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What are Thinking Skills?

Association for Supervision and Curriculum Development (Singapore)

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ASCD REVIEW

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Critical Thinking: Basic Questions and Answers

In this interview for Think magazine (April '92), Richard Paul provides a quick overview of critical thinking and the issues surrounding it: defining it, common mistakes in assessing it, its relation to communication skills, self-esteem, collaborative learning, motivation, curiosity, job skills for the future, national standards, and assessment strategies.

Richard Paul

Question: Critical thinking is essential to effective learning and productive living. Would you share your definition of critical thinking?

Paul: First, since critical thinking can be defined in a number of different ways consistent with each other, we should not put a lot of weight on any one definition. Definitions are at best scaffolding for the mind. With this qualification in mind, here is a bit of scaffolding: critical thinking is thinking about your thinking while you're thinking in order to make your thinking better. Two things are crucial:

1 critical thinking is not just thinking, but thinking which entails self-improvement and
2 this improvement comes from skill in using standards by which one appropriately assesses thinking. To put it briefly, it is self-improvement (in thinking) through standards (that assess thinking)

To think well is to impose discipline and restraint on our thinking - by means of intellectual standards - in order to raise our thinking to a level of "perfection" or quality that is not natural or likely in undisciplined, spontaneous thought. The dimension of critical thinking least understood is that of intellectual standards. Most teachers were not taught how to assess thinking through standards; indeed, often the thinking of teachers themselves is very "undisciplined" and reflects a lack of internalized intellectual standards.

Question: Could you give me an example?

Paul: Certainly, one of the most important distinctions that teachers need to routinely make, and which takes disciplined thinking to make, is that between reasoning and subjective reaction.

If we are trying to foster quality thinking, we don't want students simply to assert things; we want them to try to reason things out on the basis of evidence and good reasons. Often, teachers are unclear about this basic difference. Many teachers are apt to take student writing or speech which is fluent and witty or glib and amusing as good thinking. They are often unclear about the constituents of good reasoning. Hence, even though a student may just be asserting things, not reasoning things out at all, if she is doing so with vivacity and flamboyance, teachers are apt to take this to be equivalent to good reasoning.

This was made clear in a recent California state-wide writing assessment in which teachers and testers applauded a student essay, which they said illustrated "exceptional achievement" in reasoned evaluation, an essay that contained no reasoning at all, that was nothing more than one subjective reaction after another. The assessing teachers and testers did not notice that the student failed to respond to the directions, did not support his judgment with reasons and evidence, did not consider possible criteria on which to base his judgment, did not analyze the subject in the light of the criteria, and did not select evidence that clearly supported his judgment. Instead the student described an emotional exchange asserted - without evidence - some questionable claims expressed a variety of subjective preferences. The assessing teachers were apparently not clear enough about the nature of evaluative reasoning or the basic notions of criteria, evidence, reasons, and well-supported judgment to notice the discrepancy. The result was, by the way, that a flagrantly mis-graded student essay was showcased nationally (in ASCD's Developing Minds), systematically misleading the 150,000 or so teachers who read the publication.

Question: Could this possibly be a rare mistake, not representative of teacher knowledge?

Paul: I don't think so. Let me suggest a way in which you could begin to test my contention. If you are familiar with any thinking skills programs, ask someone knowledgeable about it the "Where's the beef?" question, namely, "What intellectual standards does the program articulate and teach?" I think you will first find that the person is puzzled about what you mean. And then when you explain what you mean, I think you will find that the person is not able to articulate any such standards. Thinking skills programs without intellectual standards are tailor-made for mis-instruction. For example, one of the major programs asks teachers to encourage students to make inferences and use analogies, but is silent about how to teach students to assess the inferences they make and the strengths and weaknesses of the analogies they use. This misses the point. The idea is not to help students to make more inferences

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but to make sound ones, not to help students to come up with more analogies but with more useful and insightful ones.

Question: What is the solution to this problem? How, as a practical matter, can we solve it?

Paul: Well, not with more gimmicks or quick-fixes. Not with more fluff for teachers. Only with quality long-term staff development that helps the teachers, over an extended period of time, over years not months, to work on their own thinking and come to terms with what intellectual standards are, why they are essential, and how to teach for them. The city of Greensboro, North Carolina has just such a long-term, quality, critical thinking program. So that's one model your readers might look at. In addition, there is a new national organization, the National Council for Excellence in Critical Thinking Instruction, that is focused precisely on the articulation of standards for thinking, not just in general, but for every academic subject area. It is now setting up research-based committees and regional offices to disseminate its recommendations. I am hopeful that eventually, through efforts such as these, we can move from the superficial to the substantial in fostering quality student thinking. The present level of instruction for thinking is very low indeed.

Question: But there are many areas of concern in instruction, not just one, not just critical thinking, but communication skills, problem solving, creative thinking, collaborative learning, self-esteem, and so forth. How are districts to deal with the full array of needs? How are they to do all of these rather than simply one, no matter how important that one may be?

Paul: This is the key. Everything essential to education supports everything else essential to education. It is only when good things in education are viewed superficially and wrongly that they seem disconnected, a bunch of separate goals, a conglomeration of separate problems, like so many bee-bees in a bag. In fact, any well-conceived program in critical thinking requires the integration of all of the skills and abilities you mentioned above. Hence, critical thinking is not a set of skills separable from excellence in communication, problem solving, creative thinking, or collaborative learning, nor is it indifferent to one's sense of self-worth.

Question: Could you explain briefly why this is so?

Paul: Consider critical thinking first. We think critically when we have at least one problem to solve. One is not doing good critical thinking, therefore, if one is not solving any problems. If there is no problem there is no point in thinking critically. The "opposite" is also true. Uncritical problem solving is unintelligible. There is no way to solve problems effectively unless one thinks critically about the nature of the problems and of how to go about solving them. Thinking our way through a problem to a solution, then, is critical thinking, not something else. Furthermore, critical thinking, because it involves our working out afresh our own thinking on a subject, and because our own thinking is always a unique product of our self-structured experience, ideas, and reasoning, is intrinsically a new "creation", a new "making", a new set of cognitive and affective structures of some kind. All thinking, in short, is a creation of the mind's work, and when it is disciplined so as to be well-integrated into our experience, it is a new creation precisely because of the inevitable novelty of that integration. And when it helps us to solve problems that we could not solve before, it is surely properly called "creative".

The "making" and the "testing of that making" are intimately interconnected. In critical thinking we make and shape ideas and experiences so that they may be used to structure and solve problems, frame decisions, and, as the case may be, effectively communicate with others. The making, shaping, testing, structuring, solving, and communicating are not different activities of a fragmented mind but the same seamless whole viewed from different perspectives.

Question: How do communication skills fit in?

Paul: Some communication is surface communication, trivial communication - surface and trivial communication don't really require education. All of us can engage in small talk, can share gossip. And we don't require any intricate skills to do that fairly well. Where communication becomes part of our educational goal is in reading, writing, speaking and listening. These are the four modalities of communication which are essential to education and each of them is a mode of reasoning. Each of them involves problems. Each of them is shot through with critical thinking needs. Take the apparently simple matter of reading a book worth reading. The author has developed her thinking in the book, has taken some ideas and in some way represented those ideas in extended form. Our job as a reader is to translate the meaning of the author into meanings that we can understand. This is a complicated process requiring critical thinking

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every step along the way.

- What is the purpose for the book?
- What is the author trying to accomplish?
- What issues or problems are raised?
- What data, what experiences, what evidence are given?
- What concepts are used to organize this data, these experiences?
- How is the author thinking about the world?
- Is her thinking justified as far as we can see from our perspective?
- And how does she justify it from her perspective?
- How can we enter her perspective to appreciate what she has to say?

All of these are the kinds of questions that a critical reader raises. And a critical reader in this sense is simply someone trying to come to terms with the text. So if one is an uncritical reader, writer, speaker, or listener, one is not a good reader, writer, speaker, or listener at all. To do any of these well is to think critically while doing so and, at one and the same time, to solve specific problems of communication, hence to effectively communicate.

Communication, in short, is always a transaction between at least two logics. In reading, as I have said, there is the logic of the thinking of the author and the logic of the thinking of the reader. The critical reader reconstructs (and so translates) the logic of the writer into the logic of the reader's thinking and experience. This entails disciplined intellectual work. The end result is a new creation; the writer's thinking for the first time now exists within the reader's mind. No mean feat!

Question: And self esteem? How does it fit in?

Paul: Healthy self-esteem emerges from a justified sense of self-worth, just as self-worth emerges from competence, ability, and genuine success. If one simply feels good about oneself for no good reason, then one is either arrogant (which is surely not desirable), or, alternatively, has a dangerous sense of misplaced confidence. Teenagers, for example, sometimes think so well of themselves that they operate under the illusion that they can safely drive while drunk or safely take drugs. They often feel much too highly of their own competence and powers and are much too unaware of their limitations. To accurately sort out genuine self-worth from a false sense of self-esteem requires, yes you guessed it, critical thinking.

Question: And finally, what about collaborative learning? How does it fit in?

Paul: Collaborative learning is desirable only if grounded in disciplined critical thinking. Without critical thinking, collaborative learning is likely to become collaborative mis-learning. It is collective bad thinking in which the bad thinking being shared becomes validated. Remember, gossip is a form of collaborative learning; peer group indoctrination is a form of collaborative learning; mass hysteria is a form of speed collaborative learning (mass learning of a most undesirable kind). We learn prejudices collaboratively, social hates and fears collaboratively, stereotypes and narrowness of mind, collaboratively. If we don't put disciplined critical thinking into the heart and soul of the collaboration, we get the mode of collaboration which is antithetical to education, knowledge, and insight.

So there are a lot of important educational goals deeply tied into critical thinking just as critical thinking is deeply tied into them. Basically the problem in the schools is that we separate things, treat them in isolation and mistreat them as a result. We end up with a superficial representation, then, of each of the individual things that is essential to education, rather than seeing how each important good thing helps inform all the others.

Question: One important aim of schooling should be to create a climate that evokes children's sense of wonder and inspires their imagination to soar. What can teachers do to "kindle" this spark and keep it alive in education?

Paul: First of all, we kill the child's curiosity, her desire to question deeply, by superficial didactic instruction. Young children continually ask why. Why this and why that? And why this other thing? But we soon shut that curiosity down with glib answers, answers to fend off rather than respond to the logic of the question. In every field of knowledge, every answer generates more questions, so that the more we know the more we recognize we don't know. It is only people who have little knowledge who take their knowledge to be complete and entire. If we thought deeply about almost any of the answers which we glibly give to children, we would recognize that we don't really have a satisfactory answer to most of their questions. Many of our answers are no more than a repetition of what we as children heard from adults. We pass on the misconceptions of our parents and those of their parents. We say what we heard, not what we know. We rarely join the quest with our children. We rarely admit our ignorance, even to ourselves. Why does rain fall from the sky? Why is snow cold? What is electricity and how does it go through the wire? Why are people bad? Why does evil exist? Why is there war? Why did my dog have to die? Why do flowers bloom? Do we really have good answers to these questions?

Question: How does curiosity fit in with critical thinking?

Paul: To flourish, curiosity must evolve into disciplined inquiry and reflection. Left to itself it will soar like a kite without a tail, that is, right into the ground! Intellectual curiosity is an important trait of mind, but it requires a family of other traits to fulfill it. It requires intellectual humility, intellectual courage, intellectual integrity, intellectual perseverance, and faith in reason. After all, intellectual curiosity is not a thing in itself, valuable in itself and for itself. It is valuable because it can lead to knowledge, understanding, and insight, because it can help broaden, deepen, sharpen our minds, making us better, more humane, more richly endowed persons.

To reach these ends, the mind must be more than curious, it must be willing to work, willing to suffer through confusion and frustration, willing to face limitations and overcome obstacles, open to the views of others, and willing to entertain ideas that many people find threatening. That is, there is no point in our trying to model and encourage curiosity, if we are not willing to foster an environment in which the minds of our students can learn the value and pain of hard intellectual work. We do our students a disservice if we imply that all we need is unbridled curiosity, that with it alone knowledge comes to us with blissful ease in an atmosphere of fun, fun, fun. What good is curiosity if we don't know what to do next, how to satisfy it? We can create the environment necessary to the discipline, power, joy, and work of critical thinking only by modeling it before and with our students. They must see our minds at work. Our minds must stimulate theirs with questions and yet further question, questions that probe information and experience, questions that call for reasons and evidence, questions that lead students to examine interpretations and conclusions, pursuing their basis in fact and experience, questions that help students to discover their assumptions, questions that stimulate students to follow out the implications of their thought, to test their ideas, to take their ideas apart, to challenge their ideas, to take their ideas seriously. It is in the totality of this intellectually rigorous atmosphere that natural curiosity thrives.

Question: It is important for our students to be productive members of the work-force. How can schools better prepare students to meet these challenges?

Paul: The fundamental characteristic of the world students now enter is ever-accelerating change, a world in which information is multiplying even as it is swiftly becoming obsolete and out of date, a world in which ideas are continually restructured, retested, and rethought, where one cannot survive with simply one way of thinking, where one must continually adapt one's thinking to the thinking of others, where one must respect the need for accuracy and precision and meticulousness, a world in which job skills must continually be upgraded and perfected, even transformed. We have never had to face such a world before. Education has never before had to prepare students for such dynamic flux, unpredictability, and complexity, for such ferment, tumult, and disarray.

We as educators are now on the firing line.

- Are we willing to fundamentally rethink our methods of teaching?
- Are we ready for the 21st Century?
- Are we willing to learn new concepts and ideas?
- Are we willing to learn a new sense of discipline as we teach it to our students?
- Are we willing to bring new rigor to our own thinking in order to help our students bring that same rigor to theirs?
- Are we willing, in short, to become critical thinkers so that we might be an example of what our students must internalize and become?

