or enthusiasm begins to run out. Before this happens, it is important to move to the third component: Presentation. Reasons for creating an occasion for a presentation have already been mentioned. Of these, the most important is that, as has often been noted, the best way to come to understand a topic is to have to teach it to somebody else. In the ideal situation, the presentation will be made to an audience that is not already informed about the topic, such as parents, or the students in another class, since the demand to be clear, complete and coherent is greatest in this case. However, there is also much to be said for making the presentation to the rest of the class, for when each group shares its findings in this way, all members end up with a broader picture of the overall theme than any have arrived at on their own.

The value of this latter approach is that it leads naturally into the last stage of any unit of work, when teacher and students reflect together on what has been accomplished. Reflection can be notionally divided into two kinds - reflection on the content of the unit, and reflection on the processes involved - although, in practice, the two are likely to be strongly interrelated. In the first, the emphasis is on what has been learned: how the outcomes of the various group inquiries fit together, what questions were answered and what new questions were raised in the process, that are still in need of an answer. At this

stage, too, the wider social and ecological significance of the inquiries should also be considered, as this is one of the most effective ways of ensuring that the knowledge that the class has constructed is related back to action beyond the classroom.

As students talk about what they have learned, their accounts will almost certainly make reference to some of the processes in which they engaged. This provides an opening for the second kind of reflection, in which the aim is to encourage them to become more conscious of the procedures they followed - the principles on which they are based, and the strategies they developed for carrying out these procedures effectively. I am referring here to a wide range of procedures, ranging from those arising from the discipline, such as ensuring that each trial in an experiment is a fair test (as in the grade three work on time), through soci l procedures, such as ensuring that all members of a group have a significant role to play and that their contributions are recognized and valued, to the procedures of intellectual activity, such as explaining a complex relationship or providing justifications for a belief. Reflective discussion of these procedures brings them to a level of metacognitive awareness at which they can be deliberately deployed and monitored.

A further benefit of such reflective discussions is that they emphasize the reciprocal relationship between product and process. When the debate about the goals of education is conducted in terms of ensuring cultural continuity versus realizing individual potential - or traditional versus progressive pedagogy - a concern with product is often seen as being in opposition to a concern with process. However, when the curriculum is approached from the perspective of inquiry, it becomes clear that product and process are interdependent. Without a specific product in view - the making of an answer to their chosen question and developing a more coherent understanding of the field within which their question is situated - students will have little incentive to hone existing processes and learn new and more effective ones; equally, without assistance in developing a more powerful repertoire of processes, they will be less able to create the high quality products that both they and their teachers have set as their goals.

Finally, such discussions provide an opportunity for students to become more responsible for their own progress as learners, as they engage in self-evaluation of what they have learned and of the strategies they have used in overcoming difficulties encountered and, on this basis, set personal goals for future learning. It is not surprising, therefore, that of all the components discussed, it is the presence or absence of occasions of reflective discussion at the end of units of activity that distinguishes the most effective learning environments from those that are less effective.

Taking Over the Resources of the Culture

So far, in this discussion of the activities which constitute the inquiry-oriented approach to curriculum, one component that has not been mentioned explicitly is the resources that are utilized in the conduct of any inquiry. This omission is not because I consider them to be of minor importance. On the contrary, they are so central to this approach that I intend to devote most of the remainder of my paper to this topic. To explain why, I need to introduce some key ideas from sociocultural theory - that is to say, from the work of Vygotsky and his colleagues and of those who are currently extending their seminal insights.

Central to the work of this school is the belief that human intellectual abilities are not biologically inherited but learned through participation in social activity. This idea is well expressed by Leontiev in the following quotation. Describing the cultural continuity which makes human society uniquely different from that of all other species, he writes:

> ... a special form of transmitting the achievement of preceding generations to the next takes place in human society; that is the achievements are embodied in the material and spiritual products of human activities, and specific human psychological abilities can be developed through the mastery of these products by each person' (1981, p.).

Since this one sentence contains many of the most important elements of the theory, let me restate them in point form.

- In order to solve the problems encountered in trying to achieve their goals, human beings invent tools of various kinds and develop procedures for using them. These products, and their associated practices, survive their inventors and, in learning to use them, succeeding generations inherit the cultural knowledge that they encode, which they can, in turn, bring to bear and adapt in solving current problems.

- In addition to material tools, such as levers, wheels, pumps, and so on, humans have also invented symbolic tools, such as number systems, diagrammatic representation and mnemonic devices of various kinds, which enable them to solve problems of an intellectual nature. Both material and symbolic tools are mediating devices which significantly extend human capacities.

