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Deliberative Curriculum Theory As Applied
To Science Education

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A Thesis

in

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of

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ABSTRACT

Deliberative Curriculum Theory As Applied
To Science Education

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This paper combines a compendious exegesis of Joseph J. Schwab's writings on curricular deliberation with an exemplification of deliberative enquiry. The latter entails an exploratory study of a current curricular aim in science education, that of scientific literacy. The general argument made is that deliberative enquiry, as a framework for curricular deliberation, is particularly appropriate to the resolution of complex educational problems such as those centering on the aim of scientific literacy in public education.

A number of formulations of this science education aim are examined in terms of historical development, conceptual elements and school practice. Three science education goals are shown to be important to the aim of scientific literacy. These are the goals focusing on science concepts, science skills, and science-society issues.

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CHAPTER I

INTRODUCTION

Statement of the Basic Argument

I propose in this thesis to combine a compendious exegesis of Joseph J. Schwab's writings on curricular deliberation with an exemplification of Schwabian deliberative enquiry. The latter will entail an examination of one current science education goal, that of scientific literacy, by drawing extensively on the phases of Schwabian deliberative enquiry.

The starting point will be a review of Schwab's major contributions to the curriculum field in regard to curricular deliberation, by focusing on his work as embodied in a series of four determinedly related papers published over the past fifteen years. This will be followed by a fuller development of the basic argument that I put forth in this thesis. The argument consists of the following propositions:

(a) deliberative enquiry as described by Schwab, is a framework for curricular deliberation that is appropriate to the resolution of complex educational problems;

(b) the science education goal of scientific literacy is a complex educational problem;

(c) the use of Schwabian deliberative enquiry in curriculum planning will point the way to possible solutions for this complex educational problem.

A New Approach to Educational Problem-Solving

Schwab elaborated The Practical over a period of some fifteen years.[1] The Practical describes a framework of enquiry for investigating the concrete nature of curricular problems, understanding them and providing possible solutions in local situations, while using "the natural language of the practical which is deliberative exchange and consideration among several persons."[2]

Each of the terms in this definition will undergo somewhat extensive analysis as the fundamental elements in the general argument are teased out and examined in detail. As a start, a closer look at the concept of 'curriculum' might be in order. Schwab's conception of the term 'curriculum' can perhaps be better appreciated in juxtaposition to a selective variety of other current conceptions. Webster's New Collegiate Dictionary provides us with a definition that is as good as any designed for abbreviated convenience: "the courses of study offered by an educational institution".[3] Some other cursory definitions would differ only mildly from Webster's by adding the condition of scheduling the course work in some manner.

Reid is more generous in his description of curriculum: "a set of activities involving teacher, learner and materials, and that these activities are provided through permanent institutions".[4] Barrow goes further when offering his definition of curriculum: "everything that is taught [in schools] whether consciously or otherwise and whether clearly advertised and timetabled or not".[5]

Whereas Reid's description of the term 'curriculum' might be placed at one end of a continuum designed to expose the nature of the term 'curriculum', Schwab's description would likely fall at the opposite end. Reid's brief outline of curricular details contrasts noticeably with Schwab's richness of inclusive detail:

> Curriculum is what is successfully conveyed to differing degrees to different students, by committed teachers using appropriate materials and actions, of legitimated bodies of knowledge, skill, taste and propensity to act and react, which are chosen for instruction after serious reflection and communal decision by representatives of those involved in the teaching of a specified group of students who are known to the decisionmakers.[6]

This is in keeping with Schwab's plea for the recognition of the importance that teaching and learning details have within the total learning situation, when trying to promote curricular changes.

A Preview of The Practical

The first of the four papers referred to above is entitled "The Practical: A Language for Curriculum".[7] It examines two realms of human activity - the realm of the theoretic and the realm of the practical. The former is characterized as seeking warranted knowledge, as in theorizing from research work, which activity serves, at least in part, as authorization or justification of such knowledge. The latter realm of human activity seeks a defensible decision because a highly specific or concrete and usually unique situation requires that some specific action be taken. The paper offers guidelines for a fruitful enquiry (styled deliberative enquiry) into the concrete situation that gives rise to a felt problem so that the felt problem is transformed into an understandable problem.

The second of these papers is entitled "The Practical: Arts of Eclectic".[8] It continues the enquiry process by describing routes to possible solutions (multiple and alternative) of the problem as formulated by the initial stages of enquiry. These routes depict an interplay of three major elements in the deliberative enquiry process: (1) the four commonplaces of any educational situation, i.e., student, teacher, subject matter and milieu, (2) theories drawn from all appropriate disciplines, e.g., psychology, sociology, subject matter of the specific course among others, and (3) the problem-as-formulated.

The third paper, entitled: "The Practical 3: Translation into Curriculum", concerns itself with guidelines to the placing of subject matter into a specific curricular context while continuing to respect adequately and equally, the three commonplaces just mentioned.[9] The generation and consideration of subject matter alternatives forms a major part of this phase. The fourth paper is entitled "The Practical 4: Something for Curriculum Professors To Do".[10] It explores the role of curriculum specialists within the deliberative enquiry framework, examines the group dynamics in such a process and suggests a way in which curriculum specialists may acquire their expertise. Each paper is designed to "exemplify arts of the practical insofar as this is possible in expository prose" and to demonstrate the "elastic boundaries characteristic of practical problems" of which curricular problems constitute one species.[11]

A reworking of Schwab's arguments for deliberative enquiry in curricular matters would seem to logically precede any attempt at exemplification. In essence Schwab recommended that, instead of solving curricular problems by the imposition of a right theory, another starting point be used. What was required, he maintained, were:

> New principles which will generate a new view of the character and variety of [curricular] problems. It requires new methods, appropriate to the budget of problems.[12]

The term 'principle' is the key to an understanding of Schwab's position. He argues that there will be "a renewed capacity to contribute to the quality of American education, only if curriculum energies" are guided by conceptions and ideas that direct these energies to perceptions of and inquiries into curricular subject matters that center on the practical and problematic situations requiring decisions.[13] He contrasted such perceptions and inquiries with those that are guided by principles directing us to warranted knowledge. The overture to this major and new curriculum perspective was the series of papers by Schwab between 1969 and 1983, briefly described above. Schwab argued that the curricular problems, both numerous and seemingly intractable, that were evident to curriculum workers, were essentially practical problems, that is, problems having their roots in the concrete, the particulars of school and classroom situations. Choices must be made by teachers; action must be taken, but ought not to be the sole focus of the curriculum planner's attention. Instead, a new language must be used, a language that is able to take sufficient account of the particulars of a school or classroom situation and the inevitable complexities they entail, while being flexible enough to convey and translate the benefits of appropriate theoretical disciplines into the classroom situation.

The starting point of Schwab's The Practical is the premise that a successful and fruitful partnership of practice and theory are necessary in education. Practical considerations in education are the actual, the alive, the concrete, the changeable, the unpredictable in everyday teaching and learning. Theoretic considerations are marked by systems of thought, generalizability, encapsulation and predictability. Just as both the practical and the theoretic will fundamentally continue to be characterized by the above attributes, they both will remain fundamentally incongruous. But acceptance of this inevitability is only the launching pad for "the methods by which [mutual accommodations] might be achieved".14

This new curricular language would be used in a process that Schwab termed deliberative enquiry.15 This curricular process would include careful and thorough discussion and consideration of the factors in a problematic situation, as viewed through the lenses of teacher, learner, subject matter and milieu.

A Science Education Problem: The Goal of Scientific Literacy

One of the major consequences of the recent American and Canadian national studies of education is the posing of a national problem in science education. These studies highlight the substantial gap between the aims or goals of the 'new' science curricula implemented in the 1960's and early 1970's, and the present state of public school science education as provided by the respective state and provincial public school systems. Because these science curricula (i.e., BSCS, PSSC, CHEM study and others) constitute the most recent and major changes in North American high school science curricula, widespread attention in science education literature has been focused on the reasons for such a gap between science education desiderata and current student performances in high school science courses.

Initially, it was believed that these science curricula would be the route of 'science for all'. Sadly, they have proved to be science for only some of the college-oriented high school students. The remaining high school graduates, either college-bound or not, have been designated, by and large, as scientific illiterates. An enquiry into the scientific literacy problem, proposed as an exemplification of Schwabian deliberative enquiry within the confines of this thesis, may shed some light on these disparities. The enquiry will include some of the major influences in the historical and conceptual development of this dichotomous and problematic situation in science education, followed by its location within educational contexts and possible approaches to its resolution.

Overview of Chapters

The style of the thesis is discursive. This is intentional: in order to grasp the general picture properly it is absolutely necessary to work through a number of basic points in detail and from different angles. There are no quick and easy curricular resolutions when faced with a problem area as essentially complicated as the goal of scientific literacy in science education.

Chapters 2 through 4 concern themselves with a description of the Schwabian approach to curricular changes, an approach that begins with the

> acceptance that problem situations are open-ended and the search for solutions should not be closed off by adherence to fixed views or the appropriateness of ends or means,

and ends with the

> recognition of the fact that practical problems can be solved only in [tested] action.[16]

This description will subsequently be used as a framework for deliberating about the state of and possibilities for science education in connection with the term 'scientific literacy'.

The remaining chapters concern themselves directly with this ongoing problem area in science education, namely the problem area centering on the goal of scientific literacy, which was briefly introduced above. As will be discussed in chapter 6, the very term 'scientific literacy' tends to defy clarity, and particularly so among educators who use it with the most assurance. However some attempt at clarity would seem to be necessary and this within the total framework of the educational complex. The concept of scientific literacy will be probed with the intent of teasing out elements that deserve considered reflection before answers to curricular questions can be productively attempted. In addition, some conceptual positions taken by science educationists will be examined in the light of these analytical probes. It is hoped that this will serve to underline the desirability of regular and substantial ties between the deliberative process and the external realities of science education.

Chapter 5 concentrates on an exposition of the multiple and contested historical concepts of scientific literacy that have arisen over the years and are re-surfacing in the wake of the national studies referred to above. Problem situations tend to have historical precursors that have collectively effected the evolution of the existing difficulties. If ameliorative or normative change is to be gradual (as advocated by Schwab) and acceptable, a better understanding of the reasons for change is needed. One avenue to such an understanding is the willingness to examine historical transitions and processes. There is no longstanding experience in the teaching area of scientific literacy and these contested concepts have not been tested by the fires of experience. This makes all the more reason for what is hoped will be a reasoned balancing of the various and competing historical, social, political, and educational factors which are all part of the scientific literacy problem.

Chapters 7 and 8 will work through the respective tasks of problem formulation and directions for solution formulation, drawing on Schwab's framework of deliberative enquiry. In connection with the tasks of these two chapters, I do not pretend to be suggesting water-tight alternatives which are logically closed and transcend all previous formulations. Rather, the intention is, by clarifying some of the key difficulties, to suggest the directions in which intellectual work ought to be moving and to illustrate some of these ideas in what is essentially an exploratory study. It is this last phrase that must be kept in mind by the reader when taking note of assertions that resemble conclusions about curricular problems and solutions concerning scientific literacy. Nonetheless, this writer would hope that the ideas explored in the following chapters would stand in some form as a contribution to the continuing debate surrounding the goal of scientific literacy in public education and formulae for curricular changes.

Some Orienting Terms

The reader now has a cursory overview of the chapter contents and sequence. An equally fundamental role for any introduction is to provide the reader with some framework of orienting terms that can then be used to steer a course through these chapters. Such orienting terms can also be used to cull from each chapter ideas, arguments and examples that can be linked to the underlying theme of Schwabian deliberative enquiry. One set of orienting terms is derived from the Schwabian phases of deliberative enquiry. These terms are particularly discussed in chapter 3: problem perception, problem formulation, solution formulation, rehearsal of solutions, and reflection.

A second set of orienting terms is useful in underscoring the dichotomous tendencies of curriculum matters. The design of most curricula is based on theoretical considerations that emphasize the subject matter or the learner. Curricular content is then linked to the nature of the subject matter and its methodology or to the nature of the learner in psychological, sociological or philosophical terms. Theories may certainly guide the practice of curriculum design and implementation but they are not enough. The limitations of any such theory when looked at from the stance of teacher or learner are serious and even crippling. Yet, the practical elements entailed in every curricular change have traditionally, consistently and effectively been ignored or downplayed in curriculum planning. Schwab's insistence that these practical elements be given a status in curriculum planning commensurate with the status given the theoretical elements is a relatively new perspective in the curriculum field. Consequently, in this thesis, the terms practical and theoretical will serve as reminders of this insistence within the framework of deliberative enquiry.

Occasionally, there will appear a sub-set of orienting terms that this writer has found to be especially useful in a particular chapter. Such terms will serve a quite local function and yet will be related to the larger and more pervasive Schwabian orienting terms. One such instance occurs in chapter 7. A sub-set of orienting terms is drawn from Dewey's explication of the problematic situation and its relation to education and experience: the indeterminate situation and the determinate situation; settled elements and unsettled elements.[17]

Concluding Remarks

It might be timely to indicate my reasons for valuing The Practical. Some of them are based on the intellectually appealing deliberation processes outlined by The Practical. Others are influenced by my years in high school teaching and concomitant experience in pedagogical and curricular problems. Let me begin with the premise that there are existing educational problems still not resolved and that the future will hold more, and add the premise that concrete problems need concrete solutions. Deliberation is an intellectually appealing and stimulating approach to problem-solving.

It provides a forum for the sharing of information and warranted points of view from all involved parties and disciplines. Such a forum should also be able to delineate the interdependence of all disciplines and educational activities connected to the learning processes of human beings. The internal educative nature of deliberation is another consequence not to be passed over lightly: the deliberative interchange among education practitioners, education theorists, education researchers, and subject matter specialists in such a forum may well help to promote better understanding of each other's concerns, methodologies and values. This may facilitate future curriculum planning.

Lastly, deliberation avoids the need to justify curricular choices or decisions based on either inductive or deductive methodologies because it offers a viable and optional rationale. Deliberation will also ensure a continuous process of evaluation of curricular choices, permitting close supervision of implemented solutions and the monitoring of their intended effectiveness and/or unintended consequences.

In summary then, I propose in this ~~thesis~~ to explore the appropriateness of Schwabian deliberative enquiry to the investigation of one prevalent and problematic science education goal. The translation of this goal into specific curricula is beyond the scope of this thesis and not part of the intention of this thesis. However, suggestions as to the direction of movement from problem to solution will form part of the total exploration of this problematic science education goal. These suggestions should be viewed as preliminary to any projected curriculum design.

The foundation of a deliberative enquiry rationale precedes its application. The explication of such a rationale constitutes the structure of the next several chapters.

CHAPTER 2

THE PRACTICAL: A PRESENTATION OF PRINCIPAL AND SUPPORTING ARGUMENTS

Joseph J. Schwab, in the first of four major papers embodying suggestions for the rescuing of the curriculum field from stagnation, decline, and ineffectuality, presents a thesis concerning curriculum planning that is consistently referred to in the subsequent papers. Briefly stated, the central argument is as follows: a renascence of the curriculum field is possible if the energies of the curriculum specialists and their colleagues are concentrated on three heretofore neglected 'modes of operation', which Schwab entitles the practical, the quasi-practical and the eclectic.

My intention in this chapter is twofold: to examine reasons for the argument that has just been stated, and to examine the nature, emphases and applicability of each of the three proposed curricular modes of operation.

Even though I will be drawing on Schwab as the principal source of the arguments presented in this chapter, there will also be some reference to the work of other important writers in the curriculum field.

Supporting Arguments

It need hardly be said that an argument in which a renascence is projected presumes some considerable difficulties with the status quo.

One of the arguments that Schwab presents in the diagnosis of the curriculum field as moribund, combines historical and methodological evidence:

> The field of curriculum is moribund. It is unable by its present methods and principles, to continue its work and contribute significantly to the advancement of education.[1]

By the time Schwab wrote these two sentences in 1969, there had already accumulated substantial amounts of evidence, resulting from the curricular renovations and innovations of the 1950's and 1960's, that continued reliance on traditional or accepted "methods and principles" (rules of procedure or investigation and their essential rationale) would likely perpetuate the equally traditional records of curricular failures and stagnation in the related academic field of curriculum.

Curricular failure can be described from a number of perspectives. One perspective directs our attention to the role of the teacher in the classroom implementation of any curriculum. Has the teacher been willing to or able to grasp, accept and implement the intentions of the curriculum designer? If not, a curriculum has failed. It remains a secondary issue whether the curriculum designer or the teacher is at fault; of course, both may be at fault just as easily.

A second perspective must be included as an example, mainly because of its prevalence. Curricular content, i.e., subject matter, from the traditional disciplines (such as history, mathematics, the sciences) may focus heavily on the inquiry or process styles characteristic of the mature research patterns of these various disciplines without sufficient regard for psychological, emotive and cognitive developmental factors of the elementary and high school learner.

The possibilities for curricular failure are numerous and varied. This became particularly evident when even the 'best' of circumstances failed to produce large-scale changes in curricular planning strategies, teaching strategies and subject matter content.[2] However, in developing the argument that leads to the statement that "the field of curriculum is moribund", Schwab used evidence located within the curriculum field itself (as opposed to evidence of curricular failures). It is not my intention to fully unpack this subsidiary argument. Nonetheless, a summary of the evidence may be helpful.

Briefly, Schwab's evidence includes the following: (1) the absence of contributions from curriculum specialists in most of the then current school curricula (e.g., the science curricula developed since the early 1960's), (2) the concern with theory development _about_ curriculum planning and curricular changes, (3) the appearance of increasing numbers of writings _about_ curricula in the form of "histories, anthologies, commentaries, and criticisms", and (4) continuing restatements of work by others (e.g., Tyler, John Dewey, behavioral objectives).[3] The details of this subsidiary argument are fully disclosed in the first of Schwab's four papers on _The Practical_. In essence, Schwab argues that this situation will not be bettered by the formulation of yet another new curriculum. "The curriculum field is moribund" because its current methods and principles no longer serve to advance the field of education.[4] Rather, what is required is a carefully considered examination of the practices and principles common to curriculum planners and relied upon by their colleagues in the academic and teaching areas of education to solve curricular problems.

Having concluded that there is enough historical and archival evidence of educational stagnation in the curriculum field, Schwab goes on to present a major argument that focuses on the essential doctrine or principle in curriculum work that requires re-examination: the "reliance on theory" which he describes and decries as "inveterate, unexamined, and mistaken".5

The Theoretic Mode: A Supporting Argument

The "inveterate, unexamined, and mistaken reliance on theory" is highlighted as the principle that is at the heart of the problems in the field of curriculum. However, "reliance on theory" is a working principle that has been considered as standard by curriculum planners and has essentially been transformed by them into a presupposition that consequently shapes the sources of problems, goals, subject matter and teaching strategies. The inveteracy of this principle could explain in part the unexamined nature of such a dependency on and recourse to the theoretic as inspiration for, guidance for, and explanation of decisions in curricular planning. Resort to precedence is likely a commonplace of decision making at all levels of human activity, including the field of curriculum.

Even in the absence of any "crises of principle in curriculum", a cogent and appealing argument can be made calling for the reconsideration or re-evaluation of standard curriculum planning practices that are grounded in theory, and advocating the essay of a 'new' curriculum planning vehicle grounded in the particularities of specific educational situations while still prepared to incorporate appropriate and examined theory.[6] It is just such an argument that will be advanced here. Whereas the proper or accepted development of theories entails the abstraction of regularities out of the irregularities, specifics and particularities of any studied case, and entails stringent control of the limits or scope of the case (and may well encourage the flowering of a number of competing interpretations emanating from the same case), the opposite is true in the implementation of any curriculum. The particularities are all too evident (there are no two students or two classrooms or two schools alike), the learning situation is affected by an ever widening set of influences (psychological, sociological, political, economic, etc.) and some single decision must be taken moment-by-moment if some act of learning is to follow.

Integral to an understanding of the difficulties resulting from an unexamined reliance on theory is an appreciation of the nature of theoretical constructions. These are usually viewed as the ultimate outcome of research and are commonly termed 'knowledge'. The nature of such knowledge (or theories) has characteristics that make for curricular difficulties when theory is directed too closely to practice: its universality, its partiality. Universal statements or generalizations are convenient shorthand constructions that represent interpretations of relatively complicated sets of data. In abstracting these statements from the pool of collected evidence, the particularities and divergencies of the evidence are left behind and ultimately lost. Because of this, such universal statements cannot be unilaterally applied to some set of specific particularities (individuals, time, space, etc.) without running the very real risk of inappropriateness or mis-match. A learning theory that emphasizes the joys and retention powers of 'learning-by-doing' may be inappropriate for students who do not require an emphasis on the concrete for sustained and effective learning, or who are pressed for time in the school program, or who are motivationally or emotionally unsuited for hands-on methods of learning. Schwab reminds us that

> theory by its very nature, does not and cannot take account of all the matters which are crucial to questions of what, who and how to teach.[7]

It is these particularities of "what, who and how to teach" that form the essence of curricula, particularities that can best be described as multitudinous and multifaceted. Neither one of these modifiers is easily assimilated to universalities in any direct manner. This is not a feature of theoretical constructs peculiar only to those often associated with the field of education, such as the disciplines of psychology, sociology and philosophy. It is a feature of theoretical constructs found in any and every discipline (scientific, historical, economic, etc.) that is concerned primarily with the 'discovery' of knowledge. Whether or not the 'discovery' process is modeled after scientific ones, the desired outcome is some abstracted formulation intended to represent general knowledge. The difficulties associated with the pragmatic concerns of "what, who, and how to teach" cannot be assuaged by a dose of theoretical constructs. Because of this, it is mistaken to use theory postulates drawn from psychology, sociology, philosophy, etc. "as principles from which to 'deduce' right aims and procedures for schools and classrooms".[8]

Should anyone, nonetheless, persist in trying to apply theoretical formulations directly to the problems associated with schooling and educational institutions, it is wise to be aware of the partiality of theories, no matter the issuing discipline. The result is the inadequacy of theory in any direct translation to practice. The partiality or incompleteness of theory has two sources: (1) the very separateness of each discipline, each with its respective subject matter, and (2) the many competing principles of methodology and theory formation. Schwab refers to the fact that none of the various schools of thought in, for example, the disciplines of psychology and sociology, satisfactorily accounts for all things psychological or sociological. (As an instance of this difficulty: among sociological positions, the structural functionalists fail to account for the distorting influences of power and economics in societal patterns, as exposed by the radicals; neither of these schools of thought, however, addresses the pervasive patterns of behavioral interactions among individual members of society). A curriculum grounded in one theory will likely be inadequate to the very complex demands of and considerations within any specific learning situation.

It is well to be reminded of the inability of any theory to address all matters involved in schools and schooling. A specific learning situation may well call for contributions from philosophy (e.g., the nature of knowledge and education), sociology (e.g., human interactions and the role or value of institutions devised and sustained or changed by the members of society), and psychology (e.g., cognitive and emotive development in the individual student). No single discipline or theory can satisfy the multiple demands of a learning situation.

It is then these characteristics of theoretical constructs that Schwab would have us keep actively in mind when planning curricula. I have so far tried to delineate some problematic consequences of an unexamined reliance on theory. Schwab does not, by any means, suggest that theories be avoided in curricular planning. On the contrary, he places theory-use in a particular framework that encourages considered and analytical use of theoretical contributions.

The Practical Mode

Schwab provides an edifice of evidence and arguments that the field of education will continue to stagnate so long as the "inveterate, unexamined, and mistaken reliance on theory" continues in the curriculum field. This traditional and theoretic mode of operation, Schwab maintains, must be replaced by three more productive modes of operation, and it is the first of these, the practical, that I am now prepared to consider.

The practical mode as proposed by Schwab, is radically different from the theoretic mode in subject matter, outcome, problem source and methodology. Each of these aspects will be taken in turn with the intention of clarifying the marked differences in each case.

Schwab considers the subject matter of the practical to be the particularities or specific circumstances of an actual situation with all of its attendant actor, environmental and time elements. The actual combinations of actor, environment and time will result in complexities of unlimited variation. It is precisely some such set of complex elements that can be found in any classroom at any level of schooling. And it is precisely such sets of complex elements that generate the learning and behavioural problems encountered in every classroom at every level of schooling. It is generally these learning and behavioural problems that curricula are intended and designed to resolve. The practical mode of operation focuses on the actual sets of complex elements; it attempts to reach an understanding of the actual social and learning interrelationships by taking into account the teacher and student actors, the intrinsic demands of the subject matter to be learned and the social, institutional, physical and cultural factors within the schooling milieu. It is this collection of particularities that must be first accurately perceived and then understood as best as possible. The totality of perceptions may include patterns or regularities emanating from comparative or longitudinal investigations. But this totality is incomplete if the evidence that does not fit well into patterns or regularities is ignored or overlooked. The totality of perceptions must include both kinds of evidence. It must be remembered that the intent of the exercise is as complete as possible an understanding of an actual situation, one that is "indefinitely susceptible to circumstance".9

For the sake of an intended comparison with the practical mode, some important elements of the theoretic mode will be reviewed briefly. The theoretic mode of curriculum planning operates under guidelines that differ markedly from the proposed practical mode. The subject matter of the theoretic mode is the set of universals constructed from careful analyses of a circumscribed range of data. The focus of attention in investigations and analyses of data is the accumulation of evidence to support perceived regularities. It is hoped that these regularities would, in turn, be useful in arriving at a deeper understanding of that part of the known world under investigation. Knowledge, then, is the final outcome of the theoretic mode, knowledge that represents the underlying principles of the disciplines that rely on the theoretic mode and that is "constant from instance to instance" and "impervious to changing circumstance".[10] It can, of course, be added that the methodologies associated with the theoretic mode tend to follow some variation of inductive or hypothetico-deductive guidelines of investigation as determined by the community of scholars within each discipline. But common to all of these methods is their

> control by a principle. The principle of a theoretic enquiry determines the general shape of its problem, the kind of data to seek, and how to interpret these data to a conclusion.[11]

In contrast, the practical mode, as proposed by Schwab, does not attempt to produce knowledge. Rather, its outcome is in the form of decisions that require eventual actions in order to support their effectiveness. As can easily be seen, the methods appropriate to decision-making are also quite different. Some form of deliberation (i.e., careful and full consideration) amenable to the requirements of a specific situation, would be chosen in contrast to some form of scientific methodology normally associated with knowledge-producing disciplines. The practical operates in the absence of any guiding principle and must wait upon the problem to emerge during the active search for data. The problem will start

> to emerge only as we examine the situation which seems to be wrong and begin to look, necessarily at random, for what is the matter. The problem slowly emerges, then, as we search for data, and conversely, the search for data is only gradually given direction by the slow formation of the problem.12

This last consideration points to important differences between the practical and theoretic modes of operation. These two modes locate their initial problems in different sources. The theoretic mode looks for gaps within the existing body of knowledge. These 'blank spaces' or "states of mind" may or may not be amenable to investigation and if investigated, the resulting conclusions may or may not lend themselves to application in the practicalities of everyday affairs.13 It is this last, namely, everyday affairs that serves as the source of problems for the practical mode. Malaise, friction, and breakdowns among the particularities of daily activities may well be perceived as problems that interfere with the optimal functioning of these same activities. The classroom as well as educational institutions of every sort are replete with instances of malaise, friction, frustration and confrontation that may well be amenable to correction or removal if investigated in an appropriate manner. The practical, then, concentrates the efforts of deliberation on the problematics as located with actual school settings. This is intended to be in contrast to the use of theories of learning, personality, etc., as the starting point wherein the problematic is a theoretical one and conformity of the practical to the theoretical is desired. Such a task is by no means an easy one. Leaving aside for the moment any consideration of methodological problems inherent to the appropriate investigative sciences, the matters of uniqueness and changeableness need to be faced:

> The ~~field situation~~ in which the action takes place is unique. No attempt to replicate it can succeed. And the uniqueness of the situation is not nominal, but significant.[14]

According to Stenhouse, uniqueness is not a minor irritant, not a commonplace safely ignored.

To make matters worse, the pre-deliberation field situation will tend not to be the post-deliberation field situation in which change is to be implemented. Fox emphasizes the changeable character of the practical problem-situation when he writes (unintentionally mixing metaphors) that "the concrete practical situation is an amorphous one", not only because the characteristics may vary and that in degrees, but also the very "location of the problem may shift several times, sometimes even after we have begun to look for solutions to it".[15]

Attempts to locate the field situation in a slower moving and more generalizable total context have been considered. One such attempt derives its stimulus and direction from historical contexts. Reid, in considering "ways in which explorations of history can be beneficial to a practically-based conception of curriculum change" suggested that, among others, history can "provide understandings of the unique contexts within which action has to be taken".[16] Reid stresses the value of understanding traditions, accomplishments, the community past: "rhetorical ground from which arguments about needed change can proceed".[17] Schwab would maintain that it is the practical mode rather than the theoretic, that is appropriate in such instances.

Interim Summary

A summary of the arguments presented so far would serve as a convenient reminder of the ground covered. The field of curriculum is "moribund" as evidenced by continuing curricular failures coupled with an inability or unwillingness on the part of curriculum specialists to pursue the solution of curricular problems within specific learning situations. The cause of this decline is to be found within the theoretic mode of curriculum planning characteristic of current curriculum methodology. The theoretic mode is inappropriate to the solution of curricular problems due to its very nature; i.e., due to its inherent subject matter (universals) and outcome (knowledge) that are both founded upon methodologies (controlled by some clear investigative principle) designed to fill gaps in some body of knowledge (the source of theoretic problems). Curricular problems call for a radically different mode of operation (the practical mode) whose subject matter (the specifics of learning situations) and outcome (decision leading to action) are linked by deliberation about the actual state of affairs in a learning situation.

The Quasi-practical

If the practical mode is to serve as the language of curriculum planning and as the framework for effective decision-making, its sphere of operation is a limited one. By this I mean that, if the particularities of an educational situation are to be fully investigated by the deliberative framework available to the practical mode as envisioned by Schwab, the scope or size of the educational situation must be limited and localized. The complexities associated with all of the factors (the commonplaces of teacher, student, subject matter, milieu) involved in the teaching or learning of one subject in one school are sufficient to occupy the investigative attention of curriculum planners for some time.

It may well be the wiser approach to limit the scope of such investigations and deliberations to relatively small and localized situations. Such a limited scope might be possible in the case of independent or private schools, each of which is relatively autonomous. However, the actual interdependencies and connections as found within a single public school system, not to mention those between public school systems, substantially reduce the effectiveness of a curriculum that fails to make adequate provision for elements of heterogeneity in its deliberation. What might be the sources of such interdependencies and connections that give rise to elements of heterogeneity? We can begin with the more obvious ingredients of teacher and student populations showing considerable internal diversity (i.e., within any given institution) as well as comparative diversity (i.e., between institutions). What might be some manifestations of diversity? In matters educational, it is easy to mention the academic backgrounds and professional experiences of teaching staff, the scholastic and social preparation of the students, and the respective value systems adhered to by the individuals in each population. We can add to this basic list of elements of heterogeneity other evidence of diversity encountered in school systems: special programs, competitions, 'feeder' schools, teacher transfers, school reputations, school ratings across a school board.

Schwab proposed the quasi-practical mode with this in mind. The quasi-practical concerns the need for common policy, relations among parts, and the influence of one part by another. In essence, the quasi-practical mode would incorporate all of the practical mode and add two qualifiers designed to fit the practical mode into a larger scale of curriculum planning. One qualifier would concern the process of decision-making: variations among the teachers, students, milieux, and subject matter content should be identified as carefully as possible and the effects of curricular decisions should be rehearsed imaginatively so as to include the previously identified variations, "cherishing diversity" all the while. Of the two qualifiers, this is quite possibly the more difficult both in investigative skills and demands on the imaginations of curriculum planners. The qualifications and range of experience of teachers, the academic, emotive, character and interest developments of students, the school and community cultural and value patterns (and likely a host of other factors including economic and political elements) provide a panoply of variations that only increase in number and variety whenever the scope of investigation is increased. However, diversity cannot be respected unless it is first acknowledged and identified. And curricula cannot be successfully implemented unless their planning stages have included an active respect for the diversities of the eventual learning situations.

The second qualifier would concern the actual formulation of the curricular decisions. The more remote the curriculum planners are from the planned-for classroom (as would likely be the case in planning for a school system as opposed to planning for a single classroom or one subject in a specific school), the less should their eventual decisions be formulated as directives. This is because the larger scope of the curriculum planning cannot realistically include as detailed a consideration of the curricular problem as in a more limited scope; there must be some allowance for a delegation of decision-making powers. That is, the ultimate curricular decision must be left in the hands of those at the teaching level. Curricula that consist of a series of directives or orders, or that are frankly teacher-proof, ignore in one stroke both the role of the teacher and the unavoidable diversities in actual learning situations. Such then is the rationale for and brief description of the quasi-practical.

The Eclectic Mode

The eclectic mode rounds out the trio of interactive modes of operation in curriculum planning proposed by Schwab:

> [This] third mode of operation commended to curriculum - the eclectic - recognizes the usefulness of theory to curriculum decision, takes account of certain weaknesses of theory as ground for decision, and provides some degree of repair of these weaknesses.[18]

The eclectic mode acknowledges the ways in which theoretical considerations can be of use in curricular decision-making. The pragmatic value of the use of theory is two-fold and each aspect represents a device of convenience for the curriculum planner. First, each theory constitutes a body of knowledge presented in some limited number of assiduously developed postulates. Access to theories is then a considerably shortened route to knowledge that has already been thoroughly and painstakingly constructed and supported by groups of scholars. Secondly, theories develop terms and distinctons which can be employed in developing emphases, developing contrasts and similarities and in general, serving as key linguistic and conceptual devices for communication among all those involved in curriculum planning.