These are profound challenges to the profession. They call upon us to do what no previous generation of teachers was ever called upon to do. Those of us willing to pay the price will yet have to teach side by side with teachers unwilling to pay the price. This will make our job even more difficult, but not less exciting, not less important, not less rewarding. Critical thinking is the heart of well-conceived educational reform and restructuring because it is at the heart of the changes of the 21st Century. Let us hope that enough of us will have the fortitude and vision to grasp this reality and transform our lives and our schools accordingly.

Question: National Standards will result in national accountability. What is your vision for the future?

Paul: Most of the national assessment we have done thus far is based on lower-order learning and thinking. It has focused on what might be called surface knowledge. It has rewarded the kind of thinking that lends itself to multiple choice machine-graded assessment. We now recognize that the assessment of the future must focus on higher, not lower, order thinking, that it must assess more reasoning than recall, that it must assess authentic performances, students engaged in bona fide intellectual work.

Our problem is in designing and implementing such assessment. In November of this last year, Gerald Nosich and I developed and presented, at the request of the U.S. Department of Education, a model for the national assessment of higher order thinking. At a follow-up meeting of critical thinking, problem-solving, communication, and testing scholars and practitioners, it was almost unanimously agreed that it is possible to assess higher-order thinking on a national scale. It was clear from the commitments of the Departments of Education, Labor, and Commerce that such an assessment is in the cards.

The fact is we must have standards and assessment strategies for higher-order thinking for a number of reasons.

- First, assessment and accountability are here to stay. The public will not accept less.
- Second, what is not assessed is not, on the whole, taught.
- Third, what is mis-assessed is mis-taught.
- Fourth, higher-order thinking, critical thinking abilities, are increasingly crucial to success in every domain of personal and professional life.
- Fifth, critical thinking research is making the cultivation and assessment of higher-order thinking do-able.

Assessment of the future must focus on higher, not lower, order thinking, that it must assess more reasoning than recall, that it must assess authentic performances, students engaged in bona fide intellectual work.

The road will not be easy, but if we take the knowledge, understanding, and insights we have gained about critical thinking over the last twelve years, there is much that we could do in assessment that we haven't yet done at the level of the individual classroom teacher, at the level of the school system, at the level of the state, and at the national level.

Of course we want to do this in such a way as not to commit the "Harvard Fallacy", the mistaken notion that because graduates from Harvard are very successful, that the teaching at Harvard necessarily had something to do with it.

It may be that the best prepared and well-connected students coming out of high school are going to end up as the best who graduate from college, no matter what college they attend. We need to focus our assessment, in other words, on how much value has been added by an institution. We need to know where students stood at the beginning, to assess the instruction they received on their way from the beginning to the end. We need pre-and post-testing and assessment in order to see which schools, which institutions, which districts are really adding value, and significant value, to the quality of thinking and learning of their students.

Finally, we have to realize that we already have instruments available for assessing what might be called the fine-textured micro-skills of critical thinking. We already know how to design prompts that test students' ability to: identify a plausible statement of a writer's purpose; distinguish clearly between purposes, inferences, assumptions, and consequences; discuss reasonably the merits of different versions of a problem or question; decide the most reasonable statement of an author's point of view; recognize bias, narrowness, and contradictions in the point of view of an excerpt; distinguish evidence from conclusions based on that evidence; give evidence to back up their positions in an essay; recognize conclusions that go beyond the evidence; distinguish central from peripheral concepts; identify crucial implications of a passage; evaluate an author's inferences; draw reasonable inferences from positions stated; and so on.

With respect to intellectual standards, we are quite able to design prompts that require students to: recognize clarity in contrast to unclarity; distinguish accurate from inaccurate accounts; decide when a statement is relevant or irrelevant to a given point; identify inconsistent positions as well as consistent ones; discriminate deep, complete, and significant accounts from those that are superficial, fragmentary, and trivial; evaluate responses with respect to their fairness; distinguish well-evidenced accounts from those unsupported by reasons and evidence; tell good reasons from bad. With respect to large scale essay assessment we know enough now about random sampling to be able to require extended reasoning and writing without having to pay for the individual assessment of millions of essays.

What remains is to put what we know into action: at the school and district level to facilitate long-term teacher development around higher-order thinking, at the state and national level to provide for long-term assessment of district, state, and national performance. The project will take generations and perhaps in some sense will never end.

After all, when will we have developed our thinking far enough, when will we have enough intellectual integrity, enough intellectual courage, enough intellectual perseverance, enough intellectual skill and ability, enough fairmindedness, enough reasonability? One thing is painfully clear. We already have more than enough rote memorization and uninspired didactic teaching, more than enough passivity and indifference, cynicism and defeatism, complacency and ineptness. The ball is in our court. Let's take up the challenge together and make, with our students, a new and better world.

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What Is a Thinking Curriculum?

The Characteristics of Successful Learners Revisited

Four important characteristics of successful learners have emerged from three research perspectives - cognitive, philosophical, and multicultural. This view of successful learners have implications for the curriculum. Given the importance of these characteristics for our conception of a "thinking curriculum," we briefly review them here. *Knowledgeable learners* acquire a substantial and organized body of knowledge which they can use fluently to make sense of the world, solve problems, and make decisions. They can also evaluate the limitations of their knowledge and their perspectives on the world. *Self-determined learners* feel capable and continually strive to acquire and use the tools they need to learn. *Strategic learners* have a repertoire of thinking and learning strategies that they use with skill and purpose to think about and control their own learning and guide their learning of new content. Finally, *empathetic learners* are able to view themselves and the world from perspectives other than their own, including perspectives of people from different cultural backgrounds. A major goal of restructuring in general and thinking curricula in particular is to develop these qualities in all students.

Traditional curricula often do not promote these qualities. Current curricula in subject areas such as science and social studies frequently attempt to cover as much content as possible, regard all content as equal, and divide content into artificial categories that bear little relationship to how individuals use content in the world beyond school. Furthermore, students' attitudes about subject matter, and the skills and strategies they need to learn it, are rarely addressed. Often, traditional curricula emphasize isolated, low-level skills, to the neglect of meaningful content and higher-order thinking, especially when dealing with lower-achieving students.

In contrast, thinking curricula, based on "new" ways of thinking about learning, treat both content and processes differently. Content includes concepts, principles, generalizations, problems, facts, definitions, etc. Process includes learning strategies and skills, creative and critical thinking, thinking about thinking (metacognition), social skills, and so on. In the next section, we describe some characteristics of a thinking curriculum.

Characteristics of the Thinking Curriculum

The Association for Supervision and Curriculum Development (ASCD) publication, *Toward the Thinking Curriculum: Current Cognitive Research* (1989), reviewed much of the research underlying the thinking curriculum. Lauren Resnick, who edited the volume, coined the term "the thinking curriculum." Thinking curricula described in this Guidebook share much with Lauren Resnick's definition of a thinking curriculum (1989) and also build on important characteristics of learners and the three research perspectives.

The overarching characteristic of thinking curricula described in this

Guidebook is: Thinking curricula fulfill a dual agenda by integrating content and process. Within this agenda, students develop habits of mind with respect to learning that serve them well both in school and in the real world.

While traditional curricula tend to teach content and process separately, a thinking curriculum weds process and content, a union that typifies real-world situations; that is, students are taught content through processes encountered in the real world. Some thinking and learning processes apply across all content areas and all areas of life and thus are generic: for example, decision making, problem solving, evaluating, and comparing.

Processes may be realized differently in different content areas. They answer the question, "What sort of thinking do historians (or mathematicians, scientists, etc.) engage in as they practice their craft?" For example, scientists hypothesize about the nature of the natural world in such a way that they can test their hypotheses. Historians may also hypothesize, but cannot test their hypotheses as do scientists; rather, they depend on primary and secondary source materials to "test" their ideas. Content is inherent in these examples - the processes that scientists and historians use clearly depend on the content with which they are dealing. Students, then, learn content and construct meaning as they employ generic and content-specific strategies. They acquire content as they plan, evaluate, solve problems, make decisions, construct or critique arguments, compose essays, and so on. In short, students acquire knowledge in carrying out tasks requiring higher-order thinking - they practice a craft, so to speak, as they acquire knowledge.

This approach to curriculum stands in contrast to traditional curricula. Traditional curricula from kindergarten through high school, expect students to master "knowledge" in school; and knowledge is usually seen as lists of facts and definitions. A traditional curriculum does not expect students to use the knowledge until they leave school. On the other hand, students engaged in a thinking curriculum acquire content as they plan, evaluate, solve problems, make decisions, construct or critique arguments, compose essays, and so on. At the same time, the content students learn has the power to promote these higher-level processes. In short, the essence of a thinking curriculum is the dual agenda. Four characteristics emerge from this agenda. These are elaborated below.

1. The scope of a thinking curriculum promotes in-depth learning.

Important concepts and strategies need to be identified, organized, prioritized, and taught in depth. This characteristic of a thinking curriculum helps clarify what it means to be knowledgeable. A thinking curriculum does not strive to produce "walking-encyclopedias," stuffed with facts, figures, definitions, and formulas. Truly knowledgeable students may possess such information, but more importantly, they possess key concepts and tools for making, using, and communicating knowledge in a field. Knowledgeable students have learned how to learn, how to organize information, and how to distinguish between important and less important pieces of information. In sum, they have a working knowledge of a field - a tool chest for the ongoing discovery and construction of meaning - rather than a junkyard of isolated facts.

Thus, in a thinking curriculum,

While traditional curricula tend to teach content and process separately, a thinking curriculum weds process and content, a union that typifies real-world situations; that is, students are taught content through processes encountered in the real world.

students develop a deep understanding of essential concepts and processes for dealing with those concepts, similar to the understanding that experts use in tackling complex tasks in their disciplines. For example, students use original sources to construct historical accounts; they design experiments to answer their questions about natural phenomena; they use mathematics to model real - world events and systems; and they write for real audiences. The thinking curriculum gives students the tools - the perspectives and methodologies and concepts they need to carry out these authentic tasks.

2. Content and process objectives are situated in real-world tasks.

Rather than focusing on simple and discrete skills, students should engage in complex and holistic thinking. This type of thinking reflects what individuals performing tasks outside of school do. As Lauren Resnick has observed, out-of-school thinking about complex tasks is: (1) situated in meaningful processes of making decisions, solving problems, evaluating situations, and so on, (2) shared among individuals also involved in carrying out the task, (3) aided by the use of tools, such as reference books, calculators, and other technology, and (4) connected to real-world objects, events, and situations. In addition, out-of-school thinking is often interdisciplinary, cutting across many "school" subjects.

Other desired attributes of real-world thinking as well as a thinking curriculum are: orientations to problem solving and critical and creative thinking; dispositions toward learning, including a sense of efficacy, a desire to ponder and learn, and persistence; and understanding and valuing multiple perspectives, especially different cultural perspectives. In a thinking curriculum, thinking processes with such attributes are carried out in collaboration with students, teachers, parents, and community members using tools and resources to perform real-world tasks. Thus, content and process objectives can be achieved when learning tasks stimulate complex thinking and involve true collaboration among students.

3. Tasks are sequenced to situate holistic performances in increasingly challenging environments.

This aspect of a thinking curriculum is both difficult to understand and express. The major point is that students should always be engaged with a whole task. We should not ask them to learn and practice one element of a task at a time and then to integrate these pieces into a whole performance. Such integration will seldom happen as easily as we might hope. Some educators may mistakenly believe that young children and low-achieving students especially must begin with the parts and gradually orchestrate these parts into wholes.

An example should help clarify this characteristic of a thinking curriculum. Summarizing is a common skill learned in school. In conventional curricula, young students frequently are expected to learn how to summarize by first learning each "step" in the summarizing process. They are taught these steps one at a time. Ample time is given to practice the first step; for example, categorizing items or activities described in a text under a more inclusive label. Indeed, they may complete numerous worksheets on categorizing. Then, the teacher may teach them a second

Students engaged in a thinking curriculum acquire content as they plan, evaluate, solve problems, make decisions, construct or critique arguments, compose essays, and so on.

"step;" for example, deleting redundant information. Again, the students practice. This approach continues until students have been taught all the steps or subprocesses thought to be involved in summarizing. In short, curriculum tends to routinize the task. Finally, students are asked to put all these subskills together. Unfortunately, many students cannot do this - they are stuck at the subskill level, each of which they might perform beautifully, but which they cannot integrate into a smooth process of summarizing.

In contrast, in a thinking curriculum, summarizing would be conceived and taught as a holistic process. Rather than fragmenting the process, it would be taught in a context or environment in which students can succeed. For young children, this might mean asking them first to summarize relatively short paragraphs that deal with information with which they are very familiar. The teacher may also ask students to work collaboratively to summarize information at this initial learning stage. As students gain skill and confidence in summarizing, the teacher would ask them to summarize longer paragraphs, perhaps containing less familiar information. In summary, a thinking curriculum always treats tasks as indivisible wholes; variations that acknowledge the novice status of the learner are changes the teacher can make in the environment.

Abundant research (e.g., Palinscar, 1984) indicates that all students - including young children and low-achieving students - can succeed with such a holistic approach. For instance, low-achievers typically perform at a much higher level than when taught skills in a fragmented manner. In addition, holistic learning is much more likely to be interesting to students and to promote a sense of control over their own learning.

Thus, a thinking curriculum is not chopped up into isolated skills and facts; rather, it involves the holistic performance of meaningful, complex tasks in increasingly challenging environments. A thinking curriculum promotes a sense of efficacy and confidence in students. Materials and content are structured so that students gradually regulate their own learning and so that learning is always meaningful and makes sense. These goals - self-regulation and meaningful learning - are promoted in a variety of ways in thinking curricula For example, a thinking curriculum encourages students to clarify their purposes in performing a task, to assess what they already know, and to predict what is to be learned. It helps them highlight what is most important and thereby fosters feelings of control over subject matter. It explores students' attitudes about themselves as learners and about learning in the content areas. It provides opportunities for students to assess difficulties they have in learning and consider strategies they could use to overcome learning difficulties. It stresses continuing to work in the face of ambiguity, solving problems despite unexpected difficulties, and looking at problems as challenges to learn more and better. By being engaged in curriculum in this manner, students come to see themselves as successful, capable learners.