- Participation in joint activities in which a tool is used enables a learner to grasp its function in achieving the goal of the activity and to 'appropriate' (i.e. take over) the way of using it. In the process, the learner 'internalizes' (i.e. constructs for him/herself) the associated cultural knowledge.

- In order to make sense of a new tool or practice, the learner must bring to bear his or her existing cultural knowledge. As a result, the processes of appropriation and internalization involve, not a simple copying, but a transformation: of the use of the tool, of the capacities of the learner, and of the problem situation in which the tool is used. It is in the creativity and originality that, to some degree, characterizes all tool-mediated problem-solving that the potential for both cultural continuity and the realization of individual potential resides.

In sociocultural theory, I would suggest, we have the basis for a conceptualization of the goals of education that transcends the old opposition between traditional and progressive, of cultural continuity versus individual empowerment. For, according to this theory, it is only by taking over and making their own the cultural knowledge encoded in the artifacts and practices developed by previous generations, that the young will develop the abilities that enable them to achieve their potential as human beings. At the same time, the need for cultural continuity is also met as, in developing their individual potential, they are apprenticed in the ways of acting and thinking that constitute the intellectual resources of the culture in which they are growing up as members.

Viewed from this perspective, then, one of the principal purposes of schooling is to provide the conditions under which this cultural apprenticeship can take place. Its function is to create opportunities for students to engage in joint activities with more knowledgeable members of the culture, in which they encounter, and are assisted to appropriate, those cultural tools and practices that it is considered important for them to take over and make their own. However, the key phrases in this definition are 'joint activity' and 'assisted'. What both point up is that the agency in this process of apprenticeship rests as much with the learner as with the teacher. For it is when the learner is engaged in an activity that has

become imbued with his or her own purpose that he or she most benefits from the model provided by a more e. pert co-participant; by the came token, it is when the teacher's guidance and instruction are contingent upon the learner's conception of the goal to be achieved that they are most properly characterized as assistance.

A further corollary of this formulation is that, although, for the teacher, it may be the cultural knowledge encoded in the tools and practices that constitutes the goal of learning, for the learner these tools and practices are no more than the terms imply - that is to say, mediating devices which enable him or her to achieve the goal of the activity more effectively. Viewed from this perspective, therefore, we should perhaps think of the content of the curriculum as no more - and no less - than the most useful tool-kit that the culture can provide to equip its maturing members to become self-directed, creative inquirers, whose goal is to understand their world so that they can live in it productively and harmoniously.

To those who feel their lives are governed by curricula that other people have devised - no doubt with the worthiest of intentions - it may seem strange to describe the curriculum as a means to other ends rather than as an end in itself. However, this follows quite logically from making understanding the aim of classroom activity, since understanding is knowledge which is oriented to action in the world rather than knowledge which is acquired for its own sake. Indeed, it is doubtful whether knowledge is ever acquired for its own sake, except in educational settings, where those who are required to engage in this process have no use for what they are acquiring except to be able to demonstrate the fact of its acquisition.

As resources that enable learners to make more comprehensive and coherent answers to the questions that drive their inquiries, on the other hand, the tools, practices and knowledge of which the curriculum consists have a vital role to play in this conception of schooling. Particularly important among these resources are the culturally sanctioned solutions to the problems that students encounter. Although it would completely negate

the value of the inquiry orientation that I have outlined to impose these conventional answers on students when their own fall short of, or even contradict, the accepted point of view, they should nevertheless be made aware of it and encouraged to consider why they have reached different conclusions. In fact, such juxtaposing of alternative conclusions is one of the teacher's most important responsibilities in the final, reflective, stage of an inquiry-oriented unit of study. How this can be done most effectively is an issue that is beyond the scope of this paper to develop further; however, there is no doubt that it is one that is urgently in need of further consideration.

The Role of Discourse in Inquiry

By now, my claim for the central role that language plays in the form of schooling that I have been advocating will come as no surprise. Given the emphasis on group work and on whole class discussion that is proposed, it is clear that discourse, in both spoken and written modes, has a vital function to perform in inquiry-oriented learning, both in the coordination of the hands-on activities of research and in the minds-on deliberation in which the significance of the outcomes of these activities is interpreted, evaluated and integrated with what is already known. Furthermore, because of the collaborative nature of these activities and of the interdependence of action and reflection in the attempt to achieve common knowledge and shared understanding, there tends to be a greater equality of participation between teacher and students than in either teacher-directed or child-centered classrooms. Moreover, the prevailing tone of the discourse emphasizes the dialogic co-construction of meaning rather than the teacher's authoritative transmission of information, on the one hand, or the students' uncoordinated experience-based monologues on the other (Wells and Chang-Wells, 1992 a and b).