However, there is a price to pay for such convenience and accessibility. Sufficient notice is to be taken of the partialities of each theory; otherwise, the resulting conceptual distortions and misunderstandings will be reflected in inappropriate curricular decisions. Reference can be made to those disciplines in which a number of theories compete for attention (such as the varied theories within the respective social and behavioural sciences), and to the content of these competing theories. The discipline of sociology with its competing theories of functional structuralism, radicalism, and symbolic interactionism is as profitable an example as any other. What will be noted is the unequal treatment given by each theory to crucial aspects of the entire field of study. Where one sociological theory dwells on the structures of society as if they were independent of the minds and individuals who constructed them, a second emphasizes the deterministic role of economic power, and a third, the fundamental and often hidden role of the individual's constructs regarding the self and the environment. Each 'explains' the functioning of society, and each explains it differently or with different emphases.

The partiality of theories is also reflected in the separateness of subject matters as studied by each discipline. Even though the general subject matter of both psychology and sociology is the human being, each discipline emphasizes only one (and a differing) set of characteristics about the totality of human beings in its scope of study. A curriculum grounded in the theories of only one discipline necessarily neglects the contributions of the other disciplines and provides a partial and, in that sense, distorted view of the learning situation. It is possible then to foresee how this would be even more so the case when a single theory is chosen to provide the guiding principles for curriculum design. The tradition of a priori grounding of curriculum planning in a single theory or discipline may well be one of the major causes of failures in curriculum implementation and, in consequence, a major cause of a serious decline in the tasks proper to the field of curriculum.

By overtly recognizing "the usefulness of theory to curriculum decisions" while also taking "account of certain weaknesses of theory", the eclectic mode is proposed by Schwab as a vehicle for theory use in curricular decisions because it also "provides some degree of repair of these weaknesses".19

Knitter agrees with Schwab that deliberation compensates for the partial nature and incompleteness of any one theory used by curriculum specialists in proposing new curricuila or modifying (reforming) existing ones.20 Adherence to any one theory is accompanied by adherence to a limited, paradigm-determined set of principles, principles which direct the scope of investigation, the interpretation of data and the possible range of conclusions. The different behavioural sciences function under the direction of different paradigms, and even within each branch of the behavioural sciences there are usually different sub-paradigms (giving rise to different schools of thought). Because the conditions or constraints of scientific inquiry require the separation of a field of study, e.g., human behaviour, into smaller and less complicated units of study, the resultant conclusions and theories will reflect only the concerns of that smaller unit of study. If specialists, interested in the application of these conclusions, view these as definitive for all of the larger areas of study, then confusion, mis-directed solutions and frustrating results can only be the consequences.

Deliberators are faced with decisions about theory applicability and usefulness in specific educational settings, decisions that are informed by an acknowledged understanding of the 'borrowed' nature of theory-use as well as the incomplete and fragmented view of each theoretical subject may encourage curricular decisions that enhance rather than disrupt teaching and learning. It becomes evident that Schwab's strong case for the <u>eclectic</u> uses of theories in curriculum deliberation is specifically <u>because</u> of objections to uninformed reliance on a single theory:

> A curriculum grounded in but one or a few [theories] is indefensible; contributions from all are required.[21]

Even though this pluralistic alternative is "unsystematic, uneasy,... and uncertain", the possible "unions and connections which can be effected in an eclectic" approach compensate well for the incompleteness and partiality of each theory taken separately.[22]

The central argument has now been completed. The practical mode, while basic to a re-ordering of principles in the field of curriculum, is effectively extended by the quasi-practical mode, and both can be connected to accumulated bodies of knowledge through the eclectic mode. Schwab's view is that this restructured framework for curriculum planning should permit curriculum specialists to resume the tasks associated with curriculum planning (tasks specific to the field of curriculum) and thereby stimulate advances in the field of education as well as a renascence in the field of curriculum.

<u>Summary of the Central Argument and Supporting Arguments</u>

The central argument in Schwab's thesis is as follows: a renascence of the curriculum field is possible if the energies of the curriculum specialists and their colleagues are concentrated on three neglected 'modes of operation', entitled the practical, the quasi-practical and the eclectic.

The supporting arguments fall into two categories. The first category emphasizes the difficulties within or problematics of the curriculum field and contains two arguments: (a) the avoidance of curriculum planning activities by curriculum specialists is evidence of "crises of principle" in the curriculum field, and (b) the theoretic mode traditional in curriculum planning is inappropriate to this task. The second category describes the potentials of three modes of curriculum planning that are projected as an alternative to the theoretical mode: (a) the appropriateness of the practical mode to the solution of curricular problems, (b) the usefulness of the quasi-practical mode as an extension of the practical mode, and (c) the usefulness of the eclectic mode within the rationale of the practical mode.

In the next chapter we will be taking a closer look at Schwabian deliberative enquiry as process. The broad outlines of this process will be described as envisioned by Schwab. This is done with two purposes in mind: (1) to provide a fuller exposition of the Schwabian deliberative enquiry style, and (2) to provide a prelude to the later application of the deliberative enquiry framework to a specific and current curricular problem in science education.

CHAPTER 3

DELIBERATIVE ENQUIRY: ARTS OF THE PRACTICAL AND ARTS OF THE ECLECTIC

Focus of Chapter

The focus of attention in this chapter is the deliberative process itself, as proposed by Schwab. Two varieties of deliberative arts will be described and discussed. They are entitled by Schwab: arts of the practical and arts of eclectic, and are designed to encompass both the theoretical and practical components of curricular deliberation. Schwab's use of the term 'arts' in referring to these two aspects of the deliberative process, emphasizes the fact that the arts of the practical and arts of eclectic cannot be reduced to generally applicable rules of procedure. Rather, they are viewed as a framework of interrelated phases in which the curricular enquiry takes place and "in each instance of their application, they must be modified and adjusted to the case in hand".[1] This modification, adjustment, and mutual accomodation is the artistic element.

Schwab is also concerned that proposed curricula be defensible. Deliberation about public policy may easily entail a proposal that is expected to be defensible. What might constitute such a defense? The deliberative process, as essential to the practical mode of curricular deliberation, would contain explanations and justification of decisions taken. In this way, defensible curricula can be developed by using essential features of the deliberative process itself.

Even though I will be drawing principally on Schwab's work, I will also be turning to several other valuable sources contributing to the curricular field.

Defensible Curricular Deliberations

Schwab reminds us that "a defensible curriculum must be one which somehow takes account of all sub-subjects which pertain to man."[2] Since one grand education theory is not foreseeable, and since educational problems exist in the here and now, often pleading for solution, some pragmatic solution must be sought, even if the solution cannot be certain or easy to implement.

Defensible curricular changes require defensible and practical curricular deliberations. Gauthier cogently argues in favor of deliberation when public policy must be formulated and enacted. Deliberation, in his view, is the best approach when decisions must be made concerning things in our power to do but about which there is no exact knowledge. Deliberation is valued by Gauthier because it both "offers an explanation of the (chosen) action" and "a justification of the action".[3] The explanation and justification together provide a defensible rationale for the chosen action. Deliberation can provide an accounting of terms and reasons that leads to an understanding of decisions taken and that substantiates the soundness or worthiness of the reasons underlying those decisions.

Schwab offers an approach to curriculum deliberation that requires a studied analysis of practical advantages and disadvantages to all curricular elements of any proposed change. <u>The Practical</u> can then be understood as a proposal for deliberation. The arts of the practical become the collective arts of group discussion about public policy matters, discussion that is neither inductive nor deductive in nature but rather eclectic or deliberative, determining relevant facts and desiderata, generating multiple solutions, suggesting possible consequences for each solution and ultimately deciding on a single but flexible course of action, given prevailing and local circumstances. He notes that concrete curricular cases invariably involve an array of principles (in turn connected to different theories) and may even evidence characteristics not found in any existing principles or theories. This has prompted him to write:

> The [arts of the practical] are arts which supplement theory, which do for practice and the charting of practice what theory cannot do. The eclectic arts are arts by which we ready theory for practical use. They are arts by which we discover and take practical account of distortions and limited perspective which a theory imposes on its subject.[4]

But this very general statement of the role of each of these categories of arts is not enough. We can now procede to a fuller description of the arts of the practical and the arts of eclectic.

<u>Arts of the Practical</u>

If one were to list the phases of the practical arts, the list might have the following appearance: (1) perception, (2) problemation, (3) problem-choosing, (4) solution-formulation, (5) rehearsing, (6) solution-choosing, (7) reflection. Each of these deliberative phases requires some description in order to be understood and appreciated within the larger enquiry process.

1. <u>perception</u>: taking note of the range of the particularities or details of a given situation within which a perceived problem is located and looking at these details from as many different perspectives as possible ("irrelevant scanning...through a succession of lenses").

As an interim measure and solely for the sake of illustration, it might be instructive to locate the practical arts within the context of a limited educational situation, that facing the replacement teacher. Replacement teachers often experience a general sense of malaise among students shortly after announcing the assignment that the permanent (but now absent) teacher left for the class of students. This malaise often precedes some display of disruptive behaviour by a minority of students. As part of the arts of perception, a succession of lenses for scanning this situation might elicit questions similar to these:

- What atmosphere tends to prevail in school: traditionally disciplined? teacher-centered? student-centered? some permutation of these?
- Has the teacher been introduced to the school's extra-curricular and tutorial activities for the day (which often take place during class time)?
- What is the socio-economic status of the school community?
- What is the pattern of reception by students of replacement teachers?

- Does the school administration share actively in the replacement teacher's responsibilities?

The application of such a succession of lenses antecedes any attempt at problemation.

2. problemation: ascribing of possible meanings to the above details, and their arrangements into possible problem propositions or formulations. Reid suggests that these processes of what he terms practical reasoning, are best found "where group members are in sufficiently prolonged contact to be able to engage in the [problem] discovery process".6

Let us return to the instance of the replacement teacher and pursue it a bit further. Normally, repeated exposure to a single school population is necessary before constructive meanings can be attached to perceived details of a given classroom situation. If the replacement teacher becomes defensive when students prefer to ignore the assignment during class time, only one collective meaning has been given by the teacher to the care-free or 'disruptive' behaviour of the students - that of disrespect for or even indirect attack on the teacher's professional status. This may be the actual case, but it is by no means a certainty as a first and only possible meaning. It is counterproductive to impose a meaning on such a situation. Premature formulation of the problem tends to prevent the discovery and ascription of meanings that would in time evolve out of the problem situation.

3. problem-choosing: involves the gauging of a variety of problem propositions and the selecting of one to carry further.

A variety of problem propositions could present themselves in the replacement teacher's situation: it is the last period of the school day and the attention span of the students has been exhausted; past experience tells the student that the assignment will not be corrected by the regular teacher; the permanent teacher has not, as a rule, required seat work from these students, i.e., seat work is always optional as long as the assignment is ready by the next class; a mistake has been made and an inappropriate assignment left for the class; group decision to test the replacement teacher's limits; test scheduled for these students and review questions are now impossible because of the regular teacher's absence. These are all possible problem propositions. Some questioning of students in the class should help to eliminate some of the problem propositions; and, in general, a testing of problem formulations by gathering of facts is called for.

4. solution-formulation: the production of various solutions related to the chosen problem.

Solution-formulations are to be as extensive and imaginative as possible always keeping in mind the need to implement them in a practical setting involving pedagogical materials and devices, teachers, students and total milieu. This is by no means an easy task. The temptation to interject a theoretic and favoured solution is always present along with the desire for early closure just to get on with the jobs of teaching and learning. Some discussion with students coupled with the replacement teacher's past experiences, may point to a limited range of temporary solutions. Discussion with the permanent teacher, other teaching staff and the administration will likely provide a larger range of solutions that might be implemented within the given school context. Four tentative solutions come to mind in our example: students are given maximum choice to do homework, socialize, use the library, etc.; students must choose <u>some</u> form of <u>individual</u> desk work; students must do some form of desk work but may do so in cooperative groups; students must leave assigned work with the replacement teacher.

5. <u>rehearsing</u>: imaginary paths are traced between the varying solutions and their effects or consequences. Solution formulations have value insofar as the potential effects of implementation are desired and are of educational importance. Familiarity with the educational context, as the result of information issuing from the preceding phases of the deliberation, would facilitate a more realistic tracing of such imaginary paths. Schwab would find Stenhouse's "educational imagination" useful: "the capacity to visualize with verisimilitude imaginary classrooms and to pre-test ideas in them in one's mind".[7] Some rehearsal of classroom consequences is normal before any attempted implementation of any solution. The replacement teacher is still faced with an imaginary testing of the proposed solutions, trying them out within the boundaries of past experience and present school context.

6. <u>solution-choosing</u>: involves the gauging of multiple solution formulations and the selecting of one to implement on a trial basis. The solution formulation would be appraised or judged against the elements of the educational context that came to light through the deliberative process.

It is possible that one of the solution formulations meshes particularly well with the total school context and the replacement teacher's pedagogical repertoire. This then becomes a good candidate for classroom trial. For example, many student-centered schools would find individual, isolated desk work onerous and would encourage cooperative work during class time, leaving it up to the replacement teacher to regulate the level of vocal cooperation.

7. reflection: involves the considered and collective judgements closing, at least temporarily, each phase of the above arts of the practical.

If anything is clear, it is that different people will approach the same curricular situation in different ways, i.e., through the perspectives of subject matter, learner, teacher or milieu. It is essential then that there be a reflective examination of each of these different approaches. Relativism and polarity are easy temptations and must be actively discouraged. The value of this mode of enquiry lies in the systematic discrimination of an extensive and adequate variety of alternatives at each phase of deliberation. Understanding and valuing the functional nature of the formulation of alternatives at all levels of curricular discussion will permit the participants to explore more profitably the parameters of curriculum decision-making and preclude the pitfalls of polarity and relativism.

These initial descriptions of the phases of the arts of the practical will be complemented, in succeeding chapters, by further discussion and utilization in the working through of the science education problem of scientific literacy. We can now turn our attention to some beneficial and serviceable extensions to these phases of Schwabian deliberative enquiry.

Suggested Extensions

As an extension of the deliberative process as proposed by Schwab, Roby would want to add to Schwab's phases of practical arts, the "arts of reflexive criticism" and the "arts of review and revision". The former set of arts suggested by Roby would include self-analysis regarding the "preconception of what (the deliberators) think the situation should be and what solutions they would prefer because of their own previous experience" in order to mitigate somewhat the emotive elements of the same preconceptions.[8] The concern is that preconceptions regarding problem- and solution-formulations may serve to retard progress through the phases of deliberative enquiry.

The example of the replacement teacher's difficulties can be used again, in this instance to indicate the value of Roby's suggestion. The teacher's previous experiences are charged with varying levels of commitment, personality, preferences and other emotive elements. A willingness to expose these elements opens up the possibilities of forging connections with other unique sets of previous experiences. A practical language of classroom experiences is not easy to initiate; resort to theoretical formulations tends to be preferred and is safer for the teacher.

A second and quite different example may be more applicable to a deliberative context. An educational researcher investigating the effectiveness of teaching, using the Flanders interaction analysis instrument, has a prior commitment to the usefulness of this instrument; it is not the instrument that is being investigated but the effectiveness of the chosen teaching episode, strategies or event. Nonetheless, the validity and reliability of the instrument should be defensible, in terms of both teaching behaviour and learning by students, and not only in terms of observer training and deductions from psychology theory. Commitment to this form of educational research entails not only an intellectual justification but also an emotive support system. Both would seem to be major aspects of the researcher's total stance. Roby would look for a willingness to expose these thought processes and emotive supports to a critical examination. Self-analysis is not viewed by anyone as an easy process. Probing questions from fellow deliberators should expedite the proposed self-analysis. Perhaps, specific analysis schemata will be developed over time, unique to each group of deliberators. Roby's concern seems to be that the emotive elements implicated in every research stance may camouflage the research pre-conceptions. Unless the latter are reasonably clear to the deliberating group, real progress in deliberation is undermined.

The second set of arts suggested by Roby as an extension of the practical, is designed as a continuous system of solution-evaluation or backtracking. The purpose is

> to discover whether the attempted solution is working, to rectify errors in its formulation and execution revealed through further experience of problem situations, and to connect the efforts to solve the formulated problem in the situation with other problems in the situation.9

It would seem that such a system for encouraging re-evaluation of decisions taken and backtracking among the phases of the practical is well within the spirit of Schwab's deliberative enquiry. Such a fluid factor serves to provide cohesiveness and reasonable progression among the process steps. The temporary nature of the judgements closing each phase of the arts of the practical is acknowledged openly and consistently.

Roby's suggestions for extending the arts of the practical by including these additional phases seem to be particularly promising since they emphasize two of the more revelatory and serviceable characteristics of deliberative enquiry, that of introspection and backtracking.

Interim Summary

The highlighted process phases of the pracical as discussed so far might be collapsed as follows: (1) perception of problematic situation, (2) problem formulations, (3) solution formulations, (4) reflexive criticism, and (5) continuous backtracking.

A closer look will now be taken at the proposed phases of the arts of eclectic within the deliberative process. The arts of eclectic are phases concerned with the considered use of examined theory within the deliberative framework of the practical mode of curriculum planning.

Arts of Eclectic

Arts of eclectic include a pair of somewhat distinctive and open-ended phases of discussion: (1) revelation and (2) reconciliation. As was done with the phases of the arts of the practical, these two phases will be described and located within the deliberative enquiry framework.

1. revelation involves (a) the identification of terms in theories and their relationships in each theory; and (b) the use of these theoretical terms and their relationships to point out the areas of incompleteness or partiality in theories from the various appropriate disciplines or schools of thought, with a view to avoiding 'tunnel vision' and early closure of the deliberative process. As was already indicated in Chapter 2, difficulties arise in the world of education when attempts are made to apply theories in an uncritical manner to the particularities of a specific educational setting. Schwab would caution deliberators about forcing the mold of any theory onto the unmoldable character of the specific, the particular. More demanding, but ultimately more productive for education, is the critical evaluation of the theory's adaptability and suitability to the particulars of the educational instance.

Identification of terms and their theory-bound relationships, the disclosure of incompleteness and partiality of each discipline and alert probing of theory-derived contributions should expose all theories to the same basic questions of validity and relevancy to educational particularities. If one is alert to the presuppositional framework, specific methodologies and principles of each discipline, one is in a better position to realize both the powers and limitations of the theories which we use to help resolve educational problems. Informed selection, adjustment or combination, as discussed under arts of reconciliation, is the more helpful stance in deliberation.

Knitter has argued clearly and effectively about the need to "focus on the use and status of theory" in curricular deliberation and that

> a critical pluralism and associated arts of eclectic are essential to curricular deliberation. A pluralistic or eclectic use of theory is essential to deliberation in the sense that deliberation is enriched by examination of problematic situations from a variety of perspectives.[10]

On the one hand, it is the nature of theories that each has been developed from a discrete unit of the living or non-living world, a unit that has lent itself to some form of investigation as to structure and/or function. On the other hand, it is tempting to interpret the partiality of the theory as a totality, as an explanation of the total subject matter investigated:

> Our most specialized, most codified, knowledge is knowledge of parts of situations, not of wholes;

and yet

> we have a tendency to confuse our limited description of goods with good on the whole.[11]

Only when the principles or theories are viewed in full power can they also be viewed in their partiality:

> Principles do have a palpable effect (on all procedures) and...along with the selectiveness of perception that makes for a principle's power goes a set of limitations involving facets of problems that will be slighted or altogether overlooked.[12]

Following on this, Knitter advocates the desirability of becoming more

> aware of the emphases, as emphases, of the views we use, of the conditions of their operationalization, and of some of the important problems and issues which are underplayed by different views.[13]

Expertise is to be valued, but the valuation can lead to inattentiveness to the proper limitations of the expertise. Knitter reminds us that

> the subjective feeling of security which derives from our firm control of a relevant, but narrow, piece of knowledge can be delusive.[14]

Tunnel vision, i.e., the viewing of a "narrow piece of knowledge" as sufficient for decisions in complex educational matters, can be avoided when there is an understanding of the nature of theory. One aspect of the nature of theory is its partiality. Even though this aspect of partiality has been more fully described in a previous chapter, it is in the arts of eclectic, that we are reminded of its place in the framework of deliberative enquiry.

A clarification of the degree or type of incompleteness and partiality associated with the selected theories could be done by indicating the postulates that structure each theory and then identifying the meanings of the terms forming these postulates and their interrelatedness. Competing theories from a single discipline may be selected for such an analysis and clarification or, conversely, certain particularly appropriate theories from different disciplines may be selected and examined. In either event (or some other combination of selection processes), similarities and differences in terms and meanings may be noted.

This brings us to the second phase in the arts of eclectic, that of reconciliation. Reconciliation involves informed selection from, adjustment of, or combination of theories, with a view to reconciliation with the particularities of the educational situation under enquiry. This follows the open and polyfocal consideration of as many disciplines and schools of thought as possible, relevant to the proposed educational problem and solution.

Three considerations should be kept in mind in this phase of reconciliation. The first is that whatever internal weaknesses, deficiencies or problematics exist inherent to the theory itself (such as those based on methodology, validity, reliability, conceptual clarity and logic) may certainly be questioned but cannot be remedied, if remedies are desired or required, by devices characteristic of the eclectic mode. The second consideration is that the eclectic mode would be applicable only to those theories selected as appropriate to educational and specifically curricular matters insofar as they share some degree of incompleteness and partiality, which are, in that sense, external weaknesses. The third consideration is the improbability that the 'repair' can ever be so effected that the initial incompleteness and partiality of these selected theories will be completely obliterated or that some grand unification of a collection of incomplete and partial theories will result in a truly complete and whole theory appropriate to all things educational. If these three considerations are kept in mind, a clearer understanding will be possible of Schwab's proposed vehicle for the 'repair of the weaknesses of theory'.

When reference is made to contributions of theories in deliberative enquiry, there are two assumptions upon which the participants in the deliberative process tend to agree. Firstly, the theories may well come from disciplines that are only tangentially directed to educational matters as they exist in the world of schooling. The discipline of psychology can serve as a representative example here.

In psychological research, the more common human educational settings are notoriously difficult and frustrating to study for any researcher. If psychology research journals are referred to, certain clear tendencies will be noted: researchers will report findings derived from the more manageable settings of animal learning experiments, case histories of those who are ill or impaired, and the controlled, observer-designed studies of healthy human subjects whose behaviour has been directed to accord with the design of the study. What will be difficult to find are studies that tell us about the learning situation <u>within the complexities</u> of schooling.

A second assumption must be included here: the results of research (referred to above) can be validly extrapolated to the variety of normal settings for human learning. It would be well, however, to keep firmly in mind the constraints of such extrapolations, constraints that are directly linked to the paradigms of research in psychology.

If theories from behavioural sciences are to have any place in the deliberative process regarding educational matters, these two assumptions would seem to be necessary, since there is no equivalent theory (or theories) derived from education itself. But is this to be an uncritical acceptance, an unquestioned interjection of 'borrowed' theory into educational matters? Schwab would insist on a disclosure and examination of the discipline's presuppositions and principles underlying its methodology and theory structure. It is in the light of such an understanding of a theory's inner workings that its contributions to education can be critically assessed.

The process of identification and clarification in the revelation phase of the arts of eclectic can provide substantial support for decisions regarding the appropriateness of specific theories in curricular planning. Decisions about the appropriateness of a serial usage of theories (i.e., two or more competing theories located in one discipline) or a conjoint usage of theories (i.e., two or more theories selected from different disciplines) can then be made with a minimum of violence done to either the theory or the practicalities of the curricular problems.

Three possible types of outcome of deliberation using the arts of eclectic can then be envisioned. One type of outcome could result from an informed selection from or adjustment of a single theory that is considered most appropriate to the solution of an educational problem. A second type of outcome could result from a serial or conjoint usage of theories, usage that shows informed selection from, adjustment of, or combination of multiple theories. These two types of deliberation outcomes effectively result in a single 'best' solution based on considered judgement. A third type of outcome would result in a set of solutions, all of which share the characteristics of being informed and appropriate alternatives, awaiting only deliberative evaluation subsequent to implementation in order to reach a 'best choice' decision.

Concluding Remarks

This, in cursory outline, is the flexible format that Schwab's deliberative enquiry calls for when using the arts of the practical integrated with the arts of eclectic. The description of the arts of eclectic can also serve as a summary of some of Schwab's concerns about the unexamined use of theories in curricular deliberation and his recognition of the valuable role of informed, polyfocal theory-use.

Underlying the discussions about deliberative enquiry are two principles that are crucial to a fuller understanding of deliberative enquiry as useful to the resolution of curricular problems. These two principles focus on the nature of curricular problems and will be the main concern of the next chapter.

A second issue in the next chapter is a consideration of an appropriate format for deliberative enquiry, i.e, group vs. single-person deliberation.

CHAPTER 4

PRELUDE TO DELIBERATIVE ENQUIRY: THE NATURE OF CURRICULAR PROBLEMS AND SINGLE PERSON DELIBERATION

There remain two principles linked to Schwabian deliberative enquiry that I would like to highlight in this chapter. These are principles that have already been alluded to in previous chapters and that will help to guide the work of the later chapters. They emanate from the nature of curricular problems when visualized as (1) essentially contested concepts, and (2) uncertain practical problems. The discussion of these principles will serve to forecast some of the concerns and focus of the deliberative enquiry that follows.

In addition, a recommendation regarding institutional consultation will be discussed as a prelude to the exposition of the scientific literacy problem.

Curricular Problems as Essentially Contested Concepts

"Some ... failure is inherent in the character of practical problems. They are never solved completely or once and for all."[1] This is an assumption made by Schwab and others, and one in which this writer concurs. Curricular problems are essentially contested concepts. Debates and arguments continue endlessly. Because of this, skill, vigilance, fortitude and probity are the accoutrements of public policy deliberators.

Knitter brings to light the perspective of curricular problems as essentially contested concepts when he points out the legitimacy of argumentation and deliberation resulting from the presentation of multiple and contested concepts.[2] Argument or debate is then seen as enabling an exposition of the innumerable factors that are inherent to these 'enduring problems', enduring because of the continuously changing variables that provide the context in which these 'enduring problems' must be studied and debated.[3] A brief listing of some of these variables would serve as an indication of the complexity of the context of any significant educational problem: economic, moral, political, community, religious, technological, scientific, personnel, precedent. Aiming for a "<u>modus vivendi</u>...which offers a reasonable balance of the various competing factors which are part of the problem" (and part of the solution) is, according to Knitter, the best approach.[4] Each of the competing approaches might, understandably, lay claim to rationality as well as philosophical and scientific justification. To presume that any of the protagonists would willingly admit to egocentricity, insularity, premature solution-closure, or moribundity in thought and habit, would be somewhat naive. The will is not enough, no matter the good intentions, to provoke detachment from habits and thought-patterns of long-standing. Not only, then, <u>will</u> there be competing positions but it is <u>essential</u> that there be contestation. Short of some 'provocation', the protagonists stand little chance of voluntary accommodation. Contestation is a vital, healthy and essential aspect of deliberation.

Perhaps all of education's curricular problems should be viewed as 'enduring problems', which seems to place an appropriate emphasis on the practical impossibility of solving once and for all curricular problems. On the other hand, when a decision is what is wanted in curricular matters, some closure of deliberative enquiry is justified, even if this closure is merely tentative. Because such a curriculum decision involves theoretical as well as practical considerations, there must be a recognition of the limited truth, trustworthiness, and warrantability of such decisions. Only long-term experience with decisions in action can provide any evidence of the effect of such decisions as well as acceptance of the essential limitations of such decisions.

It must be emphasized that closure of deliberative enquiry in curricular matters serves its purpose best when avowedly tentative. Roby makes this even clearer when he writes that the

> requirement that curricular deliberation in schools be ongoing and continuous may seem extraordinarily burdensome. The reverse, however, is the truth. It is the stop-start again character of impeded deliberation which is the most burdensome.[5]

Reinforcing Roby's position is the view, discussed above, of curricular problems as essentially contested concepts. Once it is accepted that curricular problems, no matter how ably discussed and resolved, will "never be solved completely or once and for all", proper consideration can be given to a deliberative framework facilitiating ongoing readjustment and modification of the originally tentative solutions.[6]

Curricular Problems As Uncertain Practical Problems

There are important connections that can be made between the perspective of curricular problems as essentially contested concepts and the perspective of curricular problems as uncertain public policy problems.

The one can be seen as focusing on the nature of the curricular solutions (no absolute, definite, once-and-for-all-time solutions) and the other on the justification of those same solutions (with their fallible and disputable sources of arguments). Curricular problems are enduring problems which can only be dealt with by a series of ongoing and temporary solutions, due to a "variety of competing and variable factors" which make any other approach unrealistic and unworkable in the short or long term. At the same time, it is of value to understand the type of explanation and justification that supports the formulation of such ongoing and temporary solutions. While Knitter kelps us to gain a better understanding of curricular problems as enduring problems, Reid points to the uncertainty that inevitably surrounds the bases for decisions about curricular problems.

Reid's contributions to this perspective are both interesting and valuable, particularly in helping to differentiate uncertain practical problems with their prudential and moral characteristics from procedural problems which are amenable to solution by research or computational methodologies.[7] When curricular problems fall into the former category (and admitting that solutions are relative to circumstances) only practice coupled with good to superior powers of practical reasoning and a willingness to accept solutions that are possibly temporary or even frankly 'trial', will give the participants a chance to succeed.

Public policy problems, as viewed by Reid, fall into two general categories, those arising from gaps in knowledge and those involving decisions about action. The former are labeled 'theoretic' and will be approached through the paradigm-determined methodologies of those disciplines whose orientation is towards the filling of gaps in general knowledge. The latter category of problems is labeled 'practical' following the convention that joins the resolution of problems to an action-oriented decision. However, Reid discriminates between two possible routes leading to the resolution of practical public policy problems: the procedural and the uncertain. The procedural route can be identified by its deductive methodologies and its use of objectives as guidelines. The uncertain route has recourse to neither of these techniques. Instead, it relies on a context-centered approach (vs. goal- or methodology-centered). The basic schema of public policy problems that has just been introduced can be presented as follows: (brief supplementary statements accompany each level in the schema and should lead to rough discrimination of the same)

PROBLEMS

malaise due to knowledge gaps
or indecisions about action

PRACTICAL — THEORETIC

action-oriented — knowledge-oriented

PROCEDURAL — UNCERTAIN

objectives/methods
deduced from goals

uncertainty about action;
highly conditional

PRUDENTIAL — MORAL

single-agent-centered
(wants, needs, etc.)

group-centered

It will have been noticed that the category of 'uncertain' public policy problems is subdivided by Reid into 'prudential and 'moral' sub-categories. Curricular problems, tending to be group-centered, would fall under the 'moral' category with all of its social and value-laden ramifications. Value-laden decisions for action (e.g., curricular decisions) must first and foremost respect the individuals who are directly affected. Reid maintains that insistence upon the ends of education as immutable (and as if they were equivalent to procedural goals) prevents contemplation of the learning/teaching processes as replete with uncertain problems.

Philosophical terms linked to human nature and education, can help us to be aware of the 'uncertain' nature of curricular problems:

> In cases where decisions have to be accepted that intimately affect the way of life for whole communities, it seems highly unlikely that any scientific approach could reflect the complex and varied conception of human nature.[8]

Curricular decisions, then, since they may well "affect the way of life for whole communities" ought not to be simplified through procedural techniques; the goals of education cannot be made to resemble the role of procedural goals.

Reid goes on to indicate some features that he argues are characteristic of uncertain practical problems, of which he takes curricular problems to be a subclass. A first characteristic concerns the formulations that typify solutions to uncertain practical problems: the solutions are couched in action terms, i.e., it is proposed that such and such be done. In addition, the action is designed to occur within a reasonably short period of time (months to a few years). This characteristic places uncertain practical problems well within Reid's schema of public policy problems, under the practical level of problems; it does not, however, differentiate uncertain and procedural problems. Nonetheless, this classification level focuses on the action-oriented nature of all practical problems. Reid's argument, at this point, is then one of emphasis. Unless and until curricular problems are considered by curricular planners as action-oriented, entailing a clear commitment to both stance and action following from this stance, problems will remain unsolved or poorly solved. This by no means excludes either a search for practice-grounded knowledge (while accepting the constraints of a 'lived' situation as opposed to a contrived or laboratory situation) or the need to select from within the cornucopia of theory-grounded knowledge, those propositions and guidelines most appropriate to the curricular problem. The theoretic, then, can participate in the practical, but does not contain the question that needs to be answered.

This first characteristic does not help to differentiate uncertain and procedural problems. Reid proposes a second characteristic that sheds light on the need for a distinction at this level of public policy problem-schema. It is expressed in terms that focus on the nature of the problem. Decisions about the nature of the problem and the choice of solution must be reached. With uncertain practical problems, the sources of arguments, reasons, justifications for such decisions are not self-evident. Nor are there infallible or pre-determined criteria for priority or precedence when selecting from a roster of arguments. Do psychological arguments carry more weight than sociological arguments when studying local curricular problems that inevitably find teacher and student in the same conflict-ridden arena? Do either one of these disciplines offer more valuable arguments than philosophy? Choices must be made. What remains uncertain is the best basis for such choices.