4. A thinking curriculum actively connects content and processes to learners' backgrounds.

Educators can begin to create a thinking curriculum by first considering the experiences and knowledge that students bring to school and then expanding upon and refining these experiences and knowledge by connecting them to new learning. The content and processes learned then build on students' family, community, and cultural experiences. The knowledge students acquire is meaningful and applied. In addition, students are motivated to learn when curriculum considers their experiences and the issues and problems with which they are concerned as well as their patterns of processing knowledge. The content in a thinking curriculum is relevant to important issues and tasks in the lives of students.

When students can relate school learning to important real-life issues, they are more likely to seek and value the perspectives of others - peers, teachers, parents, community members, and experts. In so doing, they develop interpersonal competencies for creating and participating in dialogue with individuals who have different perspectives and backgrounds. Thus, they not only connect content to their own backgrounds, but they also learn how different people interpret and organize content based on their different perspectives. As a result, a thinking curriculum builds multicultural understanding while encouraging the philosophical understanding of different kinds of knowledge and the limitations inherent in attending to only one perspective on a subject. Students will thus be better prepared to participate in an increasingly global society. Understanding and valuing multicultural perspectives emerges from dialogue in a classroom that is a community of open and sustained inquiry.

What Are Some Guidelines Across Content Areas That Promote a Thinking Curriculum?

Reform Efforts Across the Content Areas

In response to changes in society and new research on learning, content-area researchers and experts from professional organizations have written curriculum guidelines that schools can use to develop a thinking curriculum. These guidelines may be thought of as frameworks for performing authentic tasks in the disciplines.

This last decade has witnessed many calls for curricular reform. One of the first was in reading (*Becoming A Nation of Readers*, Anderson, Hiebert, Scott, & Wilkinson, 1985). Others followed in mathematics, science, social studies, and language arts in general.

Many strands of research support the basic assumption that learning is a meaningful activity; indeed, that learning is thinking. Thus, all reform efforts advocated moving away from a basic skills curriculum toward curriculum based on a new notion of learning in which students engage in authentic, higher-order learning tasks.

At the same time that research indicates that educators can move away from a traditional basic skills curriculum, changes in society itself require higher-order learning. Consider the following shifts:

- Our economy is shifting from a traditional industrial base to an information and service base.
- Individuals will have a number of jobs in the course of their careers, and those jobs are continually redefined by rapidly advancing technology, decentralization of authority in the workplace, and changes in the norms that define the culture of the workplace.
- Social arrangements are more fluid now - people move from place to place, families are configured differently, and child-care responsibilities are assumed by different individuals both within and outside the immediate family.
- In the political realm, citizens struggle with difficult issues related to technology, concerns for social equity in a pluralistic society, and the nation's greater interdependence with other countries.

Successful inhabitants in such a world must make sense of large and shifting bases of information, be flexible in adapting to changing environments, work effectively in teams, and truly understand and value groups with backgrounds different from their own.

In sum, societal changes compel educators to create a new curriculum. Advances in learning research show them how.

Guidelines for the Language Arts and a Thinking Curriculum

An important impetus for new guidelines in language arts curriculum was the "new" definition of reading. This new definition, with some variation in details, has been officially adopted by a number of states and professional organizations. The essence of the definition is:

> Reading is the process of constructing meaning from written text. It is a complex process requiring the coordination of information from a number of interrelated sources. Reading is an interaction of the reader, the text, and the context in which reading takes place. While this definition focuses on the activity of reading, more and more research informs us of the intimate connections between reading and writing, and, indeed, among all the language arts - reading, writing, listening, and speaking.

Recent curriculum guidelines, such as those proposed by the English Coalition Conference (1989), urge schools to recognize these relationships. The English Coalition's guidelines include assumptions about learning and language arts, aims for students, and recommendations for curriculum, instruction, and materials. These are summarized below.

Assumptions About Learning and Language Arts

A major characteristic of learning is that it is active and interactive. The new guidelines stress the intimate relationship between learning and thinking and the key role of language in learning. Both involve constructing meaning from experiences with both print and nonprint materials and engaging in inquiry and problem solving. Indeed, learning is thinking.

The guidelines also value diversity among students. The experiences that students bring to learning may differ, but all students have rich prior knowledge and experiences gained in their own cultures that enable them to learn. Schools should encourage students to value diversity by using a wide variety of texts and nonprint materials and by providing for social interaction in the classroom. In fact, the guidelines stress that learning is a social activity. In this diverse social milieu, teachers must assume new roles of facilitating and mediating learning rather than merely imparting information as is done in conventional classrooms.

Aims for Students

The teaching of writing must shift from a focus on mechanics to a goal of constructing meaning in writing both for communicating with real audiences and for learning.

Because language is central in learning and thinking, schools are urged to integrate the language arts across all curriculum. If this can be accomplished, students will be able to use all the language arts as a means for effective communication, pleasure, and reflection on their own lives and the lives of others both in and out of school. Moreover, a language arts curriculum should promote lifelong learning, inquiry, problem solving, and other higher-order thinking. In addition, students should be able to think about their own learning and to view texts from multiple perspectives.

Curriculum Recommendations

- Curriculum should be based on a variety of research (e.g., child development, psychology of language and literacy).
- Language arts should be central in all school subjects.
- Curriculum should integrate both content and process. Processes should be treated holistically; skills should be conceived as part of holistic processes and should not be taught in isolation.
- Thinking should be taught as part of the core curriculum, not in isolation.
- Content should be taught as whole ideas around which language arts can be organized rather than as isolated bits of information such as facts, lists of works or characters, or rote definitions.
- Content should include a wide variety of literature from diverse sources, such as literature from other cultures; and other texts, such as student writing, television, and technical reports.
- Students should have the opportunity to explore ideas in depth.
- Commercial materials should be used flexibly to fit a curriculum rather than take the place of a teacher-developed curriculum.

These recommendations represent a dramatic shift from the curricula in many schools. Thus, they require changes in instruction, learning activities, and materials as well as assessment. Students need many opportunities to observe a variety of uses of language and literacy; to interact with teachers, other adults, and peers in classrooms that are communities of learners; and to engage in all the language arts on their own. For example, students should have books by real authors, including books by the students themselves, readily available in their classrooms for reading on their own and sharing with others.

The teaching of writing must shift from a focus on mechanics to a goal of constructing meaning in writing both for communicating with real audiences and for learning. Composing should be taught from a process approach. Teachers need to provide ample instruction in, and time for students to use planning, composing, editing, and proofreading strategies. Students also need to interact with each other and the teacher throughout the writing process.

Relation of Language Arts Guidelines to a Thinking Curriculum

These guidelines, based on a substantial body of research from numerous areas, clearly reflect the characteristics of a thinking curriculum as we define it. Throughout, the theme of the merging of process and content is evident. This fusion is natural in an idea-centered curriculum in which learning is thinking. In this regard, the guidelines advise schools to teach processes holistically and to abandon the isolated skills approach. Another clear theme is an emphasis on teaching important content in depth. Students cannot grapple with ideas unless they have time to reflect on those ideas.

The guidelines also promote situated learning. For example, they recognize the central role of language in all human activity and thus the importance of stressing its variety of uses across subject areas. In particular, the stress on process writing better reflects what real writers do. Finally, the guidelines stress students' interacting and learning with and from others. Each student can make unique contributions to his/her own learning and the learning of others because of his/her experiences, knowledge, and cultural background.

The New Standards in Mathematics and a Thinking Curriculum

The new curriculum standards from the National Council of Teachers of Mathematics (NCTM) emphasize developing students' abilities to use mathematics in solving problems, reasoning, and communicating; and helping students to value mathematics and to feel confident in their ability to do mathematics. Thus, implementing these standards would encourage students to view mathematics as an activity that everybody can use to make sense of the world. Five general goals cut across the K-12 curriculum standards for mathematics.

Problem Solving

The NCTM proposes that problem solving should be the central focus of mathematics education. A major reason for studying mathematics is to hone one's ability to solve problems systematically. Furthermore, problem solving provides real-life contexts in which mathematical skills and concepts are learned. Mathematics should be seen as a body of knowledge and a way of thinking that is useful in approaching problems encountered in everyday situations. To promote higher-order thinking, more problems should be confronted for which there are alternate solution strategies and solutions to generate and debate. In addition, problems should be drawn from many different problem situations, and relationships among problems should be explored. And students should model problems in different ways for example, by representing them in pictures or diagrams or by acting them out with manipulatives.

Reasoning

As with problem solving, the focus in reasoning is not always to find the right answer, but to make conjectures, gather evidence, and build arguments about how to use mathematical concepts and techniques in solving problems, according to the Council. Reasoning is fundamental to creating and understanding mathematics. To make conjectures and construct valid arguments for conjectures is the essence of the creative act of mathematics. In building arguments, mathematicians, drawing from philosophy, use both inductive and deductive reasoning. Teachers can foster inductive reasoning by creating situations where students must make generalizations about patterns and relationships, and by identifying common properties among objects and problems. Deductive reasoning can be developed using logical language, such as "and," "or," and "not," and teaching the strategies of constructing counter examples and

In a thinking curriculum, students develop a deep understanding of essential concepts and processes for dealing with those concepts, similar to the understanding that experts use in tackling complex tasks in their disciplines.

evaluating alternate solutions given the problem's initial conditions.

Communicating

Mathematics is a language. As in any language, the ability to communicate requires fluency with the signs, symbols, and terms of the language and an understanding of the rules governing the combination of these in coherent expressions. The best way to acquire the language is to use the language in problem situations in which students read, write, and discuss mathematics. The NCTM states that students who possess the power of mathematical language can:

- Articulate their reasons for using a particular mathematical representation or notation
- Share solution strategies and explain why one strategy may be better than another in certain situations
- Summarize the meaning of data they have collected
- Describe how mathematical concepts are related to physical or pictorial models
- Justify arguments using deductive or inductive reasoning

Students who can communicate in mathematics frequently discuss how mathematical concepts are captured by the symbolic machinery of mathematics. Finally, students discuss the connections between concepts and procedures among various branches of mathematics.

Valuing Mathematics

Students should view mathematics as a vital human endeavor that is related to history, culture, and science. It is one of the oldest disciplines, yet it is far from a "dead" subject. Mathematical knowledge continues to grow. In fact, the period after World War II saw more growth in mathematical knowledge than any previous period in history. Mathematics also continues to help other disciplines formalize their knowledge. Mathematics is applied to the physical and life sciences, social sciences, and humanities. Mathematics, in turn, benefits from being stimulated by the problems these disciplines pose for mathematicians. To gain appreciation for mathematics, high school students, for example, can think of ways to describe and graphically represent the continuous motion of a roller coaster. As they continue to refine and formalize their representation of the continually changing trajectory of the roller coaster, they can come to see the need for a mathematical tool to capture the notion of fluid and dynamic change. They are ready to be introduced to the power and elegance of concepts in calculus, the branch of mathematics that meets their need.

Feeling Confident in One's Ability

Many students (and adults who were victims of poor math instruction) regard mathematics as an activity in which only "gifted" individuals can engage. Others think of mathematics as a strictly computational activity that can be performed entirely by computers. These individuals have never been provided with experiences where they feel they are creating mathematical knowledge.

Yet mathematics is a natural and creative activity of the human mind in which we all engage. All students come to school having encountered size, shape, and order. The teacher can build on these experiences by having students reflect on everyday experiences with mathematical concepts, confront real-world problems that motivate the refinement of the concepts, and formalize these concepts with increasingly powerful mathematical machinery. By doing this, students come to feel that mathematics makes sense, that it has a meaningful connection to their everyday lives, and that it has a power worth accessing when trying to solve certain problems.

Relation of Mathematics Guidelines to a Thinking Curriculum.

The NCTM standards draw directly on the research in cognitive sciences. The characteristics of a thinking curriculum also draw from this research base, so it should be of no surprise that they are similar. Throughout the standards, it is emphasized that mathematics should never be taught as a set of abstract, "cookbook" algorithms, but as a living subject striving to make sense of size, order, and shape and attempting to craft tools that help us solve problems. Mathematics is a language for problem solving.

The standards also articulate those core concepts on which students should focus to be able to use this language in real-life problem solving. By bringing this focus to the mathematics curriculum, students can engage in sustained problem solving using mathematical concepts in different contexts. Students are increasingly challenged to use the concepts in solving more and more elaborate problems with less and less teacher support. Finally, math educators are encouraged to help students see that they are already mathematicians, and that they often think systematically about space, quantity, and order in their everyday life. Mathematics is simply a formal expression and conceptual extension of these everyday experiences.

The focus in reasoning is not always to find the right answer, but to make conjectures, gather evidence, and build arguments about how to use mathematical concepts and techniques in solving problems

Recommendations for Science and a Thinking Curriculum

A report released by the American Association for the Advancement of Science (AAAS) makes recommendations for restructuring curricula in the sciences. The report, entitled *Science for All Americans: Project 2061* (AAAS, 1989), promotes a new view of science. *Project 2061* advocates that science be taught to students not as if it were a static body of lists, facts, definitions, and formulas, but as an active, ongoing social enterprise motivated by a fundamental and universal desire to make sense of the world. A summary of *Science for All Americans* has recommended four overarching goals for the science curriculum that support this view of science.