Language in its primary function of mediating interpersonal meaning-making is, therefore, very much in evidence in the inquiry-oriented classroom. However, to focus only on this social function is to miss the less perceptible, but equally important, part that language plays in the individual's growth towards understanding. In order to grasp this, we have to

look again at what Leontiev had to say about the development of intellectual capacities. Referring to the artifacts and practices that are the outcomes of social activities, he claimed that "human psychological abilities can be developed through the mastery of these products by each person."

Similar arguments are found in the writings of Vygotsky, but with an emphasis, in particular, on the mediating function of semiotic tools, of which the most important is language. By appropriating and internalizing the tool of language through taking part in discourse in the context of social activity, the learner is able to construct for him/herself the mental functions, or procedures, that are mediated by the use of language. Having acquired the tool of language in interaction with others, the learner is able to use it as a resource for individual mental activity. As Vygotsky (1981) puts it:

> All higher mental functions are internalized social relationships ... Even when we turn to mental [internal] processes, their nature remains quasi-social. In their own private sphere, human beings retain the functions of social interaction. (p.164)

Here, then, we see the further importance of the discourse that occurs in the conduct of inquiry. As students engage in the various genres of talk that are called for by the different components of researching, interpreting and presenting, they encounter in interaction with others the ways of using language *inter-mentally* to enact the intellectual operations involved, such as planning, observing, hypothesizing, reasoning, and so on. Then, as they become familiar with these genres, they gradually internalize them so that they are able to engage in the same intellectual operations *intra-mentally*, in the dialogue of inner speech. And, from there, they progress to being able to externalize this inner dialogue in the rather different communicative medium of written language.

This progression can be seen occurring, at the micro-genetic level, in the course of the first activity in the grade three unit on time from which I quoted above (Wells and Chang-Wells, 1992 b). The children had been given a choice of exploratory activities to carry out and Emily, Veronica and Lily had chosen to invent a way of measuring how long it took to empty a bottle of water. In a conference with their teacher when they had gathered their

materials together, the teacher had presented them with two problems to solve: the first was to invent and use a method of measuring how long it took, and the second was 'to make sure your test is fair'. To help them understand what was meant by a fair test, the teacher had discussed a number of possible variables with them:

```
T:    The meaning of 'fair test' is if you empty a bottle-
      say if you fill the bottle half . and Veronica fills her
      bottle full . would it be a fair test?

V:    No

E:    No . you have to- if I filled my bottle half and to make
      that a fair test she would fill her bottle half

T:    That's right . and what about Lily's bottle?

E:    She would fill her bottle half

T:                              half
      So all your three bottles must have the same amount of
      water
      Now how do you ensure the same amount of water?

E:    Well .

T:    Do you just estimate?

E,V:  No
```

After discussing several more examples of the application of this principle, the children return to their corner of the classroom and carry out the first trial, clapping plastic cups together to mark the beat and counting the number of claps that are made before the bottle is completely emptied. In the first trial, Lily's bottle is only half full, so the trial is aborted and they return to the bucket to fill all their identical Fivealive bottles 'to the brim'. Then they take it in turns to empty their bottles, with one child clapping and the third counting the number of claps. Lily, who goes first, takes four claps. Emily and Veronica each empty theirs in a count of three. At this point, Emily, who has assumed the role of group leader, pauses for a moment's reflection:

```
E:    I know, me and Veronica are tied
      Do you know why you were slow? (to L)
```

When Lily does not answer, she puts the question again in a different form:[4]

```
E:    What we did- . what we did was we . did a method by
```

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[4]Lily has recently arrived from mainland China and her command of English is fairly limited.

```
        timing
        Now, d'you guys think it was a fair match?

V:      Yeh

E:      Do you? (doubtfully)

V:      Cos we each used the same . <thing>
```

In the first, planning, phase of this activity, it is the teacher who introduces the principle of 'a fair test', modelling the language for talking about it as she operationalizes the principle with reference to the actions they are about to perform: selecting identical bottles, filling them with the same amount of water, using the same method of timing, etc. Here we can see the teacher providing a conceptual tool at exactly the moment when it is needed to enable the girls to carry out their chosen activity in a scientific manner. From the ensuing talk that accompanies the performance of the trial and from the brief discussion in which they review the results, it is clear that Emily, in particular, has begun to appropriate both conceptual tool and the associated language, and is able to use them in the context of interaction with her peers.