Schwab recognizes that the reduction of curriculum problems to procedural ones is an almost overwhelming impulse, an impulse based on certain traditions of rationalization, methodology and goal-setting, no matter the history of failed outcomes using comparable methods. Continuing from this point, Wick reminds us that rationality is not to be exhausted by scientific formulae and technology:

> While the concept of the technically practical is not very problematic, neither is it very interesting, for its scope is too limited to help us with our serious practical problems. At the same time, because it is not very problematic, and because it has a direct affinity with theoretic knowledge, it has tended to become the paradigm for all thinking about intelligence in action. To be 'rational' in any other way than by acquiring knowledge or applying it in seeking clearly defined but arbitrary goals has seemed impossible.[9]

Curricular problems exceed the limited scope associated with procedural problems. For the same reason, curricular decision-making processes cannot be deductive. No single partial principle (as located within a single theory) can be applied to a variegated practical problem. And even when two or more principles are appropriate, their acceptability is premised on the possibility of extracting the bits and pieces that actually help in problem-resolution from each principle. At the same time, there may even be aspects of the problem and solution that do not fall within the sphere of any existing principle.

A third characteristic of uncertain practical problems, as suggested by Reid, is linked with this feature of uncertainty regarding the choice of argument. The specific curricular problem is well located within a school setting enmeshed in a multitude of teacher-, student-, parent-, and administrator players, all of whom arrived at the present situation in some sort of historical sequence of events and personalities. In short, we can neither start afresh nor produce a laboratory-type model. The historical tensions, successes and failures are all part of the present problem, and there can be no effective control of variables.

As Westbury & Wilkof remind us in the introduction to the 1980 anthology of Schwab's major contributions to curriculum deliberation,

> curriculum is brought to bear not on ideal or abstract representations, but on the real thing, on the concrete case in all of its completeness, and with all its differences from other concrete cases, on a large body of fact concerning which the theoretic abstraction is silent.10

They caution us "to suspect distinctions and separations which remove the process of thinking from the experience in which they originated."11 Wick, likewise, focuses on the uniqueness of curricular problem situations when he writes that,

> it will not help much to think of our task as one making warranted assertions that such and such is normally the case.12 [my italics]

The theoretical abstraction to a 'normal' case removes the educational situation from its inherently multifaceted and unique context. Any discussion of curricular problems that fails to acknowledge the total context or to take it deliberately and productively under consideration, jeopardizes the applicability of any proffered solution and undermines the discussion process.

The next characteristic can be seen as either permeating all others or standing apart. It might be most simply written as the existence of conflicting aims and values. At all stages of discussion, some aims and values of the participants will be noticeably conflicting or at least in competition. Which aims and values are to be awarded precedence? Which aims and values are to be deemed the more worthwhile, the more appropriate? There is no technique for the homogenizing of aims and values. The need for judgements will have to be faced and judgements will have to be made and justified.

A last characteristic may, by now, be somewhat self-evident: the solutions are not predictable. The in situ outcome cannot be foreseen, nor fore-ordained. There are no guarantees. This is in sharp contrast with Reid's depiction of third level procedural problems which are quite simply problems that lend themselves to a behavioural or instructional objectives pattern of solutions. Easily observable behvioural patterns deduced from agreed-upon goals are the link between procedural problem and solution. There is no such empirical link between uncertain problems and tentative solutions. The major link in the latter type of public policy problems in education is the classroom teacher, but not as programmer (more of this aspect later).

So, where are we in our understanding of the type of public policy problem Schwab's The Practical is proposed to deal with? These problems need action-oriented solutions and are grounded in the matrix of unique school situations. Moreover, solutions are necessarily tentative since justification is based on adjudication of varying and competing arguments, goals and values, and implementation is mediated through teachers of varying skills and temperament, all within an ever-changing classroom context.

Group and Single Deliberation

There has already developed a small but intriguing set of papers exemplifying deliberative enquiry in varying dimensions and modifications. Fox offers an illuminating deliberation example in the form of a transcript of one practical protocol.[13] Even though there is a limited number of participants in the protocol-instance, it is certainly helpful to see an aspect of deliberation-in-action under the chairing skills of a curriculum specialist. Roby demonstrates how a one-person deliberation is able to make an acceptable and reasoned contribution to an exceedingly problematic and vexing local community college situation.[14] Pereira and Roby take this instance one step further by showing ways in which the skills and attitudes peculiar to deliberative enquiry might be effectively practiced by educationists who have one foot in the academic world and the other in the world of the local school and classroom.[15]

A number of cogent reasons can be put forth for the need of a deliberating group (vs. individual). Shulman suggests that one such reason is the role the group plays in "enlisting general commitment to changes agreed upon", and to stimulate maximum staff development.[16] But he does go on to argue the possibility of individuals thinking eclectically under proper circumstances. Shulman's argument supporting eclectic thinking coupled with the example of Roby's single-person deliberation have encouraged me to choose single-person deliberation concerning the problem of scientific literacy.

In what is to be hoped will not be a futile compromise between the desirable and the actual, I will call upon educational researchers, in the form of their public and professional writings to present problem-formulations and solution-formulations. I will attempt to act as expositor in such a gathering of specialists, all the while respecting the integrative and screening role of the educational commonplaces of teacher, student, content, and milieu.

It is also well to be reminded that there is no discussion pattern that can be pre-determined for the discussions in Schwabian deliberative enquiry. Its spiraling arrangement of problem-formulation, solution-formulation and continuous interacting feedback must be, in practice, random, free of procedural and theoretic constraints, and always responsive to the appreciations of the practical and local education situation.

Under these circumstances, I have welcomed advice from those more experienced in deliberative matters. The lack of fixed methodological direction and the difficulties of a 'different' justification (i.e., in contrast to the accepted procedural or theoretic justifications elaborated since the beginning of the century) may produce some discomfort in deliberators. Westbury responds to this potential discomfort by offering advice to curricular deliberators.[17] They would be wise, he feels, to have a number of well-honed skills and attitudes that combine flexibility with commitments. Westbury advocates the following for deliberators:

1. awareness of and familiarity with theoretical interpretations of education and its accompanying structures and resources plus willingness and ability to practice the Schwabian arts of the eclectic;
2. knowledge of specific teacher, student, subject matter and milieu interplays;
3. awareness of subject matter totalities available to schools;
4. familiarity with arts of the practical;
5. value commitments of deliberation must be apparent if only because education is essentially a normative concept.

If Westbury is being read correctly, he is advocating lots of practice in Schwabian deliberative enquiry. Good deliberators are formed through occasions of practice. Perhaps one outcome of the exemplification to come will be to show the need for such deliberation about any number of current curricular problems; there is no scarcity of curricular tensions in present-day public education.

Roby also offers some advice to deliberators. He suggests that certain reflective habits are useful to deliberation and that others impede the deliberative process. Habits, whether viewed as behaviour patterns or dispositions to action are invariable elements of the deliberators' modus operandi.

Some of the habits deleterious to deliberation may be summarized below: (a) the 'rush' to a solution, three type-examples of which are the pet solution, the global solution, the problem as the-absence-of-the-solution; (b) 'crisis consciousness', which sacrifices relevancy ~~to an~~ appealing and available pet or global solution; (c) two-alternatives thinking, as in the either ... or ... format; (d) inability of deliberators to share deliberation; (e) absence of backtracking, i.e., linear or vertical thinking patterns only; (f) avoidance of educational commonplaces; (g) absence of self-criticism.[18] In the single-person deliberation to come, it should be possible to notice and limit habits a), b), c), and f); evidence of this will be couched in the exemplification of deliberative processes in succeeding chapters. Habits d) and g) would seem better linked to active group deliberation. And this writer hopes to exemplify backtracking, at least in ways that lend themselves to expository prose.

Eisner agrees that Schwab doesn't ease the pain of curriculum decision-making.[19] Instead, he probably aggravates it, and Schwab, conscientiously, does seem to admit to that eventuality. If procedural security and ready conceptual acceptability are what is wanted, deliberative enquiry is to be eshewed. So much the worse for educators, would be Schwab's view. If practical usefulness and acceptability are what is wanted, however, deliberative enquiry just might provide them.

Schwab admitted to the "onerous and complex" nature of the practical but saw no other enquiry framework and style that would meet the demands peculiar to educational realities face-to-face with educational problems.[20] By using the framework of the practical, the enduring problems of interplay between theory and practice in education might benefit from a fresh approach.

Concluding Remarks

Willingness to practice the Schwabian arts of revelation and arts of reconciliation may well be the best way to pose and answer certain questions accompanying curricular deliberation. For example, questions regarding the role of procedural structures and objectives in curricular matters have been raised before by others and will likely continue to be raised by educational professionals. Such questions, receiving admittedly brief discursive treatment in this chapter, need the forum of active deliberative enquiry for anything approaching adequate responses. They have been raised here for two reasons: 1) to bring them to light as existing problem areas in any curricular deliberation, and 2) to indicate ways in which deliberative enquiry can provide an appropriate forum for responses.

In like manner, concerns about value-free discussion rhetoric need to be addressed. The arts of revelation, if adequately practiced, would expose and clarify existing values and biases, which can make communication a clearer and more productive task.

Lastly, this writer is in full agreement with Schwab and Shulman that deliberative enquiry likely works best in a group or committee style, and is a more appealing and ultimately productive format than single-person deliberation.[21] Notwithstanding, there might well be instances of single-person 'deliberation' that contribute to a more generalized deliberative exchange, by using expository prose forms instead of the give and take of active and local group discussions. It is in this spirit of investigation and trial that the remaining chapters of this thesis are presented. Schwab's deliberative enquiry framework presents a challenge that can only be ultimately validated if attempted, and practiced. And just as deliberative enquiry respects the particularities of local situations, so should it be able to work with local and individual skills, aptitudes and predilections. There is no idealized deliberative enquiry; there are only separate and sincere attempts at deliberative enquiry.

In the next chapter, I have followed Reid's invitation to place curricular problems within their appropriate historical contexts before proceding to decisions about the nature of the problem. The chapter will review the historical context of the curricular problem that is to be the focus of an exemplification of deliberative enquiry. As introduced in an earlier chapter, a major and current problem area in science education is the goal of scientific literacy. The remaining chapters will contain my efforts to reach a better understanding of the historical development of this goal, its nature, and its place within science curricula and school settings, all the while locating these discussions within the framework of Schwabian deliberative enquiry.

CHAPTER 5

SCIENTIFIC LITERACY: THE HISTORICAL DEVELOPMENT OF A CONCEPT AND A PROBLEM

Focus of Chapter

This chapter will confine itself to the historical development of a collection of concepts generally referred to under one title as scientific literacy. These concepts will be traced from their beginnings in science education literature to their current status in the conceptual paraphernalia of the science education professional. Even though the phrase 'scientific literacy' first appeared as a political slogan, it soon became translated into an educational slogan within the domain of science education. As a slogan, scientific literacy had a confusing, troubled and precarious existence in the 1960's and 1970's. Nonetheless, there were a few leaders in the field of science education who tried to make the transition of 'scientific literacy' from education slogan to education goal. The efforts of three of these educators (Karplus, Klopfer, Roberts) will be presented as each, in his own way, made curricular proposals that incorporated his concept of a scientific literacy goal.

By the 1980's, more thought had been given to the place of a scientific literacy goal within a public philosophy of education. At the same time, spokesmen from some of the 'applied' careers (such as engineering) were voicing concerns about the lack of public schooling directed towards these applied careers. These philosophical and career concerns, coupled with re-emergent political concerns, are presently contributing to a view of scientific literacy as a universal and essential goal in public education.

As a form of desired 'literacy' emerging from public school science education, scientific literacy has had a variegated existence in the dialogues of science educators and curriculum planners. At first glance it would seem possible and perhaps desirable to concentrate on the present in our study of this concept in science education, and leave the past to those with other aims in mind. It will soon become clear, however, that the past is not that distant, includes many of the same contextual elements as does the present, and shows evidence of some of the same science educators and curriculum specialists at work. The connective elements and influences are too numerous and important to be severed or ignored with impunity. A richer appreciation of the evolutionary factors that have led to the scientific literacy goal as a current problem can come from a respect and inclusion of its past.

Problem situations tend to have antecedents or precursors, and their development can usually be traced historically. As Reid has argued throughout many of his writings, the existence of curricula (however viewed as acceptable) entails some sort of historical process to help explain their existence.[1] That process undoubtedly involved teachers, students, content, and milieu to some degree or other; therefore, Reid argues that, "before devising schemes to make things different, we might pause to ask how they got to be the way they are".[2] Reid's intention is to provide a basis for understanding those "forces tending to preserve the <u>status quo</u> as well as making those making for change" and "a recognition that change involves the abandonment of practices as well as their adoption".[3] Since the stabilizing forces have resulted in the continuation of whatever presently exists in the highly complex systems of curricula, they would certainly warrant some historical treatment.

The particular problem situation that will be examined in this paper has taken some 30 years to develop. In more general terms it concerns the value place of science programs in the larger curricula of elementary and high schools. More specifically, it concerns the goal of scientific literacy by the end of a typical post-WWII 12-year elementary and high school education (or schooling) in North America. What does this goal entail? Why is it of great concern now in educational circles? This chapter will try to answer these questions within their connnections to an historical process.

National Crisis and Public Support: Scientific Literacy as Slogan

The term 'scientific literacy' came into usage in writings concerning education sometime before it was transformed into a goal or aim of the science components of the curriculum in pre-university schooling. Roberts has traced the phrase to a 1958 paper written by Hurd for Educational Leadership and titled "Science Literacy: The Meaning for American Schools".[4] By 1960, both Alan Waterman (the Director of the National Science Foundation) and Frederick Fitzpatrick (the Head of the Department of Teaching of Science at Teachers College, Columbia) felt comfortable enough with this phrase to use it as if its meaning were readily apparent to their respective readers. They likely assumed a shared general consensus. Waterman had authored a 10-year summary of National Science Foundation activities and urged, in the name of the NSF, "that the level of scientific literacy as a part of the general public be markedly raised" [italics mine].[5] Waterman felt that U.S. citizens ought to share "at least a general knowledge and understanding of the nature of science and its implications for the national defence and welfare".[6] As spokesperson for NSF, he wrote that "progress in science depends to a considerable extent on public understanding and support".[7] These themes of 'national defence and welfare' and 'public support' are probably only natural considering the preceding decade's preoccupation with the political and scientific ramifications resulting from the use of atomic power, as well as the USSR's first place position by 1957 in the race for space supremacy. Thirty years later, the same themes are resurfacing in certain influential and vocal quarters of the educational professions.

Fitzpatrick, as editor of Policies for Science Education in 1960, voiced the concerns of the Science Manpower Project at Teachers College, Columbia, that the public "be favorable to the scientific enterprise, including both academic and industrial programs".[8] In order to be favorable, the public should be able to "appreciate the general nature of scientific endeavor and its potential contributions to a better way of life".[9] This 'appreciation' would be a consequence of proper education through the nation's school systems. The themes of 'public support' through taxes and 'sympathetic acquiescence' to (or approbation of) industrial, governmental and academic scientific/ technological research and development programs were openly stressed.

Roberts credits Fitzpatrick's use of the phrase 'scientific literacy' in its transformation into an educational slogan, "as a rallying symbol for an educational ideology".[10] This is, of course, a far cry from an understanding of the specific meaning(s) associated with this phrase. Additionally, and more pertinent to this paper, neither Hurd, Waterman or Fitzpatrick offered specific guidelines for the translation of 'scientific literacy' into teaching or learning behaviors. We can see, however, the association of need for 'scientific literacy' with national crises of defence and economic/ industrial welfare.

Did the general public offer its support to the governmental, industrial and academic scientific and technological research and development programs? All indications are that the citizenry did so en masse and willingly, even before any innovative science school programs had been implemented. NASA and its space program received enthusiastic public support; media records and U.S. congressional allocations leave no doubt about this. Nuclear power stations proliferated in the U.S. and were eagerly exported to acceptable and friendly countries. The chemical industries, drug companies and medical technology companies experienced tremendous growth. Technologies, whether directed to agriculture, air transportation, ground transportation, energy supplies, construction, or office equipment, all grew vigorously in the 1950's and 1960's, i.e., before 'scientific literacy' was translated into science curriculum terms, no matter the meanings of the term.[11]

Historically, then, if the existence of scientific literacy is to be seen in terms of public support for science and technology in the nation's economy, defence and general welfare, there seems to be more than enough evidence for its existence <u>prior</u> to the science curriculum innovations of the 1960's (BSCS, CHEMS, PSSC, etc.), particularly since it was the <u>adult</u> population who supplied the financial and moral support.[12] How then did concerns for scientific literacy persist and vigorously resurface a generation later among educational leaders?

<u>Educational Research: Scientific Literacy as Educational Goal</u>

The transformation of 'scientific literacy' as slogan into 'scientific literacy' as educational ideology and education research concept was gradual and multi-faceted.[13] Beginning with 1960, the use of the term 'scientific literacy' in an ideological or philosophical sense was found more and more frequently in writings from within the education community. Well-recognized education journals ranging from <u>Teachers College Record</u> through <u>Science Education</u> and <u>Theory into Practice</u> carried articles addressing 'scientific literacy' as an overall goal for science education.[14] Initially, meaning and interpretation were primarily assumed rather than enunciated. Within a few years, however, <u>choices</u> of meaning were acknowledged by education writers, though without the constraints of curriculum-specific recommendations. Some empirical research was begun but often was confined to content analysis of popular media (e.g., vocabulary and science concepts in newspapers). These excursions into research prepared the ground, not only for further research, but more importantly at this stage, for some commitment to concept formulation. This ensured a start to the removal of 'scientific literacy' from the realm of assumed and shared meaning to the realm of concept delineation. There followed a voluminous outpouring of models, referents, assessments of students, assessments of teachers and schools, examination of curricula and their goals and science course case studies, all related to 'scientific literacy'.15

The mounting analyses of scientific literacy show no signs of abatement, particularly since both the U.S. and Canada have recently produced national studies each of which has concluded that there is a crisis in science education and that scientific literacy is an essential goal for science education.

Does this mean that we are closer to a consensus about the place of teaching for scientific literacy in school curricula? Have education professionals reached any agreements about the meaning of scientific literacy or its implementation in elementary and high school settings? In short, is there a better and more useful sense of the problem surrounding the slogan and now aim of scientific literacy?

Perhaps it is time to let some of the more prominent North American education professionals speak for themselves on this issue, since they are the ones responsible for supporting it as a continuing problem in science education. Roberts considers that there are currently two clearly differentiated concepts of scientific literacy in the relevant literature, one by Robert Karplus, the other championed by Leopold Klopfer. Both developed their concepts of scientific literacy and its curricular expressions within the context of the 1960's with its political concerns and curricular innovations. Each has been and continues to be a leader in the field of education: Karplus, for his developmental work in the Science Curriculum Improvement Study (SCIS) for elementary schools; and Klopfer, as editor of Science Education and as educational researcher.

Karplus calls 'scientific literacy' a "functional understanding of science concepts", with "functional" meaning "to be able to use information obtained by others, to benefit from the reading of textbooks and other references" thanks to a "conceptual structure and a means of communication that enables him to interpret the information as though he had obtained it himself."16 This would seem to be quite a demanding goal for any science program regardless of the interpretation of the degree of understanding, communication, etc. He adds that this "should be the principal objective of the elementary school science program" in order to ensure "the increase of science literacy in the school and adult populations".17

Karplus' intent was to concentrate the curricular efforts toward a learning of the basic concepts of science and an understanding of the nature of science. Any other learning connotations of the term 'scientific literacy' were deliberately excluded. The stipulation that this objective be fulfilled within the elementary school setting would serve to indicate Karplus' concern that all students be exposed to the same science program and have a chance to develop similar levels of scientific literacy, since definitive tracking or streaming of students doesn't usually begin until the junior or senior high school years.

Klopfer sees the problem in a different light, different in three ways: (1) schooling level (2) target student population (3) content emphases. He would wait until high school before introducing a strong curriculum program dedicated to the production of scientifically literate students. He would direct this program to most but not all of the high school student population, namely to the some 90% or so who have not been streamed into a pre-professional science program. (He either assumes that the 10% who are in a science stream won't need the type of science education provided to the 90%, or will receive it anyway in the science stream courses; it is not clear which he really assumes.) As far as content is concerned, the curriculum of the 90% would concern itself with science-technology-society interaction, values/ethics, and science inquiry processes. This curriculum-for-the-90% would contrast with the curriculum-for-the-10% in a number of ways. The latter would have a curriculum that emphasizes major scientific facts, principles and concepts, the organization of scientific knowledge, development of science skills and intellectual processes, such as understanding the nature of scientific enquiry. All in all, a very different curriculum for the 10% is encouraged.

Roberts prefers what he sees as a more balanced science curriculum for all students. Stated briefly, this balanced science curriculum would use 'scientific literacy' as an ideal aim incorporating all of the emphases that Klopfer wants to separate, while at the same time providing for particular preferences relevant to other student, school or community education goals.[18] The emphases would represent categorizations of scientific literacy components while leaving the treatment (i.e., in percentage of time, emphases, etc.) up to the local schools.

Interim Summary

So far, I have attempted to trace the transformation of the phrase 'scientific literacy' from its politically-centered origins as a patriotic slogan to its present acceptance as a desirable goal in science education. In addition, the views of three educators who have written extensively on various aspects of the scientific literacy goal were presented. Their interpretations of scientific literacy both as a general education goal and a goal specific to certain science curricula were compared.

Would these three positions, as represented by Karplus, Klopfer and Roberts, fairly represent the dimensions and parameters of the curricular problem in respect to scientific literacy? Let us see if a more diagonal or tangential approach to the problem is at all helpful–a variety of scanning that might bring to light the wider reaches of this curricular problem.

Some Additional Views: A 1970's Focus on Students, Teachers and Texts

Butts in his helpful article on U.S. science education, brings to light evidence that by 1970, i.e., less than a decade after implementation of the reformed science curricula of the 1960's (BSCS, CHEMS, PSSC, etc.) in impressively large numbers of U.S. classrooms, the number of students enrolled in such courses was decreasing year by year.[19] Despite the largesse of federal funding that had initially made the science curricula reforms possible, that continued to provide for the development of more 'new' science curricula, and that provided financial support for inservice teacher programs (e.g. summer institutes), the anticipated large-scale high school enrollment in the new 'alphabet' courses never materialized. By 1977, only 6.9% of high school students were enrolled in chemistry courses (both new and traditional) and 3.1% in physics courses (also both new and traditional).[20] These percentages were part of a general decline in enrollment in all science classes from 59% in 1960-61 to 48% in 1976-77.[21] It was taken for granted that the majority of students, either enrolled in more traditional science courses or no science courses at all were not being exposed to the "intellectual content of contemporary science disciplines".[22]

A second concern emerged in the late 1970's -- based on a reported decline in student achievement in science as measured by national achievement test scores and by The National Assessment of Educational Progress.[23] These results were interpreted as indicating a decline in scientific literacy in the general high school student population, with greater declines evidenced in scores made by female students and minority students. However, there was no apparent decline in the scores of science stream students who were planning on science careers.[24]

State graduation requirements also seemed to be implicated as a causative factor in the perceived decline in student interest in high school science courses and/or their performance on science achievement tests.[25] In 75% of U.S. school districts, only one year of science was required in grades 9-12.[26]

The National Science Foundation (NSF) studies investigating the status and needs of pre-college science curricula, showed some disturbing classroom situations that tended to coincide with the above student enrollment, achievement and interest statistics.[27] In elementary classrooms, science was often taught by teachers whose training, interests, skills and administration-determined priorities were in non-science areas, from texts unmatched to student interests, and with a minimum of observational experiences.[28]

At the high school level, there appeared to be two distinct levels of science teaching as presented by the NSF studies. The first two years offered general science and biology courses, often taught by teachers whose competencies were in other disciplines and whose priorities tended to be ones of student socialization and classroom management rather than the teaching of science. Textbooks whose focus was the more traditional one of solid factual foundation helped to ease the teaching-strategies strain (given the often limited science background of most teachers assigned to the entry-level science courses) but did little to provide for laboratory or field lessons.

The senior high school level offered more demanding and stimulating science options, usually taught by well-qualified teachers and incorporating respectable amounts of laboratory experiences. However, as has already been noted, a markedly small percentage of students were actually enrolled in these courses (primarily chemistry and physics) with no other science courses available for the non-science stream students.

Studies of all kinds continue to demonstrate that the classroom teacher is usually the single most important factor in student learning when compared to other external factors in the school setting such as learning materials, classroom environment, fellow students, the school community.[29] However, the relative number of qualified science teachers has been decreasing in the U.S. since 1970, while the amount of teacher time spent in teaching science has increased from 11.7% (1961) to 13.1% (1976).[30] This, coupled with the drastic reduction of NSF funding for science in-service institutes, workshops and courses, has resulted in a noticeable shortage of teachers at elementary and junior high school levels who feel themselves adequate in the teaching of science. As evidenced by the NSF studies, classroom performance and effectiveness tend to be equally inadequate.

It should not be surprising that the move from 'scientific literacy' as philosophical goal of science education to 'scientific literacy' as curricular expression and student achievement, is a precarious one. Student perceptions, interests and attitudes, teaching competencies and strategies, and textbook usefulness all play varying roles in determining the appropriateness and acceptability of any curriculum. These commonplaces of educational situations cannot be ignored or shunted aside. Even when they are actively and equally considered (as Schwab would have us do), curricular changes still tend to be fraught with difficulties. Changes in the direction of scientific literacy seem not to be an exception to this general rule.

By the 1980's, some additional perspectives about scientific literacy as a science education goal, were being made known. It will be useful in rounding out the historical setting of this goal to review these perspectives.

Technology and Engineering: A 1980's Need for Scientific Literacy

Instead of locating the problem in textbooks, student interests or teacher preparedness, Risi approaches the scientific literacy problem as an offshoot of neglected education in technology.[31] He considers that technology education can encourage lateral thinking and creativity more easily than can science education. He views the latter as preoccupied with linear and procedural concerns in contrast to technology's lateral thinking and creativity. In addition, science is presented as remote from human needs, whereas technology could easily be presented as filling human needs, drawing upon the sciences for contribution, but extending far beyond them to speak to direct human needs. He views technology, not as the handmaiden of science (the more traditional stance), but rather as the leader in innovation, spurring on curiosity, observation and creative thinking because it is specifically linked to practical and human-centered problem-solving.

George shares Risi's perspective but would spell out the place of engineering.[32] George argues that because engineers and technologists were not consulted in the 1960's when the scientific community was mandated to restructure the science curricula, science has been taught as if technological applications were second-rate 'science' and not worthy of serious pre-college study. The non-science stream student has suffered the most as a consequence. The general science courses that this student would normally take have received the least consideration by science curriculum planners, have the least prestige of all high school science courses, and rarely include technological or engineering applications even though most of the students enrolled in these courses will go on to pursue careers or jobs connected in some way with technology. But even the science stream students are neglected. George deplores the fact that science career orientation, other than to pure sciences, is missing from pre-college courses. Most of these students will not pursue careers as 'pure' science researchers. Yet other career possibilities, such as engineering are, for all practical purposes, often totally unrepresented. His position then would emphasize realistic career or job possibilities, thereby encouraging students to obtain the required level of scientific literacy. He maintains that the present lack of a basic and substantial minimum proficiency in science and mathematics is handicapping countless numbers of potential technologists and engineers.

While these career concerns are certainly important in the totality of public education, they might be viewed as part of the pragmatic end of the educational goals spectrum. At the other end of the spectrum of public education goals would be the philosophical concerns about the nature of educational goals.

A Search for Philosophical Perspectives

Philosophical perspectives are often contained in statements about the aims, goals and purposes of education. Suggestions for desirable student learning can find expression in the behavioural language of educational objectives as well as in the prescriptive language of educational philosophy. Three basic emphases can be noticed as characteristic of the purposes of education in general and of science education in particular: psychological (e.g., personal and career needs), sociological (e.g., societal concerns), and academic (e.g., preparation for further study). These emphases may be seen in the form of 'goal clusters', learning objectives and even attitudinal studies. All of them point to a strengthening of the position of scientific literacy in the roster of educational goals and purposes. What ought to be the science education goals of public education? Some attempts have been made to answer this question.

Harms and Yager chose to begin their quest by locating philosophical perspectives in the field of education through a literature search for science education goals.[33] Articles and publications addressed to goals or rationales in science education were culled from the available literature. Project Synthesis, the name of the project headed by Harms and Yager, eventually devised four clusters of science education goals having identifiable learning outcomes relevant to the individual, society, academic preparation and career choices. (Three of the four sets of learning outcomes speak to scientific literacy concerns as identified by Karplus and Klopfer: the self and career choices when Karplus writes of the "functional understanding of science concepts"; and society and career choices when Klopfer writes of science-technology-society interaction.) Taking these learning outcomes as "desired states," it was then a relatively straight forward matter for them to compare the "desired states" with the "actual states" found in the studies by Helgeson et al., Weiss and Harms & Yager. If the biology education section is taken as an example of the Project Synthesis approach, location of scientific literacy is clearer.[34] As might be expected, the "actual states" were noticeably (and undesirably) different from the "desired states". Since three of their four goal clusters contain primarily scientific literacy desiderata, one can only conclude that much corrective curricular work needs to be done if "actual states" are to come closer to the "desired states". Hurd, who authored the report of the biology focus group within Project Synthesis (with contributions from Roger Bybee, Jane Kahle and Robert Yager), explains the rationale used in developing the "desired states": "The overarching rationale of the desired biology program is the use of biological knowledge to enhance the understanding of oneself and to benefit the quality of life and living for human beings".[35] As to why this shift away from the 1960's 'new' biology courses organized around the structure and logic of biology as a discipline, Hurd asserted that

> the validity of the ['desired'] model rests upon 1) the present character of the science enterprise; 2) the current emphasis on scholarship within biological disciplines; 3) biology/social-based issues that exist and are likely to persist throughout several decades into the future; 4) personal needs relevant to biology that are evident in contemporary culture; 5) public reactions to conventional educational goals and practices.[36]

Even though academic preparation seems to be still highly valued, the student-perceived personal, social and career needs play a large role in the validation process. The focus of the problem in science education for Hurd centers on the stated discrepancies between perceived personal, career and societal needs and present biology education.

The philosophical perspective developed by James and Smith also supports the goal of scientific literacy:

> in this technological age, successful participation as citizens and consumers increases the importance of

> scientific literacy. If some reasonable measure of this general education goal is to be accomplished, means for reducing the alienation from science should be found.37

They had become aware of data in the education literature that reported increases in general disinterest in science, with disinterest progressing through the K-12 years of schooling. They constructed a 14-item questionnaire designed to elicit attitudes about science-influenced jobs and careers. A dramatic drop was noted between the 6th and 7th grades in favorable attitudes toward science. They presented a number of suggestions as to why, particularly since they found a strongly positive attitude in grades 4-6. They suggested that curricular and/or pedagogical events occurring at the 7th grade level are the potential key.

INTERIM SUMMARY

Considerable territory has been covered so far in this examination of the historical development of the science education aim or goal of scientific literacy. I located its origin in the late 1950's as a rallying phrase in the science education literature and in its links to the perceived political and scientific crises of the early 1960's. These political considerations both as education slogan and as national crisis, have continued as undertones into the 1980's. In between, however, i.e., from the late 1960's through the 1970's, science educators have come to value the scientific literacy goal as justifiable and even necessary on grounds other than political ones, and to insist upon its inclusion in the collection of goals characteristic of science education.

In so doing, much effort has been put into developing relevant teaching and learning objectives. There are, of course, the expected concerns about teaching and learning objectives that focus on concepts and skills derived more or less directly from core science disciplines (physics, chemistry, biology). These objectives that are discipline-centered, continue to provide a sense of stability to the subject matter of science education. However, two additional concerns gradually become more noticeable in the science education field, one containing a 'resurrected' focus out of the pre-1960's public science education, and the second, containing a new emphasis in science education.

This 'resurrected' focus may be stated succintly as a need for public science education goals that include adequate introductions to applied science fields and related technological fields, introduction now generally absent from science curricula; this is a major concern of educators having an interest in the technological or applied fields (such as engineering and industrial chemistry). Even though post-WWII teaching objectives have fluctuated dramatically in respect to this focus, its resurgence is an indication of societal pressures for adequate high school career preparation for the non-science stream students, i.e., the majority of students. At the same time, this concern about science education of the majority of students has also become a concern of science educators who have concluded that the majority of students need and deserve a better education in the core sciences. Karplus and Klopfer have been at the forefront in these efforts for some time now. Such career introductions are seen by these educators as preparing the ground for career choices leading to the applied sciences and technological fields.

The new focus would have students formally study science-society interactions and their consequences. This new focus carries with it moral implications (e.g., the 'goodness' of nature conservation vs. its exploitation). It also has sociological implications that include the development of skills and the transmission of knowledge useful in the making of political decisions regarding science-related societal issues. This new focus, although having fewer historical precedents in science teaching and learning objectives, is enthusiastically advocated by a number of science educators.

Emerging then, in the 1980's from among the major political features of the historical development of scientific literacy as an educational goal are two important themes: scientific literacy as a universal goal, a goal for the masses of students who do not choose to follow the science stream route to high school graduation, and scientific literacy as a moral goal, a goal that would encourage the learning of constructive decision-making about everyday matters that are science-based. Because the two themes are characteristic of the 1980's concerns of science educators, I will develop each in the succeeding paragraphs.