Understanding the Scientific Endeavor Project

2061 urges schools to guide students to develop an awareness of what the scientific endeavor is and how it relates to their culture and their lives. Students come to see how science, mathematics, and technology often work together, each spurring the growth of the others. They should see that an understanding of how things behave leads to the development of technology. They should appreciate how various natural and social sciences differ in subject matter and technique, yet share the assumption that objects and events have a constancy in pattern and structure that can be revealed through systematic study. They should understand that mathematical knowledge arose out of an early need for better navigation and calculation of land areas. And they should see that scientific knowledge is an open inquiry with a long history, motivated by a fundamental human desire to be curious, to probe the mysteries of the universe and life, and to gain some illumination of those mysteries in systematic study. This inquiry is furthered by development of instruments that extend our capability to hear and see phenomena in the world. Mathematics gives us a language to carry out this inquiry. Thus, the scientific endeavor is an ongoing, human endeavor uniting science, mathematics, and technology in extending our ability to understand and create change in the world.

Developing Scientific Views of the World

Project 2061 also states that students should be able to use their knowledge of science, mathematics, and technology to make their world more comprehensible and more interesting. Students must develop well-articulated views of the world based on scientific principles and concepts. Some examples of such views include an understanding of the structure of the universe and the evolution of life within it. This understanding emerges from an intriguing and increasingly sophisticated insight that the materials and forces are the same everywhere in the universe. Everywhere substance is made up of atoms, and matter attracts matter through the force of gravity. Students can use basic concepts of matter, energy, force, and motion to understand the stars above and the earth below. Students come to appreciate the rich diversity of life forms on earth at the same time that they develop an understanding of the surprising similarity of these life forms in structure and function. In addition, the recommendations propose that students should be knowledgeable about the general features of the planet earth, the living environment, human life and society, and technology.

Forming Perspectives on Science

Project 2061 notes that the social and historical nature of science are an important part of a curriculum. Students should see how the powerful ideas of science emerged from particular historical, cultural, and intellectual contexts. Students should understand that scientific knowledge has a history. Most of that history has been marked by a gradual accretion of facts, but certain remarkable episodes in this history caused us to dramatically reconceptualize how we view the world. Students should appreciate these episodes, what led up to them, and their significance for the scientific endeavor and the broader culture and history. For example, students should understand how conceptions of the physical world changed from Aristotle, to Galileo, to Newton, up to Einstein. They can role-play individuals who hold to these various conceptions and explain phenomena from these diverse perspectives. To account for a rock being pulled to earth, the Aristotelian would explain how earth (the rock) seeks out the like substance of the ground, while the Newtonian would appeal to the universal force of gravitation. Or students could study how Chinese ideas about astronomy differed from medieval European ideas, and reflect on how these different perspectives imply different conceptions of humanity's place in the universe. Or they could study how in the past, many great mathematicians learned math in Africa rather than Europe. The purpose of considering these topics is not to add yet more to an already overburdened curriculum, but to prompt students to think critically about knowledge claims made in science.

Establishing Scientific Habits of Mind

If students are to be scientifically literate, they must possess certain scientific values, attitudes, and ways of thinking. To develop these, *Project 2061* urges schools to help students internalize values inherent in the scientific endeavor. These values include 1) a respect for the use of evidence, 2) an appreciation of logical reasoning in crafting scientific arguments, 3) honesty and curiosity in conducting scientific inquiry, 4) openness to ideas that challenge old ways of viewing and explaining the world, and 5) healthy skepticism about current scientific claims and arguments. Students should form balanced and well-reasoned beliefs about the social benefits of the scientific endeavor.

Students should also develop a positive attitude toward learning science, according to *Project 2061*. Their attitudes should affirm their capability to make sense of the world through science, highlight the importance of accurate measurement and precise instruments in producing sound scientific knowledge, and value critical thinking.

Finally, the guidelines recommend helping students develop scientific ways of thinking. This requires honing skills in observation; analyzing data; synthesizing this information by using scientific ideas; organizing data in tables, graphs, and diagrams; and communicating one's conclusions both orally and in writing.

Relation of Science Guidelines to a Thinking Curriculum

There seems to be a rather clear relationship between the characteristics of a thinking curriculum and the guidelines from *Project 2061*. The guidelines are patently directed at higher-order outcomes in science, as revealed in verbs such as "understanding," "forming perspectives," "thinking critically," and so on. In fact, these higher-order thinking processes are the means by which content is acquired, used, and infused with meaning. A teacher might choose to teach Chinese views of astronomy as a way for students to see that scientific activity is common to all cultures and that a culture will influence how scientific knowledge develops. The guidelines also articulate organizing principles and key concepts, such as evolution and energy transformations, that students should be able to use to develop scientific views of the world. Indeed, these core concepts enable students to think meaningfully about issues and problems in science. In addition, *Project 2061* insists that scientific habits of mind cannot be established unless students engage in the real-life task of posing a question, designing an experiment to address the question, and synthesizing the information gathered to develop a defensible answer. Finally, the *Project 2061* report, *Science for All Americans*, suggests that students see the scientific endeavor as a fundamental human impulse to explore the environment. Hence, educators should build on the experiences that students bring to class; help them articulate what conceptions they already have of the natural world; and provide them with real-life, structured experiences where students can rethink or even restructure their conceptions in the face of new evidence and new explanatory ideas.

Guidelines for Social Studies and

the Thinking Curriculum

Because social studies combines *the fields of history, geography, and* the other social sciences, and draws much of its content from the humanities, it deals with issues that are especially vulnerable to shifts in the winds of national mood and political climate. Concerns about the meager knowledge that many students have of history and geography have further fueled the debate about what social studies curricula should encompass. But there have been recent attempts to articulate a balanced approach to the social studies. An approach consistent with a thinking curriculum would help students think more clearly about current issues confronting them and their world and also explore the past and other places, thereby helping them expand their perspectives on today's issues. As students build knowledge of history and geography, they can use this knowledge to inquire more deeply into the origins and dimensions of present problems. Students can generate questions about society and seek out answers by exploring what is distant in time or place or culturally different. In this way, a historian's habits of mind are cultivated, bolstered by familiarity with problem-solving processes in the social sciences, and undergirded by conceptually-based, well-organized knowledge drawing from history, geography, and civics.

This approach is advocated in *Charting a Course: Social Studies for the 21st Century,* a report on curricular reform in the social studies issued by the National Commission on Social Studies in the Schools. This commission has recommended that social studies curricula for the 21st century embody a number of characteristics. Some of these characteristics are highlighted below.

Understanding One's Role in Democratic Society

The Commission stresses that social studies in a thinking curriculum should help students acquire a number of attitudes. Students gain an awareness of their roles as individuals and as members of a society. Students come to understand the responsibilities these roles entail, especially in a pluralistic democracy. Respect for the richness that cultural and individual diversity brings the nation and the world should be developed through civic understanding and global awareness. Students attain a profound sense of connection to others in the past and across the globe by identifying common democratic passions and concerns. Students studying the American Revolution understand various manifestations of human strivings for basic rights - in American colonists, students protesting in Tiananmen Square, and Nelson Mandela and his followers in South Africa. Students see connections between the actions of radicals in the French Revolution and recent executions in Romania. Finally, students develop respect for themselves as participants in a democratic society when they are given real opportunities to render community service or solve social problems within the school or classroom. Students involved in a thinking curriculum for social studies see themselves as active and responsible members of a community, society, and a "global village."

Building on Core Integrative Topics Throughout the Social Studies Curriculum

To develop the viewpoint and strategies of one conducting social inquiry, students need to focus on core integrative topics in depth. A social studies curriculum should be consistent and cumulative in treating these topics in depth and over the entire K-12 school experience. The Commission suggests some of the following topics and concepts:

(1) Social studies can develop an international perspective by having students study other places and by providing multicultural perspectives. Students should understand the many ways in which groups, communities, and nations evolve, create, and modify rules to structure social interactions.

(2) The concept of community should be explored in all its various manifestations. Portraits of communities from the past and across the globe, as well as investigations of their own neighborhood communities, can deepen students' understanding of the origins, purposes, and variety of communities.

(3) Students should develop increasingly sophisticated models of the physical and social world. Each learning experience should be located in space with globes and maps, and located in time with notions of generations, eras, and periods. Students then develop a matrix of time and place that will help them make connections between history and geography.

(4) The important concept of culture can be developed by considering ethnic diversity and the various ways culture is embodied in artifacts and events, such as holidays, art, music, literature, and bodies of knowledge. For example, students can learn how the Chinese use an abacus to perform calculations and how ancient Arabs developed our current number system based on the abacus.

Integrating Concepts From the Social Sciences With History and Geography

To keep the study of history and geography from focusing exclusively on memorizing dates and capitals the Commission urges that concepts and understandings from political science, economics, sociology, anthropology, and the other social sciences be integrated throughout the social studies curriculum. Students should develop a firm understanding of the concepts, principles, and methodologies of the social sciences so that they have the tools to construct meaning in history and geography. These tools include strategies for acquiring, organizing, and using information, as well as relating knowledge acquired to interpersonal relationships and social participation. Students should know how to generate and synthesize data on social phenomena, how to find primary sources, and how to search information bases. In addition, the Commission states that students need to:

- Think critically about the reliability of information sources
- Give meaning to the gathered information by forming concepts
- Develop arguments that explain patterns in data
- Represent problems and issues (often by presenting information visually through graphs, maps, diagrams, and tables)
- Make informed decisions about historical events and current policies
- Reflect on how they have thought through a social issue and the possible limitations of their methodology and conceptual framework

Finally, students should be able to use their knowledge and beliefs to inform actions in their personal and social life and in community and political participation.

Deeply Exploring Cultures and Major Civilizations Other Than the United States

In this time of greater interdependence in the world, it is especially important, according to the Commission, that students develop understandings of other civilizations. The point is not to cover all major civilizations superficially, but to look at selected civilizations in depth to cultivate genuine understanding of the history, geography, values, and ways of a people. In addition, students develop a heightened awareness of their own heritage, values, and behavior when they see similarities and differences among other cultures and civilizations. This awareness can promote multicultural learning in the classroom and beyond.

Developing Interdisciplinary Perspectives on Topics in Social Studies

The content of social studies curriculum offers abundant opportunities to make connections between the humanities and the natural and physical sciences as well as among the social sciences. The human adventure extends to all these areas. People produce knowledge and express their human desire in the context of a particular culture and historical period. Thus, any field of human endeavor - science, mathematics, literature, music, dance, art - can be seen from the perspective of the time and place in which it was undertaken and its course of development over its history.

Using Knowledge From Social Studies Actively to Confront Vital Questions and Issues

Content knowledge from the social studies should not be regarded as fixed knowledge to be memorized, but as the means through which open questions about society can be explored. Teachers can challenge students to explore the historical origins of any current problem or issue, to see the connections between how that problem or issue is addressed by our society and how the same issue is addressed by societies distant in time and space, and to pursue how this study might help us think more innovatively about solutions to societal problems.

Relation of Social Studies Guidelines to a Thinking Curriculum

The relation of these recommendations from the National Commission on Social Studies in Schools to the characteristics of a thinking curriculum is clear. The recommendations emphasize helping students construct meaning in history and geography by employing the methodologies and concepts of the social sciences. The recommendations repeatedly emphasize the importance of resisting the push for coverage; instead, they recommend in-depth study of selected civilizations to explore themes such as culture and community that cut across the social sciences. Consistent with the characteristic of content objectives situated in real-world tasks, the recommendations also insist on using content to address open issues and vital questions in the lives of students. The Commission insists that social studies curriculum have continuity and that this continuity derive from core concepts that are treated in more and more complex ways as the students move from kindergarten to high school graduation. Finally, the Commission suggests that these core concepts be tied to what is familiar to students and then be expanded to larger and unfamiliar contexts.

Can Implementing a Thinking Curriculum Foster New Learning?

The different curriculum standards reveal a common spirit. Over and over again, these professional organizations admonish traditional models of education for emphasizing memorization, and decry their push to cover content at the expense of deep conceptual understanding. Instead, the reports regard learning as the active, goal-directed construction of meaning. All emphasize in-depth learning; learning oriented to problem solving and decision making; learning embedded in real-life tasks and activities for thinking and communicating, and learning that builds on students' prior knowledge and experiences.

Implementation of the new standards in schools would help to develop students who are successful learners - learners who are knowledgeable, self-determined, strategic, and empathetic. By focusing on core concepts and treating them in depth, students acquire a firm conceptual base for organizing the content they learn into coherent knowledge structures. By emphasizing the connection to their own experiences and attitudes, the guidelines, when implemented, would validate students' experiences and enable them to become competent "knowledge workers" in the various disciplines. By uniting process and content, students learn the strategies they need to acquire, produce, use, and communicate knowledge. And, finally, by looking at the subject areas from multiple personal, cultural, and historical perspectives, students develop empathy for the experiences, feelings, and world views of others.

The new definition of learning can serve as the framework for restructuring a curriculum. By using a new school-based definition of learning, all members of a school community and its broader community can develop a common language for curricula reform. Sharing this language will help build a community of individuals who have a common framework for curricular reform. They will have a basis for rethinking, as a community, the content and intent of the curriculum.

In addition, all professionals in the school will come to see that the reforms in their own disciplines - whether it be language arts, mathematics, science, or social studies - have a common basis, since all reforms are guided by a common research base and conceptual framework for learning. Thus, they can make curricular changes as a community, and they also can have common ground for interdisciplinary efforts. The characteristics of a thinking curriculum will become part of the school mission that the school as a whole and its community formulate in collaboration.

Fundamental Restructuring in Urban and Rural Contexts

Rural and non-rural schools may engage in the process of fundamental restructuring in very different ways. Below are descriptions of two schools that illustrate these differences.

Urban Example - East St. Louis Public Schools, IL

Fredrick Birth, science coordinator for the East St. Louis schools, developed a science curriculum to solve serious social and academic problems in that district. The students did not have adequate prior knowledge to understand the science textbook and were unable to conduct the experiments in them. Consequently, students' already limited science experiences were not being addressed. Many teachers were reluctant to use the texts because they did not have adequate time in their crowded curriculum to provide the background knowledge students would need to understand the concepts and experiments. In addition, many elementary teachers had limited experience in teaching science. This situation was reflected in students' very low science scores on the California achievement test. Students graduated without the skills they would need for technical jobs.