At this point, Emily goes to fetch their science logs so that they can record their results. But she is obviously continuing to wrestle with the problem of the discrepant results in some form of inner dialogue for, when they have finished writing, she returns to it again.

```
E:      I want to ask you some questions before we do something
        Why do you think it was a fair match?

V:      Cos the bottles were filled to the exact same amount .
        because exactly the same *

E:      Yeh, like we counted EXACTLY . *

V:                                         Yeh like I ****-

E:      Now . why d'you think . she lost? (referring to L)
        Why?

V:      Cos she was .

E:      Prob-bly she poured it- probably she poured it slow

V:      Like she goes like this (demonstrating) and then she-
```

While Veronica is speaking, the teacher joins the group to find out how they are getting on.

Emily and Veronica describe what they have been doing, ending with a summary of their recent conversation. The teacher's follow-up question prompts Emily into a statement that shows that she has recognized that, for the test to be fair, there is a further variable that they must control.

```
T:    OK, so you- so that is a good observation- you observed .
      that Lily's count . was more . than both of you . and you
      figure that it's because of the way she poured it
      Now, how can you make sure . that it's a fair test
      between all three of you?

E:    Well . a fair test- well I don't really think it's fair
      now because . it was fair we put it the same size of the
      cup by the measuring cup, but I don't think it was fair
      because we poured it- we turned it right over . and Lily
      just poured it like this, kind of
      So I don't think it was fair .(T: Uh-huh) I that- I think
      that's why she um- . was slow
```

Looking in her log book later, I saw that she had made the following entry:

Test 1 It wasn't a fair match because Lily tilted her bottle sideways. Our method was claping.

and for the activity as a whole:

What I learn I learned that if the bottle has a small mouth the water will come out slower than a wide mouth bottle.

From the episode that I have just summarized, it seems clear that Emily, at least, has developed some understanding of the principle of a fair test and, as leader of the group, she has also drawn the other two girls into using this principle in a consideration of their results. She has also developed sufficient familiarity with the languaging of the principle to write about it in her log book. However, it is also worth noting that, in her spontaneous use of it in talking to her friends and subsequently in her writing, she uses the expression 'a fair match'. In taking over the teacher's concept, it seems, she has assimilated it to her knowledge of the somewhat similar concept of a fair competition and, as a result, she has recast the results of their first trial in terms of Lily having 'lost'.

As Vygotsky emphasizes, in internalizing a mental tool, the learner does not simply copy it from 'outside' to 'inside'. 'It goes without saying,' he notes, 'that internalization transforms the process and changes its structure and functions.' In this example, we see the significance of Vygotsky's assertion. Emily's understanding of the activity has certainly

been transformed by her appropriation of this cultural semiotic tool but so, in the process of internalization, has the tool itself. No doubt, with further experience of applying the principle in action, and in talking about it, it will be further transformed in the direction of the cultural norm. But probably Emily's version of it will continue to be associated in her inner dialogue with the principle of the fair match.

In tracing the developing understanding of the application of one mental tool over the course of a single activity, we have seen some of the different functions that spoken and written discourse serves in the conduct of an inquiry. If we were to follow Emily through all the components of this unit on time, we should see a variety of others. In the following table, I have included those that I actually observed in this and other classrooms. Although not observable, similar entries to those shown for Social Speech can be inferred to be occurring under the heading of Inner Speech.

Social Speech	Written text	Inner Speech
a. Responding to Experience	Journal Entry, Poem	
b. Wondering, Brainstorming, Formulating Questions, Theorizing, Predicting	Statement of Inquiry, Initial Theory, Hypothesis, Prediction	
c. Planning, Negotiating	List, Plan	
d. Controlling, Coordinating and Monitoring Ongoing Action		
e. Observing, Interviewing, Consulting Reference Books	Notes, Tables, Diagrams, Protocols, Data Charts	
f. Interpreting Evidence, Drawing Conclusions	Webs, Concept Maps, Statement of Results or Findings	
g. Debating Alternative Interpretations/Conclusions	List of Arguments For and Against	
h. Reviewing	Revision of Existing Text	
i. Reflecting, Self-Evaluating	Reflections, Evaluations	
j. (Re)Presenting in Monologue, Dramatization	Explicit Communicative Texts in Various Genres	

Table 1. Functions of Discourse as a Tool for Inquiry

The Role of the Teacher

Teaching for understanding through inquiry can be seen, to some extent, as requiring a combination of the skills and strategies found in both traditional and progressive classrooms. However, in the demands it makes for versatility in the use of these familiar skills and strategies and for judgment in deciding when and how to deploy them, inquiry-oriented teaching calls for a conceptualization of the teacher's role which is radically different from that found in either of these traditions. Two analogies may help to clarify what I mean.