Many educationists (especially Yager) have concentrated their efforts on the inclusion of a science-society perspective in high school science education, a perspective that carries with it sociological and moral elements. This perspective of science education as a moral goal will also be developed through the contributions of science educators to science education literature. Still others (particularly Klopfer) have been instrumental in moving the scientific literacy goal from a position of one-goal-among-many in science education to the position of a universal science education need on the high school level. My intention in reviewing some of these efforts is to establish a basis for the theme of universality in science education, a theme usually linked to the scientific literacy goal.

Scientific Literacy as a Universal Goal in the 1980's.

Klopfer, in a 1984 Science Education editorial, cited the following groups as supporting his position in scientific literacy (summarized earlier in this chapter): the Task Force on Education for Economic Growth (U.S. Department of Education), the National Commission on Excellence in Education (Education Commission of the States), the Commission on Precollege Education in Math, Science and Technology (National Science Board), and the National High School Board (Carnegie Foundation for the Advancement of Teaching). In citing the above sources of support, Klopfer points to a broadening of the base of leadership support for "an increased emphasis on science education for all young people", and to the fact that it is no longer primarily scientists and science educators who are calling for such an emphasis. "Proper preparation for life, emphasis on national needs and the collective good of society (vs. individual welfare), productive and responsible citizenship" based on sufficient educational skills were foreseen as the happy outcome of a curricular emphasis on scientific literacy:

> All young people must have ample opportunities for learning to understand science and the scientific ways of thinking. This is a necessity for all young people, not only those moving toward scientific or science-related careers, but for everyone.[38]

A 1980 joint NSF and U.S. Department of Education Report to the President entitled <u>Science and Engineering Education for the 1980's and Beyond</u> had made the same points (summarized below) and had emphasized the universality of such a need for scientific literacy: all citizens, not just those preparing for science or engineering-related careers, need scientific and technological education. The rationale for universality had some 8 premises in the report:

1. there is a "growing discrepancy between science, mathematics and technological education acquired by high school graduates who plan to follow science and engineering careers and those who do not".[39]
2. "scientific and <u>technical</u> literacy <u>is</u> increasingly necessary in our society".[40]
3. citizens who control the ultimate processes of society must be scientifically and technically enlightened; decisions can be helpful only if science and technology are understood;
4. science is the key to success in many occupations;
5. the pool of future science and technology personnel is dwindling;
6. equity and personnel needs have resulted in a push for minorities and women to get the maximum of science and mathematics in high school;

7. other industrialized nations (Japan, Germany, USSR) require more science and mathematics in their public education programs than does the U.S.;

8. a commitment to national excellence must be reasserted.

This rationale was formulated after examining data that showed:

a. lower national scores on achievement tests;

b. a basic skills emphasis in many school districts;

c. lowered admission standards of colleges and universities;

d. lowered state high school graduation requirements;

e. science courses and student needs often mismatched;

f. teacher shortages.

The same theme of universality is taken up by Aikenhead.[41] His rationale for scientific literacy is based, as many other science educators propose as well, on perceived citizenship needs: science-related issues are many (e.g., energy resources, food production/distribution, pollution, health) about which the public has, does, or will have to make decisions in a democracy. Scientific literacy components for Aikenhead include: the nature of science, the limitations of science, basic knowledge of science concepts/principles, and exposure to the interrelation of science with society.

The theme of universality is also echoed in the earlier (1978) ethnographic study by Stake & Easley.[42] They found that administrators, supervisors, teachers, and students, offered the following as problem situations in science education, with many of the conclusions similar to those in the above 1980 joint report, but grounded differently, i.e., within the participants. The study's conclusions could be summarized as follows:

1. courses: lack of science courses for 'below average' students;
2. students: want science as-used-in-everyday-life to be included in science courses;
3. students, teachers and administrators: all want science courses oriented to present and future job markets in addition to 'pure' science courses now offered;
4. science education goals supported by all: science knowledge, human issues, career preparation;
5. competency tests: the majority want a science component to be included in the minimum competency high school leaving tests if and when such tests are implemented.

What can we conclude about this theme of universality in connection with scientific literacy? Universality seems to be a dimension of the scientific literacy goal that is finding substantial support in the 1980's among science educators. It matters little whether universality is associated with citizenship needs as perceived by leaders in science education, or 'grassroots' concerns resulting from surveys of students and teachers. What does seem to matter is the amount of support being generated for scientific literacy as a reasonable goal for all students.

Along with the resurgence of an emphasis in public education on preparation for future citizenship responsibilities has come an even newer dimension of the scientific literacy goal, that of scientific literacy as a moral goal.

The 1930's: Scientific Literacy as a Moral Goal

Even though Yager has been one of the most outspoken among science educators in advocating the inclusion of a moral element in scientific literacy curricula, his position underwent some transformation since the early 1980's. Kahle & Yager described a two-year history to their 1980 study of educators, a study that located "Current Indicators (of Problems) for the Discipline of Science Education"; eight problem indicators were presented.[43] Science teachers' competencies and pedagogical devices and materials were of greatest concern among those surveyed science educators. The second most frequent concern expressed by these teachers was the need to focus on science-technology-societal problems from appropriate inquiry and data perspectives. Kahle & Yager maintained that, even though there may always be a need for science teaching assessments (specifically referring to all of the most recent U.S. national assessment studies), the crisis in science teaching should provoke more than just reports of assessments. Some reform was called for in science curricula.

Three years later, however, Yager suggested that unless science education is defined differently and accepted in this 'new' proposed definition, science teaching and science learning would not reach the more "desired states" that Harms and Yager had suggested in their 1978 study.[44] Science education, Yager felt, should be defined as "the discipline concerned with the study of the interaction of science and society, i.e., the study of the impact of science upon society as well as the impact of society upon science" with accompanying moral/ethical values as integral parts of science education.[45] Science education research, science curriculum development and science teaching should all "center upon this interface" of science and society.[46] It was felt that this new perspective in the goals of science teaching would increase the population of students enrolled in science courses (either core or elective) and would also engender more sustained interest in enrolling in senior high school science courses since this is where the most dramatic decline in student enrollment is located according to all available data.

Riechard locates the scientific literacy problem in the lack of political and policy-making will within science education leadership:

> In a world contending with population explosion, hunger, disease, depletion of fossil fuels, environment degradation, and the ability to destroy ourselves in a matter of minutes, science education policy must establish scientific literacy as a national goal with science as general education for all.[47]

His view of scientific literacy combines universality (science as general education for all) with moral values accompanying the study of science-society interactions (depletion, degradation, destruction). His argument can be summarized as follows: "A scientifically illiterate populace spawns a scientifically illiterate government" which invites natural and political disasters because of the lack of knowledge and skills when addressing social implications of science and technology. Because of a combination of mis-education and lack of education in science, "the public's expectations are often inappropriate, unattainable or both".[48]

A summary of Riechard's scientific literacy characteristics reveals a somewhat different emphasis from the Harms and Yager list:

a. understand the nature of science and the nature of scientists;

b. understand basic natural phenomena;

c. develop objective, open-minded and questioning attitudes and abilities;

d. be able to interpret science-related information as found in the popular media;

e. understand the sociology of schools, government and scientific enterprises;

f. understand societal relationships as participatory ones;

g. develop the habits of asking questions, seeking answers, studying consequences, acting on the basis of the best information available, habits involved in critical thinking and decision-making.

The ambitious inclusion of sociological perspectives instead of only society as perceived through the eyes of science, is relatively new to scientific literacy proponents. Zeidler may be included in this new camp.[49] He assumes the acceptance of scientific literacy as a major goal in science education. Even though he offers no definition of scientific literacy, he does go on to argue for the inclusion of an "interdisciplinary approach" in order to achieve "a more complete realization of scientific literacy".[50] By this he refers to a concern with moral and ethical issues that would emanate from the interdisciplinary offerings in such areas as law, sociology and moral philosophy.

Concluding Remarks

It is noticeable that a) the concept of scientific literacy has, over the years, acquired descriptions that have become both considerably more concrete and more diversified; b) curriculum guidelines that include scientific literacy have become more frequent; and c) a sense of urgency coupled with national and citizenry welfare have become attached, once again, to the concept of scientific literacy.

Even though the origin of the term 'scientific literacy' seems to be in the 1960's concern about the need for U.S. taxpayer support of scientific and industrial projects and enterprises, it has been considerably modified and is gradually being institutionalized within the public school curricula. Nonetheless, the 1960's argument can still be found in the 1980's literature: the public would be favorable to scientific and industrial concerns if they were able to have a positive appreciation of the needs of scientific research and technological products. This positive appreciation of science and its benefits would be engendered through schooling that teaches an understanding and appreciation of science and it's beneficial effects in society. The 1980's argument not only would not reject the 1960's argument, but would add arguments drawn from the philosophy of education, sociology and moral philosophy. These 'newer' arguments are intended to widen the appeal of proposed additions to the science curricula, particularly at the secondary levels.

My intention in this chapter has been to present the broad outlines of the historical process that has propelled forward the educational goal of scientific literacy. In so doing, it is hoped that a basis has been provided for understanding the societal, academic and institutional forces that favor stability as well as those forces favoring change. All of these forces will make a number of appearances when the goal of scientific literacy as problematic is examined within the framework of deliberative enquiry.

The next chapter will try to tease out of this collection of offerings from science education leadership and educational researchers, a more limited and more student-centered view of the scientific literacy problem.

CHAPTER 6

SCIENTIFIC LITERACY: SOME ELEMENTS IN A CONCEPTUAL ANALYSIS

Focus of Chapter

So far, I have tried to place the science education goal of scientific literacy into its historical context, indicating its origins as a slogan and its multiple meanings as interpreted by numerous science educators and science education researchers. In so doing, Karplus and Klopfer were selected as two of the major exponents of scientific literacy and their views were discussed. My intention is to develop a dialectic using the writings of these two educators as they have addressed the educational goal of scientific literacy. Such a dialectic will help to unmask the concepts that have formed around the term scientific literacy.

The starting point of this chapter will be an examination of the nature of a concept and as applied to the term 'literacy'. This will be followed by a closer look at Karplus' view of functional understanding as an essential element in the concept of scientific literacy. Klopfer's views of essential elements in the concept of scientific literacy will serve as a response to a certain incompleteness in Karplus' development of functional understanding. But Klopfer does more than this. He presents a substantially different emphasis, one that focuses on the socialization potentials of a scientific literacy curriculum.

If the goal of scientific literacy is to be acknowledged as having a validity beyond its historical persistence, a clearer and educationally pragmatic conceptualization of this goal would seem to be among the deliberative preliminiaries as well. Without some workable consensus about a core concept of scientific literacy, the deliberators will be hard pressed to know the focus they should be using in developing perceptions of the 'problem' surrounding the goal.

The place of this chapter within the framework of deliberative enquiry is to exemplify one attempt at working through the so far unexamined concept of scientific literacy. Needless to say, my attempt does not exhaust the analytic possibilities nor preclude others. Briefly, my intention is to demonstrate the complexity of a superficially simple science education goal expression. What are the major threads that hold this scientific literacy tapestry together? What components can be identified in this problem situation? In what ways can we formulate the points of unease? Do we notice discernable orientations to the deliberation components of students, teachers, subject matter and milieu? Pereira and Roby suggest that a valuable activity initiating deliberation about the problematic situation is the assignment of meaning to the details in the problematic situation. One by one, elements of the problematic situation will be teased out and then reassembled, in order to point to some of the important educational aspects of a scientific literacy concept.

As of now, there is no single, easily described, concept of scientific literacy. It is important that educators and curriculum planners begin to recognize this fact. One way to encourage such recognition is to unmask the various versions of 'scientific literacy' developed by science educators and curriculum planners. Once again, Karpus and Klopfer, both as science educators and curriculum planners, will be called upon to contribute their version of 'scientific literacy'. Some of their contributions have already been presented. However, more needs to be done in order to unmask further elements in their respective concepts of scientific literacy.

Scientific Literacy as Concept

In the The Philosophy of Schooling, Barrow's discussion of the term 'concept' is apropos.[1] He distinguishes it from the terms 'word' (as in the naming of an object) and 'image' (as in a mental picture of a concrete particular). The term 'concept' is reserved for "an abstraction that represents or signifies the unifying principle of various distinct particulars."[2] What might be the "various distinct particulars" and what might be the "unifying principle"?

It would be interesting and helpful to begin with a verbal definition of literacy or, better still, literate, since literacy is simply "the quality or state of being literate".[3] One finds a number of possibilities, most of which are concerned with a relatively thorough education in the written forms of cultural heritage. Some examples will suffice: "versed or immersed in literature or creative writing", "dealing with literature or belles lettres", "characterized by or possessed of learning as in educated or cultured".[4] This can be extended to the description "well executed or technically proficient as in polished or lucid writing".[5] At first glance, none of these definitions would seem to enjoy a comfortable juxtaposition with K-6 learning outcomes. One must honestly admit to some difficulty in visualizing millions of American 12-13 year-olds (i.e., grade 6 graduates) being "versed or immersed" in science, or "dealing with (science) literature", or "characterized by or possessed of (science) learning".

These adjectival definitions are not usually applicable to such 12-13 year-olds even in areas of learning such as language arts (mainly reading and writing skills) and mathematics (mainly arithmmetic), areas of learning that are allotted a much larger amount of time and emphasis in the elementary school day and curriculum than science has been, or is likely to be, allotted. Perhaps there is less that needs to be learned in science as opposed to English and mathematics. Or perhaps science is much more easily learned and therefore needs less time. Even a cursory look at actual classroom situations and learning patterns of elementary school students should indicate that these two conjectures cannot long remain in consideration.

If a sort of 'higher' view of 'literate' as educated, cultured, lettered is likely not possible by the end of a typical American K-6 number of years in school, is there a 'lower' view of 'literate'? Yes, there is: "able to read and write".6 But how can we use this for scientific literacy? "Able to read" science texts, "and write" science answers, reports, papers? "Able to read" newspaper or magazine science articles "and write" to the editor? If the writing requirement is dropped and speaking is substituted, perhaps a combination of reading and speaking could be made useful: "able to read" and discuss science articles and books. Actually, much of science information comes to most people through the electronic media. Would violence be done to the description of literate if someone watched, listened and discussed science information presented in the form of television or radio documentaries, science shows, thematic debates or discussions? Probably not. Would the discussions be at the "able to read and write" level? Probably. Is this what Karplus had in mind? Probably not. Why not? Because his concern was not with the development of science skills (equipment manipulation, practice with science procedures as equivalent to the skills of reading and writing) as with the understanding of concepts so that they could serve a future use.[7] Karplus is concerned that students have and demonstrate an acquaintance with the fundamentals of chemistry, physics and biology, which acquaintance will allow them, as adults, to make intelligent decisions about all sorts of personal, social and political matters, using (and assuming some understanding of) scientific arguments, at least in part, and particularly when the matter to be decided about has some basis in science. Let us take one example that has popped in and out of the public decision-making arena for the past 40 years, namely that of the building of nuclear power plants.[8] It goes without saying that economic, moral and political arguments may well be included, but certainly, at least part of the total picture often is science-based arguments. Let us include our K-6 graduate who is now of voting age (18 years in most American jurisdictions) and has had a maximum of one more year of science, in high school. Would this imaginary 18-year-old have a reasonably sufficient acquaintance with the fundamentals of chemistry, physics and biology (since all three are directly involved) in order to understand the science-based arguments, no matter whether they be for or against the building of nuclear power plants? Or would he be strongly tempted to either resort to moral or economic or political arguments, or to throw his/her hands up altogether and say: "Let the experts battle it out, they know best"? Is leaving-it-to-the-experts part of literacy? Might this be included in Karplus' notion of scientific literacy? He doesn't write about this possibility but his other concerns for citizen-based decisions would lead one to suspect not, or at least not often.

Should scientific literacy then be imagined to fall somewhere between the 'higher' and 'lower' definitions of literacy? Possibly. Karplus is convinced both of its usefulness and its necessity. Is it necessary to understand and use science-based arguments before reaching a decision about the construction of nuclear power plants? It doesn't seem to be. Economic and political arguments have been traditionally the more persuasive and the more urgent. Well, if not necessary, then certainly useful? In what way? Actually, there might be many ways. Let's examine some. Would it not be useful to understand what the experts are arguing about? Certainly, but based on the fundamentals acquired in a K-6 program plus one year of science? The inherent limitations would seem to be overwhelming since the experts' disputes are anyway invariably either about data specific to the field of expertise or outcome speculations, neither one of which is directly or indirectly linked to the K-6 fundamentals of science that Karplus includes in his SCIS curriculum.

Well; what about understanding something less overwhelming such as: "What is wrong with my car (or TV, or radio, or dishwasher)"?

Science concepts will certainly help one in these areas if and only if one also receives training in car repair (TV repair, radio repair, etc.) or can benefit from an explanation given by someone who has repaired one's car (TV, radio, etc.). Will the latter equip me to repair the car the next time it stops working properly? Not likely. Similar questions could be asked about health care, ecological concerns, asbestos in the work place, etc.

What have we been able to tease out of the term 'scientific literacy' so far? Have any "distinct particulars" been noticed? Has a unifying principle been located? The set of particulars seems to include items such as ability to read and understand science-related popular reading matter, ability to listen and understand popular science-related programs broadcast by the electronic media. Perhaps ability to discuss science-related topics should be included as well; of course, understanding is assumed in this instance. The notion of understanding seems to be a "particular" associated necessarily with the skills of reading, listening and discussing. The kind of understanding, however, would seem to include more than implied by the skills themselves. It is the understanding of basic science concepts that forms the basis of whatever later understanding is wanted in the reading about, listening to and discussion of science-related topics. The "unifying principle" within the concept of scientific literacy can then be located in the understanding of basic science concepts. Ultimately, this is Karplus' intention for the SCIS curriculum.

Functional Understanding as an Element in Scientific Literacy

What then could Karplus' "functional understanding of science concepts" mean? I will develop two senses in which science education can contribute to a "functional understanding of science concepts". For a start, the image of practicality, of usefulness in future (or even present) life activities comes to mind, and would be one sense. A concomitant sharing with scientists of perceptions and comprehension of the physical world would seem to be implied, and would be a second sense. An examination of examples of curricular subject matter arranged by topics may provide some understanding of these two senses of "functional understanding".

The classic and continuing pattern-in-practice in elementary school classrooms is that of instruction in health practices: tooth care (the single most favored topic by teachers), nutrition (a close second), minor illnesses (e.g., colds) and human anatomy (heart, lungs, digestive system being favored). Ecology, a fifth theme, is more recent but also popular. The four components of student, teacher, subject and milieu all receive consideration in these themes. The student's interests in new terminology and concrete experiences dealing with egocentric concerns can find full expression in topics connected with food, human anatomy, illness and animals. The content level is both uncomplicated by large numbers of theoretical concepts and is usually well within the (even non-science) background of the elementary school teacher. Lastly, the community has traditionally supported these 'science' themes as part of the larger and ongoing socialization processes for which the teacher (and the school) are held, in large measure, responsible. In addition, the student has likely had some introduction in the home regarding each of these five themes.[9] It is most possible that the classroom repetition will serve to reinforce the original parental instruction (at least in regard to tooth care, nutrition and minor illnesses) especially since the instruction will occur in a somewhat different manner, i.e., different from the parental instruction patterns. In what sense is the understanding to be functional? One sense might be the possession of factual information (tooth structure, food categories, causes of certain illnesses, prevention of certain illnesses, standard textbook names of body parts, predator-prey data).[10] This factual information could then be useful in reading, listening to lectures/talks, and television/radio programs, and discussion whenever such scientific terminology is used. This is certainly also a sense of the term understanding when Karplus refers to 'functional understanding'. We can probably all agree that familiarity with vocabulary-in-use is a useful precursor, even though not sufficient to a fuller understanding of the spoken or written word. But are there any other senses beyond what seems a truly basic, even though essential, level of understanding?

Karplus does carry the notion of understanding beyond the concrete naming process into the abstract realm of concepts. His entire elementary school science program is based on the introduction and exemplification (through a variety of student 'discovery' strategies) of concepts integral to chemistry, physics and biology.[11] If we then assume that Karplus would be in agreement with Barrow's notion of concept, we are in a good position, potentially, to understand the full phrase "functional understanding of science concepts". The concepts are a) restricted to those related to the physical world, and b) serve as "unifying principles of various distinct particulars". It soon becomes clear that the previous considerations of the pragmatic nature of an enlarged vocabulary of terms useful in, even if not peculiar to, science, is not enough. It is then not carpals and tarsals that Karplus is actually thinking of but a concept such as 'the functional relationships of internal body structures in certain animals'. (It so happens that Karplus' program avoids anatomy of any kind, but I believe that the illustrative point can still be taken.) Whether this particular concept can find easy reception in an elementary school population or is an appropriate and necessary part of a science curriculum at the elementary school level is, at the least, disputable. Perhaps 'the interconnectedness and interdependence of all body parts' is a concept more appropriate to the elementary school level. Or is 'microbial causation of disease' better suited to this level? Perhaps 'good nutrition makes for good health' is easier to handle? The cell theory coupled with homeostasis, evolution, heredity and ecological interdependence of life forms are major biological concepts. Where do they fit into an elementary school curriculum and with what understanding?[12] Karplus seems to want to go beyond the mere teacher-introduction and student-recognition-of-concepts type of education.[13] Perhaps some level of understanding of the textbook or teacher-produced science information is what is acceptable. Karplus does write (see also previous chapter) that the student should "be able to use information obtained by others". The 'others' are presumably the collection of writers and speakers whose task it is to write or speak about science in easily understandable terms (after all, Karplus has designed his concept of scientific literacy to fit in with the educational framework of elementary schools). Elementary school science textbooks would likely fall into this sphere (and Karplus does refer to "the reading of textbooks"). Would newspapers and magazines be included in this sphere of 'others"? Possibly, yet most elementary school students have difficulty even reading non-science articles and <u>understanding</u> them. No study has shown better comprehension results with science articles and magazines as compared to non-science articles and magazines. Karplus adds: "and other references". Might he be thinking of technical references or the more demanding popular science magazines written for an adult (and usually university-educated) audience or the overwhelmingly numerous professional magazines? And how does he see an elementary school education preparing anyone for these? Or would he limit the "other references" to the popular press with its record of distortions, misinformation and incomplete information?

Karplus does not address any of these questions.[14] Instead, and wisely so, he concentrates on a rationale for science education as part of the elementary school program. He expresses two concerns, only one of which actually includes scientific literacy as an outcome. One concern centers on the disinterest in and even hostility to high school science courses in evidence in the majority of students in North American high schools. There is no lack of data backing up this concern even in the most recent high school surveys (some 10-12 years after the implementation of Karplus' SCIS curriculum). In most North American high schools, there is a state-determined graduation requirement of one year of a science course. In some 80% of the enrollments in such a required science course, either General Science or Biology (or a biology-derived) course is chosen. Chemistry and Physics courses are traditionally available as electives, with some 6.9% choosing Chemistry and 3.1% choosing Physics.[15] If a larger enrollment in all high school science courses is desirable, then his concern is well-placed, especially since studies show much positive interest in science among elementary school student populations. Between the end of elementary school and the beginning of high school, these same students show a marked shift from interest to disinterest, and from positive attitudes to negative attitudes.[16] Karplus would like to change this pattern so that more positive interest in science would remain in high school students as evidenced by their choosing to enroll in Chemistry and Physics electives.

He does not seem to see this change occurring in the near future or in large enough numbers to inspire a conviction that the majority of students will remain in science courses throughout their high school years. Instead, he links his second and prior concern of scientific literacy with the elementary years. He sees the possibility of capitalizing on the natural and easily stimulated curiosity of K-6 students to enable teachers to introduce and students to willingly and actively 'discover', in those seven years, all major science concepts emanating from the disciplines of chemistry, physics and biology. By use of standard science terminology (such as systems, motion, solution, concentration, interaction) by both teacher and students and sequentially linked to concrete and pre-determined instances of concept-exemplification (recipe 'experiments', demonstrations, field trips, A-V aids -- all of which Karplus considers to be 'discoveries' for the students) he foresees that all major science concepts can be presented in those seven years AND THAT SOME UNDERSTANDING WILL BE POSSIBLE FOR MOST STUDENTS.

This last point has been emphasized by this writer for two reasons: (1) without this possibility, all of the concept expositions and 'discoveries' of the K-6 years are perhaps still necessary (i.e., to stimulate continuing interest in science in order to keep positive science attitudes positive) but clearly not sufficient for scientific literacy; (2) innate cognitive developmental patterns, as worked out by researchers such as Jean Piaget (on whom Karplus relies greatly), tend to show that the intellectual processes involved in understanding (of science concepts) are in full operation before the end of the seventh elementary school year for the vast majority of students.

It is this combination of exposure to science concepts and understanding of science concepts that Karplus envisions as readily possible in those seven elementary years. At the same time, since everyone could be exposed to and benefit from such a science program, all citizens, no matter their future pursuits, would be literate enough, scientifically speaking, to make use of scientific information in everyday life and in decision-making instances that necessitate some familiarity with science concepts and particularities. For Karplus, students would be using evidence, reason and arguments in support of claims. Likewise in the case of conflicting claims; they would be trying to resolve the discrepancies in a rational manner.

Interim Summary

It might be best to stop here momentarily in order to recapitulate the implications of the concept of scientific literacy that have been introduced so far. To begin with, these implications are not meant to be exhaustive, or even coincidental with the reader's. They are introduced as indicators of the complexity and even confusion and occasional contradictions possible in a concept that is frequently treated as unproblematic, functional and self-evident in meaning.

The writer has tried to link some of the pragmatic implications of literacy with the notion of usefulness or practicality in Karplus' expression of "functional" as in his "functional understanding". In so doing, questions were raised about the implications and place of a K-6 level of scientific literacy in career decisions, science-oriented discussions, the workings of everyday technology. The possibility of differing levels of understanding was introduced.

It is not unreasonable to argue that scientific literacy, as envisioned by Karplus, has sharply limited long-term career and citizenship value, but has short-term value in possibly maintaining some level of student interest in science and ensuring a universal introduction to concepts inherent to the major science disciplines. However, divorced from the functional significance of long-term career and citizenship concerns, this last educational value would seem to find a more comfortable home in a classically 'liberal' educational setting than in a pragmatic literacy setting.

If we now turn our attention to Klopfer's view of scientific literacy (see also preceding chapter), we can at least make some progress toward the establishing of a convenient dialectic.

Socialization as an Element in Scientific Literacy

Klopfer sees the need for a mandatory and full (traditonally 4-year) high school science curriculum for all students, much as all are required to take four years of English and four years of social studies in the U.S. And, as in most American high schools, tracking or streaming will separate students, fairly efficiently, into two levels: the 10% of students who have elected to pursue science programs in higher education and are thereby in a science stream, and the 90% who will either not go on to higher education or who have chosen to pursue non-science programs in higher education.[17] It is within this statistical context, distributing both students and teaching, that Klopfer offers his rationale for scientific literacy. However, before we proceed, it must be noted that he does not anticipate any problems about elementary school science -- neither about its absence nor its presence. (It may be safely assumed that 'absence' would provide recruits for the ranks of the 90% and 'presence' would provide at least some of the recruits for the 10%.)

In terms of curriculum content, Klopfer's notion of scientific literacy translates itself into the study of science-technology-society interaction, science values and ethics, and science enquiry processes.

On the surface, this looks promising if the pragmatic nature of literacy is to be emphasized. In contrast to Karplus' basic preoccupation with the realm of the theoretic, Klopfer seems to want students to come face-to-face (unlikely in classroom, but provisionally possible) with the realities of everyday encounters with the products, problems and benefits of science and technology. Societal and personal values may conflict with values shared by members of the scientific community; citizen decisions may have to be made; and students are exposed to the type of reality they will be faced with upon graduation. Along the way, exposure to scientific methodology will help students to understand, to some extent, the working style peculiar to scientists, a style that is linked to the accumulation of knowledge and the discovery of truth.

All of this is to be accomplished within some four years and with a minimum of major science facts, principles, concepts and science skills. An understanding of the organization of scientific knowledge, the development of intellectual processes specific to science, and an understanding of the nature of scientific inquiry plus an emphasis on major science facts, principles, concepts and skills are the content of the curriculum destined for the 10% in the science stream, and are pointedly not to be included in the curriculum having the goal of scientific literacy.

What does Klopfer's view of scientific literacy imply? One of the most noticeable implications is the absence of science concepts. Klopfer does not see them as necessary. Even though arguments could be made (and have been made) that the possession of science concepts is not sufficient to ensure scientific literacy, it is not at all clear how one might argue to their being unnecessary. If the position is taken that literacy should quite reasonably and even necessarily involve familiarity with the fundamentals of a certain sphere of knowledge, and if certain major concepts are inherent to that sphere of knowledge, would it not be equally necessary to be familiar with those major concepts? This is not to suggest that the fundamentals alluded to consist only of certain major concepts. On the other hand, it is hard to imagine their being excluded from the notion of literacy, unless a radically different view of literacy is postulated.

This, I believe, is the case when delineating Karplus' view of scientific literacy as against Klopfer's. It is not simply a difference in schooling level (elementary vs. high school) or target student populations (all vs. 90%) or even curriculum content emphases (neither is meant to totally exclude non-emphasized content). Rather it is the essentially differing notion of the value of scientifically literate individuals. As products of schooling, Karplus' view contains elements of continuing individual growth as useful for future plans. Klopfer's view is imbued with concerns about proper socialization. This requires some explanation. Perhaps an analogy would be a convenient starting point. Civics classes are a traditional part of required American high school programs. In such classes, students are shown the workings (processes) of local, state and national governments through recourse to readings, texts, audio-visual presentations, visits from government representatives and trips to courtroom and officials' offices. The values of a democracy, in general, and as presently organized, are emphasized; the correct ethical positions of government officials are indicated, and it is hoped that the students will come away with feelings of patriotism and pride in the existing structures as well as with the values embedded in concepts of democracy, individual and societal rights and duties, justice, etc. A sort of civic literacy is wanted, coupled with some emotive outcomes that are at least not against the status quo. (After all, it is not in the interests of a government that funds public schools to encourage anti-goverment hostility and anger). The students have experienced another stage in the general socialization process to which the school is committed.

It is not too difficult to visualize Klopfer's scientific literacy curriculum following a similar format (particularly since there are textbooks already available at the 6th, 7th and 8th grade levels incorporating Klopfer's curriculum emphases for scientific literacy). Many science educators applaud the urgent inclusion of value or ethical considerations in the teaching of science courses; it must be understood that the values and ethics referred to are, of course, those emanating from the scientific community.

What are the implications in Klopfer's notion of scientific literacy? Let us examine his notion using a strategy similar to that used with Karplus' notion of scientific literacy. Does Klopfer's idea of scientific literacy lend itself to a 'higher' type of literacy? Not likely, since all elements related to scientific knowledge are removed from the curriculum designed to produce scientific literacy. Barring the chances of even a noticeable minority of high school students, on their own (i.e., outside of class and unrelated to class activities or assignments) pursuing the quest of scientific knowledge (facts, principles, concepts, etc.), literacy, as in "educated or learned", is not an outcome to be expected. Then, surely a 'lower' type of literacy or minimum literacy might be possible, i.e., a reading, writing, listening type of literacy. It is difficult to see how, since vocabulary peculiar to scientific disciplines seems, by and large, to be absent from the scientific literacy curriculum. Concepts, facts, and principles, all of which are replete with scientific codes and scientific terminology, are confined to the science stream curriculum.

If the vocabulary useful to science concepts such as, say, nuclear energy, is introduced into the scientific literacy curriculum, without the accompanying concept, what sort of learning could take place? If construction of nuclear power plants is part of the focus of the science-technology-society interaction emphasis of the curriculum and teaching/discussion/learning takes place <u>without</u> the concept of nuclear energy and accompanying vocabulary, what sort of learning could take place? Let us examine some possibilities. Will the teaching presentation be in favor of the construction of nuclear power plants (powerful, cheap energy source, technologically advanced, safe, etc.) and relatively easy and straightforward? Or will the teaching be against the construction of nuclear power plants (dangerous, expensive, etc.)? The latter is unthinkable without some attempt to present the opposing side, which would then require some rational dexterity grounded in both rational processes and scientific facts, concepts, etc. If only the side favorable to the construction of nuclear power plants is presented, we avoid this difficulty and replace it with questions of indoctrination in the guise of socialization. In any event, even this side, without the use of science concepts and terminology, would need to use arguments drawn from economics, politics, moral philosophy, etc., which arguments transform the course into something other than science, the result of which could not easily be termed scientific literacy. (There is no intent on the part of this writer to, in any way, disparage attempts at an inter- or multi-disciplinary approach to the teaching of science-technology-society interactions; the question is, rather, the form of literacy that is thereby attainable.)

Concluding Remarks

It is timely, now, to summarize the results of analyzing the concept of scientific literacy, results that are for the moment, cursory and incomplete. Nonetheless they will be able to point to promising directions in the deliberative enquiry.

What are the major threads that hold this scientific literacy tapestry together? Even though its linguistic origins show some associations with the more general state of 'being educated', there is no ready denotation for the term 'scientific literacy'. Instead, connotations must be sought out among the writings of science educators who have contributed extensively to the development of this science education goal. Karplus would have us think of scientific literacy as a form of "functional understanding" whereas Klopfer considers scientific literacy as a form of socialization necessary to a well-motivated citizenry.