Mr. Birth's approach reverses the order of science instruction typical in some schools. He developed laboratory centers in which students first engage in hands-on activities, especially experiments, and then learn the concept involved either by listening to teacher explanations, inferring the concept themselves, or reading about it in a text. Currently, there are six teachers and twelve centers. Each teacher is responsible for two centers. Students who attend are those most in need of science literacy. They spend two to three days, 30-40 minutes per day at their center. They learn all aspects of science over a year (e.g., biology, chemistry), but with no time constraints for any one element. In addition to a hands-on approach, the curriculum stresses scientific habits of thinking - observing, hypothesizing, planning an experiment, reaching a conclusion - and helps students make connections between science concepts and processes and their own lives. For example, students hypothesize what will happen if they use drugs, observe effects of drugs on people, and reach conclusions about taking drugs. Parents are encouraged to participate in the program and have become enthusiastic about their children's participation in science fairs. Students' who participated in Mr. Birth's experimental program saw not only dramatic increases in their science scores on the California test but in their motivation and self-confidence. It is expected that the achievement of students in the program now will also increase. Teachers, too, have benefited. They meet regularly to share ideas and problems.

This program exemplifies a thinking curriculum within a content area. Students learn science concepts and processes in depth without the limitations inherent in "covering content." They engage in science authentically and holistically, as real scientists do. The approach - examining and puzzling about natural phenomena and then inferring concepts that explain phenomena - reflects the sort of processing these students are familiar with. Finally, students learn how science can inform their own lives and how it can help them make decisions about issues they face out of school.

Rural Example - Deer River Public Schools, MN

Deer River is a rural community in Minnesota where more than 50 percent of the student body come from low-income homes. In addition, Native Americans represent 30 percent of the population. In an effort to help students deal with our changing society and to value and understand cultures other than their own, specifically the Ojibwe culture, four teachers in the district are developing a technological, multicultural curricular strand. Other cultures common in the area will be studied in the future. The four teachers received support to develop the curriculum when they were named Christa McAuliffe Fellows by the National Foundation for the Improvement of Education.

The Ojibwe people are involved in developing the curriculum. They are identifying aspects of their culture - artifacts, history, government, customs, and so on - that are important for students to learn as well as misconceptions the curriculum should help dispel. In addition, Ojibwe people will interact directly. Students will interview the Ojibwe people and visit them as they work. The community's White Oak Society is constructing replicas of Ojibwe villages where students can learn about the Ojibwe culture in its authentic state. Such an in-depth focus on a whole culture quite naturally will involve interdisciplinary learning. In addition to learning important social studies concepts (e.g, factors that make up a culture, importance of getting along with other people), students will have many opportunities to develop language arts skills through interviewing, writing and interpreting their interviews, and learning traditional Ojibwe stories. They will be able to learn some math concepts and skills through Ojibwe counting games, and some science concepts as they learn about native plants, herbal medicine, and the like. They can learn design concepts by studying Ojibwe art. With help from teachers, students will develop hypertext (combination of video, disc, computer information, and word processing technologies) that will become a learning resource students both create and use. High-school students will learn sophisticated video technology so they can videotape both the interviews and the Ojibwe people in various settings.

This multicultural curriculum richly embodies the concepts of a thinking curriculum. It fuses content and process. Students will engage in processes such as analyzing data from interviews as a way to understand what they have learned about Ojibwe culture. Students will learn about the culture in depth by interacting with and observing Ojibwe in their natural context. Such experiences are an authentic model for learning about any culture; as such the curriculum will be situated in the real world. In addition, students will perform holistic tasks such as interviewing, analyzing data, drawing conclusions about what they observe and write about their experiences, making decisions, and so on. Finally, the content will make connections to and build on students' prior knowledge by focusing on a culture close to home and by connecting math, science, language arts, and social studies to real-world embodiments of concepts in those content areas.

Todd F Fennimore and Margaret B Tinzmann were both Program Associates at the North Central Regional Educational Laboratory, USA.

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Thinking, Thinking Skills and Teaching Thinking Skills

Jessie Wong Yuk Yong

Thinking can be defined as using the mind in an active way to form ideas. It is the mental manipulation of sensory input and recalled perceptions, in the form of information and thoughts stored in the memory, to make or find meaning, to reason about or with, to formulate thoughts and to judge. Why do we think? For simple reasons, for example, we need to resolve problems, we need to comprehend a lesson, we need to make decisions and we need to conceptualize something. Thinking helps us to fulfil these needs. It involves complicated mental activities that consist of multilevel processing which makes use of considerable knowledge and information.

All human beings are capable of thinking. I have something for you to think about now. Can animals think? To find the answer to this question, you need to perform a thinking process which requires particular skills which we call thinking skills. Can we teach thinking skills directly? What are the thinking skills that we can teach? How can we teach thinking skills effectively?

Thinking skills are the discrete, precisely delineated operations used in varying combinations as we think. Many of such skills have been identified such as remembering, distinguishing the relevant from the irrelevant, classifying, predicting, judging, synthesizing, inferring relationships, and making conclusions. These skills are the tools of effective thinking. They are used over and over again to carry out many thinking tasks.

Teaching thinking skills

There are four things we must be able to do before we are able to teach thinking skills effectively:

1 Identify and describe the attributes of thinking skills.
2 Design lessons for teaching thinking skills.
3 Develop assessments of student proficiency in thinking skills.
4 Integrate the teaching of thinking skills into the subject areas in the curriculum.

Identify and describe the attributes of the thinking skill

The most important features of any thinking skill are often referred to by information processing specialists as *attributes*. A skill attribute is a component of a thinking skill that is engaged or utilized in the process of carrying out that skill. Experts have suggested that the most important attributes typical of most thinking skills are:

- A procedure which consists of a series of steps by which the skill is carried out. A procedure is what one does mentally in doing the skill.
- The rules one follows which inform and guide the execution and application of this procedure.

For example, thinking about as many alternatives as possible before deciding on one, is an important rule in decision making.

- The criteria which are applied in carrying out the procedure as the skill is executed. This is the knowledge required to carry out the skill well. For example, to make a decision on which university to choose to go for a higher degree, some criteria needed will be the cost, the courses available, the location of the university and the entry requirements.

Table 1 is an example showing the attributes of the thinking skill "PREDICTING". How can we identify the attributes of a skill as shown in the table?

Two ways of doing it are:

1. Use a process of reflective analysis, the 3-D procedure, that is, first, you define the skill you have selected. Second, you carry out the process of thinking about the skill yourself. Third, you define the skill in detail.
2. Refer to the specialists' description of the attributes of that skill.

Whether you are using 1 or 2, you would need to revise the description and rewrite it to make it appropriate to your students.

Design lessons for teaching thinking skills

Once you have identified the major attributes of the thinking skill you wish to teach, you can develop lessons to teach this skill. There are many approaches you could take to help your students become proficient in particular thinking skill. You could, for example, stimulate and encourage students to think by asking thought-provoking questions and by concentrating on subjects of interest to them. Or you could foster and facilitate thinking by asking carefully structured questions that move from data gathering to data processing or by providing inquiry-oriented classes. Or you could exercise student thinking by making students respond to questions, research tasks, or written assignments requiring different kinds of thinking. However, none of these approaches teach students directly how to carry out the thinking skills they are required to used when they respond to the questions you may ask them, the tasks you may assign them, or the opportunities and encouragement you may offer them. Students benefit most from encouragement, teacher facilitation, and exercise when these are coupled with deliberate, systematic instruction in how to carry out the skill being learned. There are six kinds of lessons that can be useful in teaching a skill at different levels of proficiency.

TABLE 1: ATTRIBUTES OF "PREDICTING"

Definition: Stating in advance what will probably happen, forecasting, extrapolating, foretelling, prophesizing, projecting
Procedure: 1. State clearly what the prediction is about. 2. Collect data relevant to the prediction. 3. Recall information that you already know about the topic. 4. Identify a pattern in the recalled data. 5. Map the perceived pattern on the given data to imagine the next possible instances of the perceived patterns. 6. Determine the probability of each imagined outcome actually happening. 7. Select the outcome most likely to occur.
Rules: 1. When to use? In hypothesizing about any topic In forming new categories... 2. How to start? Ask yourself what would happen next? Arrange the data ... 3. What to do if ... Little relevant information exists? It is difficult to generate possible outcomes?
Criteria: 1. Comparing, contrasting. 2. Various types of patterns. 3. Probabilities. 4. Potential intervening conditions, variations, influences related to the subject. 5. Historical, analogical situations.

1. Introduction lesson

Instruction in any thinking operation may be initiated whenever a teacher senses a need for students to be able to execute it better than they seem able to do. The purpose of this lesson is to introduce students to the major attributes of a new skill at simplified level. Instruction here focuses directly on the thinking skill being introduced as students not only see the operation modeled but also have one or more opportunities to engage in it with appropriate teacher guidance. Introductory lessons like this do not, by themselves teach a skill. It only serves as a starter to launch the study of this skill.

2. Guided Practice lesson 1

Once a thinking skill has been explicitly introduced, students require many more lessons of guided practice to learn it. Unlike introductory lessons in which students must focus exclusively on the operation, guided practice lessons allow time and opportunity to deal with the subject matter used in the lesson and the substantive products of skill use. After discussing and analysing how the thinking operation being practiced was employed, students can then use the insights generated by their application of it to carry forward the subject matter learning in which they are engaged. Gradually, as students become more proficient with the new thinking skill, you can reduce the amount of explicit guidance to eventually little, if any, skill instruction.

3. Independent application lesson

As students demonstrate an ability to execute the thinking operation being practiced without assistance, you can then provide them repeated opportunities to use it on their own. These applications should continue to be in the same kind of data or subject matter in which the operation was originally introduced or practiced. When students independently apply the skill as specifically required by you, they integrate the various steps in the procedure by which it is made operational, and they begin to internalize the rules, principles and other knowledge that inform it. Such application is an important step en route to automatizing a thinking operation and to taking ownership of it. Once the students have demonstrated that they can do it on their own, you can then offer additional instruction designed to help them apply the operation in a variety of settings to transfer it beyond the introductory setting.

4. Transfer and elaboration lesson

Transferring a thinking operation consists of helping students learn how to execute a previously learned skill in new settings. This means helping them identify the cues in these settings that signal the appropriateness of using the operation. Lessons that launch such transfers are reintroductions of the thinking operation but in new situations. In these reintroductions, students review what they have already known about the operation being learned and then receive instruction in how to execute it in the new setting.

5. Guided Practice lesson 2

Once a thinking skill has been initially transferred to a new context, it must be practiced again until students demonstrate proficiency in using it in the new context. This is a repetition of guided lesson 1 but in a new setting.

6. Autonomous Use lesson

Being able to use a thinking skill to generate knowledge on one's own, is the major goal of the teaching of skill. Students at this point need guidance and practice in selecting which operations to use as well as in applying them accurately, efficiently and effectively. This kind of lesson should provide them opportunities to do so.

Develop assessments of student proficiency in thinking skills

Anything worth teaching in depth is worth assessing. This is especially true of thinking skills. Such assessment should be frequent and continue throughout your course. Currently there are few instruments to assess thinking skills. These include process portfolios, performance assessments, group and individual assessments, and paper-and-pencil assessments. These instruments should vary in structure and content according to which level the students are at in learning the skill to be assessed. A test on a newly introduced thinking skill should focus exclusively on the skill and use data from that portion of the course just completed by the students. This test, consisting of five or six items, may be attached to the regular unit test usually used to assess student learning of that content. This might include two items about the skill, one calling for a definition of it and the other calling for recognition that it is being used; three items that require students to apply the skill to data they know something about and to show how they do it; and finally an item asking them to explain to a novice how to do the skill. Observational instruments may also be used to assess student proficiency in thinking skills. Table 2 shows an example of a test for the skill of "classifying".

You can learn how to write any instrument to assess student proficiency in thinking skills by doing the following:

1 Select the instrument you wish to use
2 Analyse examples of the kind of instrument you want to prepare
3 Draft the instrument yourself
4 Check and revise your draft
5 Administer the test at an appropriate time, analyse the results and revise it for later use.

Table 2: A test for the skill of "classifying"
1. Which of the following best defines the skill of "classifying"? (a) to arrange things in the order in which they occur (b) to put together things having a common characteristic (c) to put together names alphabetically
2. Which of the following shows information that has been classified? (a) People - Indian, Malay, Chinese Animal - monkey, elephant, lion, cat, deer Plant - ixora, oil palm (b) When Tom woke up this morning, he brushed his teeth and ate his breakfast. He went to school with his friend. But he did not feel well. He returned home almost immediately.
3. The following are words associated with food: tasty, too salty, bacon, orange juice, rice, soft, fish, peanut butter, bread, soup, jam, strawberry jam Classify them into 3 different groups.
4. Tell the class the steps you have followed to classify the items in question 3.
5. Give a list of other items not related to question 3. Try to classify them into groups. Explain how you can do it. Explain why you did it the way you did.

Integrate the teaching of thinking skills with subject matter

Once you have learned how to teach the various kinds of lessons for teaching thinking skills and use the strategies appropriately, and feel comfortable in doing so, you will want to integrate instruction in thinking skills into your regular teaching. This means mixing the two to the point where they complement and support each other. By infusing instruction in thinking skills with the teaching of academic subjects, you can provide instruction in important thinking operations at a time when they are needed to accomplish subject-matter learning objectives.