The first is that of 'apprenticeship', which has been much used by those writing from the perspective of sociocultural theory to describe the transactions between learner and someone with greater expertise that, taking place in the context of a joint activity, provide the opportunity for the learner to appropriate the relevant cultural resources that are modeled by the 'master craftsman' (Rogoff, 1990). What this analogy so successfully captures is the emphasis on learning as being concerned with knowledge-for-action, and on the teacher's role as both model and mentor. It also underlines one of the functions of schooling, namely that of ensuring cultural continuity through the passing on of the knowledge associated with the use of the tools for the craft.

However, there is more to apprenticeship than simply ensuring cultural reproduction, for the ultimate goal is that the apprentice should become an independent master craftsman who creates new artifacts and adds to the cultural resources. From the beginning, therefore, the apprentice needs to be encouraged to develop his or her own style, to experiment with new uses to which existing resources can be put, and to set novel goals for which new tools and practices will need to be invented. By the same token, teaching must be equally concerned with cultural renewal and development, and with fostering the creativity and originality that make this possible.

From this perspective on the teacher's role, one of the most important features of the

teaching-learning relationship is the manner in which the transactions between teacher and learner are conducted. To capture this, I shall turn to my second analogy, which is that of parenting. What characterizes this relationship, at least as it is understood within our culture, is the parent's desire to encourage the child's development as an individual with unique aptitudes and interests while, at the same time, fostering a disposition of responsibility and concern for other members of the family and community. How this is played out in detail can be seen in the increasing number of studies that focus on parent-child interaction in the course of the activities that make up everyday life in the home (e.g. Teale and Sulzby, 1986; Tizard and Hughes, 1984; Wells, 1986). Here there is no pre-planned curriculum and little that resembles a traditional lesson. Nevertheless, the amount of learning that occurs is phenomenal.

The reason for this is that, in general, parents 'lead from behind'. That is to say, they frequently encourage their children to take the initiative in deciding on the activity or, when the child joins in one of the household tasks, in deciding on what aspect of it to attempt. Then they monitor the child's level of success or focus of attention and offer support and guidance in talk and action that is both contingently responsive to the child's intention and aimed at helping him or her to achieve it.

Vygotsky (1978) refers to this as 'working in the learner's zone of proximal development' (ZPD), which he defines as the zone with respect to any task that lies between what the learner can manage alone and what he or she can achieve with the assistance of an adult or more knowledgeable peer. He also adds that it is only when they are appropriately pitched within this zone that the partner's interventions constitute effective teaching. Discovering the learner's ZPD is thus a prerequisite for intervening in a manner that will enable him or her to benefit from the interaction. However, the zone is not a general attribute of the learner that is independent of the particular activity or the person with whom he or she is interacting. Rather, it is created by both participants, in the context of the specific task, as they attempt to achieve intersubjective agreement about the meanings they are making together.

Parents have little difficulty in doing this, because they are genuinely interested in their children's concerns and, at least when they are not preoccupied with their own affairs, are willing to follow their children's leads. For teachers to adopt the same stance is often more difficult, because, when they get the chance to interact with individual students, they typically have their own agendas: with one eye on the curriculum content to be covered and the other on the clock, they rarely feel able to give the time to simply watching and listening. Yet this is essential if their interventions are to focus, build upon or, where necessary, redirect the meanings that are being constructed.

In sum, to teach for understanding through the medium of inquiry requires an ability to act as both master craftsman and parent, as the occasion demands - and in many other roles as well. From my own experience, however, there seem to be two levels on which one needs to concentrate in the course of any curricular unit.

The first I see as the 'macro' level of teaching: creating a challenge that one hopes will interest the students and inviting them to engage with questions that stretch their capacities and lead them to extend and deepen their understanding of their chosen topics. This is where the choice of theme is so important for, in addition to building upon or arousing students' interests, it needs to be one that will encourage both action and reflection and, within the community of inquiry, set expectations for collaborative group work, whole class sessions of various kinds, and occasions for individual meaning-making. At this stage, too, the teacher needs to anticipate the resources that are likely to be required, both the material resources for hands-on work and also the semiotic resources of books, computer software, and so on, that are needed to support the minds-on work.