It is to be hoped that the analyses developed in this chapter have resulted in exposing some of the multiple facets of the scientific literacy concept as well as the minefield of conceptual difficulties that are a legacy of a 30-year history as science education slogan cum science education curricular goal. Even though the goal of scientific literacy is probably, in practice, as distant from classroom teaching objectives as other curricular goals tend to be, its resurfacing as a politically-tinged science education goal in the 1980's must be viewed with caution. The next decade may well see the transformation of scientific literacy as a distant goal into scientific literacy teaching objectives that will serve to form generations of students. As Roberts writes: "The unfortunate legacy of the phrase 'scientific literacy' is that, used by different speakers, it can mask legitimate and important differences in value preferences concerning the goals of science education".[18] Roberts argues that these values and positions need to be aired and that this can be done only when the goal of scientific literacy is recognized for what it is, namely, a mask for any number of different values. There is no single, easily described, concept of scientific literacy, nor is it likely that there will be in the near future. Of greater importance is recognition of this fact and conscientious efforts put into the unmasking of each version of scientific literacy that is offered to curriculum developers. Only then can decisions be made, locally or otherwise, about the curricular emphases and content that best translate into desired learning.

The next chapter will place scientific literacy, as science education problem, within the framework of deliberative enquiry. The historical background and conceptual analysis of the goal of scientific literacy should help in the perception and understanding of at least some of the details of the problem situation surrounding this science education goal.

CHAPTER 7

SCIENTIFIC LITERACY: PROBLEM PERCEPTION, FORMULATION AND CHOOSING

Focus of Chapter

The work of this chapter will center on a consideration of the teaching and learning situation regarding scientific literacy "in all its completeness and with all its differences from other concrete cases (i.e., a large body of fact concerning which a theoretic abstraction is silent)."[1] One task is to identify "frictions and failures in the machine [of educational practices] and the inadequacies evidenced in felt shortcomings of its products" using the arts of perception.[2] This will be followed by a formulation of the problems using the arts of problemation. Because of the non-procedural and non-sequential nature of these arts (as discussed in chapters 2 and 3), the powers and capacities of deliberators form the basis of potential success. There is no technical expertise in curricular deliberation that will rescue the deliberative process by resorting to a fixed methodology, thereby absolving the deliberator(s) of failures in perception or problem formulation.

In this problemation phase of the arts of the practical, I will also use the device of separating settled from unsettled elements in the generally troubled and indeterminate educational situation initially exposed in the problem perception phase. The teasing out of settled situational elements from unsettled ones will prepare the way for a movement from the initially ambiguous and indeterminate educational situation to a partially determinate situation. This movement from indeterminate to determinate will be accompanied by much back-and-forth reviewing and reconsideration between the perception and problemation phases as well as some tentative projections to solutions. These solution projections (or imaginative rehearsals) are intended in this instance solely to expose further details of the eductional situation and to suggest possible meanings for these details.

Karplus and Klopfer will be called upon to help in the identification of "frictions and failures ... and the inadequacies" of the teaching and learning situation regarding scientific literacy. The dialectic introduced in the preceding chapter will be taken up again and developed further. Additional science educators will be called upon as well to contribute to an elaboration and/or criticism of the views and themes expressed by Karplus and Klopfer. Some will also bring new concerns to light. It is hoped that these efforts will also be characterized by careful consideration of and reflection on defensible problem choices made. The choices made will involve dispositions to action, action that is tailored to somewhat specific teaching and learning situations.

The resulting written discourse should be viewed as one modality for an exemplification of curriculum deliberation. Other modalities, involving actual in-the-field and group practice as opposed to written and single-deliberator practice are definitely necessary to a fuller exemplification of curriculum deliberation, but are not part of this discursive deliberation. The descriptive nature of this discourse on prospective curriculum practices will have served its purpose if the reader can be persuaded to undertake an empathetic sharing in the deliberative experience.

Attention will now be directed to a brief overview of the variety of sources on which I will be drawing for perceptions of the problem situation surrounding the educational goal of scientific literacy, and suggestions for problem formulations.

Perception of Problem: Scientific Literacy as Viewed by Public Education Stakeholders

Schwab's practical arts are based on two premises: "that institutions are normally to be preserved and changed" only gradually and with much care, and "that legitimate differences of interest (and opinion) exist among men."3 It is the second of these premises that deserves adequate and detailed consideration when investigating the source(s) of an educational problem.

Connelly et al. have identified a somewhat lengthy list of stakeholders in elementary and high school curricula: students and teachers as prime stakeholders; parents and school trustees sharing concerns about socialization, career preparation, custodial care and learning of skills and information; politicians with rhetorical concerns about democratic availability of services; taxpayers having financial concerns ('value for payment'); consultants, administration and universities sharing professional educational concerns; business and occupational groups sharing job or career preparation concerns; private and government agencies sharing third party analysis and investigative concerns; and lastly, the ministries or departments of education having policymaking responsibilities for the education of the general public and in this task having to balance the various claims of other stakeholders.[4]

Most of these stakeholders are seen by Tyler and Goodlad as thwarting what ought to be the true meaning of a curriculum.[5] The majority of Connelly's stakeholders would be political, occupational and educational leaders and policy-makers espousing education for political and economic values related to the market place, whereas Tyler and Goodlad see what they consider the true values of education short-circuited: self-development, autonomy, inquiry skills, self-awareness. They argue that, if students were educated in this 'personal domain', the literacies required by society would be forthcoming. Direct education of the 'personal domain' would indirectly reap individual harvests of knowledge and skills in subject matter areas. However, this stance, with it philosophical concerns, is not nearly as evident in science education literature as are career, social and national concerns.

The views of a succession of curricular stakeholders will be presented with the intention of eliciting their perceptions of scientific literacy as a curricular problem. Helgeson et al. introduce us to a range of some 12 possible sources of scientific illiteracy derived from an extensive archival review. Power focuses on the role of teachers as partners with educational researchers and on the need for curricular continuity in science education. Pella and Showalter have made important contributions to the development of learning objectives in science education. Green, Klopfer, Yager and Hofstein share their views about the educational and social values of curricula that are designed to produce scientifically literate students. I will take the opportunity to examine the notions of importance, relevancy, and enjoyment when applied to courses of study. And, lastly, drawing on Hare, I will examine some implications associated with the inclusion of controversial issues in course content.

Beginning, then, with the collection of science lacunae identified by Helgeson et al., I go on to a more detailed discussion of some of these lacunae in order to arrive at a better understanding of some of the dimensions of the scientific literacy problem as perceived by some leading educators. These educators will help to extend the views and themes in the positions held by Karplus and Klopfer. In addition, they will help bring to light new concerns about the curricular goal of scientific literacy.

Helgeson, Blosser & Howe concluded, in their major archival study of the status of pre-college science education as revealed in science education literature from 1955-1975, that scientific illiteracy has many sources: 1) science lacunae in the policy-making of elementary and secondary schools; 2) lack of articulation of many available instructional materials with existing science programs; 3) a consistent and large decrease in student enrollment in senior science courses as compared to junior science courses; 4) lack of science education in the elementary teacher training programs; 5) lack of intensive science institutes for in-service training; 6) lack of adequate science preparation for teachers assigned to science courses below the senior level (i.e., assigned to grades 7-10); 7) decrease in U.S. federal and state financial support for science programs; 8) exclusion of science from the return-to-basics curricular emphases, particularly on the elementary school level; 9) lack of equal educational opportunities for the senior level non-science stream students; 10) frequent absence of science education goals in lists of state education goals; 11) education objectives in public sector science education restricted to pre-college varieties (i.e., cued in to college admission preferences); 12) lack of effective communication of the results of research in science teaching/learning, particularly to the teaching body.[6]

This last difficulty is taken up in a promising way by Power who sees a practical relationship between science education research and the teaching process. In Power's view, which he backs up with a number of interesting examples, science education research

> can and should sensitize teachers to the nature of the problems they face, help them to make more informed clinical judgments about what is worth trying, and provide a foundation on which to build new materials and approaches.[7]

Power also suggests that the lack of a planned developmental process going from elementary through high school produces "significant discontinuities" in the learning experiences of students which in turn disrupt or prevent the acquisition of well-organized mental structures about science.

Any review of current science education literature will soon conclude that the formulation of educational objectives for scientific literacy is seen as a necessary and even critical occupation by any number of science educators. Pella's now classic list of referents for scientific literacy is one of the first of such lists. A lengthy and elaborate archival review by Pella and his colleagues, of some 18 years of professional science education literature, resulted in (not surprisingly) a composite description of the scientifically literate individual

> as one with an understanding of the basic concepts of science, the nature of science, ethics that control the scientist in his work, interrelationships of science and society, interrelationships of science and the humanities, and the differences between science and technology.[8]

These characteristics eventually were transformed into science education objectives by others. Pella, some 10 years later, can write that

> science teaching for literacy must refer to education for those who are capable and desirous of a general or liberal education.[9]

This statement is not to be confused with an exhortation to provide science to all students. Instead, he sees scientific literacy in terms of the ability to "read and interpret technical literature" because personal "welfare or decisions depend on it".[10] This reading and interpreting of technical literature is to be based on a "knowledge of the library of science", i.e., "empirical concepts and laws, theoretical concepts and laws and the protocols of development", and should be basically restricted to "those who are capable or desirous of a general or liberal education".[11] Even though there are 10 years separating these two examples of Pella's thoughts regarding scientific literacy, it must not be assumed that we are witnessing a shift away from a more composite description of a scientifically literate individual to a more restricted one. The 1966 paper was in essence a cataloguing of referents to scientific literacy culled from the writings of a comprehensive number of science education leaders and authors. The 1976 paper shows a concern with a view of scientific literacy that has more manageable dimensions, manageable in so far as the capacities of public education will allow. Unfortunately, Pella's referents from the 1966 study are treated by many other science educators as an essentially composite definition of scientific literacy from which behavioral objectives can and should be deduced.

No such misinterpretation is possible in the writings of another influential contributor to the delineation of the concept of scientific literacy. Showalter also began his study of scientific literacy by a search of relevant literature (in this case some 15 years' worth).[12] His conclusion was quite different from Pella's. Instead of literature referents, he produced a definition of the scientifically literate person and went even further by listing and describing some factors determined by him to be specific to each of the seven dimensions of his definition. These were all translated into behavioral objectives by Showalter and later revised by others.

These composite senses of scientific literacy, whether it be Pella's 6 referents or Showalter's more elaborated 7 dimensions (see Appendix D for the latter),

> are not too useful to a curriculum policy committee trying to think through legitimate program differentiation.[13]

There are two potential difficulties with composite senses of scientific literacy: (1) their translation into appropriate science education goals in public education, and (2) the camouflaging of important value positions. Roberts argues that a selection from these comprehensive views of scientific literacy would seem to be in order and more suitable to the capacities, exigencies and limitations of a typical 12-year public education system. However, those who argue in favor of the more composite or multifaceted views of scientific literacy are currently in the majority and emphasize the importance that should be attached to an inclusion of all these facets in science education.

At the same time, the presence of a large number of scientific literacy dimensions, or as is more usual, the presence of a large number of learning objectives written to guide the development of scientific literacy in learners, distracts one's attention from the underlying values positions. Views of scientific literacy that try to be composite often mask the value positions of the authors of such descriptions of scientific literacy or its related learning objectives.

Value positions may be explained and justified in a number of different ways, often including economic (e.g., future careers, funding of school labs) and political (e.g., citizenship, equality of educational opportunity) rationales.

Three of the more interesting and candid expositions of science education value positions can be found in Green's and Klopfer's projections to the future in science education, and Yager & Hofstein's prescription for quality science education in the public schools.[14] Green groups North American societies' predominant educational values as those of managerial (functional), traditional (cultural heritage), humanistic (philosophic) and religious, and argues that the managerial values will acquire even more importance in the last quarter of the 20th century, leaving traditional, humanistic and religious values trailing the field when educational objectives (as opposed to aims or goals), measured student outcomes and curricula-in-use (i.e., the totality of school practices) are examined. The traditional, humanistic and religious values will continue to be represented in the vague school board statements addressing the philosophical underpinnings of curricula-in-use, but they will be neglected in the quantitative and qualitative measures of schooling and student outcomes. Nonetheless, the resulting discrepancies, in Green's view, will not lead to serious conflicts because of the strongly held, even though perhaps unwritten, managerial values of the vast majority of educational stakeholders.

Klopfer is one of the few persons in the science education field who seems to hold strong structural functionalist views and who is a consistently influential science educator.[15] His position on values in education is suggested in the following lines:

> The key feature in the science education pattern of 1991 will be the clear distinction of two curricular streams through the secondary school and college. One curricular stream will be designed for students planning to enter careers as scientists, physicians and engineers We shall call this the Prospective Scientists stream, or PS stream. The other curricular stream will be designed for students who will become the nonscientist citizenry in all strata of the society, that is, people who will have careers as housewives, service workers, salesmen, business managers, artists, accountants, government officials, history professors, clergymen, etc. We shall call this the Scientific Literacy stream, or SL stream. Differentiation of students into the PS stream or the SL stream will begin at about age fourteen when they choose the high school they will attend.[16]

At the elementary level, the science program would remain unstreamed and would be shaped partly by content (science processes and major science concepts) and partly by "the recent insights obtained by behavioral scientists into the child's physical, emotional and intellectual development."[17] A 'Career Prediction Test Battery' administered in the 8th grade, will be the most efficient and reliable measure of scientific literacy (SL) or prospective scientists (PS) choice for high school (there being separate high schools for the PS students). The SL high school courses will fall into three types and are obligatory: history of science, sociology of science, and the interrelationships of science disciplines. School debates will serve as a particularly valuable pedagogical device for citizenship preparedness. By the end of the 12 years of public schooling, the SL student, according to Klopfer, should be able to make intelligent choices in both personal and societal science-based matters, should be able to translate these choices into appropriate action, and should be able to understand, appreciate and support the functions of science and technology in modern society. The PS student, on the other hand, will pursue a largely (1/2 to 3/4 of courses) science-oriented 4 years of high school "which will be highly specialized and demanding", and presumably will also subsume the SL objectives but without the SL courses.[18] In any event, Klopfer's major assumption regarding scientific literacy is that the SL student will be able to achieve the SL objectives based on science concepts and processes from elementary schools that will be enriched by the historical and sociological additions in high school. This two-tiered science education agenda will be easily reproduced because the future SL teachers will come from SL schools and the PS teachers will come from PS schools.[19]

Karplus, while using a curricular route that differs substantially from Klopfer's, would agree with Klopfer's major educational purposes in a scientific literacy curriculum. One of these purposes may be summarized in a phrase when he writes of "functional understanding", a level of understanding that leads to ready application of science concepts and skills in everyday matters. Klopfer also advocates this level of understanding, differing primarily in the curricular route most likely to encourage its development. A second purpose is that of universality. Karplus clearly believes that the development of "functional understanding" is possible as an educational goal for all students, not just those who elect to concentrate on science courses in their individual educational programs.

Underlying both the more traditional positions (particularly as exemplified by Karplus and Klopfer) and the newer positions (especially as presented by Yager) are educational and moral values that deserve to be brought to the surface and examined in relation to the other elements in the scientific literacy situation. In so doing, linkages and similarities between superficially disparate positions can be exposed and examined in such a way that a fuller perception of the scientific literacy problem can be hoped for.

For the purposes of this paper, I have also chosen to focus on a third position that happens to be one of the newer dimensions that many science educators attach to the concept of scientific literacy, new and at the same time provisionally controversial. Klopfer's science-technology-society dimension and Showalter's "understanding and appreciating the joint enterprises of science and technology and the interrelationship of these with each and with other aspects of society" are characteristic expressions of this third value position.[20] At the same time, these expressions already point to some emergent differences in value positions among those proposing curricula specific to the development of scientific literacy.

These emergent differences serve to mark an important development in this deliberative enquiry. The discrimination of differences will help to regroup the concerns of the stakeholders, by pointing to, for example, previously unnoticed shared concerns or divergent values. Certain major or minor consistencies can be observed, consistencies that may eventually direct the enquiry to an awareness of settled elements within the educational situation as well as to unsettled elements. The initially indeterminate educational situation then becomes somewhat less so. The enquiry is still far from fully displaying the exposed educational situation, but a step has been taken in the direction of fuller perception of the curricular problem and incipient formulation of the problem.

In formulating the scientific literacy problem, Klopfer and Showalter, among others, consistently stress the traditional and supporting role that a scientifically literate citizenry should play in respect to science, a role that falls well within Green's managerial values. Yager & Hofstein, while not opposing such a role, introduce a relatively new feature to this role, namely, that of morality. Most writers tend, though, to the use of a vaguer or more general term, namely, that of 'values'. Yager & Hofstein conveniently combine them:

> Many now call for values to be approached directly and forthrightly as an important dimension of science - this

is not to suggest teaching correct values, but to confront the undeniable fact that most science has ethical/moral dimensions.[21]

It should be noted that the "call for values" is usually linked to personal decision-making (in the sense of for one's private benefit), decisions as a citizen (and thereby for society's benefit), and course relevancy or importance in the eyes of students. As a participant and co-author in a number of the most recent national U.S. science education studies, Yager's "call for values" (he being one of the many) may be taken as fairly representative of the concerns of like-minded science educators.

Let us take a closer look at Yager's position as just summarized. Yager writes that if the values dimension of science were "approached directly and forthrightly" in scientific literacy courses, the relevancy of the course would become more evident and thereby increasing the interest and motivation of students in such a course. However, if a decision to include a values dimension in a science course is based on available accumulated data instead of speculation, a somewhat different picture emerges. Student polls, questionnaires and observational studies tend to show that the importance of a course in the eyes of students rests on a number of variables, the least indicated of which seems to be morality or 'values' content. General academic prestige, relationship to career possibilities, requirement for high school graduation, requirement for admission to post-secondary institution, peer group interest are all more accurate as student indicators of course importance than content per se, moral or otherwise. At least four of the five indicators just mentioned, hold true for high school science courses in general, as a result of which high school students have no difficulty whatever in acknowledging the importance of science courses.[22] Moreover, students are not immune to the kinds of managerial values prevalent in modern society. The functional relationships between course content and future usefulness in education and/or career choices do not need to be spelled out in further detail for students to be understood as linked to the notion of course importance.[23] Even when importance is considered in traditional or humanistic senses (that is, linked to inherent worth of the subject), students have no difficulty placing science courses on a pedestal of prestige and importance.[24] Does all of this inevitably lead students to choose to enroll in a science course when given another option?[25] It would seem not. All of the statistical evidence from the U.S. and Canadian national studies bear witness to unquestionably enormous drops in student enrollments in those science courses (usually at the senior level) not required for graduation.

Yager also suggests that the relevancy of the course will be enhanced if a values dimension were to be included in the course content. Relevancy is frequently spoken of as a criterion in course selection in general. The claim is often phrased in the following manner: if the student believes the course to be a relevant one, he/she will choose the course over others that he/she believes to be less relevant or irrelevant. Again, it is best to be reminded that we are dealing with the same population of 13-18 year-olds who have already accepted the importance of science courses as given. It then should also be clear that the claim to importance is not readily linked to the choosing of science courses for most high school students. Hare's treatment of the criterion of relevance may serve us well in this instance.[26] He makes three observations which are pertinent to this paper. Firstly, the terms 'relevant' and 'irrelevant' are so emotionally-laden that it is with difficulty that a search for the meaning of the concept and its place of value in the school setting can be undertaken. Secondly, it is a relational and context-dependent term, that is, the term cannot be understood by examining the intrinsic nature of something (for example a course), but rather by showing connections between two or more things within a given context; if the context were to change, the connections previously established may easily be broken. Thirdly, the connections just alluded to are not between objects but between concepts or ideas:

> comments, suggestions, remarks, programs and criticisms are among the sorts of things which can be relevant or irrevelant;

and

> whether or not X has a bearing on Y is not written into things. It calls for human decision, and it is quite possible not to notice a connection which in fact exists.[27]

The question that must be asked is: In what way(s) is X relevant (or irrelevant) to Y? And the answer, since it is a judgement, "demands experience, skill and expertise".[28] Yager & Hofstein are prepared to leave this type of judgmental decision in the hands (or minds) of 12-17 year-olds, the judgment being made <u>before</u> the course is taken. Belief in someone else's (teacher, counsellor, parents, peers, older siblings) judgment of relevancy would seem to place a very different type of judgment in the picture. But then, is the latter not precisely the way in which course election has been made traditionally, at least on the high school level? Parents, teachers, etc. suggest to the student faced with a course election, that course C's ideas, information, skill training will be helpful in the hoped-for job J or profession P. For those who lack "experience, knowledge, skill and expertise", suggestions that are related to concrete issues of job or profession are more easily understood than if related to more nebulous notions such as intellectual independence, decision-making, open-mindedness.29

On the other hand, if Yager had dwelt, at least partly, on the promise of an excitement, enjoyment or entertainment to learning ratio in the science course, his speculations about the eagerness of students to elect such a course might have been more promising. The appeal to enjoyment does not have to be based on the level of "experience, knowledge, skill or expertise" of the student. And, more importantly, it is a universal appeal, exactly what is needed in order to encourage voluntary enrollment. A plethora of studies have already provided some constructive guidelines as to ways in which to promote enjoyment of courses for students. It has been found that certain teaching strategies, certain teacher personalities, certain textbook styles, certain classroom physical conditions all can lead a student to like a course.30 Course election can then be freed from the complications associated with relevancy (at least as seen by Hare) and the objective of science course election will have been achieved. Any learning that can take place within the confines of the course is then a happy by-product and one that is not to be disparaged just because of the means used.

Once the student is in attendance, the content of the course becomes somewhat critical, and it is here that Yager would seem to allow for great latitude as long as personal and citizen decision-making skills about science-based issues are stressed. (It would seem necessary to assume some level of controversy in these science-based issues, otherwise questions of decision-making would tend not to arise.) Environmental issues (pollution, acid rain, overpopulation, conservation, etc.), health issues (drugs, nutrition, reproduction, illness, etc.) and political issues (nuclear power, space exploration, defence programs) would certainly be candidates for topics in any high school science programs having the above objectives. It is precisely in the designing and planning of such a course that the problems alluded to earlier in this chapter, can be discovered.

A closer examination of the implications in choosing such material for course content cannot be avoided. Hare has offered some discussions and arguments that are pertinent to such an analysis and they will be, in part, drawn upon. To begin with, there will need to be certain assumptions acceptable to all of the stakeholders in this high school scenario. They might be summarized as follows:

1. the administrative and school board officers have found no reason (political, legal, religious/moral, cultural) to oppose such a course;

2. the parent body is in accord with the treatment of controversial science-based issues as provided by the teaching staff;

3. the larger community (as in a public school milieu) is in accord

with the treatment of controversial science-based issues as provided by the teaching staff;

4. the student body has no reason (religious, cultural) to oppose such a course;

5. the teaching staff is willing and able to teach such a course.

Unless these potential barriers are avoided or effectively removed, the implementation of such a course becomes highly problematic and the examination of its content is equally problematic. Westbury & McKinney, in a case study of the Gary, Indiana, public school system develop the view that, if change is to be more than tenuous in its hold on the already established ideas and habits of educational personnel, i.e., "if a given idea is to be enacted and with a continuity that transcends the life of a given teacher in a given school", there must be recognition of "the necessity for explicitly institutional structures of support and control".[31] It must at all times be remembered that courses promoting scientific literacy and encompassing Yager's educational objectives, will always be faced with these public considerations. If this can be agreed to, then we can go on to address the nature of such courses, at least as proposed by Yager, keeping in mind that his views are shared by many others. Harms & Yager phrase it well enough in their study addressed to science teachers:

> A common element of personal and societal goals is the importance of the <u>application</u> of science to problems of personal and societal relevance. In order for students to be able to apply science to such problems, it is necessary that they have an understanding of the problems and of the relationship between science and these problems. Students should also have experience in the processes of applying science to the solutions of such problems.[32]

It is this "common element" that is, in practice, quite controversial. There is, at the moment, no best answer to questions of purpose, rationale and methodology: what is the intended student outcome? What is the intended connection between scientific or social problems? Which personal or social problems are best suited for course work? Is science to be the only source of information and methodology in the solution of personal or social problems? Because of its importance in proposed scientific literacy curricula and in order to delineate and exemplify the ambiguity surrounding this "common element" I will concentrate, a while longer, on this aspect of proposed curricular content.

Controversial Issues in a Science Course: A Rehearsal

As has just been discussed, a consistent element in all of the most recent suggestions for scientific literacy curricula is that of science-society interactions. I propose to accomplish three things in this section of the chapter: (1) to take a detailed look at one example of a science-society interaction that could quite conceivably be included in a typical scientific literacy course, namely that of abortion; (2) to rehearse imaginatively and discursively, a variety of projected scientific literacy course scenarios about this interaction example and (3) to tease out of such rehearsals, details of the teaching/learning situation that might lead to a fuller understanding of the educational situation.

Questions related to the nature of a controversial issue, the treatment of controversial issues and teacher neutrality will now be considered in more detail. Drawing again on Hare, we are offered a view of 'controversial' that can be applied without violence being done to the type of course content under consideration:

> (1) that it is a dispute of some significance in a public forum;
> (2) that the resolution is not readily available;
> (3) that it is disturbing, though the factor which disturbs varies from case to case.[33]

He regards these three conditions as each necessary and jointly sufficient in order to consider an issue as controversial.[34] For the purpose of example and as an aid in this part of the discussion, a specific and current dispute in the public forum will be introduced and periodically referred to: that of abortion. Abortion is often presented in juxtaposed and polar positions when discussed publicly: either it is an act of murder or it is a personal and moral-free (i.e., scientific or health-related) decision. The public nature of this dispute can be seen as emphasized in direct relationship to the extent of public funding for the act. Canada's provincial positions on the legality of abortions and the U.S. federal funding (or rather absence of it) in abortion cases involving women on welfare, have provided sufficient examples supporting the significance of this dispute and its public nature. It is also evident that resolution is not readily available: the provision of legislation and abortion facilities, and the lessening of social stigma have not lessened the level of dispute. And lastly, "that it is disturbing" cannot be doubted by anyone who has watched debates, seen picket lines and read any reasonably articulate publication. The specific factors in the dispute may vary from questions of physical and mental autonomy through origins of life and humanness (i.e., when does life begin for the human being and when does humanness begin?). These questions inspire arguments ~~having~~ embryological, healthcare/technological, psychological, moral/ethical, religious, legal and philosophical bases. (This list is not meant to be exhaustive; rather, it is to be hoped that it illustrates the many-layered nature of this particular issue.)

If such is the nature of one science-based controversial issue, can implications be projected if it were to be included in a 'typical' high school science course? Would it be reasonable to adhere to the science-based components of the dispute and leave the non-science components to other parts of the total curriculum (e.g., Moral Education, Introduction to Law)? This is already generally what happens in a science course that is required to introduce a controversial science-based issue.[35] Science teachers, by and large, have no professional formation in the treatment of psychological, moral/ethical, religious, legal or philosophical extensions of science-based issues and, if required to, will treat the physiological and health aspects of abortion, but avoid at all cost, the non-science extensions. Such a treatment could cover the technological and physiological aspects of abortion: types of, equipment used, recovery rate, contraindications, genetic and other physiological reasons for, etc. None of these aspects in themselves would easily be classifiable as controversial. But are these the factors that come to the fore in the controversy? The factors that rise to the surface seem to be those that are the furthest from data-based statements.[36] If a scientist of some standing, favors the beginning of life as at conception and another, with equivalent standing, insists that human characteristics must be developed before life can be spoken of in human terms (i.e., to oppose the counter argument of murder in the earlier stages of in utero development), and a third, no less reputed, has grounds for waiting until after birth before human life can be spoken of in a truly viable sense, and the taking of spoken of as murder, is the teacher or student to choose among these and is the choice to be based on scientific concepts and processes? If the latter is the condition of choice, the science part of the course would end rather quickly, since, at present, there is no science concept or process that will preclude choosing. This might be helpful to the student, nonetheless, since the student would have been exposed to the formidable difficulties in attempting to substantiate scientific arguments that address these fundamental questions of life and humanness. An understanding of the need for caution, careful analysis of statements, credentialed credibility of statements by experts, the type and amount of experimental evidence and data interpretation examined using certain criteria, in short an understanding of how the structure, philosophy and content of science can be used when trying to make science-based decisions would certainly be a worthy science education objective. The abortion issue has not been dealt with as a total issue in this type of course. This treatment might, however, be preferable to an incompetent (highly probable) treatment of the additional aspects of the abortion issue if the science teacher were required to include them in the course work.

Even more serious would be the problem of potential confusion in the student's mind among the differing values and authority sources of each discipline perspective as presented by a science teacher and in a science course. An hierarchical arrangement of positions with science likely at the top in importance, could easily be the outcome, if not the intention, of the curriculum.

One way of resolving these problems would be the use of either interdisciplinary or multi-disciplinary treatments of such controversial issues. Unfortunately, most of the pertinent non-science disciplines are not usually included in the typical public sector high school program of studies: philosophy, psychology, religion (not to be confused with comparative or historical religions) and law. Some public sector schools do have some variety of moral/ethical education course or values clarification course. It is doubtful that this type of course could, by itself, represent the totality of the non-science-based positions in regard to abortion.

And what of the teacher in such courses? Three scenarios seem to be possible. The teacher remains neutral, presents an unsupported opinion or presents a supported opinion. The most comfortable and traditional position of science teachers is overt neutrality. To be consistent with this stance, the teacher would need to ensure an even-handed and 'objective' treatment of enough sides in the controversy. Even with the best of intentions, this is a surpassingly difficult task. Research skills and time would both be severely taxed. The usual format, however, in North American public schools, is to conduct a review of the various sides in the controversy as interpreted by an acceptable publisher, thereby saving time and energy and avoiding the need to question the accuracy, validity, etc. of archival sources. If the publisher has come out with such a student text and it is destined for a science course (as opposed to, for example, a moral education or current events course), the arguments will invariably support the scientific stance and reduce any others (the few that are present) to secondary or tertiary status.

In short, it is hard to know what to make of the efforts to introduce scientific literacy courses adhering to Yager's objectives, into the high school science program, so fraught are they with problems. It should be added here, that some science educators, perhaps in trying to avoid certain categories of controversial issues, feel that it is most suitable to use environmental studies as the vehicle or basis for scientific literacy courses.[37] In so doing, issues such as abortion can be effectively precluded from the course. This seems to reduce the call on non-science disciplines as well. Unfortunately, it also precludes the treatment of concepts and skills at a high school level that might have been included within such an issue. On the other hand, since human overpopulation is traditionally included within the scope of environmental issues (controversial or not), perhaps not all is lost. However, contingent questions of treatment similar to those raised above, would then also resurface.

Yager summarizes his view of a new-style school science curriculum and includes the educational objectives discussed above. After having reviewed the recent major U.S. national studies in science education and highlighting their main generalizations, concerns and recommendations, he concludes with a series of suggestions for a quality science curriculum. In his view,

> such a curriculum would:
> a) emphasize science in a social setting
> b) include applications of science as central
> c) stress local relevance in establishing a plan
> ....
> f) focus on the resolution of problems and issues while de-emphasizing the solution of text and teacher-made problems
> 38

The development of decision-making skills, the use of local resources, a focusing on problems of local concern in order to "increase motivation", the inclusion of moral/ethical dimensions "that will accentuate the importance of studying science" are put forth by Yager as "some ideas for science curriculum development for the 80's".39 In the long run, it is not clear how serious Yager is in these recommendations since they are prefaced with a "whenever possible" in each instance. The pressures of meeting college/university admissions requirements as measured by national achievement tests in the U.S. (and provincial leaving examinations in the Québec school system) will likely cause Yager's recommendations to be sidelined. However, Yager's focus on environmental, social and personal applications of science does fill lacunae in most existing science curricula. So far, this focus is supported only by a minority of his colleagues in science education, though this support shows some signs of growing. On the other hand, Yager's location of the scientific literacy problem within the curriculum content of science courses is, in this sense, similar to Klopfer's and Karplus' perspectives. In addition, the location of the scientific literacy problem within curriculum content is certainly shared by the majority of science educators and other science education stakeholders who participated in or responded to the recent national U.S. and Canadian science education studies.[40]

Nonetheless, Yager and like-minded colleagues would seem to have certain blind spots regarding the constraints of public education. The joint pressures of time and student demands of achievement test requirements (factual and process problem-solving) will effectively discourage the 'wasting' of such time on items perceived as non-essentials. The rest of the student population, that is, those who have not chosen a pre-college science preparation, will continue to fulfill the minimum high school graduation science requirements, as they have consistently done in the past. These students are convinced of the importance of science and would seem to have enough motivation to enroll in these science courses. However, there is no incentive in Yager's recommendations for a major science curriculum revision for these students, and his "whenever possible(s)" will have the same fate as in the science stream courses. Additional science courses for the non-science stream students would hold some promise (assuming that the major barriers that were noted above, i.e., administration, parents, teachers, etc., are overcome), as long as there is a concomitant awareness of the severe problematics intrinsic to the content of such courses, as examined above.

So far, the stakeholders who have been considered in this problem perception phase of the practical and whose contributions have been presented and examined, have all come from the professional ranks of academia. While still more academic professionals will be called upon for their contributions, it is time to expand the range of stakeholders to include contributions from appropriate representatives of administrative, teaching, economic, political and community stakeholders.