Integrating the teaching of thinking skills in subject matter is not without difficulty, however. All too often attention to subject matter overwhelms skill teaching. In integrating instruction in thinking skills with instruction in subject matter, you should, in your first few lessons on any new thinking skill, concentrate on the skill rather than on any subject matter. In the subsequent lessons, when the students are able to use the lessons well enough, attention can be given equally, first to how they carry out the skill and then to what they learn by so doing. Eventually, focus is given almost exclusively to subject matter objectives while students apply this skill because they can do it well. In this way, your students learn both the subject matter and the skills. In fact, with the skills mastered, they learn the subject matter more effectively.

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Higher-Order Thinking Skills and Assessment

Rosalind Y. Mau

Today, learning has changed from simply recalling discrete facts to learning concepts at higher-order thinking levels of analysis, synthesis, and evaluation. Concomitantly, the assessment of current learning must move from static to dynamic assessment and from uni-dimensional to multi-dimensional modes of assessment.

Traditionally, assessment consists of collecting test scores where some students achieve and others fail at one point of time. Authentic and alternative assessment now measures students' progress and products of learning through multi-dimensional modes. Rather than administering only convergent-answer tests, authentic assessment requires higher-order thinking skills to solve contextualized problems. Alternative assessment is multi-dimensional since diverse students can demonstrate what they have learned through self-assessment, peer assessment, performance checklists, portfolios and learning logs.

This paper focuses on promoting higher-order thinking skills by using various modes of authentic and alternative assessment. The premises underpinning this article are:

- Students are learning how to think for themselves and how to use higher-order thinking skills.
- Teachers are capable professionals who believe all children can learn. They are committed to a lifelong educational process by facilitating intellectual and emotional growth of students.
- Learning is connecting ideas through reading and writing and engaging one's own ideas with the ideas of others.
- Diversity is inevitable and desirable. Authentic assessment of learning help diverse students develop higher-order thinking skills to communicate and use their ideas effectively.
- Assessment is closely linked to teaching and learning. As teaching and learning practices encompass more higher-order thinking skills, assessment concurrently must evaluate the process and products of higher-order thinking.

Learning, Teaching and Assessment

Learning, teaching and assessment of higher-order thinking skills are invariably linked. Learning is a continuous process when students receive and connect information to their schema in order to make sense of information. They revise and adapt their prior knowledge to new conceptions (Bransford, Arbitman-Smith, Stein and Vye, 1985). They can monitor their own progress through self-assessment or through peer and teacher assessment. Authentic assessment provides useful information about the learning process and products that are of value to students and others.

When teachers assess students' learning through observation and

Table 1. Higher-order Thinking Skills and Assessment Questions

Higher-order thinking skills	Definition	Assessment question
Analysis	Divide wholes into component parts. Part/whole and cause/effect relationships are essential to complex tasks.	Describe different parts of the character's personality.
Comparison/Contrast	Explain similarities and differences. Similar to Bloom's level of synthesis when students go beyond breaking the whole into parts in order to compare similarities and differences.	How was the character like his father?
Inference	Both deductive and inductive reasoning. Application of 'if-then' relationships, hypothesizing, predicting, concluding, and synthesizing all require students to relate and integrate information.	What might be a good title for a book about the character?
Evaluation	Require judgement of quality, worth or practicality. Criteria are established and students explain how criteria are met or not met.	Why is the character a good model of morality?

alternative assessments, they can teach their students better. Teachers can continuously assess higher-order thinking skills of students through observation, paper and pencil tests, learning logs, checklists and portfolios. As they analyze their students' progress, they can dynamically adjust their teaching plans accordingly. So assessment is an essential component of teaching and learning higher-order thinking skills of analysis, comparison/contrast, inference, synthesis, application, and evaluation.

The Quellmalz Taxonomy (Quellmalz, 1985) used in Table 1 defines four higher-order thinking skills, namely analysis, comparison/contrast, inference and evaluation and provides possible assessment questions.

Authentic Assessment Includes Reflection and Rescripting

Teachers and students hold pivotal positions in the teaching and learning of higher-order thinking skills. Assessment that requires reflection and rescripting are key to both professional teaching and to student learning. Higher-order thinking skills are hinged on reflection which is careful thought about what is being done. Learning to a large extent is a reflective activity which takes place through the action of the learner. Analytical reflection enables students to conceptualize and formulate their own rules and principles.

Along with reflection, students develop a conscious process through rescripting when they become aware and create a mental picture backed by clear intentions. Steven Covey (1989) used the term, rescripting, in his book, *Seven Habits of Highly Effective People*, when he wrote that change must first come from within oneself. Students are told that they have sort of a mental "automatic pilot" that lets them do things without thinking. Although this capacity is useful, it can limit patterns of thinking and behavior. Further, they have many scripts in their heads that were taught to them or were synthesized by them. Rescripting involves a paradigm shift or refining of existing scripts to see things in a new way. When students feel that their thinking is ineffective, incomplete, or inaccurate, rescripting is required. In short, when students reflect, use imagery, talk to themselves, and reconcile new ideas with their schema of previous concepts, they develop higher-order thinking skills (McNeal, 1995). They rescript themselves or plan new ways to analyze and solve problems.

Authentic Assessment Uses Various Tools To Measure Higher-order Thinking Skills

One way to measure higher-order thinking skills is the usual paper and pencil test based on a table of specifications. Another way is a performance-based assessment for an oral or written report. Self-assessment, peer-assessment, or teacher-observation checklists are several examples. Personal communication is yet another way to assess higher-order thinking skills when students keep a learning log or portfolio of their learning and consult with their teachers.

Paper and Pencil Assessment Using Table of Specifications

Paper and pencil tests can be used to assess higher-order thinking skills if a table of specifications is used. Table 2 shows is an example of a table of specifications for science assessment of Primary Four students with the textbook and workbook numbers listed. The questions are divided by relative importance of topic areas and the kinds of thinking questions included on the test. The teacher has given more weight to comprehension and application questions which reflect higher-order thinking skills.

On the school level, the results are used to measure how well knowledge and thinking achievement targets are met. Also, test results indicate how effectively teachers have taught their students. Completing an item analysis of the test administered to the students based on a table of specifications assists teachers to diagnose and refine their teaching. Analysis of test results serve as a diagnostic assessment tool to guide specific instructional decisions. Paper-and-pencil tests are not meant to capture the full range of skills, learning styles, and ability of students.

Assessment can take various forms to promote goals of acquisition of content knowledge, creating personal meaning from new information and prior knowledge, solving problems, and measuring student performance to a specified criterion or standard. So besides a paper and pencil test based on a table of specifications, an alternative form of assessment is performance assessment (Bratcher, 1994).

Table 2. Table of Specifications for Science at Primary 4 Level

Topic	%	No. of questions	Knowledge	Comprehension & application
Ch. 1 Matter	100	50	20	30
Part 1. What is matter?	30	15	6	9
Part 2. Solids, liquids, gases	30	15	6	9
Part 3. Gases in the air	30	15	6	9
Part 4. Variables in experiments	10	5	2	3

Textbook: pp 1-23
Workbook Activities: pp 1-9

Format: 60% multiple choice + 40% open ended = Total
(30 questions) (20 questions) (50 questions)

Duration: 45 minutes

Performance Assessment Checklists for Oral and Writing Assignments

After an oral report on science the following performance assessment checklist can be completed (adapted from Herman, Aschbacher and Winters, 1992). An example of two items on a checklist is shown in Table 3.

Yet another alternative assessment is a portfolio folder compiled by students and which may encompass teacher observations as well. According to Tierney, Carter and Desai (1991), the evaluation process is sequenced as follows:

1 Teacher and student discuss and negotiate portfolio goals.
2 Development of criteria, guidelines and procedures.
3 Student compiles portfolio with peer input.
4 Self-evaluation comments are presented.

Table 3: Examples of Performance Assessment Checklist

Achievement levels	Skill: Critical Thinking	Skill: Use of knowledge (application)
Minimal	Demonstrates little understanding and limited comprehension of topic.	Reiterates one or two facts without complete accuracy. Vaguely covers concepts.
Rudimentary	Demonstrates a very general understanding of the scope of the problem and focus on only one issue.	Provides basic facts with some degree of accuracy. Explains concepts in general terms.
Commendable	Demonstrates a general understanding and more than one of the issues involved.	Relates only major facts with a fair degree of accuracy. Analyzes concept with substantive support.
Superior	Demonstrates clear understanding of at least two critical issues.	Offers accurate analysis of information. Provides facts to relate to major issues involved.
Exceptional	Demonstrates a clear and accurate understanding and the implications of the issues involved.	Offers accurate analysis of issues. Extensively uses knowledge to provide in-depth understanding of problem.

5 Student selects criteria to evaluate portfolio contents.
6 Portfolio is submitted to teacher who reviews content against stated criteria.
7 Portfolio is returned to student with teacher comments.

One caveat to remember when using portfolio assessment is "Not everything that counts can be counted and not everything that can be counted counts," which was purportedly hanging on Albert Einstein's office wall (Herman, Aschacher, and Winters, 1992). Moreover, portfolios can more realistically measure various intelligences (Armstrong, 1994; Gardner, 1993) such as musical, spatial, intrapersonal, interpersonal, and kinesthetic. It would be unfair to measure how much a student has learned through music when the test is administered through the printed word. Similarly, a student who learns cooperative learning skills cannot explicitly demonstrate his/her interpersonal intelligence through a paper and pencil test. One example taken from Armstrong (1994, p. 126) demonstrates how a linguistic task can be assessed using each of the seven intelligences:

- linguistic assessment - read a book and write a response
- logical mathematical assessment - read a book then develop a hypothesis
- spatial assessment - read a book then draw a picture
- bodily-kinesthetic assessment - read a book then build a model
- musical assessment - read a book then create a song
- interpersonal assessment - read a book then share with a friend
- intrapersonal assessment - read a book then design your own response

In summary, the purpose of the portfolio is instructional in terms of monitoring student progress and generating dialogue between the teacher and individual students. An example of a mathematics portfolio may include a competent performance on a timed test, a practical application of mathematics to daily life, several samples of creative problem solving and a long-term project which links mathematics to another content area such as history.

When students compile, organize and prepare their portfolios, a natural link is made between learning and assessment. Students may clarify teacher-stated criteria or develop criteria with the teacher.

This process helps the student think about and focus on the value of their learning. In the process of selecting what should be included into the portfolio, students need to reflect on their learning and which products can best meet the achievement criteria. In addition, a final self-reflection either written or as an oral report can be incorporated when the portfolio is given to the teacher.

Conclusion

The interest in higher-order thinking skills has risen to an elevated priority in Singapore. This renewed insurgence for higher-order thinking skills is exemplified in Director of Education John Yip's assertion that Singapore schools are promoting "innovation, creativity, informed decision-making and problem solving" (Yip, 1995). Also, in the United States the National Assessment of Educational Progress noted a greater precipitation of major curriculum and assessment development of higher-order thinking skills to statewide and standardized tests (Arter and Salmon, 1987).

Are classroom teachers assessing these higher-order thinking skills? A study was conducted in the United States of primary and secondary school teachers to see whether students' higher order thinking skills were assessed in mathematics, science, social studies, and language arts. The results revealed that paper-and-pencil assessments were dominated by recall questions. Oral questions tapped analysis and inference skills, but comparison and evaluation questions were rare. Those teachers who were trained to assess higher-order thinking skills had a higher proportion of questions on the higher-order thinking level (Stiggins, Griswold and Wikelund, 1989). The implication of the study is that more teachers need to be trained in using authentic and alternative assessment tools such as learning logs, self and peer assessment, performance assessment, portfolio, observations, and oral consultations.

Teachers who know and implement authentic and alternative assessment are better able to engage students in learning. Engaged students have positive attitudes toward learning because they know what the achievement target is and have various ways to display their knowledge. As students relate basic concepts to their own schema, authentic assessment requires them to apply what they have learned to meaningful and real-world applications. Alternative assessment encourages them to tap higher-level thinking and problem solving while they extend their knowledge. Teachers well know that most students study those things they will be tested on and conversely, ignore those things which they will not be tested. So authentic and alternative assessment can be the impetus and catalyst to learn and foster higher-order thinking skills.

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A Certain Sameness: Structuring the Curriculum for Higher Order Thinking

Dennis Rose

What do we do when we solve problems in mathematics or science? How do we think when we write or read? What processes do we use? What can teachers do to teach their pupils to think?

Educators frequently associate higher order thought with the upper levels of Bloom's taxonomy of educational objectives (Linn & Gronlund, 1995). These entail the analysis, synthesis and evaluation of concepts, rules, strategies, etc. Carnine (1991) argued that the process that underlies concepts, rules, strategies and so on is noting samenesses.

Every concept, rule, or strategy is defined by a *sameness*. For example, the concept "new" can be applied to new clothes, new ideas or new car. Each of the new things has the sameness that they are not old, or not previously known or possessed. We can also look for sameness according to polar concepts (e.g., full, hot), comparatives (e.g., bigger, faster), positional concepts (e.g., on, beside), colours, and class concepts (e.g., dogs, cars).

Merely being able to identify something as blue, or big, or hot is not evidence of concept learning. To demonstrate knowledge of a concept, a learner must be able to identify novel instances of an object or event as belonging to a particular class of objects or events. The learner notes the sameness of the objects or events. For example, a car, the sky and a T-shirt may all be classified as blue. They may be different shades of blue, but still identifiably blue, and not green or indigo.

Expert learners organize their knowledge in an interconnected and hierarchical structure around explanatory or causal relationships (Feltovich, 1981, cited in Carnine, 1991). Samenesses in mathematics include solutions, methods and numerical patterns, while in science the important samenesses are underlying laws and in history they are methods of analysis.

Noting samenesses is an indiscriminate process and can lead to misconceptions. For example, a young child may learn that the four-legged creature in the house is a cat. When the child sees a dog, she may notice some of the samenesses (e.g., animal, four legs, fur or hair) and call it a cat. As her learning becomes refined and she also notices differences, she will be able to classify both as animals and even as mammals because of the samenesses they share. She will also learn to discriminate between them because of differences. Within a class such as dogs, she may eventually be able to classify dogs as terriers or not terriers. This involves noting samenesses and differences.