Then, having set the process in motion, the teacher's task is to manage the pacing, adding or deleting elements according to expressed interests and time constraints, and making sure that adequate time is allowed for the various tasks to be brought to a satisfying conclusion, including time for reflecting upon and evaluating the what and the how of the understanding gained. Like the conductor of an orchestra, the teacher is concerned, at this

level, with continuity and coherence, and with making sure that the work that emerges from the sum total of the individual performances is recognizable in terms of the cultural score.

In addition to this macro level, there is also the 'micro' level of teaching, as the teacher engages with individuals or groups of students to assist them with whatever task they are currently undertaking. I see this as being a form of dialogue - what Tharp and Gallimore (1988) call an 'instructional conversation', or what I and my colleagues have called 'collaborative talk' (Wells and Chang-Wells, 1992 b). Unlike the monologic presentation, or lecture - which may well have a place in the overall design - this dialogue arises out of the student's current engagement in a particular task and has as its first function to facilitate its satisfactory completion. In engaging in this dialogue, however, the teacher also has a second purpose in mind. This is, within the ZPD which is constructed around the task in progress, strategically to introduce procedures and knowledge that are in some sense 'in advance' of the student's current mode of engagement so that, as the significance of these new tools is understood in the inter-mental context of the current task, they may be appropriated and internalized to become an intra-mental resource for use by the student in similar tasks in the future.

At both macro and micro levels, then, the teaching-learning relationship is essentially dialogic. At the macro level, which involves the whole class, the teacher initiates with a challenge of some kind, to which the students respond by making sense of the challenge in terms of their existing resources. The teacher then follows up by making available resources that are relevant to the student response and by developing or modifying the overall scheme in the light of student uptake. However, the most important kind of follow-up, I am convinced, is the dialogue that I have described as constituting the micro level of teaching and learning. Here, as the teacher engages with small, task-based, groups or with individual students, it is the student's way of responding to the initial challenge that should provide the initiating move, with the teacher responding to that response in whatever way she or he judges will enable the student to gain greater control and

understanding of the task in hand.

A single example will have to suffice to illustrate this sort of collaborative talk. I have selected an episode from Nir's grade six class, at the end of the year, when the whole class was studying the metamorphosis of a brood of painted lady caterpillars (Wells, in press a). For the first week, the questions were largely concerned with the caterpillars themselves, their anatomy, eating habits and whether males could be distinguished from females - questions that could be answered, for the most part, through careful observation. Then, one by one, the caterpillars, having reached their full size, secured themselves by their rear ends to the gauze covering the transparent plastic cups in which they were kept and spun their cocoons. Unfortunately, this process seemed always to occur when nobody was observing. At this stage, the teacher invited the students to come up with further questions, and it is with the questions asked by Nir's group that we shall be concerned.

Nir, Vi-Hung and Ian are in the corridor when a visiting teacher joins them. The three boys have already arrived at their question and are engaged in some interesting speculation.

```
V:    What happens in the -

N:                          - inside the chrysalis?
      How does it change?

T:    That's a really interesting question because when they
      go in they're caterpillars and when they come out they're
      butterflies so SOMEthing must happen in there

V:    How do they eat when <they're inside **>

T:    Well, when you say "How do they eat?" you're making an
      assumption that they DO eat

I:    I know they eat when they're not in the chrysalis

T:    How do you know?

I:    Well, you could see them

T:    What did you see that makes you think they eat when
      they're in the chrysalis? (T seems to have misunderstood)

I:    DO they eat? Like, is there food for them in the
      chrysalis?

T:    Well, wait a minute, there are two ways you could think
      about this: does the chrysalis make contact with food
```

```
        outside itself?

I:      No, it can't get out of its shell

T:      So if the chrysalis feeds inside its shell what would
        the food be? Where does it come from?

N:      I think they like ate- they ate a lot to get energy to
        change inside the chrysalis
        So I think they were eating very much like for seven days
        and they almost ate the food - you see there's almost
        none left - and now it's got like a lot of energy to
        change and it's changing inside
        That's what I think

T:      So you think it doesn't need food during this stage
        because it's already stored a lot

N:      Yeah .. What do you think?

T:      I think I agree with you

V:      I think I agree with you too
```

Once again the inquiry starts with a general sense of wondering, into which the teacher willingly enters. However, when there is speculation on how chrysalises eat, he is quick to push the boys into making their conjectures more explicit. When Ian recognizes that the chrysalis can't leave its shell, Nir draws upon his observations during the caterpillar stage to propose a more plausible hypothesis.