Some Additional Problem Perspectives

While the inclusion of personal and social issues in science curricula are seen by many as pivotal foci in the development of scientific literacy, there are a number of other perspectives that need to be introduced in this perception phase of deliberative enquiry. Most have been advanced and argued by some of the same science educator stakeholders as were concerned about the 'personal needs' and 'societal issues' positions above. In order to round out the concerns of a variety of educational stakeholders, three remaining issues will be teased out of the educational situation surrounding the goal of scientific literacy: student motivation, teacher competency and budgetary constraints. These issues will be examined in some detail as they are perceived as crucial by a majority of stakeholders. In order to emphasize the size of support for these issues, I have labeled them complementary issues. Additionally, I will present a number of issues that, while the concern of only a minority of stakeholders, surface often enough in science education literature to warrant some acknowledgement. These I have labeled supplementary issues.

The scientific literacy problem tends, then, for many to be seen as a problem with multiple-foci, some of which are complementary and others supplementary. One example of a complementary problem-focus is found in the frequent referral to a lack of motivation in the non-science stream student, that is, as indicated by not electing science courses.[41] Because the stakeholders who proffer this problem-focus invariably assume that the science program, as offered in the public high school setting, is essential to the fulfillment of the proper and adequate personal and citizenship functions, these stakeholders claim that if a vehicle for motivation were found, the problem of scientific literacy would resolve itself. The vehicle for self-motivation is seen by them to be the advertised inclusion of 'relevant', topical and contemporary themes and issues in the curriculum of scientific literacy courses. (Klopfer would favor another motivation vehicle, that of a core or mandatory 4-year science; however, most other science educators assume the continuation of elective science courses beyond the one or two that are already required by most high school juridictions.) It is my contention that this focus deserves more attention from the various stakeholders than heretofore given.

A second complementary focus is the question of teacher competency. This is a perennial focus for a range of educational problems and is included in the writings of many stakeholders both within and without the national studies.[42] Many, such as Karplus, Brandwein, Welch and Lévy, decry the continued absence of cohesive and formally structured 6 to 8-year obligatory elementary science curricula, taught by teachers who have a science background sufficient to this teaching task.[43] These educators speak eloquently to these persistent problems found at the elementary school level.

There seems to be no lack of reasons for the lack of adequate science teaching at the elementary level: public pressure to concentrate on the teaching of reading, writing and arithmetic skills, the continued lack of emphasis on science in teacher training programs, the general failure of teacher-proof science kits to effectively replace the teacher, the absence of any science requirements for admission to high school, the paucity of elementary school in-service science training and the prevalent minimal amount of science education in the elementary school teacher's general academic background. However, the elementary school teacher is hard pressed to fulfill such expectations.[44]

In truth, most of the educator stakeholders tend to avoid the conundra of elementary school science and concentrate on improving or properly using the competency levels of high school science teachers. This third complementary focus is then a high school focus. The following have been suggested as problems that can be brought to some ready solution: mis-assignment by the administration, i.e., teachers who majored in one of the sciences being required by administrator-determined scheduling to teach another; lack of university programs leading to the formation of general science teachers (it is usually assumed by stakeholders, other than teachers, that any science teacher should be able to teach general science); teachers from non-science disciplines being scheduled to teach lower level (i.e., grades 7-9) science classes. There exists in the literature, consistent and clear consensus, that the senior high school science teachers perform their subject matter duties competently and have adequate academic backgrounds.[45] It is then only those teachers who are assigned to the junior grades whose competence is in question. The student outcome of scientific illiteracy is traced by these stakeholders to incompetent junior high school science teaching. Since adequately prepared senior high school science teachers are able to perform their teaching duties adequately and to the benefit of the science stream students (perceived as having a higher level of science education), it should be possible to produce scientifically literate students (perceived as having a lower level of science education) if there were adequately prepared junior high school science teachers available for these classes. So goes the argument. The content of the junior level science courses is not in question here; rather it is the subject matter competency of the teachers, with subject matter viewed here in terms of discipline concepts and inquiry skills.

As a fourth complementary focus, a good number of stakeholders identify shortages of science equipment, science laboratory facilities, appropriate science texts and sufficient scheduled class time for science instruction.[46] These may seem to be four distinctly separate problem-foci, but in essence, they are all linked to the reduction of financial support for active or inquiry-centered school science programs. At the same time, others point to an inefficient <u>usage</u> of science equipment, facilities and texts, all of which are already available on school premises. Short of re-direction of funds set aside for the purchase of computers and computer software, it is somewhat difficult to see how the typical school board would succeed in arguing for intensive science funding after having done just that for the past some 25 years. In a sense, this problem-focus is neither here nor there unless the preceding problem-focus is resolved. Study after study has shown that the teacher makes substantially more of a difference in the ultimate learning outcomes of students than do the physical conditions of the teaching/learning environment.47

These are, then, the four emphases that the majority of science educators in both national and local studies have presented for our consideration: omissions in science curriculum content, lack of student motivation, lack of competent science teachers, lack of science equipment, science laboratory facilities, science texts and scheduled class time. A more comprehensive inquiry into scientific illiteracy is however warranted for two reasons: the four perspectives described above do not exhaust by any means the list of proffered reasons for scientific illiteracy among graduating high school students. We have just finished discussing four issues that are located in the scientific literacy problem area and that are perceived as crucial to scientific literacy curriculum planning by a majority of stakeholders: the inclusion of personal and social issues in the formal subject matter of scientific literacy curricula, student motivation, teacher competency and budgetary constraints.

In order to round out the stated concerns of educational stakeholders some supplementary issues will be looked at briefly. While each of these supplementary issues is the concern of only a minority of stakeholders, they provide a view into the scientific literacy problem using lenses that differ somewhat from those used in looking at complementary issues. High school tracking, high school matriculation tests, effective learning and teaching strategies, and realistic educational objectives are some supplementary concerns encountered in the literature regarding scientific literacy.

Efficient high school tracking or streaming is seen by some as integral to a scientific literacy program.[48] Even though Klopfer would favor entirely separate high schools (i.e., scientific literacy high schools and professional science high schools), others are willing to continue the present arrangement, wherein both streams or tracks are in each high school. Once this separation is complete, they would argue, scientific literacy can be taught uncontaminated by confused and overlapping science education goals.

Inappropriate or inadequate learning strategies are the problem-foci for certain curriculum developers and other stakeholders.[49] These are usually translated into some form of group instruction - lecture, discussion, questioning - which are thought to curtail the sequential and cognitive development of the individual student. Individualized instruction, in some form or another, is usually suggested as the alternative and better strategy. There remain, however, serious verification problems with this latter strategy.[50] The only science curriculum that is entirely premised on individualized instruction is the ISCS curriculum, a self-paced program in commercial operation since 1970. Unfortunately, the meager evidence that does exist regarding the cognitive outcomes of students educated in this curriculum, cannot as yet support an improvement in student cognitive outcomes as contrasted with cognitive outcomes subsequent to traditional teaching strategies, such as those using group instruction. The temptation to jump from problem to solution is particularly and clearly evident in this problem-focus.

The next problem-focus is one that has already been alluded to in the discussion of science content omissions: the lack of interdisciplinary or multi-disciplinary courses.[51] Both terms are found in the literature and are invariably meant to convey an integration of some selected and appropriate disciplines as the pedagogy of choice in the treatment of science themes or issues. The perceived need for such a curricular approach would seem to be contingent upon one's notion of scientific literacy. If the preferred notion of scientific literacy is one that requires an understanding of a complex science-based situation, then the components of this complexity may well require sociological, legal, philosophical, moral and psychological understandings. It would then, perhaps, be somewhat pretentious or presumptive to label the exercise as one in scientific literacy. It might just as readily be labeled philosophical or legal or moral literacy having a science component. In actuality, the term 'interdisciplinary' or 'multi-disciplinary' is usually limited to a selection of science disciplines (physics, chemistry, biology, earth science, etc.) with or without (usually the latter, in practice) closely related technological fields such as engineering. This is somewhat reminiscent of the traditional and typical general science course, only following different patterns of organization. Instead of sequential samplings of various science disciplines with the sampling based on a selection of major concepts, the sampling of the same disciplines would be determined by selected themes or issues of some perceived concern to students.

Another problem seen as a science content omission centers on the inability of high school graduates to assess science reports due to two related curricular problems. The second is contingent upon the first. As long ago as 1950, Schwab had emphasized the need for an understanding of the structure of a science discipline before one could even begin to assess, analyse, evaluate, synthesize any information related to this science discipline. One of the curricular results based on this concern, was the development of the BSCS high school program in the early 1960's. Twenty-five years later, there is general admission that the wholehearted implementation of the BSCS curriculum (still the most prevalent of the 'alphabet' curricula of the 1960's) did not include the structure of the biological sciences among its objectives-in-practice. Norris and a few others suggest that teachers should give the Schwabian objective another try.[52] In this perspective, scientific literacy is tied to the cognitive abilities of analysis, application, synthesis and evaluation, validated by an understanding of the structure of the relevant science discipline.

The last supplementary problem-focus should have particular appeal to those who prefer re-definitions (in the name of reality) to frustration and futility (for the sake of idealistic but perhaps unrealistic education goals).[53] The argument may be summarized in this way: streaming based on Piagetian cognitive development stages combined with a respect for the contextual realities of schooling (teachers, texts, etc.) will point the way to science education objectives that have good potential of being realized.[54] Instead of starting with education objectives that represent maximal desiderata primarily deduced from discipline-centered goals, the starting point should be the sphere of the possible, induced from previous teaching experience and cognitive development studies.[55]

So far, the arts of the practical and more specifically, the phase of problem perception, have been exercised in order to expose details of the problem situation as perceived by a variety of stakeholders in science education. All of the stakeholders that Connelly et al. identified as present in public education, are represented. Even though many educators might wish to discount the importance of some of these stakeholders, particularly those stakeholders who espouse the inclusion of political or economic values in public education, there has so far been no question as to the legitimacy of their concerns about the values of different courses and programs of study in public education institutions. It is with this in mind that I have presented the views of educational researchers, subject matter specialists and curriculum developers along side those of the leaders of various interest groups, such as AAAS, AASA, NCPT, NPTA, NSBA espousing concerns about science education.[56]

There were a number of differing perceptions uncovered that are related to scientific literacy in public education. Collectively, these stakeholders connected the student outcome of scientific illiteracy with the following general factors: school policy, teachers, funding, and the students themselves.

Even this cursory archival review has been able to show that the goal of scientific literacy is fraught with curricular problems and uncertainties. It does not much matter whether the literature review concentrates on the 1960's, the 1970's or the 1980's. Each decade has produced a panoply of identified problems, of course formulated differently by any number of interested parties.

Where do we go from here? What sense can we make of these details attached to this problem situation surrounding the goal of scientific literacy?

Formulation of Problem: Settled and Unsettled Elements

One of the tasks of problemation in Schwabian deliberative enquiry is the ascribing of possible meanings to the details uncovered in the problem perception phase. A first step in such a process might be a search for settled elements in the situation, a search for regularities, for patterns, as distinct from the remaining or unsettled elements. Both settled and unsettled elements can then serve as the facts which need to be observed and given meaning in terms of the problematic. When enquiry can point to connections among the elements of the troubled situation, the seemingly chaotic or indeterminate situation may be transformed into a determinate situation, i.e., a situation in which, ultimately, a problem can be articulated.

What are some of the settled elements in the indeterminate situation surrounding the educational goal of scientific literacy? We have been discussing in this chapter, the contributions of a wide-ranging group of stakeholders. Many of them have considered science education to be in a state of crisis, of varying degrees and for varying reasons, ever since the 1950's. In this latest version of the crisis, namely that surrounding the goal of scientific literacy, is it at all possible to tease out the more settled elements in order to modify the fractious atomosphere surrounding this goal? Are there any substantial agreements that can serve as potential parameters, serving to stabilize at least some of the elements in an otherwise troubled situation, a situation that is full of competing and even conflicting tendencies?

There seem to be four settled elements, i.e., elements assumed or acknowledged by all stakeholders, that accompany the goal of scientific literacy. One such element is the target population. Those students who do not choose to enroll in senior level high school science courses are invariably thought of as in need of scientific literacy, particularly in this day and age replete with the products and by-products of science and technology. In the public sector, this target population represents anywhere from 50% to 95% of high school students.

A second settled element concerns one aspect of the content of any proposed scientific literacy curriculum. All stakeholders believe that students need to learn and understand some major science concepts and inquiry processes. And in addition to this now standard science curriculum mixture of knowledge (concepts) and inquiry (skills), most stakeholders would insist on adding decision-making skills regarding science-based issues. The assumption seems to be two-fold: (1) that these decision-making skills will not be learned outside of the science class and (2) that the special nature of science-based issues requires skills best or only taught through a science curriculum. A deeper level of assumptions would include the need for and efficacy of such skills in one's personal decisions as well as those of a more political nature made when acting within the duties and rights of a citizen.

A third element that would appear to be fixed by all current available research findings is the centrality of the teacher's role in the implementation of any curriculum. Speaking for many, Tisher & Power write that

> a curriculum depends on the degree to which goals and content are blended to form meaningful learning tasks, and the degree to which the selection, presentation and ordering of the tasks captures the attention, maintains the interest, and enhances the understanding of the learners.57

This is because,

> what is received by the pupils is not the curriculum as a whole, but some adaptation of it. It is the teacher's role to actively evaluate curriculum units, to select, order, modify, adapt and translate its component parts [to match the needs of] some group of students.58

These normative features of the teaching role lead one to assume that this role requires a certain level of competency. And this is precisely what the stakeholders also take for granted. The goals of teacher-proof curricula have not been realized. At their best, they equalled the more traditional teacher-directed curricula as measured by achievement tests of student learning. At their worst, they made little room for the emotive factors bound up with teacher-student exchanges. Again as Tisher & Power point out so well, the teacher's level of involvement in the designing of a curriculum are critical to its success as measured by student learning:

> It is now generally recognized that the curriculum reforms of the 1960's failed to produce any substantial changes in classroom practice (a) because reforms were imposed from above, and (b) because insufficient

attention was given to the problem of teacher preparation.59

The imposition of curricular reforms, while certainly linked to a range of other problems associated with the implementation of any curriculum, is more of an administrative problem and, as such, will remain outside the scope of this enquiry. However, the competency of the classroom teacher as principal facilitator in the implementation of any curriculum, must be addressed in some manner by this enquiry, if only to table this as necessary for a separate and more appropriate forum.

A fourth fairly well-established element is the need to understand the student's degree of cognitive development and to key the curriculum to this pattern of development. It is not particularly easy to fulfill these two needs, but unless there is a reasonable matching of one to the other, the teaching and learning processes will be overwhelmed by untold frustrations.

These then appear to be four major and well-settled elements. It only remains to bring them into interplay with the unsettled elements in order to attempt some problem formulations. Before this is done, and as part of the deliberative efforts of this phase of the arts of the practical (i.e., the formulation of a problem), there remain a handful of elements that are partially settled (or at least not seriously contested), and that would be profitable to tease out of the remaining indeterminate situation. One such element is that of standardized state-wide (or province-wide) competency tests in scientific literacy.60 Only some 13 American states have competency tests of any kind and none includes a science test (the Province of Québec, however, has tests for each science discipline). The back-to-basics tendency in government circles might be the impetus for more widespread use of such state-wide standards. As previously mentioned, when students were questioned about their support of such tests, they voiced massive approval. Parents, as well, seem to support such a move. There is no evidence of serious opposition from science educators, but then there is no clear support either. If these tests are constructed as reasonable incentives for literacy in a variety of core areas, perhaps their usefulness in this respect will be justification enough for their implementation.

A second partially settled element concerns the compulsory condition of high school science courses. The science stream courses are <u>de facto</u> compulsory because of the pattern of requirements for admission to science programs at college/university level. In addition, it is taken for granted by all stakeholders that these courses will surely produce scientifically literate students. It is then once again, to the non-science stream student that we must direct our attention. All national studies provide data on the number of states/provinces requiring the successful completion of high school science courses before permitting graduation. As has already been discussed above, the quality of such courses varies enormously, dependent principally upon the teacher assigned to such courses. Leaving the question of quality aside for the moment, what meets with approval from every stakeholder (including students) is the <u>de jure</u> compulsory condition of at least one and sometimes even two such courses. It would not be stretching a point too far to say that most stakeholders would likely support a minimum of two such compulsory science courses for all high school students. Klopfer, true enough, would encourage a 4-year compulsory high school sequence; on the other hand, it is hard to imagine stakeholders maintaining serious objections to a 2-year high school sequence constituted of courses that are planned with care and for articulation within the 2-year science sequence (and possibly even with other high school courses). In summarizing the factors involved in this element, it is fairly clear that stakeholders would generally support a 2-year sequence of high school science courses in order to attain the goal of scientific literacy for graduating high school students. Because there are no reported enrollment problems in the existing patterns of compulsory science courses, and because a 2-year compulsory sequence is not radically different from the majority of existing high school graduation requirements, there should be substantial agreement regarding this element.

A third and last partially settled element can be linked rather easily to the preceding one. Contrary to the opinion of some stakeholders (mainly in the area of science education research), students, parents and the public in general have no difficulty in accepting the importance of science in the K-12 curriculum. By and large, science does not have to surmount the stumbling block of indifference with which art, music, most history courses, and foreign languages are often faced.[61]

Both curriculum developers and teachers have much fertile ground on which to sow the seeds of literacy. There remain, however, two largely unsettled elements in this complex educational situation. One is the level of teacher preparedness and the other is the total curricular content of scientific literacy courses. The latter is in turn connected on one side to the science education goals of such courses and on the other side to the testing of student outcomes.

Problem Formulation and Problem Choosing

Teacher preparedness can be viewed as a general term (i.e., readiness to teach due to the possession of appropriate pedagogical and subject matter learning and skills), or one that is specific to a particular aspect of the teaching role (e.g., extensive subject matter learning). It is the second view that will be empasized here. But it is well to review very briefly the first.

Teaching strategies are based on the emotive factors in a classroom, the cognitive development of individual students, the learning styles of individual students, curricular objectives, parental and teacher expectations, test requirements, the managerial components in a room full of students, and the administrative demands placed on the classroom teacher. These have all been studied, measured, analysed and criticized resulting in a somewhat bewildering array of conclusions, suggestions, and recommendations addressed to teachers in general and, more often than not, precipitating an appreciation of the uniqueness of each teaching act.[62] In a very real sense, of course, teacher preparedness viewed as an all-inclusive term, is a superior candidate for the position of 'unsettled element in the indeterminate situation'. It is not, however, generally from this total perspective that the stakeholders in the scientific literacy literature examine teacher preparedness. Rather, teacher preparedness is seen to be a deficiency in respect of subject matter preparedness. When discussing this issue earlier in this chapter, each deficiency category was directly connected to the subject matter component of teaching: mis-assignments, use of non-science teachers in science courses, and the absence of university-level science courses directed specifically to the teaching of lower level high school courses. Some teachers learn to adapt university science to high school science content; others do not. Some teachers can keep one step ahead of the students (as in the instances of non-science teachers teaching science courses); others cannot. Some teachers have a talent for extemporizing, adapting and re-organizing subject matter ingredients dependent on teacher or student needs and interests; others cannot. If the teacher has a comfortable acquaintanceship with the range of the subject matter content in a certain science discipline, and some exposure to and skill in science processes, much of the unease and uncertainty with subject matter content, conveyed so easily and quickly to high school students, can be precluded. The good will and respect of students toward teachers tends to be readily proffered at the start of a course, and just as readily lost when subject matter incompetence is exposed. (Other factors, such as teaching strategies and rapport with students, may and do influence student learning outcomes as well; nonetheless, subject matter competency is a major factor in high school teaching.) Those who still believe in the greater efficacy of teacher-proof curricula (whether as kits, contracts, computer programs or written modules based on behavioral objectives) as compared to teacher-directed curricula will have difficulty seeing the element of teacher preparedness in subject matter as of major importance and unsettled. For other stakeholders, however, (and these seem to be in the majority) this element of teacher preparedness in subject matter is a major and unreliable factor in science education for the high school student who is in the non-science stream.

The science preparedness of elementary school teachers is even more unreliable (less than 25% of surveyed elementary school teachers were willing to say that they were well qualified to teach science).63 But because the junior high school situation (grades 7-9) exhibits more manageable proportions (both in number of teachers affected and the state of their academic backgrounds), it would seem reasonable to recommend that this problem be formulated in terms of high school science teachers and their subject matter background in university programs and as supplemented by local in-service programs. The problem is then one of articulation between university level subject matter education and lower high school level subject matter teaching. It is the rare high school that has the flexibility of assigning <u>only</u> senior level science courses to science teachers. Almost invariably, these teachers are also assigned science courses that fall outside of the science discipline of their university major or minor. And, accompanying this scheduling 'fact of life' is the assumption by administrators that a major or minor in any university level science program should qualify the teacher for <u>any</u> science teaching assignment. In keeping with the self-limiting condition of manageable proportions that this writer introduced above, it is probably apparent by now that the practice of assigning teachers who lack either a major or a minor in a science discipline to the teaching of a science course falls outside the scope of the problem as formulated in terms of articulation; one can only hope that this practice will be sharply curtailed in the future.[64] In short then, if scientific literacy is to be an accepted and reasonable goal in science education, the existing discrepancies between university-level subject matter credentials and science teaching assignments must be resolved.

The second major unsettled element that begins to take shape as a problem, concerns curricular content in those science courses available to non-science stream students. At the moment, there are no instances of standardized scientific literacy learning objectives equivalent to those demanded of science stream students through the mediacy of college/university admissions or achievement tests. There are a very few regional examples of standardized scientific literacy high school leaving objectives (the Québec provincial high school matriculation examinations being one such example). Considering these two facts, it may well be asked what the basis was for announcing the existence of widespread scientific illiteracy among high school graduates. As described earlier, lists of scientific literacy desiderata were compiled using an extensive variety of science education referents, students were tested against these desiderata and a large number of inadequacies in student outcomes were noted.[65] However, there would seem to be considerable difficulty both in concept and methodology when determining scientific literacy using this approach. Strange as it may seem, the concept of scientific literacy is not one that has percolated throughout the high school level of teaching ranks.

As a matter of interest, it is the rare science teacher who has even heard of the term, let alone understands its import and implications.[66] Notwithstanding, science education researchers and science curriculum developers use the term frequently and relatively freely, to mean a variety of goals and objectives (many of which were discussed earlier in this chapter and in the preceding one). Is it possible to determine an agreed-upon minimum in science education as equivalent to scientific literacy? Or would it be possible to determine an agreed-upon series of science concepts and skills that would collectively promote scientific literacy? And who should determine either one? Is it reasonable or necessary to have one standard for scientific literacy (i.e., state-by-state or province-by-province) or should this be left to the individual school board or science department? And what of the call for the inclusion of non-science ingredients in the often-proposed scientific literacy goal of skills in personal and citizen decision-making about science-related issues?

Scientific literacy goals, course content and student outcome testing are all intrinsically related. Until there is more realism connected to descriptions of the scientific literacy teaching/learning situations, the very formulation of the problem will be thwarted, let alone its possible solution. The problem situation is firmly located within the student contexts of cognitive development patterns among high school students (and principally those in grades 7-9), a highly variable elementary school science education for these same students, reasonable interest in and eagerness for some high school science education, and the multifarious needs, interests and behavior patterns of adolescents, the great majority of whom will not enter the science stream. The teacher and administrative contexts have been referred to above. This amounts to a highly complex situation and it would seem vital to have a clearer and more realistic set of scientific literacy goals; course content and testing of the same would follow contingently.

It is difficult and perhaps unwise to bring the phases of problem perception and problem formulation to closure before proceeding to problem choosing since there can be much back-and-forth movement (backtracking) while problem possibilities are being considered. But it does seem necessary to reach some form of considered closure, at least temporarily, to the phase of problem choosing in order to be able to begin deliberation regarding appropriate solution formulations. This move in deliberative enquiry does not preclude continued backtracking between the solution formulation phase and previous phases. Its effect, rather, is to concentrate deliberation efforts on potential solutions, given continued acceptance of the problem(s) as formulated.

It is with this in mind, that I remind the reader of the two problem formulations that are being advanced: (1) there are existing and major discrepancies between university level subject matter credentials of teachers and the actual science teaching required in lower level high school science courses, and (2) many of the science education goals and objectives designed with the aim of scientific literacy in mind, are inappropriate for this aim.

Concluding Remarks

Karplus and Klopfer, though differing markedly in their respective curricular approaches to the goal of scientific literacy, shared an intended learning objective, that of "functional understanding". Each hoped that students would leave such a science program with knowledge and skills necessary for personal and citizen decision-making needs. Even though the problem situation that has been investigated in this chapter was mainly limited to particularities normally found in a junior high school setting, Karplus' curricular work at the elementary level can easily be extended to the junior high level without undue violence to his position. If we then continue this comparison of the work of Karplus and Klopfer, a few but important differences begin to emerge. One difference, noted rather quickly, is the discipline-centered nature of Karplus's curricular designs. What begins to emerge then at another level of perception, is the way in which each educator is prepared to construct and display science for young minds. While Karplus assumes that the students in his science program will exhibit a full range of ability and interest levels, the 'hands-on' or participatory structure of the program would promote student motivation or involvement in the learning process. The student would thereby learn more willingly and easily, the science concepts and skills that are fundamental to an understanding of the basic independent and thoughtful decision-making about science-based questions and issues. The graduate would thereafter have to rely on whatever public information came his/her way, to add on to the science fundamentals already learned. But more importantly, these fundamentals would also serve to help the graduate evalu~~ate this~~ public information, thereby giving him a kind of educated independence of thought. In a sense, then, Karplus' program would have humanistic and philosophic values supporting it, if we refer to Green's set of educational values.

Klopfer, on the other hand, envisions scientific literacy curricula that show many signs of managerial values, using again one of Green's terms when he describes sets of educational values. The crux of the matter for Klopfer seems to be one of encouraging the development of functional understanding of science in students who are not able or willing to elect the science stream in high school studies. Because these students are in fact in the majority in public education, and because the minority of career scientists and their research programs are in many ways dependent on this majority for continued political and financial support in any democratic society, Klopfer views it as essential that this majority of students acquire proper attitudes towards and understandings of matters scientific before leaving high school. He does not doubt that competent teaching will ensure the development of such attitudes and understandings. However, these attitudes and understandings must be taught directly; a curriculum that is discipline-centered may not be appropriate to the ability levels and interests of the non-science stream students, or so he believes, and may not elicit the desired attitudes and understandings. He has more confidence in scientific literacy curricula that are centered on science-based questions and issues arising from science-society interactions. He feels that future personal and citizen decision-making can then be modeled on the directed experiences encountered and skills learned with such scientific literacy programs.

Yager shares Klopfer's views on the subject matter content of scientific literacy curricula. He also envisions these curricula as centered on science-society interactions. However, he would like to add a new dimension to the learning outcome of scientific attitudes towards and understandings of science-based questions and issues. This new dimension is the awareness of moral elements in the science-society interactions. Yager believes that, by emphasizing the presence of such moral elements, the scientific literacy program will have greater appeal to non-science stream students and will be translatable into a motivational force in the same student. With such motivation, the student will learn more willingly and effectively the scientific portions of the scientific literacy program.

The work in this chapter has centered on an exemplification of those phases of deliberative enquiry leading to the formulation of a problem. The most recent and respected scientific literacy problem formulations were presented from the perspectives of representive stakeholders. Reasons for and against were examined and weighed. The teaching and learning situations were given <u>in situ</u> descriptions. Frictions, failures and inadequacies were teased out (arts of perception). And in line with arts of problemation, this writer has formulated two problems that are distinct enough to require <u>separate</u> but simultaneous solutions because they have unavoidable and intrinsic influences one on the other, no matter the type of solution eventually proposed.

It is to this latter task that I will turn in the next chapter. Formulations for possible solutions will be considered and imaginative rehearsals of these potential solutions will take place within the framework of Schwabian deliberative enquiry.

CHAPTER 8

SCIENTIFIC LITERACY: CONCRETE MEANINGS AND QUESTIONS

Focus of Chapter

Three major and recurrent curricular themes have already been identified (in the preceding chapter) among the various goals and objectives falling under the educational aim of scientific literacy. These are (1) the transmission and understanding of major science concepts, (2) the development of science skills, and (3) the development of decision-making skills regarding science-based societal issues. Each of these themes will be examined deliberatively with the intention of, probing for some directions leading to solution formulations.

In identifying these themes, I have shown how the slogan of scientific literacy arose in particular historical and social circumstances. Additionally, I have shown how these three themes have slowly emerged as science education writers have reflected more on what are important components of the concept of 'scientific literacy'.

In one sense, I have focused on the clarification of goals. However, the meaning of scientific literacy as 'curriculum' is a story only partly told by a statement of goals. As McKinney and Westbury state, "a curriculum [is] an idea that becomes a thing."[1] What follows from this principle for my project is this: the meaning of the three themes of scientific literacy must be discovered, in part, in what is done in texts and school practice in the name of these goals.

Therefore, as a closing phase of this deliberation, I will briefly examine some typical textbook treatments of these three themes of scientific literacy. My point here is to provide enough illustration to raise questions about the issues which are still to be faced in giving meaning and definition to scientific literacy, and in giving scientific literacy, as an idea, an appropriate curricular embodiment.

Science Concepts as Scientific Literacy Goal

Let us now take a closer look at one of Karplus' premises, that of basic science concepts. Given current curricular means, what will scientific literacy be in practice if we make the goal of basic science concepts central to a scientific literacy curriculum? Descriptions of representative textbook curricula as exemplars of curricular means should help to illustrate connections that can be made between the goal of basic science concepts and the aim of scientific literacy. The great majority of junior high school science students receive some form of 'general' science education and representative general science textbooks will serve as exemplars of curricular means.

One such 'general' science course uses, as its curriculum, Everyday Problems in Science, described by the authors as a "basic science program" text.[2] There is an ancillary reason for choosing this text as exemplar: Hurd, a leading science educationist and advocate of scientific literacy as a distinct education goal, is a co-author and many of his views are expressed in the companion text Teacher's Guidebook for Everyday Problems in Science.[3] Additionally, the Chicago Board of Education, one of the largest of the U.S. school systems, includes Everyday Problems in Science on its approved list of science textbooks for junior high school (grades 7-9).[4] I mention this fact only to indicate that the use of this text is not confined to a negligible student population.

There are 20 units to be studied in this 'basic science program'; with an average of 40 week per school year in the typical school calendar, the student is potentially exposed to two weeks worth of instruction per unit. Included in these 20 units are 3 on chemistry concepts (materials and fire), 4 on biology concepts (3 of which focus on human anatomy, food and health), 5 on physics concepts (gravity, energy and force), 3 on technology (machines, communication and transportation), and 1 each on astronomy, meteorology, geology, conservation and scientific method and thinking. Students may graduate from high school with this one-year course as the only required science course. Could we say that such students are scientifically literate, assuming that these students were able to 'pass' the course? Some questions may have to be raised. For one, is the omission of most concepts characteristic of biology of any consequence? Does the student need to have an understanding of heredity, evolution, cellular activities and ecology in order to be considered literate in biology? Or will the concepts related to a cursory survey of some human body systems (the endocrine and reproductive systems are not included), food requirements and the role of bacteria in causing disease suffice? Similar questions could be raised about the representative nature of the other science concepts in this one-year program.

Hofstein takes a different approach. He suggests that the starting point be lists of essential science concepts that are mostly appropriate to a high school level science course. Traditionally, lists have been formed by drawing on the areas of study usually associated with the three major science disciplines and may be itemized as follows:

(a) Biology: evolution, genetic continuity, biological behavior, homeostasis
(b) Chemistry: conservation of mass, equilibrium, energetics, bonding and structure
(c) Physics: time, space, matter[5]

According to Hofstein, these concepts were selected because they:

(a) represent basic ideas of the structure of the discipline;
(b) have the greatest capacity for explaining scientific phenomena;
(c) have the greatest potential for interpretation and generalization;
(d) can be developed from experimental evidence;
(e) provide many opportunities for the development of cognitive skills;
(f) convey the role of science in the human being's intellectual achievement.[6]

If we use Hofstein's biology concepts as a probe for inspecting the 'general science' high school course just described, we would be hard put to find any of these major concepts receiving anything approaching adequate treatment. One tempting, and yet to my mind dangerous, assumption is that scientific literacy can be achieved <u>without</u> any demonstrable understanding of any major biology concept located within biology as a discipline. The other side of this educational coin, and equally unacceptable, is that only those students in college preparatory biology courses need to concern themselves about the major biology concepts. The same questions, of course, could be asked about the relationship between scientific literacy and major physics and chemistry concepts.

For comparison, let us take a look at another popular 'general science textbook also written for use at the junior high school level: Matter, Life and Energy by Herron & Palmer.[7] This textbook does include a wider range of biology concepts. Human anatomy (again excluding the endocrine and reproductive systems), food and health (including even first aid) are all represented; so are botany and zoölogy classifications; and genetics and the economic value of plants and animals. It doesn't take too long to notice why Matter, Life and Energy is double the length of Everyday Problems in Science, and this in the absence of any 'experiments' within the covers of the former text. (A companion workbook is to be used, which includes both a study guide to each chapter and some 'experiments'. Everyday Problems in Science, in contrast, features detailed suggestions for an 'experiment' every other page.) Matter, Life and Energy contains 34 chapters; a 40 week school year then becomes markedly rushed for time if all 34 chapters are given equal treatment. On the other hand, if a smaller number of topics (or chapters) is selected, the basis for such selection would still remain to be justified.