Slightly older children may note a sameness between the letters *d* and *b* and between the words *was* and *saw*, while failing to notice their differences. Later they should be able to identify b when it is written in different fonts and sizes because they all possess the sameness that makes them b.

As students seek samenesses, they sometimes attend to irrelevant features. While subsequent experience often causes students to revise or refine their understandings, many do not and proceed with faulty information. Even if students do eventually self-correct, their learning has been less efficient than if they had learned correctly at first. Well-designed curriculum materials can provide frameworks that cause students to notice relevant samenesses and learn efficiently. The sections that show examples in some curriculum areas.

Mathematics

In geometry students learn equations for surface area and then for the volume of various figures. They are usually expected to memorize seven formulas to calculate the volume of seven solids:

Rectangular prism: $V = lwh$
Wedge: $V = (lwh)/2$
Triangular pyramid: $V = (lwh)/6$
Cylinder: $V = \pi r^2 h$
Rectangular pyramid: $V = (lwh)/3$
Cone: $V = (\pi r^2 h)/3$
Sphere: $V = 4/3\ (\pi r^3)$

Merely memorizing equations does not require or encourage higher order thinking about volume. A sameness analysis reduces the problem from seven separate formulae to slight variations of one formula: the area of the base times the height ($b \times h$). It also introduces an important concept: volume is a function of the area of the base and the height. Programmes that present seven diverse formulae, and encourage rote memorization of them, obscure this function (Carnine, 1991).

The first step is to classify the solids as rectangles (prism, wedge, cylinder), pyramids (rectangular, triangular, cone), and the sphere. The second step is to transform the formulae using prior knowledge of how to calculate area of bases, b: ($b = l\,w$ or $b = \pi r^2$).
Rectangles: $V = b\ h$
Pyramids: $V = (b\ h)/3$
Sphere: $V = 2\ (b\ h)/3$
(For the sphere, the base is the area of a circle that passes through the centre and the height is the diameter.)

Engelmann, Carnine and Steely (1991) provide several other examples of sameness analyses in mathematics. For example, they apply the sameness principle in the number family to word problems requiring comparisons, sequencing, classification, data tables, multi-step problems, fractions and percentages.

History

History often concerns the decisions and actions of people and governments in response to problems. Kinder and Bursuck (1991) proposed teaching students to use a *problem - solution - effect* structure for analyzing historical events. In their analysis of American history, they found the causes of the problems to be small in number and that there were a few, common solutions to those problems. The outcomes or effects of the these solutions frequently resulted in other problems. This pattern (*problem - solution - effect*) is a sameness that can facilitate understanding of relationships between events, facts, and concepts.

Most of the problems they analysed shared the sameness of being economic in origin, although they also identified issues such as human rights and religious freedom. Solutions could be classified as fighting, moving, inventing, accommodating, or tolerating the problem. Kinder and Bursuck (1991) suggest that, if learners can identify the problems, solutions and effects in historical events, they may look for these features when reading history. This framework will assist them to organize and understand information. This approach does not eschew the need to teach knowledge such as the basic economic principles necessary to make a problem analysis, and skills such as note taking.

Science

Learners may apply underlying scientific principles to a range of scientific phenomena. that share the sameness of the scientific principle. Woodward and Noell (1991) propose that students learn conceptual models that will help them think systematically and apply their knowledge to other problems.

To describe the principle of *convection*, Woodward and Noell (1991) use the example of a pot of boiling water. Heat transfers from an element to the molecules of water which then move in a roughly circular pattern. Several principles are imbedded in this. These include the principle of dynamic pressure (movement from high to low pressure), the principle of conduction, and relative density (expansion reduces density). Woodward and Noell describe how to teach each principle independently and then cumulatively link them to other principles. Students can generalize their understanding of how convection cells work in a pot of boiling water, to phenomena such as circulation patterns in the atmosphere, the oceans and the earth's mantle. Students learn that explanations of these include the model of the convection cell. It is also important for students to also learn relevant differences between these phenomena. For example, the rotation of the earth also influences atmospheric movements.

Knowledge of the samenesses and differences provides an explanatory framework for higher order thinking. Woodward and Noell (1991) describe the following problem: A person is standing on a beach watching the sunset. A mild wind is blowing and no special weather factors are present (e.g., an approaching storm). In which direction is the wind blowing and why? Students should be able to draw on their knowledge of convection cells and changing heat sources (as the sun sets the land cools faster than the ocean). Once they deduce that air will rise over the ocean and begin a convection pattern, they will be able to state that air will move from the land towards the ocean and explain why.

Composition

A source of sameness in writing is the recurring patterns or structures in text (Englert & Mariage, 1991). A number of structures underlie the organisation of text. These include the narrative structure and the expository text. Narrative text shares the samenesses of having a setting (characters, time, place), a problem, a response to the problem, an outcome and a conclusion. This sameness enables students to analyze a narrative text and to structure and create their own narrative passage. Following such a structure will help students to include all of the necessary elements and to use correct sequencing.

There are several expository text structures to guide writers. These include comparison/contrast, explanation, problem/solution, and thesis/statement (Englert & Mariage, 1991). Each of these structures answers different questions. For example the comparison/contrast structure answers the questions: What is being compared and contrasted? On what features? How are they alike? How are they different? The explanation structure answers questions such as: What is being explained? What materials are needed? What are the steps? What happens first? Second? and so on.

Students need some prior knowledge and skills to use these text structures. For example, they need a semantic knowledge of terms such as alike, different, similar etc. They also need to be able to classify a writing or analysis task as requiring a particular structure and to identify the correct elements within the structure (e.g., what is to be compared or explained).

Conclusion

Students can learn information more efficiently and think conceptually about their learning if samenesses are made explicit in the curriculum. For example, the sameness in the formula for calculating the volume of solids is not only more efficient to learn, it requires students to think about volume as a concept. Teachers can teach students to apply the sameness principle to academic skills such as writing or analyzing history.

The structure of the curriculum shapes how it is taught. Curricula sometimes appear as collections of facts to be memorized and recalled during examinations. Such structures and examination procedures sometimes lead teachers to present the curriculum as a memory task. This does not promote higher order thinking. Instead, it restricts learning to Bloom's simplest educational objective: the memorization of unconnected facts.

Note

This paper is based on the work of Douglas Carnine and his colleagues. A detailed overview may be found in a special series of articles in the *Journal of Learning Disabilities*, Vol 24 (5 & 6), 1991.

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Systems Thinking in the Classroom

Ron Zaraza

Something strange is happening in Tim Joy's sophomore English classroom. Crowded around a computer, these La Salle High School students in Milwaukie, Oregon, are not reading or writing - they are creating electronic graphs. Polite discussions, as well as rancorous debates, focus on the graphs. Has some other class - perhaps economics or biology - invaded the sacred precincts of literature?

No, Tim's students have just finished reading William Golding's *Lord of the Flies*, and now they are using a special kind of software to graph each character's influence on the rising action. Defending their graphs with excerpts from the novel, students share work in groups and then make presentations to the entire class. The debate renews as discussions of power and influence open the door to deeper understandings of the novel.

With assistance from Steve Peterson of High Performance Systems, Inc., Tim has used STELLA II software to simulate the novel's processes and forces. Called Savage Instincts, his dynamic model charts the boys' declining civility as they change from innocents to murderers. As the model runs, students respond to prompts about key events, adjusting the savagery level according to their interpretation of events. A graph displays these levels of civility and savagery. Before continuing the simulation, students must cite evidence from the text as a rationale for their input.

Interest

Although initial work requires mastering the software, the task of analyzing the novel soon dominates student interest. One to one and in groups, Tim's students discuss the novel, analyzing symbolism and making judgments. Working with their peers on something that has become important to them, they intensify their discussion. They find they must rely on evidence and rational discussion, rather than feelings or memorization.

Absorbed by the task, students put in their own time to complete, repeat, or extend their work. Rather than simply answer questions posed to them, students formulate their own questions. They criticize and modify the model. As Tim puts it, "No longer did the students look to me for answers or direction, but they drove themselves, seeking to know something on their own, to plumb an idea that intrigued them."

CC-STADUS

Tim's work is a part of the CC-STADUS (Cross Curricular Systems Thinking Using Stella) Project. Funded by the National Science Foundation, this three-year project is training teachers in the Pacific Northwest to build and use systems thinking and computer modeling in science, mathematics, and social science classrooms, as well as in cross-curricular environments.

In the project's first two years, 66 teachers have completed training in three-week summer institutes. After learning the basics of systems thinking and computer modeling, these teachers developed more than 20 major cross-curricular models and supporting curriculum materials. Also, they and the project staff have developed scores of other models and units like Savage Instincts. Some models were created especially for use with low-achieving students; 19 teachers are now using these models.

Systems and Problems

Systems thinking is a way of looking at occurrences as a whole; of looking at problems in their complete environment. Rather than isolating one part of a problem, trying to solve it, and put it back into the system, the systems-thinking approach attempts to take in a larger scope, studying the interactions between different parts of a system. Related to this is System Dynamics - the study of structures and typical behaviors underlying system actions.

Researchers at the Massachusetts Institute of Technology have studied the structures of dynamic systems and systemic thinking for more than 40 years. These concepts, however, have yet to influence public education to any great extent. Though not conceptually complex, system dynamics only appears mathematically abstruse.

The development 10 years ago of STELLA software (Systems Thinking in an Experiential Learning Lab, with Animation) made it possible to simulate dynamic models on personal computers. To really understand system dynamics and thinking, such models are essential; they bring the study of system dynamics within the grasp of middle and high school students. Although other packages have since been developed, the CC-STADUS grant uses STELLA II, a second-generation software package for Macintosh and IBM computers.

Designing and solving systemic problems with STELLA II is conceptually dynamic. The modeling language uses icons to create diagrams for defining the system under study. As users test their assumptions with variables in a system, the software simulates the impact of such changes. Mathematical connections between components may be defined so as to generate graphs and tables, describing a system's behavior over time. Tim Joy and other participants in the CC-STADUS project find that this activity stimulates lively class discussions.

Concept Development

Dynamic models are excellent tools for guiding students to develop and master concepts in numerous areas. Teacher Mike Collins in Portland, Oregon, uses CC-STADUS materials with an accelerated/honors, after-school algebra class (even though this resource was originally developed for use with low-achieving students.) Clustered around a Macintosh LC II, Mike's students enthusiastically discuss the screen display - a graph of the water level in a bathtub. A simple STELLA

A Few Notes on Systems Thinking

Alan November, a consultant to ASCD's Technology Futures Commission, shared with us these views on systems thinking:

Systems are anything that have inputs and outputs. And there are systems of every kind: weather, cultural, economic. The classic system we think of is biological, with birth and death rates. In between, there are lots of details - disease, hunting, and food - as you would expect in a rabbits and foxes system, for example.

Systems are everywhere. We are immersed in them like fish in water, so we don't always recognize them: traffic systems, city systems, workplace systems. There are even systems in literature, such as in Shakespeare's play Romeo and Juliet. The inputs and outputs can be mapped as a system.

Curriculum, as we usually know it, doesn't resemble systems. It is all chopped up and separated. Kids, however, learn best when thinking in whole systems. Many problems are systems or subsystems. In order to solve complex problems, kids need to know systems thinking.

Software like Stella shows whole systems at once. You assign values or rates to various entities, and Stella projects it into the future. Stella is to system modeling as word processing is to writing.

Alan November can be reached at Educational Renaissance Planners, 2300 Harrison Street Evanston, IL 60201. Tel: (708) 475-5250. E-mail: november@cedar.cic.net model, The Bathtub simulates the filling and draining of a bathtub. As the faucet adds water at a constant rate, the drain removes water at a constant rate; both rates can be adjusted by students or the teacher. By varying faucet and drain rates, students develop an understanding of the concept of slope of a graph without ever having seen its formal mathematical definition.

The concept of slope, central to numerous dynamics in science, eludes too many students, particularly those who reach 10th-12th grade without successfully learning algebra. But in less than half an hour, these students have internalized, and not merely memorized, a model or definition for slope. Like their peers in other algebra classes, they use their model throughout the course, extending beyond numerical calculation to conceptual application.

Training

Summer training institutes accomplish CC-STADUS project goals through a three-week program in which teachers acquire expertise and materials for classroom use. Project sequence and training materials were designed by classroom teachers, so they are realistic and relevant.

Week 1 of CC-STADUS training introduces concepts of dynamic modeling and basic model structures. Beginning with Fishbanks Simulation(1), a resource-depletion model, teachers form groups, each managing a fishing fleet company. Attempting to maximize assets over a simulated 10-year period, groups make challenging decisions about purchasing ships and where to fish.

The remainder of the week is devoted to introductory training with STELLA II. This first phase of training is done in content-area groups; cross-curricular activities come later. Intended to develop at least minimal comfort with the software, this part of the training provides teachers with models in their own disciplines that can be used immediately in their classrooms.

In Week 2, guests demonstrate uses of STELLA and other modeling approaches in their professional work. They present practical applications of systems thinking, from pharmacological research to climate modeling - even the evolution of historical patterns and events. Interspersed with these applications are presentations on the basics of systems thinking, with emphasis on basic dynamic models that describe certain behavior patterns.

Cross-curricular teams begin forming during this second week. Ideally, a team is composed of a social science teacher, a mathematics teacher, and a science teacher. These teams will ultimately collaborate in building their own model - an excellent experience in cross-curriculur planning.

In the project's final week, teams complete their cross-curricular models and design related curriculum materials. Steve Peterson, a co-founder of High Performance Systems (publishers of STELLA II software) provides personalized help. This is a period of intense activity as teachers collaborate in developing original dynamic models with others of different educational backgrounds and perspectives. Afterward, ongoing support is provided in monthly meetings and through assistance from project staff.