At this point, it would seem that the question about feeding has been answered. But Ian is not convinced: they missed seeing them fastening themselves to the gauze. They only saw them when they were already hanging, adds Vi-Hung. So they must have done it at the week-end or overnight. This prompts Nir to another speculation:

```
N:      It always happens at night that they change
        They do it at night, that's what I think

T:      You think that the change INSIDE the chrysalis
        takes place at night?

N:      Yeah (inaudible) maybe they need dark

T:      It's certainly possible

N:      Because like a lot of animals- when the bears change
        they do it under the snow
```

A few more exchanges follow about the mother bear spending the whole winter under the snow and giving birth to her cubs during this time, at the end of which the teacher turns

the conversation back to the chrysalis.

```
T:  But you're suggesting that the chrysalis- the development
    inside the chrysalis only takes place during the night?

N:  Um, no, but going up or turning into a butterfly I think
    that will be just <at night> * that we will not get to see

T:  Well, if you think about eggs hatching, they don't just
    hatch at night, do they?

N:  Babies aren't born just at night
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The issue, in fact, is left unresolved, as it is now too late to test Nir's hypothesis about when the caterpillars take up the hanging position. However, the fact that not all their questions are answered, on this occasion, is relatively unimportant. What is important, on the other hand, is that, as the conversation proceeds, the boys are being pushed beyond mere speculation to consider the warrant they have for the suggestions they make. Learning to take part in the genre of rational argument is more important, in the teacher's estimation, than being told the 'correct' answers.

At this point, the conversation returns to the original question - what happens inside the chrysalis - and the teacher asks them how they might answer it. Nir immediately proposes a solution.

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N:  You can take a chrysalis and open it and see ****
    and take one pair a day - like if they both were born on
    the same day and they both got up at the same day - so
    like get like eight of these or twelve every day to look

T:  You mean every day open one up to find out how far it's got?

N:  Yeah

T:  I think that would be an excellent way of finding out but
    you end up with no butterflies if you do that

N:  Yeah that's what you could do, you could really <observe>
    the change

T:  I think that's a very good idea

N:  Do you think we should do that?

T:  I think you should ask what other people think before you
    do it

N:  Yeah, because other people - I'm one of them ** - like
    some people won't like ruining animals
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A few minutes later, the class teacher joins the group and the proposal to have a class

discussion on the issue is put to her. She agrees, and for the next forty minutes or so, a really intense debate ensues on the ethical principles involved. And, such is their involvement, that students who, in a whole class session, have hardly ever spoken before, lose their shyness and speak with passion for or against the use of vivisection in scientific inquiry. (Unfortunately time does not permit me to go into more detail here but, as an example of the sustained engagement that a real question can generate, this discussion certainly merits a fuller analysis.) Finally, when the matter is put to the vote, there is an overwhelming majority against Nir's proposal. He is not to be deflected, however, and argues that, since some of the chrysalises have fallen from their hanging positions, these can be deemed to be dead and subjected to an autopsy. However, even this proposal is rejected, and there the matter ends for the day.

The next morning, Nir reopens the matter and, surprisingly, the majority now agree to allow him to dissect the 'dead' chrysalis. The teacher also agrees, provided that the results of the autopsy are recorded in drawing and writing in a proper scientific manner. She also requests that the whole event be recorded on videotape so that other students can subsequently view the proceedings.

Within minutes, preparations have been made. Donning white surgical gloves, Nir approaches the chrysalis with scalpel in hand, while Alicia holds it firmly in the middle of the table. Then, as Nir makes the first incision, the tiny creature suddenly begins to vibrate quite violently. Surprise and consternation: it is clearly still alive! Nir is immediately told to desist while a decision is taken on the right course of action to follow. By now, a large group has gathered round the table, all wanting to make their views heard. Is it really alive, or was the vibration just the nerves reacting although it was actually dead? Most believe it is still alive, and the question for them is: Can it still recover if it is treated with care, or would it be more humane to put it out of its pain by killing it immediately? Once again, a heated debate ensues and it is finally decided to leave it in the hope that it will survive.

It did, and a week or so later it hatched into a butterfly and was released with the others in the field next to the school. Unfortunately, the incision had damaged the lower of its two pairs of wings and it was unable to fly away with the rest. But, in the final judgment, perhaps it was worth it. For those students learned more from the various discussions that arose from Nir's attempt to make an answer to his question than they would have learned from hours of traditional teaching about the life cycle of a painted lady.