A very different approach is used by the authors of still another junior high school science textbook, Focus on Science by Gough & Flanagan.[8] Of its 357 pages, roughly one-half treat of biology concepts with the other half treating a mélange of geology, astronomy, meteorology, physics and chemistry. Included are many suggestions for 'investigations' all of which use the traditional format of materials, procedure and observation. The biology concepts may be grouped into taxonomic, botanical and ecological concerns. Evolution and genetics are noticeable missing.

This review of junior high school science textbooks also provides a closer look at the curricular strategies of junior high school science teachers faced with content demands of junior high general science courses. It is the overwhelmingly common practice of teachers assigned to 'general' science courses to rely on the course's text as the curriculum. If the three science texts just reviewed are indicative of the median range of available texts (as opposed to an extreme text such as Introductory Physical Science which excludes biology altogether and concentrates almost exclusively on 'investigations' related to a few concepts drawn from chemistry and physics), then it is easy to see that a particularly wide variety of groupings of science concepts is available for the 'general' science type of science course.[9] This is a satisfactory situation when what is wanted is maximum freedom to choose a general science program to best fit the interests of students and competencies of the teacher. The history of science education and research into current science education practices tell us that 'general' science courses slanted towards biology concepts, tend to show signs of such a best fit. Such courses have a wide and better reception among high school students than courses concerned more with chemistry and physics concepts, and usually conflict less with teacher competencies. Notwithstanding this last statement, a major exception this writer is aware of is the course based on the Introductory Physical Science text. The appeal here seems to come from two learning features of this course: (1) a truly minimal amount of factual information that needs to be learned by the student, and (2) a maximum amount of class time spent in manipulating laboratory equipment.

What can we conclude from this review of examples of basic science concepts and textbook curricula? If the intention of scientific literacy proponents is to expose the student to all of the major science concepts from the three traditional science disciplines (as suggested by Hofstein), adequate provision ought to be made for this teaching and learning task in allotted course time, textbook resources and teacher competencies. Time would seem to be a merciless factor since the 40-week school year never allows for 40 weeks of subject matter teaching (of course including, in the case of the sciences, all of the laboratory and field experiences as well). Also, efficiency of teaching strategies would be taxed to the limit if general science course objectives were to be couched in terms of a reasonable understanding of the major science concepts listed by Hofstein. On the other hand, deletion of any of these major science concepts would certainly call for substantial justifications. In any event, textbook resources structured to account for all of Hofstein's major science concepts at the general science level are, at the moment, non-existent. Teacher competencies suited to such a general science course are also severely limited. Even though this last point, i.e., regarding teacher competencies, cannot be fully explored here, the relevant problem formulation that I proposed in the preceding chapter deserves considered attention in an appropriate forum.

Let us now take a look at some alternative possibilities for the selection of science concepts. This look will be in the form of projected and imaginary rehearsals of some aspects of junior high school science programs using textbook curricula and the incorporation of selected science concepts.

One curricular pattern that might appeal to scientific literacy proponents is to spread the teaching of scientific concepts over two years, with the second year treating only the biology concepts. This is the de facto situation in many school jurisdictions; even though only one year of science is required for high school graduation, a large majority of students who are not in the college preparatory stream elect a second year of science, with the great majority of these choosing biology. Such a separation of sciences may be necessary and is already in place for many school systems. A better reworking of subject matter and laboratory content for such a two-year sequence would then be advisable along with justifications for science concepts included in each year. This option of a two-year sequence instead of a one-year high school course would seem to allow for a more realistic and justifiable scientific literacy program.

However, this scenario does not provide well for the inclusion of science disciplines originally derived from the three traditional sciences but now considered as separate disciplines: psychology, sociology, geology, anthropology, meteorology, oceanography and ecology. Insistence on their partial or total inclusion or exclusion would call for clear and reasoned justifications. This is particularly necessary if the aim of scientific literacy is meant to have societal, political and personal ramifications for the development of problem solving skills.

How do the textbook curricula (discussed above) contribute to scientific literacy in these projected scenarios? They share what are certainly positive contributions in the form of some major science concepts, without which it would be impossible to participate to any great extent within a common cultural setting. As permeated as western societies are with conceptual and linguistic constructs as well as technological artifacts resulting from the various sciences, it would seem important that the members of these societies be given intellectual, linguistic and manipulative tools with which to participate effectively in such societies. However, the actual range of science-related intellectual and linguistic tools is under considerable dispute among science educators. For example, the IPS program is designed to develop the concepts and linguistic symbols of volume, mass, characteristic properties of matter, solubility, elements, compounds and molecular motion, and is offered as "a solid foundation" even "for those [students] taking no further science".[10] The authors imply by the last phrase "no further science", science of any kind, not just chemistry, to which the program is indebted more so than to any other physical science. The authors of Matter, Life and Energy considered the concepts of volume, etc., as basic also. The style of developing these concepts in Matter, Life and Energy is clearly expository whereas the style in IPS is experimental. There is, however, no dispute in either textbook curriculum about the foundational place of these concepts in the scientific edifice. What would appear to be questionable is the sufficiency of such a foundation. Can the core concepts of other individual scientific disciplines be left out of a science course whose goal is scientific literacy? Is it enough to expose the high school student to a minimum number of concepts fundamental to all of the natural sciences? Can an understanding of the concepts related to atomic structure and functioning of matter be reasonably presumed to equip a high school graduate to handle well science-related questions in everyday affairs - questions that may easily involve matters concerning personal health, evironmental changes, energy supplies and technological development? Or is it more appropriate and reasonable for the layman to recognize a question as scientific and then simply consult the scientific community or authority most likely to have an answer? In spirit, the IPS program, for example, favors the development of some intellectual independence and does not really provide for student experiences with data from outside authorities (the course data are generated by the individual laboratory activities, pooled, and freely discussed within the bounds of the class). On the other hand, the Matter, Life and Energy curriculum fosters the learning of scientific conclusions and deferential respect for scientific authority. The authors also write that these are to be "good authorities" but do not give the student any guidelines for choosing as to the goodness of the authorities. Is the adjective 'scientific' as in 'scientific authority' enough to separate out the good from other authorities or is more needed?

As to the remaining two general science texts, it is frankly difficult to decide why particular sets of science concepts are excluded. The authors of Everyday Problems in Science have decided not to include any reference to everyday health problems or environmental problems, even though these two areas represent the majority of science-related problems reported to the general public by the media. It is understandable that any course designed for scientific literacy can only introduce the student to the world of science. The citizen must be prepared (at least through reading and listening skills) and willing to pursue scientific questions outside of the course's confines. There is, however, room to question the justification of such a course when it overlooks important citizen concerns, concerns that can be anticipated fairly easily.

It is time to pause for a moment and formally review the result of the deliberative efforts expended so far. Are we approaching a first solution formulation? We are making some headway on one part of one tentative and admittedly partial solution formulation but much ground still needs to be covered. So far, we have formulated a partial solution based on Karplus' view of scientific literacy components: that certain concepts basic to science be learned. Drawing upon the science disciplines themselves, I have tried to relate the notion of basic science concepts in 'general' science courses as found in existing popular science texts used in North American public schools, to the collection of science concepts considered by many science educators to be basic to the representative science disciplines. Concepts related to biology have been used as exemplars in order to bring out this comparison in some detail. Lastly, imaginary paths were traced between the partial solutions and some of their learning consequences.

Can some conclusion be generated from these deliberative efforts? Or, at least, can some guidelines be noticed that can point out the way to some curricular solution? It is my contention that one workable conclusion is possible: some set of science concepts ought to be introduced to students in any scientific literacy curriculum. This conclusion must then be followed by a guideline question that can only be resolved by a specific school system. This question might be phrased as follows: which set of concepts can be taught competently within a restricted period of time (1-2 years) and at a junior high school level?

Much more needs to be deliberated at a local school system level before this part of the larger curricular problem is resolved. It is timely now to turn to a second major goal of the scientific literacy aim, that of the development of science skills.

Science Skills as Scientific Literacy Goal

It is the consensus among science educators that the development of inquiry and manipulative science skills is to be an integral part of every science course. These skills are seen either as complements of the science concepts component in the course or as exemplifications of certain science concepts basic to any science course. I will be drawing on the textbook curricula described in the preceding section in order to illustrate current curricular means designed to develop science skills. Using these ~~textbook~~ curricula as exemplars, I hope to show connections that can be made between the goal of science skills and the aim of scientific literacy.

Focus on Science is a somewhat unusual junior high school science text in that there is no description of any scientific method or desirable scientific habits and attitudes directed openly to the student reader. The text is, however, peppered with 'investigations' (never 'experiments') that are all inductive in purpose and recipe-like in style, and are based on severely limited amounts of data. In addition, students are shown the value of controls in one rather complicated experiment; the concept of experimental control is not mentioned or used again in the text, which treatment is, nonetheless, quite typical of high school general science texts. If pressed for a philosophical stance, it could be assumed that logical positivist values related to observations, classification, causation and induction are conveyed: facts speak for themselves, the sharing of physical characteristics is a clear guide to classification relationships, causation is readily deduced from circumstantial proximities, and observed regularities quickly lead to theoretical generalizations.11

In comparison, the authors of Matter, Life and Energy expend much more effort in writing about the nature of science. Science is presented as a dual entity: (1) an organized body of knowledge able to explain the world in which we live, and (2) a way of problem solving, a way of thinking. The student is not left long to wonder about the content of this organized body of knowledge. As has already been mentioned, the text is a lengthy rhetoric of conclusions over a variety of science disciplines. There may, however, be some confusion in the student's mind about the nature of scientific problem solving or ways of thinking. The authors describe scientific methodology under the subheading "What methods do scientists use to increase knowledge?". It develops, that the methods are singular and this single method is first called a method of reasoning (logical) and then described as a method of working using five basic steps: recognition of a problem, collection of facts, formulation of hypothesis, testing of hypothesis by experimentation or collection of more facts, and statement of a conclusion. This is the more traditional approach for high school science texts to take, that is, a discussion of some basic steps (similar to those just listed), and conforming to the same methodology.

The authors of Matter, Life and Energy go on to encourage the student reader to acquire the "scientific attitudes" of curiosity, honesty, open-mindedness, determination, perseverance, co-operation and communication in trying to solve everyday problems. However, the student reader is then informed of a major difference between real scientific work by scientists and scientific-like activities by non-scientists:

> There is a difference between applying this method of problem-solving to science and to your everyday problems. The difference is that in science you want to test a theory about nature. In solving an everyday problem you want an immediate practical result.12

Yet the single science example that is presented concerns neonatal blindness (retrolental fibroplasia), first reported by a Boston physician, and a practical result was most definitely wanted as quickly as possible. The accompanying Study Guide and Laboratory Activities for Matter, Life and Energy includes the occasional recipe-style laboratory activity. These represent the only attempts to show scientific methodology in action.

Some general comments are now possible in respect to the development of laboratory skills among junior high school students.

Firstly, and probably most noticeably, the science activities, as found in representative textbooks in a junior high school science course tend to be empirical and inductive in tenor, time-consuming in practice and problematic pedagogically unless the teacher has a solid repertoire of laboratory management skills. This must not be interpreted as disparaging the technical atmosphere of the laboratory in which the student is working. Some precision and accuracy, the use of simple laboratory apparatus and attempts at cleanliness and order are hallmarks of the typical high school laboratory. However, these hallmarks coupled with recipe-like 'experiments', the occasional demonstration, and audio-visual laboratory replacements, give the student a decidedly circumscribed look into the world of science.

The content of such experiments or investigations follows the familiar recipe-like format of materials, procedure and observations. The student is told rather clearly which materials to use, what is to be done with them and what to look for. The one exception is the IPS text. It differs noticeably from the other three texts in the way experiments are presented: (1) fewer details are given the student when experiments are described; (2) the format of the experiments is not written in an obvious and clearly headlined style using titles such as: materials, procedure, observations; (3) there are many more of them; (4) they are all confined to the laboratory premises. The other three texts vary considerably in the number of laboratory and field activities from few (as in Matter, Life and Energy) to many (as in Everyday Problems in Science and Focus on Science).

Against this foreground of 'hands-on' busyness there is, of course, a background of philosophy about the nature and values of the science activities. These activities help to make concrete a special group of science concepts that are often included rhetorically under the rubric of methodology but passed over quickly in favor of procedural descriptions regarding scientific method. These concepts are treated within the philosophy of science and could easily include those of perception, observation, theory, fact, confirmation, deduction, induction, truth, falsity, causation, validity, reliability, rationality, objectivity and predictability. Even though not exhaustive, this is quite a list of epistomological and methodological concepts that are inherent to any philosophy of science and have traditionally elicited differences both within the scientific community and among philosophers.[13] If inquiry strategies are closely tied to a philosophy concerning the generation of scientific knowledge, then evidence located in textbook curricula would seem to point to an inductive and logical positivist approach to scientific inquiry and scientific ways of thinking. Only one inquiry pattern is represented as acceptably scientific.

Of course, the factor of limited time tends to rule out more laboratory experiences, but it does little to explain or justify the nature of those included. On what basis is a one and a half hour investigation of the melting and freezing points of moth flakes (Haber-Schaim *et al.*) justified, if scientific literacy is the aim? The basis is usually two-fold: (1) melting and freezing points are characteristic properties (actually in this case singular) of matter and (2) this is a relatively easy hands-on experience that can sustain the interest of students. The need to make scientific abstractions concrete for students is ever present. If one attaches to this the pedagogical wish to keep them happily occupied, it is not difficult to formulate time-consuming experiences that seem to interest students and are related to scientific concepts.

Haber-Schaim et al. have a more thoughtfully elaborated point of view. They see the value of such science activities as serving to lay "a solid foundation for students" who will continue with future science courses as well as "for those taking no further science".[14] "The theme of the [year-long] course is the development of evidence for an atomic model of matter" and all experiments are directed to this theme, designed to develop concepts of volume, mass, characteristic properties of matter, solubility, compounds, elements and molecular motion.[15] The authors of the IPS text state that

> one of the best ways to find out how a thing works - and what it is made of - is to take it apart ... in some instructive fashion.[16]

Leaving aside the confusion between function and constituent elements as noticed in this statement, it does introduce us to the reductionist or atomistic perspective in methodology that we see reinforced with every experiment in the text. In conjunction with this experimental emphasis, precision and accuracy in measurement are stressed repeatedly throughout the text. The other three texts being used as exemplars and for comparison, do not stress the 'laboratory' atmosphere of science to anywhere the same degree.

Anyone familiar with the IPS text would know that Haber-Schaim et. al. have a fundamental reason for the inclusion of laboratory activities within the IPS curriculum. Scientific inquiry is the methodological half of science and just as essential to the very nature of science as the knowledge half. If the sentence "science is ..." were to be completed, there seems to be common consensus among scientists and science educators that its completion would have to include a knowledge as well as an inquiry component. Science is an organized body of knowledge about nature and a set of methodologies for its investigation. The latter leads to and verifies the former, and is accomplished in a manner that is peculiar to the needs of each science discipline. The exact propositional formulations of science's dual nature do show some variations, some modifications from author to author, but the essentials of the definition are easily understandable and acceptable as just stated.

It was with the intention of allowing high school students to experience this duality that the 'new' curricula of the 1960's were planned and implemented. It remained only for the curriculum writer to decide how many and what kind of science experiences should be included in each science curriculum. If these experiences could also be student-centered and interesting to the student, so much the better.

Beginning, then, from a science discipline-centered concern, i.e., to expose the full or dual nature of science to a high school population of students, science curriculum writers became inevitably involved in psychology-centered concerns about 'experiments', 'investigations' or 'inquiry'. Solely for the sake of simplification, I shall refer to all such laboratory-based activities as discovery learning, a term used by Ausubel and recognized by science educators as equivalent to the other science activities terms just cited. Discovery learning is a term used to indicate the type of learning in which "the material to be learned is not presented to the learner in final form, but [which the learner] must recognize or transform ... in some fashion prior to its incorporation into cognitive structure".[17] Concept formation, the formation of generalizations, problem solving and creativity are all "kinds of learning [in which] there is no alternative to discovery learning".[18]

A survey of possible and actual curricular and teaching strategies shows us that the teacher component in the learning situation may well provide a highly variable amount and type of guidance for the student who undertakes discovery learning. Even 'pure' discovery learning, in a school setting, would require the teacher to provide the environment in which discovery is to take place. If plants are to be discovered, plants must be made available, which environment is then determined, selected, manipulated by the teacher in order to guide the learner in a somewhat expeditious and 'calculated' manner. This is only reasonable, given the constraints of any school setting. Usually, however, much more guidance is given the student - by asking leading questions, by providing detailed instructions (e.g., as in recipe-like experiments), by class demonstrations (either by the teacher or a few students) and/or by verification of generalizations as opposed to their formulation (by far the most widely-used type of discovery learning in school laboratories).

Certain questions can now be raised about any scientific literacy course. Is it the course's goal to produce little scientists, science connoisseurs, or persons knowledgeable about science-related matters? To what extent is evidence of laboratory skills a necessary goal of such a science course? Is introduction to scientific knowledge and methodology sufficient as the primary goals in any science course? And if so, which parts of knowledge and which method(s) would fulfill the expectations of this goal? If "curriculum defines what counts as valid knowledge", which philosophical and methodological approach to scientific knowledge is to be used?19

Analogously, language arts, music, the fine arts, physical education and languages also have an ~~act~~ive and important method component to impart to students. For the majority of public school students, the extent of skill development and connoisseurship are the two questions centered on subject matter activities that need resolution. What instrument skills should the music course make possible? What range of music connoisseurship is to be reasonably expected - types of music? types of instruments? history of music? reading of written music? Is the course's goal to produce little 'musicians' and little music 'critics'? Or is its goal simply to introduce the student to some selected areas of all things musical?

How do all these concerns about 'laboratory' activities relate to a course in scientific literacy, a type of course designed for the majority of students in the public education systems? These students, for whatever reason, have chosen or have been placed in a single-year, 'dead-end' science course (i.e., a course that is neither vocational or college preparatory) in order to fulfill high school graduation requirements. Should the student be required to experience a methodology of science in order to come away with a better and fuller understanding of science? If so, which methodology(ies) is most appropriate, given time and skill limitations, and the need to form or reinforce certain selected concepts and generalizations? If we extend these public education course considerations to post-secondary citizenship concerns as expressed by many science educators and reformers, we face an additional set of questions that the public school music, fine arts, language and physical education courses do not have to face. Democratic governments are monitored by citizen groups and are ultimately replaced or retained by citizen votes. As has already been discussed earlier in this chapter, and in the preceding one, many political decisions currently and for the foreseeable future include scientific or science-related issues. Health care, defense systems, space exploration, government subsidies of industrial and military scientific and technological research are all directly connected to governmental positions which are supported or repudiated by citizens. The basis of such support or repudiation is then called into question, and the ability of the citizen to understand science-based arguments for either support or repudiation is the proposed link with high school scientific literacy courses. The goals of the high school music course imply no such citizen responsibilities. In exposing these questions, I have tried to indicate the kind of deliberation that might serve well the educational situation surrounding the goal of scientific literacy and that may generate promising directions for resolution of this curricular problem.

Once again, can some conclusion be generated from these deliberative efforts? Can some guidelines be noticed that can point the way to some solution? One workable solution seems possible: some understanding of scientific methodologies ought to be possible as a student learning outcome. This conclusion then prompts the following guideline question: which laboratory experiences would most expeditiously and effectively provide students with some basic understanding of scientific methodologies? There remains one last curricular theme to consider.

Societal Issues and Scientific Literacy

The teaching of science concepts and skills is and will remain in varying ways, a fundamental and substantial portion of the scientific literacy curricula. Without these, the core nature of scientific literacy would likely be put in jeopardy. Not as clearly fundamental is the set of objectives or goals connected in various ways to the role of high school graduates as social, political, autonomous individuals. These goals are phrased in varying styles and emphases:

(1) Klopfer writes of the need to study science-technology-society interactions and related scientific values and ethics;

(2) Harms & Yager advocate identifiable learning outcomes relevant to personal needs (e.g., health), societal issues and career choices;

(3) Berkheimer & Lott suggest applying science in students' lives and the study of science-society issues;

(4) Stake & Easley report of students wanting to learn science as-used-in-everyday-life as well as science oriented to present and future job markets and other human issues;

(5) Aikenhead is concerned about the needs of citizens to understand science-related issues about which they may have to make political decisions;

(6) Kahle & Yager report that high school teachers have expressed, as a second most frequent concern, the need to focus on science-technology-societal problems from appropriate inquiry and data perspectives;

(7) Yager proposes that science education be redefined as "the discipline concerned with the study of the interaction of science and society";

(8) Riechard would like scientific literacy to be characterized by the ability to interpret science-related information found in the popular media, to understand the sociology of scientific enterprises, to develop scientific habits of critical thinking and decision-making in personal and social matters.20

To what extent are some or all or any of these superficially diverse but fundamentally linked goals appropriate for students in a high school scientific literacy course?

If, as Bernstein maintains, "educational knowledge is a major regulator of the structure of experience", curriculum planners are faced with an array of serious psychological and sociological considerations-quite apart from subject matter considerations.[21] Bernstein goes on to write that "curriculum defines what counts as valid knowledge".[22] The question raised above can now be restated: which socio-political paradigm will shape the treatment of societal issues to be included in the scientific literacy curriculum? This third goal, viewed by many science educators as of the first importance for the proper psychological and sociological development of the non-science student, is plagued with difficulties, difficulties that may defy solution at the high school level.

Let us look at one example. The largest Québec school system, that of the Catholic School Board of Montréal (la Commission des Ecoles Catholiques de Montréal), was faced with curricular problems involving several issues not, it must be said, confined to science courses, but rather potentially including all courses. Teachers were given, by their teachers' union, written materials about a number of topics and issues as part of the union's professional development program. The union interpreted its mandate broadly enough to include the dissemination of political position papers from sources outside of the province's usual political agencies. Some teachers then proceeded to use these position papers as discussion papers in a number of high school courses. Shortly thereafter, there was a considerable uproar among elements of Montréal society as to (1) the validity of such position papers and (2) their dissemination by <u>teachers</u> to students <u>in the public school system</u>. The implications were clear enough: (1) the disseminated political stance did not enjoy acceptable shared meaning in Montréal society and (2) that teachers in the public school system are charged with transmitting society's <u>shared</u> values and cultural heritage. The conceptual ecology of a given community is not easily avoided or ignored when teaching in the public school system.[23]

What then are we to make of science educators' efforts to introduce this third scientific literacy goal into high school curricula? Is autonomous decision-making really the aim of this pedagogical strategy? If so, why are decision-making skills being taught in a science course? Is it because these skills are basically scientific skills akin to scientific problem-solving skills? (One is brought to speculate on the advisability of sharpening such problem-solving skills on societal issues located in the scientific literacy courses, when an examination of societal issues is not one of the goals in any other course in the science program.)

Let us set aside for the moment any further questions about the appropriateness of teaching decision-making skills about <u>societal</u> issues in a science course. If we approach these societal issues from another perspective, namely that of their scientific connections, is there then not sufficient reason to include these in a scientific literacy course as a major focus of the course? As has already been mentioned by any number of science educators, and even generally agreed upon by society writ large, science plays a part in everyday affairs as well as in major economic, industrial and governmental decisions. It follows that the average citizen's awareness and understanding of such economic and political decisions are crucial to his/her role in monitoring, supporting or rejecting such decisions (of course, only if it is assumed that citizens have such a role). What will be taught about the science in the science-technology-society interface in regard to nuclear power, drugs, space exploration, recombinant DNA that could not have been included in the teaching of science concepts? Since the one year is all that most of these student will have for chemistry and physics concepts (though a second year of biology is usually elected by many of these same students) should not the adequate treatment of science concepts take priority? Or, given that only one year is available for the teaching of chemistry and physics concepts, would it not be more advantageous to the student to show him/her a 'correct' scientific position on nuclear power, drugs, space exploration, recombinant DNA as proper preparation for the future role of citizen?

In any event, it is highly doubtful that the high school scientific literacy teacher would have the ability to act as arbiter among the differing intra-science views on nuclear power, drugs, space exploration and recombinant DNA. Much more likely, the teacher would have received some education favoring one view and would find it too problematic to present any other.

It is entirely possible that satisfactory answers will be forthcoming to any number of these questions. But the questions deserve, nonetheless, to be raised in order to alert the curricular participants to the possible educational and sociological ramifications of this third scientific literacy goal. Consideration of student cognitive readiness, of teacher subject matter competency, of parental and community constraints would seem to be major influences on decisions about the appropriateness of a focus on societal issues when practice in 'scientific' decision-making skills is wanted at the junior high school level.

The deliberative efforts surrounding this third scientific literacy theme can now draw to a close. Has some conclusion been generated out of these efforts? I believe that one is possible: science-related issues ought to find a place in scientific literacy curricula. Two important guideline questions would, however, seem to follow the acceptance of this conclusion: (1) should science-related societal issues be a <u>major</u> focus in such a science course? (2) If so, what are some expeditious and effective pedagogical strategies for exposing students to the <u>science</u> component of science-related societal issues?

Concluding Remarks

<u>No single conclusion</u> regarding the curricular problem surrounding the educational aim of scientific literacy has resulted from the deliberative enquiry process as worked through in this chapter. Nonetheless, it is possible to point to two results that have been generated by the enquiry process. One such result takes the form of directions that might be followed by educators to arrive at a curricular solution to the scientific literacy curricular problem. The foundations of these directions involved an examination of candidates for appropriate goals related to science content and science skills. Questions were raised and discursively pursued regarding the selection of representative science concepts appropriate to the typical one-year junior high school obligatory science course. In like manner, I

discussed positions for and against the inclusion of science-based societal issues in the curricular content of such a course. Because it is a necessary part of science education protocol to include the development of some science skills in every science curriculum, equally serious attention was paid to the skills aspect of science curricula. In addition, I examined some suggestions regarding the form or extent of such skills development in a one-year junior high school obligatory science course.

A second result is the intended exemplification of the arts of the practical and the arts of eclectic. I tried to exemplify the curricular advantages to the interplay of these arts within the Schwabian deliberative framework. The phases of problem formulation and solution formulation were extensively developed, leading to possible conclusions and guideline questions concerning the appropriateness of three scientific literacy goals: the transmission and understanding of major science concepts, the development of science skills, and the development of decision-making skills regarding science-related societal issues. The guideline questions can serve as directions pointing the way to solution formulations.

It is, then, my thesis that use of the Schwabian deliberative enquiry framework can generate guidelines for constructive curricular solutions to ongoing curricular problems. This is particularly so with curricular problems that have their bases in underlying concepts that are essentially contested and that include educational peculiarities that are historically and inevitably changeable. If these statements are taken as a preamble, I will be able to summarize the character of the Schwabian deliberative enquiry process as well as the proposed curricular considerations regarding the aim of scientific literacy in public science education.

The science education curricular problem of scientific literacy has been insufficiently and inadequately examined at a conceptual level, if science education literature is any guide to an understanding of the concept of scientific literacy. I have tried to show that important elements in the concept of scientific literacy have resulted from somewhat convoluted historical processes and may be expected to include assumptions that are grounded in the same historical processes. I began the deliberative process with an historical review of the development of scientific literacy as an educational aim, relying principally upon archival evidence from science education literature. This historical review revealed a relatively wide range of conceptual formulations that have surfaced in the literature. Going on from these fundamental and historical considerations, I developed some conceptual formulations that are grounded, not only in the concerns of science disciplines and in the economic and political concerns of public education, but that also take into account community, student and teacher concerns and particularities.

Even though no single or 'best' concept of scientific literacy evolved from this exploratory study, it opened to view educational particularities that such a process might reasonably and profitably include. I tried to demonstrate that, <u>if distinctions are wanted</u> between pre-professional science courses and scientific literacy courses, attention must be paid to student and community concerns and expectations. These concerns and expectations include motivational factors, career plans, personal interests, parental and peer expectations. If scientific literacy courses are wanted that are distinct from pre-professional science courses, the target population of high school students needs fuller and more considered inclusion in both the development of the scientific literacy concept and its translation into specific learning objectives.

Having reviewed a considerable number of views and conclusions reached by science education professionals and adding to these my own views based on professional experience and reflection, I have concluded that there is a need to develop science curricula that are distinct from pre-professional science courses, and that these science curricula (whether or not termed scientific literacy curricula) ought not to focus solely on the conceptual and methodological concerns emanating from specific science disciplines, but ought to place some emphasis on the role of science in personal, career and social concerns.

A recapitulation of the major directions in the deliberative process would quickly remind us of the phases in this process as well as their outcomes. The practical mode focused on the circumstances surrounding the curricular problem area because the perception of the problem is critical to a fuller understanding of the educational situation. These circumstances are to be equably representative of the four educational commonplaces about which Schwab reminds us repeatedly, namely the curricular circumstances centered on the teacher, the student, the subject matter to be learned and the milieu in which these three elements are intertwined and interact.

A focusing on these curricular circumstances calls for historical considerations of facts and concepts, which I have attempted to do when reviewing the historical development of the scientific literacy concept. While history does not necessarily repeat itself, it can provide a fuller understanding of the present educational circumstances or commonplaces.

This was followed by a discursive examination of a number of problem and solution indicators. Proposed learning objectives (or student outcomes) for course content and skills development were looked at through the lenses of teacher, student, subject matter and milieu. In so doing, I chose to adhere as closely as possible to unavoidable constraints related to the subject matter content of a typical one-year junior high school science course and related to the motivational, interest and cognitive development factors of the target student population.

This examination of the current educational circumstances surrounding the scientific literacy problem revealed questionable correspondences between the goals or learning objectives ascribed to the educational aim of scientific literacy as desiderata and the conceptual structure of such a science education aim. Questions surfaced regarding the content of textbook curricula as well as the related level of teacher competency. What was found over and over again was the tendency to use science education goals appropriate to pre-professional science courses as equally or sufficiently appropriate to scientific literacy courses.

In this exploratory study, I have tried to expose some of the questions that still need to be fully addressed: Which sciences are to be represented in a scientific literacy course? Which concepts from these sciences are to be included in such a course? Which scientific methodologies and laboratory skills are to be introduced in such a course? Should science-related societal issues be a major focus in scientific literacy curricula? How are societal issues to be integrated into such a course, i.e., as positions to be espoused or as decision-making exercises?

These questions centering on curricular means have followed from the three conclusions that I have submitted and that translate readily into curricular ends: (1) some set of science concepts ought to be introduced in any scientific literacy curriculum, (2) some understanding of scientific methodologies ought to be possible as a student learning outcome of such a course, and (3) science-related issues ought to be part of scientific literacy curricula.

In closing, then, I return to the propositions of the initial argument that I put forth: deliberative enquiry is a framework for curricular deliberation that is appropriate to the resolution of complex educational problems; the scientific education aim of scientific literacy is such a complex educational problem; and the use of deliberative enquiry has been able to generate guideline positions pointing the way to possible solutions. I feel that each of these propositions has been addressed and that adequate evidence and arguments have been presented in support of each proposition.

APPENDIX A

Taken from Harms & Yager, eds., What Research Says to the Science Teacher, Vol. 3, pp. 6-8.

The term "goal cluster" was used throughout [Project Synthesis]. This term reflects the reality that it is impossible to embody all the major goals of science education in a few short statements, but that it is indeed possible to characterize broad goal areas by relatively brief descriptors, useful in discussing major emphases in science education. The goal clusters used in Project Synthesis were determined jointly by the project staff and the leaders of the five focus groups, with useful input from Dr. Bentley Glass and Dr. David Hawkins who participated in the first meeting of group leaders. The goal clusters finally used divided learning outcomes into categories of relevance for 1) the individual, 2) societal issues, 3) academic preparation and 4) career choice. They are defined here briefly, and used later in the Focus Group reports.

Goal Cluster I: Personal Needs. Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world.

Goals that fall into Category I focus on the needs of the individual. For example, there are facts and abilities one needs to be a successful consumer or to maintain a healthy body. One should have some idea of the many ways science and technology affect one's life. Knowing that is still not enough. Science education should foster attitudes in individuals which are manifested in a propensity to use science in making everyday decisions and solving everyday problems.

Goal Cluster II: Societal Issues. Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

Category II goals relate to the needs of society. They pertain, for example, to the facts and skills a person needs to deal with the environmental and energy issues which affect society at large. In order to vote intelligently on science-related societal issues or participate in responsible community action, not only are specific facts and skills important, but also an understanding of the role of science in society, a knowledge of issues and how science relates to them, and a recognition that in providing the solution to one problem science can create new ones. Of course, to develop informed, concerned citizens and wise voters, science education also must be concerned with attitudes. It must instill in students a sense of responsibility, an appreciation of the potential of science to solve or alleviate societal problems and a sense of custodianship to protect and preserve the natural world with which science concerns itself.

A common element of personal and societal goals is the importance of the applications of science to problems of personal and societal relevance. In order for students to be able to apply science to such problems, it is necessary that they have an understanding of the problems, of the aspects of science which apply to the problems and of the relationship between science and these problems. Students should also have experience in the processes of applying science to the solutions of such problems.

Goal Cluster III: Academic Preparation. Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs.

Goals in this category pertain to scientific ideas and processes which form a part of the structure of scientific disciplines, which may not be related easily to specific decisions about one's own life or about societal issues, yet which are necessary for any further study of science.

Goal Cluster IV: Career Education/Awareness. Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.

Science classes in all disciplines and at all levels which prepare students to make informed career decisions regarding jobs related to science and technology would logically place emphasis on topics and learnings such as: awareness of the many possible roles and jobs available in science and technology including such careers as laboratory assistants, as well as jobs which apply scientific knowledge in agriculture, nutrition, medicine, sanitation, conservation, etc.; awareness that persons of both sexes, all ethnic backgrounds, wide ranging educational and ability levels and various handicaps can and do obtain such jobs; awareness of the contributions persons in such jobs can make to society as a whole; knowledge of the specific abilities, interests, attitudes and educational preparation usually associated with particular jobs in which individual students are interested; a view of scientists as real people; a clear understanding of how to plan educational programs which open doors to particular jobs; a recognition of the need for science, mathematics and language arts coursework as well as a broad base in the social sciences to better understand the relationships between science and society; a knowledge of human and written sources for further information in all areas listed above.

APPENDIX B

The following are annotated sample references from science education literature spanning the years 1968 through 1978, and having as a general theme 'scientific literacy'.

WOOD, Roger L., PELLA, Milton O. and O'HEARN George T. 1968. "Scientifically and/or Technologically Oriented Articles in Selected Newspapers." Journal of Research in Science Teaching 5:151-53.

How best to develop citizens capable of understanding science and the "importance of the press as a medium for communicating current achievements in science to the public and as an aid in improving the public's understanding of what science is, how it operates and the circumstances that make it prosper".

WEISS, Thomas M. 1969. "The Spirit of Science." Science Education 53(4):365-67.

Stresses the need for scientific thinking and scientific methodology by everyone and in everyday affairs.

HURD, Paul DeHart. 1970. "Scientific Enlightenment for an Age of Science." Science Teacher Jan. 37(1):13-15.

An enlightened citizenry needs to understand science properly and to support it.

EVANS, Thomas P. 1970. "Approaching Scientific Literacy." Science Teacher May 37(5):93-5.

Plea for a common understanding of scientific literacy terms and an educational program that will develop scientific literacy through appropriate teacher-training, curricula and the media.

DAUGS, Donald R. 1970. "Scientific Literacy - Re-examined." Science Teacher Nov. 37(4):10-11.

Plea for a clear definition of scientific literacy in order to be used as an objective in science curricula.

NATIONAL SCIENCE TEACHERS ASSOCIATION COMMITTEE ON CURRICULUM STUDIES. 1971. "School Science Education for the 1970's." Science Teacher Nov. 38(8):46-51.

Prescription for science education: "the major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action" through new science curricula that balance science and the social aspects, and through better teacher training.

AGIN, Michael L. 1974. "Education for Scientific Literacy: A Conceptual Frame of Reference and Some Applications." Science Education 58(3):403-15.

Plea for a more specific definition or concept description of scientific literacy to help communicate this science education goal; he offered his own, one that stressed the need for a social setting, no matter the other components.

SMITH, Norman F. 1974. "The Challenge of Scientific Literacy." Science Teacher Sept. 41(6):34-5.

Plea for a realistic scientific literacy definition instead of the positing of unattainable and idealized goals.

PELLA, Milton O. 1976. "The Place or Function of Science for a Literate Citizenry." Science Education 60(1):97-101.

Offers a particular view of a literate citizenry capable of reading and interpreting science literature.

O'HEARN, George T. 1976. "Science Literacy and Alternative Futures." Science Education 60(1):103-14.

Advances four operational categories for scientific literacy and then examines existing school curricula in light of these categories.

FRASER, Barry J. 1977. "Selection and Validation of Attitude Scales for Curricular Evaluation." Science Education 61(3):317-29.

An examination of current science attitude scales used in research and a comparison made to stated science curriculum aims.

TARP, John R. 1978. "Toward Scientific Literacy for all our Students." The Science Teacher Dec. 45(9):38-9.

Sees scientific literacy in terms of a universal schooling preparation so that an informed citizenry would participate effectively in a democratic society.

BOWYER, Jane B. and LINN, Marcia C. 1978. "Effectiveness of the Science Curriculum Improvement Study in Teaching Scientific Literacy." Journal of Research in Science Teaching 15(3): 209-19.

Uses Pella's 1966 scientific literacy components in examining the SCIS stated objectives in developing scientific literacy.

RUBBA, Peter A. and ANDERSON, Hans O. 1978. "Development of an Instrument to Assess Secondary School Students' Understanding of the Nature of Scientific Knowledge." Science Education 62(4):449-58.

Using one of the dimensions of scientific literacy as developed by Showalter, namely, understanding the nature of science knowledge, developed and tested a 48-item instrument to use with a high school student population.

APPENDIX C

ACRONYMS:

AAAS - American Association for the Advancement of Science

AASA - American Association of School Administrators

ASCD - Association for Supervision and Curriculum Development

ISCS - Intermediate Science Curriculum Study

MAPS - Modular Activities Program in Science

NAS - National Academy of Science

NRC - National Research Council

NCPT - National Congress of Parents and Teachers

NPTA - National Parents and Teachers Association

NSBA - National School Board Association

NSTA - National Science Teachers Association

KEYS:

* indicates sponsorship and funding by the National Science Foundation (NSF), an American agency

**indicates sponsorship and funding by the Science Council of Canada

Each key will be used only for the first appearance of the pertinent group or individual in the list of problem-foci.

PROBLEM-FOCI IN SCIENTIFIC LITERACY: A summary of problem-foci perceived as major by research groups and individuals, and as reported in recent U.S. and Canadian science education literature.

1. Omissions in science curriculum content:

a. contemporary social issues and personal issues

NAS, NRC	(1980)*	Orpwood & Souque	(1984)**
AASA	(1980)*	Helgeson et al.	
AAAS	(1980)*	Ste-Marie	(1982)**
ASCS	(1980)*	Risi	(1982)**
NSCA	(1980)*	Désautels	(1982)**
Rosenthal	(1985)	Harms	
Butts	(1981)	Yager & Penick	
Klopfer		Trowbridge et al.	

b: the development of a publicly positive and supporting attitude towards scientists and the scientific enterprise

NAS, NRC		Nossal	
ASCD	(1980)*	Ste-Marie	
NSCA		Risi	
Rosenthal		Sormany	(1982)**
Schwab (1978, 1962)		Chisman	
Klopfer		Yager & Penick	
Harms			

c. history and sociology of science

Ste-Marie
Désautels

d. the structure of the science disciplines and cognitive skills development

AASA	Schwab (1950, 1961, 1962)
Norris (1984)	Sormany

2. Motivation:

a. based on curriculum content

AAAS	Rosenthal	
AASA	Lévy	(1982)**
NAS, NRC	Liutec	(1982)**
	Yager & Penick	

b. based on competency tests

NCPT, NPTA (1980)*
NAS, NRC

3. Lack of competent science teachers:

NSTA (1980)* Karplus
AAAS Brandwein
NAS, NRC Lévy
AASA Welch, G. (1982)
ASCD Welch *et al.* (1981)
NCPT, NPTA
NSBA (1980)*

4. Lack of science equipment, science laboratory facilities, science teaching texts for students, and scheduled class time for the teaching of science:

NSTA ASCD
AAAS NCPT, NPTA
NAS, NRC NSBA
AASA Butts

5. Inefficient high school science tracking or streaming:

NCPT, NPTA
Klopfer

6. Learning strategies, based on group instruction:

NCPT, NPTA
ISCS program, designed to be self-pacing and teacher-proof
MAPS program, designed to be teacher-proof
Bangert *et al.* (1983)

7. Lack of inter-disciplinary or multi-disciplinary courses:

NSBA DEsautels
Orpwood & Souque Gauthier (1982)**
Helgeson *et al.*

8. Unrealistic science education objectives:

Welch *et al.*
Lucas & Tulip (1980)

9. Cognitive and emotive maturation levels of high school students:

Welch *et al.*
Lucas & Tulip

10. Lack of effective communication of the results of research in science teaching/learning, particularly to the teaching body:

AAAS ASCD

APPENDIX D

Scientific literacy learning objectives as proposed by Showalter:

I. The scientifically literate person understands the nature of scientific knowledge.

II. The scientifically literate person accurately applies appropriate science concepts, principles, laws, and theories in interacting with his universe.

III. The scientifically literate person uses processes of science in solving problems, making decisions, and furthering his own understanding of the universe.

IV. The scientifically literate person interacts with the various aspects of his universe in a way that is consistent with the values that underlie science.

V. The scientifically literate person understands and appreciates the joint enterprises of science and technology and the interrelationships of these with each and with other aspects of society.

VI. The scientifically literate person has developed a richer, more satisfying, more exciting view of the universe as a result of his science education and continues to extend this education throughout his life.

VII. The scientifically literate person has developed numerous manipulative skills associated with science and technology.

Taken from Rubba & Andersen [1978]

APPENDIX E

Test Instruments for Measuring Various Dimensions of Scientific Literacy

NSKS	Nature of Science Knowledge Scale	(Rubba & Andersen 1978)
TOES	Test of Enquiry Skills	(Fraser 1980)
TBSK	Test of Basic Science Knowledge	(Showalter 1974)
SPI	Science Process Inventory	(Welch & Pella 1968)
TOSRA	Test of Science-Related Attitudes	(Fraser 1978)
ATTA	Adoption of Science Attitudes	
ATTC	Career Interest in Science	
ATTE	Enjoyment of Science Lessons	
ATTL	Leisure Interest in Science	
ATTN	Normality of Scientists	
ATTS	Social Implications of Science	
CRITHINK	Test of Thinking Process Skills	

FOOTNOTES

Chapter 1

[1](1969) "The Practical: A Language for Curriculum"
(1971) "The Practical: Arts of Eclectic"
(1973) "The Practical 3: Translation into Curriculum"

These three papers are included in the collection of Schwab's papers as edited by Westbury & Wilkof: Science, Curriculum and Liberal Education (q.v. footnote 7 below).

(1983) "The Practical 4: Something for Curriculum Professors To Do"

This last paper is an extension of the preceding three.

[2]Joseph J. Schwab, "The Practical 4: Something For Curriculum Professors To Do," Curriculum Enquiry 13 (~~1983):239-266.~~

[3]Webster's Third New International Dictionary (unabridged), 1981, p. 277.

[4]William A. Reid, "The Changing Curriculum: Theory and Practice", in Case Studies in Curriculum Change, ed. William A. Reid and Decker F. Walker (London: Routledge & Kegan Paul, 1975), p.247.

[5]Robin Barrow, The Philosophy of Schooling (Brighton, England: Wheatsheaf Books, 1981), p.74.

[6]Schwab, p.240.

[7]Ian Westbury and J. Wilkoff, eds., Science, Curriculum, and Liberal Education: Selected Essays of Joseph J. Schwab (Chicago: University of Chicago Press, 1978), pp.287-321.

[8]Ibid., pp. 322-364.

[9]Ibid., pp.365-383.

[10]Schwab, pp.239-266.

[11]Ibid., p.239.

[12]Westbury and Wilkoff, p. 278.

[13]Ibid.

[14]Ibid., p.323.

[15]Schwab's spelling of enquiry will be used throughout this thesis when treating of the Schwabian deliberative process.

[16]Reid, Thinking About the Curriculum (London: Routledge & Kegan Paul, 1978), p.12.

[17]John Dewey, Logic: The Theory of Inquiry (New York: Holt, 1938).

Chapter 2

[1]Westbury & Wilkoff, p. 287.

[2]As evidenced by the 1960's heavy funding supplied by national agencies in the United States, enthusiastic teacher support, widespread curriculum planning by large numbers of subject matter specialists and psychologists and the cooperation of textbook publishers.

[3]Westbury & Wilkoff, p.304

[4]Ibid., p.287

[5]Ibid.

[6]Ibid., p.302.

[7]Ibid., p.287.

[8]Ibid. [9]Ibid., p. 289

[10]Ibid. [11]Ibid.

[12]Ibid., p.290.

[13]Ibid., p.289.

[14]Lawrence Stenhouse, An Introduction to Curriculum Research and Development (London: Heinemann Educational Books, 1975), p.136.

[15]Seymour Fox, "A Practical Image of 'The Practical', Curriculum Theory Network 10 (1972): 46,47.

[16]Reid, "Curriculum Theory and Curriculum Change: What can we learn from history?" paper presented at the AERA symposium 'History of Education and Curriculum Theory', New Orleans, LA, April 1984, p.7.

[17]Ibid., p. 3.

[18]Westbury and Wilkoff, p. 295.

[19]Ibid.

[20]William Knitter, "Curriculum Deliberation: Pluralism and The Practical," paper presented as part of an AERA symposium 'What to do about deliberation', 1983.

[21]Westbury and Wilkoff, p.308.

[22]Ibid.

Chapter 3

[1]Westbury and Wilkoff, p.323.

[2]Ibid., p.307.

[3]David P. Gauthier, Pracical Reasoning (Oxford: Claredon Press, 1963), p.28.

[4]Westbury and Wilkoff, p.323.

[5]Ibid., p.325.

[6] Reid, "Practical Reasoning and Curriculum Theory: In Search of a New Paradign," Curriculum Inquiry 9(1979): 198.

[7] Stenhouse, p.25.

[8] Thomas W. Roby, "Problem Situation and Curricular Resources at Central College: An Exemplification of Curricular Arts, Curriclum Inquiry 8 (1978):8.

[9]Ibid., p.9

[10]Knitter, p. 2

[11]Ibid., p.8, 9.

[12]Ibid., p.22.

[13]Ibid., p.6.

[14]Ibid., p.11

Chapter 4

[1]Westbury and Wilkoff, p.322.

[2]Knitter, Curriculum Deliberation.

[3]A term ascribed by Knitter to Kekes.

[4]Knitter, Curriculum Deliberation, p.16.

[5]Roby, "Habits Impeding Deliberation, Journal of Curriculum Studies 17(January-March 1985): p.15.

[6]Westbury and Wilkoff, p.322.

[7]Reid, "Practical Reasoning," pp.187-207.

[8]Ibid., p.194.

[9]Warner Wick, "Theory and Practice of 'The Practical', Curriculum Theory Network 10 (1972): 40-41.

[10]Westbury and Wilkoff, p.54

[11]Ibid.

[12]Wick, p.38.

[13]Fox, "A Practical Image."

[14]Roby, "Problem Situations."

[15]Peter Pereira and Thomas Roby, "Practical Enquiry and Curricular Research," paper presented for the Colloquium on Quality and the Master's Degree, DePaul University, 24 May, 1980.

[16]Lee S. Shulman, "The Practical and the Eclectic: A Deliberation on Teaching and Educational Research," Curriculum Inquiry 14 (1984): 186.

[17]Ian Westbury, "The Character of a Curriculum for a 'Practical Curriculum'," Curriculum Theory Network 10 (1972): 25-36.

[18]Roby, "Habits."

[19]Elliott Eisner, "No Easy Answer: Joseph Schwab's Contributions to Curriculum," Curriculum Inquiry 14 (1984): 201-210.

[20]Westbury and Wilkoff, p.312.

[21]Schwab, pp.239-266; Shulman, pp. 183-200.

CHAPTER 5

[1]Reid, "Curriculum, Community and Liberal Education: A Response to the Practical 4," Curriculum Inquiry 14 (1984): 103-111; Idem. "Curriculum Theory and Curriculum Change" ; Idem, "The Changing Curriculum."

[2]Idem, "The Changing Curriculum," p. 247.

[3]Ibid., p. 248.

[4]Douglas A. Roberts, Scientific Literacy: Towards Balance in Setting Goals for School Science Programs (Ottawa: Minister of Supply & Services, 1983).

[5]Ibid., p. 18.

[6]Ibid.

[7]Ibid.

[8]Ibid., p. 16.

[9]Ibid.

[10]Ibid.

[11]McKinney & Westbury, in their case study of the Gary, Indiana, public school system (1940-1970) make a similar point, but in respect of the Gary school system's efforts at science curriculum changes.

[12]Biological Sciences Curriculum Study
Chemical Educational Materials Study
Physical Science Study Conference

[13]Roberts, Scientific Literacy.

[14]Douglas Roberts (1983) extensively documents this transition. See Appendix B for a listing and pertinent highlights of a number of references relevant to this period of transition.

[15]Milton Pella, Douglas Roberts, Lawrence Gabel, William Ogden, Janis Jackson, Victor Showalter (among others) have also been instrumental in developing comprehensive and composite views of scientific literacy.

[16]Robert Karplus and Herbet D. Thier, A New Look at Elementary School Science: Science Curriculum Improvement Study (Chicago: Rand McNally & Co., 1967), p. 24.

[17]Ibid.

[18]Douglas Roberts' composite sense of scientific literacy, based on aims in science education: organization of knowledge, intellectual processes, values and ethics, inquiry processes, science as a human endeavor, interaction of science and technology, interaction of science and society, interaction of science, technology and society.

[19]David P. Butts, "Science Education," in Encyclopedia of Educational Research, 5th ed. (New York: The Free Press, 1982).

[20]I. P. Weiss, et al., Report of the 1977 National Survey of Science, Mathematics and Social Studies Education (Washington, D.C.: U.S. Government Printing Office, 1978).

[21]Ibid.

[22]D. P. Butts, "Science Education," p. 1669.

[23]National Science Foundation, National Assessment of Educational Progress (Washington, D.C.: U.S. Government Printing Office, 1978); 1977 Yarms, Yager & Wiley

[24]Alphonse Buccino, et al., Science Education Databook (Washington, D.C.: National Science Foundation, 1980).

[25]Weiss, Report of the 1977 National Survey.

[26]Ibid.

[27]Ibid.; Helgeson, et al., What Research Says; Robert E. Stake and Jack W. Easley, Jr., Case Studies in Science Education Vols. I & II (Washington, D.C.: U.S. Government Printing Office, 1978).

[28]Buccino, et al.

[29]M. J. Dunkin and B. J. Biddle, The Study of Teaching (New York: Holt, Rinehart & Winston, 1974); John Olson and Thomas Russell, eds., Science Education in Canadian Schools, Vol. III: Case Studies of Science Teaching (Ottawa: Minister of Supply & Services, 1984); Graham W. F. Orpwood and Isme Alam, Science Education in Canadian Schools, Vol. II: Statistical Database for Canadian Science Eduction (Ottawa: Minister of Supply & Services, 1984); Helgeson, et al., The Status of pre-College Science; Weiss, Report of the 1977 National Survey; Stake and Easley, Case Studies.

[30]Weiss, Report of the 1977 National Survey; Buccino, et al., Science Education Databook.

[31]Marcel Risi, Macrosole: A Holistic Approach to Science Teaching (Ottawa: Minister of Supply & Services, 1982).

[32]Donald A. George, An Engineer's View of Science Education (Ottawa: Minister of Supply & Services, 1981).

[33]Harms & Yager, What Research Says.

[34]See Appendix A.

[35]Harms & Yager, What Research Says, p. 13.

[36]Ibid., p. 12.

[37]R. K. James and S. Smith, "Alienation of Students from Science in Grades 4-12." Science Education 69(1985):39.

[38]Klopfer, "New Friends and New Forms for Science Eduction," Science Education 68(1984):1-2.

[39]National Science Foundation, Science, and Engineering Education for the 1980's and Beyond (Washington, D.C.: U.S. Government Printing Office, 1980), p. 2.

[40]Ibid.

[41]Glen S. Aikenhead, Science in Social Issues (Ottawa: Minister of Supply & Services, 1980).

[42]Stake & Easley, Case Studies.

Interestingly, the same study showed that the following were felt to be adequate: textbooks, teachers, pre-college science courses, and the general science curriculum. In addition, tracking or streaming was felt to be inevitable in the larger high schools, and satisfactory.

[43]Jane Butler Kahle and Robert E. Yager, "Current Indicators for the Discipline of Science Education," Science Education 65(1981):25-31.

Science education for all was not included as a problem indicator; it is somewhat difficult to interpret the significance of this omission.

[44]Robert E. Yager, "Defining the Discipline of Science Education," Science Education 68(1984):35-37.

[45]Ibid., p.36

Kahle & Yager's "Current Indicators" listed this as the least frequently mentioned concern of science educators, i.e., no. 8. Helgeson et al. (1978) point to the historical absence of moral/ethical values as part of the overt science curriculum. This is no longer the case in all

North American school jurisdictions: e.g., Québec has included desirable moral values in each new or revised science curriculum guide.

[46]Ibid.

[47]D.E. Riechard, "Politics and Scientific Literacy," Education 106(1985):108.

[48]Ibid., p. 109.

[49]Dana L. Zeidler, "Moral Issues and Social Policy in Science Education: Closing the Literacy Gap," Science Education 68(1984): 411-419.

[50]Ibid., p. 411.

CHAPTER 6

[1]Robin Barrow, The Philosophy of Schooling (Brighton, England: Wheatsheaf Books, 1981).

[2]Ibid., p.7.

[3]Webster's Third New International Dictionary, p. 1321.

[4]Ibid.

[5]Ibid.

[6]Ibid.

[7]Robin Barrow [1981] has quite a lot to say about the place of concepts such as usefulness in the larger concept of education or schooling. For the sake of this argument involving scientific literacy, a place for practicality will be assumed to be justified.

[8]An additional reason for the choice of this example is because nuclear power plants were not an unknown phenomenon when Karplus developed the SCIS curriculum, whereas some other public science-based issues such a DNA manipulation, were either non-existent or negligible as a public issue in the 1960's.

[9]We will leave aside for this discussion, the highly problematic pedagogy and learning of the first three of these five themes when the school's student population comes from poverty-stricken neighborhoods or has substantially conflicting cultural or religious food requirements.

[10]Children will happily extend their vocabularies and even more so if the terms are ones that the parents might not use readily - as in many of the names of body parts.

[11]Karplus' SCIS is a K-6 program.

[12]It would be redundant to deal one after the other with the remaining science disciplines; suffice it to say that biology concepts have been shown, by repeated and numerous studies, to be the most frequently taught of all science concepts, and the most easily learned by most students.

[13]Even though this is the most frequently used evaluation technique, as in multiple choice tests, and used by in-school as well as out-of-school evaluators.

[14]Robert Karplus and Herbert D. Thier, A New Look at Elementary School Science: Science Curriculum Improvement Study (Chicago: Rand McNally & Co., 1967).

[15]Weiss, Report of the 1977 Survey.

[16]James and Smith, "Alienation of Students."

[17]Klopfer takes this as a given and necessary in the high school level of schooling. Even though this continues to be a controversial dimension of many high school programs, it is not my intention to emphasize this aspect of Klopfer's proposals. Rather, it is my intention to examine his notion of scientific literacy as such.

[18]Roberts, Scientific Literacy, p. 33.

CHAPTER 7

[1]Schwab, College Curriculum and Student Protest (Chicago: University of Chicago Press, 1969), pp. 301-2.

[2]Ibid., pp. 309-10.

[3]Ibid., p. 25.

[4]Michael F. Connelly, Albert S. Dukacz and Frank Quinlan, eds., Curriculum Planning for the Classroom (Toronto: Ontario Institute for Studies in Education Press, 1980).

[5]Louise L. Tyler and John I. Goodlad, "Personal Domain: Curricular Meaning," Curriculum Inquiry, John I. Goodlad, ed. (New York: McGraw Hill Book Co., 1979).

[6]S. L. Helgeson, Patricia E. Blosser and Robert W. Howe, The Status of pre-College Science, Mathematics, and Social Studies (Washington, D.C.: U.S. Government Printing Office, 1978).

This study includes an interesting breakdown of the views of science education as held in the 50 states (p. 168).

[7]Colin Power, "Tinker, Tailor, Soldier, Spy - Implications of Science Education Research for Teachers," Science Education 68(1984): 179-193.

Power's favorite are the uses to which conceptual maps can be put as long as the appropriate one is chosen, i.e., learners' maps that start with concepts that the learner has already acknowledged as acquired, discovery maps that start with the historical path taken in concept development, and experts' maps that start with rhetorical conclusions.

[8]Milton O. Pella, George T. O'Hearn and Calvin W. Gale, "Referents to Science Literacy," Journal of Research in Science Teaching 4(1966):206.

[9]Pella, ""The Place or Function of Science for a Literate Citizenry," Science Education 60(1976):98.

[10]Ibid., p. 99.

[11]Ibid., pp. 98-99.

[12]Peter A. Rubba and Hans O. Andersen, "Development of an Instrument to Assess Secondary School Students' Understanding of the Nature of Scientific Knowledge," Science Education 62(1978):449-458.

[13]Roberts, Scientific Literacy, p. 32.

[14]Thomas F. Green, "Schools and Communities: A Look Forward," Harvard Education Review 39(Spring 1969): 221-252; Klopfer, ""Science Education in 1991," School Review 77(1969):199-217; Robert E. Yager and Avi Hofstein, "Features of a Quality Curriculum for School Science," Journal of Curriculum Studies 18(June 1986):133-146.

[15]Most of the other science education writers support claims of equality in educational opportunity throughout K-12 as well as humanistic educational aims.

[16]Klopfer, "Science Education in 1991," pp. 203-4.

[17]Ibid., p. 207.

[18]Ibid., p. 205.

[19]Interestingly enough, a similarly 2-tiered and functional high school system of education (not, however, science-based) was effectively

dismantled in the Province of Québec in the 1960's and replaced with comprehensive high schools which delayed specialization until after high school graduation. In this instance, humanistic values replaced at least some of the previous managerial values (to use Green's term), but not to everyone's satisfaction.

[20]Rubba and Andersen, p. 450.

[21]Yager and Hofstein, p. 140.

[22]Buccino *et al.*; Lucas and Tulip.

[23]Yager and John E. Penick, ""What Students Say About Science Teaching and Science Teachers," *Science Education* 68(1984):143-152.

[24]Buccino *et al.*; E. D. Hobbs and Gaalen L. Erickson, "Results of the 1978 British Columbia Science Assessment,"" *Canadian Journal of Education* 5(1980): 63-80.

Whether 13-18 year-olds *should* be making choices based on traditional or humanistic criteria (as opposed to graduation or career criteria) is a question that falls outside the scope of the *in situ* fact gathering necessary at this stage of deliberative enquiry.

[25]Notice that Klopfer's program of studies avoids the risks posed by choice; the vast majority of scientific literacy course proponents are prepared to allow unrestricted choices, at least for the two senior years (years that evidence a drastic drop in the number of students choosing science courses).

[26]William Hare, *Controversies in Teaching* (London, Ont.: The Althouse Press, 1985).

[27]Ibid., p. 20.

[28]Ibid., p. 21.

[29]Ibid.

[30]M. J. Dunkin and B. J. Biddle, *The Study of Teaching* (New York: Holt, Rinehart and Winston, 1974).

[31]Reid & Walker, p. 6.

[32]Harms and Yager, p. 7.

[33]Hare, p. 112.

[34]Disputes/disagreements within the science disciplines and treating of methodological and/or interpretation matters do not concern us here.

[35]For example, teaching about contraceptive devices (no longer a public issue in Québec) and abortion are required to be included in the present Sec III Human Biology course (obligatory for all students).

[36]We must leave aside for this discussion questions related to the accuracy, validity, etc. of these data-based statements.

[37]Trudi L. Volk, "Project Synthesis and Environmental Education," Science Education 68(1984):22-23.

[38]Yager and Hofstein, pp. 144-45.

Suggestions d), e) and g) concern experimental teaching strategies that have been favored by curriculum developers since the early 1960's and are not a 'new style' focus in science curricula.

[39]Ibid., p. 142.

[40]See Appendix C, no. 1.

[41]See Appendix C, no. 2.

[42]See Appendix C, no. 3.

[43]Karplus and Thier; Brandwein; Welch, "20 Years of Science Curriculum Development,"; Québec Ministère de l'Education, The Schools of Québec: Policy Statement and Plan of Action (Québec: Gouvernement du Québec, 1979).

[44]Butts, "A Summary of Research"; Hobbs and Erickson; Harms and Yager; Helgeson et al.; National Science Foundation, What are the Needs; Orpwood and Alam, Science Education in Canadian Schools; Weiss, Report of the 1977 National Survey.

[45]All U.S. and Canadian national studies support such a consensus. In addition, the national college admission tests taken by students from these senior level high school courses show no decline in test score averages, even though non-science test score averages have shown some decline. [Buccino et al., 1980; Helgeson et al., 1978]

[46]See Appendix C, no. 4.

[47]Dunkin and Biddle.

[48]See Appendix C, no. 5.

[49]See Appendix C, no. 6.

[50]Bangert et al., "Individualized Systems of Instruction"; Ann C. Howe and Bessie Stanback, "ISCS in Review," Science Education 69(1985):25-37.

[51]See Appendix C, no. 7.

[52]Stephen P. Norris, "Defining Observational Competence," Science Education 68(1984):129-142.

[53]The use of the term 'last' is not meant to exhaust the realm of problem-foci regarding scientific literacy; for the purposes of this paper, however, allowance must be made for reasonable limitations on the number of problem-foci.

[54]See Appendix C, no. 8.

[55]Harms and Yager; Welch et al., "The Role of Inquiry".

[56]See Appendix C.

[57]Tisher and Power, p. 53.

[58]Ibid., pp. 53-4.

[59]Ibid., pp. 52-3.

[60]Also known as matriculation examinations or high school leaving examinations.

[61]Buccino et al.

[62]Dunkin and Biddle; Tisher and Power; Robert E. Stake and Jack A. Easley, Jr., Case Studies in Science Education Vol. I & II (Washington, D.C.: U.S. Government Printing Office, 1978); J. F. Eggleston, M. J. Galton and M. F. Jones, Processes and Products of Science Teaching (London: Macmillan Educational, 1976).

[63]Weiss, Report of the 1977 National Survey.

[64]This problem is, however, increasing in Québec English language high schools. In order to show the Ministry of Education that a certain percentage of French is being taught outside of French language classes, certain courses become easy candidates for the 'taught-in-French' category: ecology (Sec I), geography (Sec I-III), history (Sec I-III), physical education, art, music. The teachers need primarily to show a speciality in the teaching of French to qualify to teach these courses.

[65]Harms and Yager; Welch et al.

[66]Results of an informal survey initiated and conducted by this

writer since no information can be found in the literature regarding this matter.

CHAPTER 8

[1]W. Lynn McKinney and Ian Westbury, "Stability and Change: The Public Schools of Gary, Indiana, 1940-70," in Case Studies in Curriculum Change by William A. Reid and Decker F. Walker (London: Routledge & Kegan Paul, 1975), p. 6.

[2]Wilbur L. Beauchamp et al., Everyday Problems in Science (Chicago: Scott Foresman & Co., 1964).

[3]Beauchamp et al., Teacher's Guidebook for Everyday Problems in Science (Chicago: Scott Foresman & Co., 1964).

See also Appendix B for P. de H. Hurd entry.

[4]Chicago Curriculum Council Committee on Science, Curriculum Guide for Science (Chicago: City of Chicago Board of Education, 1966).

[5]A. Hofstein, "Science: Key Concepts," in The International Encyclopedia of Education 8 (1985): 4466.

[6]Ibid.

[7]W. B. Herron and N. P. Palmer, Matter, Life and Energy (Chicago: Meredith Corporation, 1967).

[8]Douglas Gough and Frank J. Flanagan, Focus on Science (Toronto: D. C. Heath Canada, 1980).

[9]Uri Haber-Schaim et al., Introductory Physics, 2nd ed. (Englewood-Cliffe, N.J.: Prentice-Hall Inc., 1972).

[10]Ibid., Preface.

[11]Ernest Nagel, Teleology Revisited and Other Essays in the Philosophy of Science (New York: Columbia University Press, 1979).

[12]Herron & Palmer, p. 9.

[13]Harold Brown, Perception, Theory and Commitment (Chicago: University of Chicago Press, 1977); Robert E. Butts, "The Hypothetico-Deductive Model of Science," in Basic Issues in the Philosophy of Science, edited by William R. Shea (New York: Science History Publications, 1976); Thomas S. Kuhn, The Structure of Scientific Revolutions (Chicago: University of Chicago Press, 1962); Henry E. Kyburg, Jr. and Ernest Nagel, eds., Induction: Some Current Issues (Middletown, CT: Westleyan University Press, 1963); Karl Popper, The

Logic of Scientific Discovery (London: Hutchinson & Co., 1968); Stephen Toulmin, *Human Understanding: The Collective Use and Evolution of Concepts* (Princeton: Princeton University Press, 1972).

[14]Haber-Schaim *et al.*, p. v [my italics].

[15]*Ibid.*, [my italics].

[16]*Ibid.*, pp. 2-3.

[17]David P. Ausubel and Floyd G. Robinson, *School Learning: An Introduction to Educational Psychology* (New York: Holt, Rinehart & Winston, 1978) p. 481.

[18]*Ibid.*, p. 581.

[19]Basil Berstein, *Class, Codes and Control*, Vol. 1 (London: Routledge & Kegan Paul, 1971) p. 47.

[20]Yager, "Defining the Discipline of Science Education," *Science Education* 68(1984):36.

[21]Bernstein, *idem*.

[22]*Ibid.*

[23]George Posner, *The Conceptual Ecology of Science Education: A Response to W. F. Connell*, paper presented at the Annual Meeting of the AERA, Montreal, Canada, 12 April, 1983.

The term 'conceptual ecology' is borrowed from Posner (1983). He identifies the matrix of societal expectations and understandings as the conceptual ecology within which public education and new ideas must interact; as in nature, a role or place must be found for new ideas if they are to survive the competitive environment of ideas that have already found a role or niche.

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