An atypical example, it may be objected. How often do occasions of this sort arise in the normal course of learning and teaching? To which I would reply that, when students' real questions are taken seriously, such occasions occur on a weekly - if not daily - basis, if only teachers are ready to watch and listen, and follow the students' leads.

In fact, what made this event unusual was not the students' intense engagement with the question, but the presence of a researcher with a video camera, who was able to capture the whole sequence on tape so that it could be reported to other teachers in the hope of encouraging them to join the community of inquirers. All the teachers from whose classrooms examples have been cited in this paper are teacher-researchers. They have learned from their own classroom inquiries the value of learning by asking questions that arise from their own practice and which lead to knowledge that informs their subsequent practice. They have also discovered the importance of discourse - of conversations with their colleagues and the visiting researchers about their questions and the answers they are making to them, and of internal conversations with themselves as they strive to write about their inquiries for others. And, as they are professionally empowered by the understanding that they are achieving, they are naturally trying to provide comparable learning opportunities for their students.

Conclusion

It may be thought that, because all the examples I have quoted have been drawn from inquiries in the field of science, the model of inquiry-based learning that I have presented

here applies only to this area of the curriculum. Certainly, themes that can be addressed through inquiry most readily·spring to mind in relation to the study of science and technology. However, I believe that this approach is equally valid in all areas of the curriculum. All that stands in the way of its wider adoption is our traditional ways of thinking about learning and, perhaps even more, our traditional ways of thinking about teaching.

But those can change - as pioneering teachers in many parts of the world are demonstrating. In social studies, for example, teachers are experimenting with case-based units, in which a carefully constructed narrative case-history provides the starting-point for inquiries into the factors that are claimed to have had a bearing on the course of events portrayed (Wasserman, n.d.). Another initiative has been to use collections of facsimiles of authentic historical documents - letters, newspaper reports, diaries, and so on - to enable students to 'do history' by carrying out inquiries into historical events or periods, instead of simply reading about history in text-book prose from which all the passion and controversy of genuine historical inquiry has been removed.

In drama, improvisation can also be treated as a form of inquiry, as students and teacher together attempt to understand through role-play how participants in real or imaginary predicaments might have felt and acted. Writing in role provides a further extension which can naturally involve all the components of inquiry, with the written texts produced being comparable, in significant ways, to the reports in which scientific inquiries are communicated (Barton and Booth, 1990). In similar vein, the reading of literature can generate its own appropriate form of inquiry, as students first respond to poem, play or novel and then attempt to discover what in their transactions with the text gave rise to their responses (Chambers, 1985; Swartz, 1992).

In mathematics, too, it has been found that opening up to inquiry and discussion such basic operations as multiplication, or the conversion of fractions to decimals, pays dividends in terms of the greater mathematical understanding that students achieve. Describing such

work with grade five students, Lampert (1992) writes: 'This means we do not proceed as if whatever the teacher says, or whatever is in the book, is what is assumed to be true. It also means that lessons must be structured to pursue the mathematical questions that have meaning for students in the context of the problems that they are trying to solve. And this means that lessons are more like messy conversations than like synoptic presentations of conclusions. (p.307)

In short, in all areas of the curriculum, there are teachers who, believing that the goal of learning is understanding, have experimented with an interactive inquiry approach and found it to be superior to either teacher-directed or child-centred learning.

There seem to be two reasons for this. First, what counts as knowledge in all areas of the curriculum is a cultural construct, developed over time through the very same processes of inquiry and discourse that I am advocating that students should experience. And secondly, with its 'hands-on, minds-on, hearts-on' learning, integrated through the discourse that directs and interprets its component activities, inquiry is, as I hope to have shown, the most effective route to understanding, which should be the goal of learning-and-teaching at *all* levels in the educational system.

But perhaps the most important reason fo. adopting this approach is that it offers a way of transcending the limitations of both sides in the debate on the goals of education. As long as the pendulum of public opinion swings back and forth between 'back-to-the-basics' and 'let-them-discover', neither of the goals will be met. However, when students are challenged and their learning is driven by the asking of real questions, to which teachers respond by providing them with the cultural tools they need, and with support and guidance in using them to make intellectually worthwhile answers, the debate will be resolved. Students will be empowered by taking over the achievements of the past but, by transforming them to solve the problems that they encounter in the present, they will ensure not only the continuing existence of our culture, but also its ability to adapt to the demands of the future.

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