Curriculum

Teacher-made models reflect a broad range of topics, from disease spread (Invasion of the Body Snatchers) to studies of population growth and a population's interaction with nonrenewable and renewable resources (The Rulers). Topics often focus on biological, economic, ecological, or sociological areas; but curriculum materials have also included units from multiple disciplines, especially mathematics. Participants are often amazed at how much mathematics is required for truly understanding some "nonmathematical" topics.

As "standalone" units, models can be taught without linkage to other units created through the project. And, although activities with systems dynamics do not constitute entire courses, we have found that their wise use raises levels of interest and expectation, improving performance in other activities as well.

We have not attempted to develop a comprehensive curriculum in any one discipline, nor have we aimed to develop a completely integrated curriculum. But we believe that systems thinking provides a useful tool for addressing some problems, for linking disciplines in studying those problems, and for fostering critical thinking.

Primary goals of the CC-STADUS project are to establish a rudimentary understanding of system dynamics, be familiar with STELLA II software as the vehicle for communicating the concepts of system dynamics, and gain experience in developing curricular materials for use with models. An additional goal is to create a library of single discipline and cross-curricular models for teacher and student use.

Teaching and Learning

In Tim's classes, models provide a starting point for open-ended learning. Algebra and science

Resources on Systems Thinking

Stella II

This software creates dynamic modeling in social studies, history, biology, economics, mathematics, literature, chemistry, physics, psychology, and environmental science. Available in Windows and Macintosh formats. Contact High Performance Systems, Inc., 45 Lyme Road, Suite 300, Hanover, NH 03755; (603) 643-9636; FAX (603) 643-9502. For a free demo disk, call (800) 332-1202

Improving School Quality

Educational Leadership, Vol. 50, no. 3, November 1992. Several articles on systems thinking and systemic change in schools. $5.00. ASCD stock # 611-92149.

Inventing New Systems

Educational Leadership, Vol 51, no. 1, September 1993. Theme of systemic change, reform, interdisciplinary learning. $5.00. ASCD stock # 611-93166.

Keeping Content Alive: What is the Relationship Between Integrating the Curriculum and the New Discipline-Based Content Standards?

This 1993 ASCD audiotape by Frank Betts explains how systems thinking with an emphasis on core values and other basic elements of the teaching and learning processes unify interdisciplinary and traditional approaches to curriculum. $9.95. ASCD stock # 612-93162.

Designing Interdisciplinary Curriculum K-12

This 1993 ASCD audiotape by Heidi Hayes Jacobs explains how a systems approach to implementing interdisciplinary curriculum keeps student learning at the heart of all school processes. $9.95. ASCD stock # 612-93157.

Systems Thinking and the Integrated Curriculum

This essay by Frank Betts is found in Chapter 13 of the ASCD Curriculum Handbook. It explains the 10 underlying premises of systems thinking and how it applies to schools. Limited quantities of reprints available for $8.75. Call ASCD Customer Service at (703) 549-9110.

classes use models as vehicles for expanding knowledge. Learning is directed, yet driven by student discussion, rather than by teacher-dominated presentations.

Through using models, students learn to look at problems in depth, to consider options, and to be less likely to assume that there are simple, or "right" answers - a radically different approach for both teachers and students. Learners develop more sophisticated questioning strategies and take a more active part in their own learning.

Use of dynamic models influences teaching styles. Classrooms become more discussion oriented and less teacher centered. In-depth learning, with critical thinking, rather than rote memorization or mastery of simple concepts, requires students to become more involved and to take greater responsibility for achievement. Students "learn how to learn," a most desirable outcome in any classroom.

Project participants have made good use of their own models, as well as those created by others. Over 70 percent of the participants are using models in their classrooms, and many of them continue to build new models. One teacher, Matt Hiefield, was honored as Oregon Social Science Teacher of the Year on the basis of some of his work using STELLA.

At Franklin and Wilson High Schools in Portland, (home schools of two of the project's principal investigators), the idea of system dynamics as a learning tool has been pushed still further. Both schools offer classes in system dynamics and computer modeling. Here, students learn the basics of both systems thinking and modeling using STELLA. After mastering the basics, students build models on assignment.

Student Projects

In Scott Guthrie's class at Wilson, students create models of systems they are familiar with through personal experience or through media coverage. It was logical, therefore, that students create models of hydroelectric dams with complex systemic dynamics. Dams are a major source of electrical power in the Northwest, but also a source of controversy, from impact on salmon to allotment of water for irrigation. In building these models, students quickly discovered the need to start with simple models, increasing complexity slowly as they studied systems. As students select and research their topics and develop and document models, their final assignment is a major report based on their studies. This is the heart of the course in the second semester.

Diana Fisher, Project Director, has her Franklin High School students tackle daunting problems with amazing success. One pair of students studied the capitalization and operation of a Bed and Breakfast. Their model is a detailed look at the first 10 years of operation. To develop their model, the students gathered data on loan and real estate costs, market research, and all costs of operation. Another group, using data from the Centers for Disease Control, developed a model that simulates the spread of the Ebola virus. An economics class at Franklin played a business game based on the law of supply and demand. That provided a jumping-off point for a group of students who built a model of supply and demand for an industry; the model included research and development, investment, and marketing costs.

Guthrie's students simulated the progression of a natural environment from grassland to climax forest. One student modeled energy use in China, using it to predict future problems. That same student used a STELLA model as part of his successful early admission application to Harvard University. Some of the students at Wilson were also interested in business growth and management. One group modeled the growth of a winery business, and others looked at coffee production and importation.

Both classes give students unique learning opportunities and control. Students choose a problem and research it - sometimes choosing a new problem when their original idea proves too complex. They plan and build models, learning how to troubleshoot and problem solve as they go.

Once they have a basic model, students refine it, documenting their work along the way. This documentation crystallizes the logical thinking process, ensuring a well thought-out model. Finally, their reports pull all their work together, presenting it in a usable, readable format. Such reports are quite impressive, bearing more resemblance to college, graduate level, or business research than to typical high school assignments.

A Combination of Skills

We have found that constructing and documenting models encourages creativity and critical thinking. Our students have become self-motivated and self-directed learners capable of evaluating choices and making thoughtful decisions. This combination of skills prepares them not only for higher-level education, but also for the world of work--one of our highest goals.

Note

(1) Fishbanks Simulation is produced by IPSSR, Hood House, University of New Hampshire, Durham NH 03824.

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Scientific Reasoning - Why it is so difficult for students?

Boo Hong Kwen

Research (Boo, 1994; 1995; 1996) has shown that A-level students have difficulties in reasoning scientifically.

What is 'Scientific Reasoning' ?

In order to understand what we mean by the term 'scientific reasoning', it is necessary to consider what the nature and aims of science are. Einstein (1954) offered the following definitions of science, and the aim of science:

> Science is the attempt to make the chaotic diversity of our sense-experience correspond to a logical uniform system of thought. The aim of science is, on the one hand, a comprehension, as complete as possible, of the connection between the sense experiences in their totality, and on the other hand, the accomplishment of this aim by the use of a minimum number of primary concepts and relations.

Implicit in Einstein's definition is that scientific knowledge is never absolutely true but is a theoretical construct to be constantly refined.

Chalmers (1990) suggested that:

> the aim of science is the establishment of generalisations governing the behaviour of the (physical) world.

Reif and Larkin (1991) offered the following definition:

> The central goal of science is to achieve optimal prediction and explanation by devising special theoretical knowledge which parsimoniously (i.e. on the basis of a minimum number of premises) permits inferences about the largest possible number of observable phenomena.

The important point from all these definitions is the predictive nature of science; i.e., the ability of science to not only adequately explain observable phenomena but also to provide a basis for the prediction of unfamiliar or unobserved events.

From these definitions, it could be inferred that, among other things, scientific reasoning involves both inductive and deductive thinking. It involves inducting concepts, principles, generalisations, theories, models from perceptual experiences with natural phenomena, and then through a process of deductive thinking uses these (few) basic concepts, generalisations, principles, theories or models, to explain and make predictions about a wide range of natural phenomena.

For example, one would reasonably expect an average A-level chemistry student who had been exposed to chemical reactions probably for 5 to 6 years (from secondary 1 to junior college/pre-university level) to have abstracted the chemist's view that all chemical reactions, while superficially different, can be explained or predicted by a single consistent reference model, viz.:

> Chemical change involves interactions between numerous particles which are in constant motion. Such interactions include collisions between particles of reactants; breaking of existing bonds and making of new bonds within/between particles. Bond breaking is a process which requires energy input while bond making is a process which is accompanied by the liberation of energy. The magnitude of the overall energy change is governed by the difference in strengths of the bonds formed vis-a-vis bonds broken. Where bonds formed are stronger than bonds broken, the reaction would be overall exothermic - as is the case in all 5 reactions discussed. Where bonds formed are weaker than bonds broken, the reaction would be overall endothermic. The driving force of the change is the decrease of heat energy in the chemical system resulting in an overall more stable state or the increase in the total entropy of the universe.

Only about 10% of the subjects interviewed by Boo (1994; 1995; 1996) were able to reason consistently according to this (or, indeed, any other) reference model.

In general it was found that students tended to use everyday/ layman language rather than scientific concepts and principles in their reasoning overall energy change and driving force of chemical change.

At A-level, having studied at least 10 years of science and 3-4 years of chemistry, one would expect these students to be able to make predictions of the type of change expected based on concepts, inciples or models that they have learnt. Instead, when asked for the bases of their predictions (of the type of change expected or of the overall energy change), the vast majority were: 'based on what I can recall' or 'based on what my teacher (or textbook) said' or 'based on what I learnt in school' (or words to those effect). These responses showed that there were little understanding of the role of concepts, principles and models in prediction.

Why do students find it difficult to reason scientifically?

There are at least three possible reasons why students find it difficult to reason scientifically. These are:

1. They lack understanding of the nature and goals of science.

If students view science as a body of facts rather than predominantly a process of constructing predictive conceptual models, then it is likely that they might not have attained and internalised the scientific concepts, which in turn would mean that they would not be able to use these concepts consistently in explaining and making predictions about a wide range of chemical phenomena.

2. They learn labels for concepts without learning the full conceptual meaning.

Many studies have shown that students have a tendency "to reduce theoretical knowledge and principles to a 'factual' level and 'apply' this in a rote fashion" (Garnett, Garnett and Hackling, 1995, p. 89). If students have learnt by rote and have not abstracted or constructed the scientific concepts, principles and

If students have learnt by rote and have not abstracted or constructed the scientific concepts, principles and models for themselves, then it would be difficult for them to apply these across a variety of superficially different phenomena.

Students therefore need to be explicitly informed of the nature and goals of science and how these differ from those of non-sciences as well as from the everyday life.

models for themselves, then it would be difficult for them to apply these across a variety of superficially different phenomena.

3. They have confused the goals and hence ways of thinking of science with goals and ways of thinking of the everyday life.

This third reason is discussed by Reif and Larkin (1991) and is probably related to the preceding two reasons. As a consequence of not understanding the nature and goals of science, and/or of not having learned the concepts meaningfully or deeply, and because the influence of everyday life is stronger than that of school science, students tend to confuse the goals and ways of thinking of science with those of the everyday life. In everyday life, knowledge and rules of conduct tend to be compartmentalised i.e. various kinds of knowledge can be used as appropriate in different contexts without requiring great generality. Not understanding the nature of science and scientific knowledge means that students tend to compartmentalise their knowledge of different type of chemical reactions rather than recognise the generic model underlying all chemical reactions.

In fact another compounding factor which is suggested by Reif and Larkin (1991) is that school science often does not adequately foster the scientific goal of understanding. Instead, many science courses taught in schools tend "to encourage and reward the memorisation of knowledge rather than the ability to make diverse inferences leading to scientific understanding."

Implications for teaching

Today, much science teaching in the classroom is carried out in the 'top-down' manner reflected in the student responses just mentioned. The teacher will introduce a topic, present and explain the concept and its meaning and then follow up with practical work to reinforce the material covered.

As suggested by Gilbert (1991) science education should proceed from a definition of science as "a process of constructing predictive conceptual models". Students therefore need to be explicitly informed of the nature and goals of science and how these differ from those of non-sciences as well as from the everyday life. If they are not explicitly made aware of the nature and scope of science perhaps it is not surprising that their conception of science has been a rather narrow one.

This process of constructing predictive conceptual models has a number of well ordered steps:

1 Observation of a range of natural phenomena.
2 Grouping and categorisation of data collected from observations.
3 Construction of a conceptual model to explain the relationships between data within a category.
4 Design of controlled experiments to test the correctness of the model against the possible values of data within the category.
5 Acceptance of the model as the best explanation currently available of the relationships between data within the category.
6 Use of the model to predict as yet unobserved outcomes, ie to extend the boundaries of the category.
7 In the event that (a) the model is shown to be an inadequate representation during controlled experiments, or (b) new observations are at variance with the prediction, then the process is repeated from either stage 2 or

stage 3.

8 In the search for maximum explanation with the minimum number of primary concepts, science will test the boundaries between categories with the aim of one category subsuming another.

If science teaching is carried out in a 'bottom-up' manner, i.e. through using a wide variety of concrete and perceptual experiences to guide students to abstract and construct concepts, principles and models for themselves, then it in fact, maps the course of development of many scientific concepts, theories and models. In other words, it is this researcher's belief that science teaching carried out in a 'bottom-up' manner and which takes into account the historical development of science could result in more meaningful and effective learning of concepts and principles, and hence, scientific reasoning.

As observed by Lunetta and Cheng (1987), students can learn that they are developing conceptual models to better understand the world around them and that they can come to understand that as they get more information then their conceptual models must grow and evolve and change. Following concept formation, students should be given examples illustrating the wide application of these concepts, rules, principles and then they given situations where they could learn to apply the concepts, principles to make inferences about unfamiliar phenomena.

Another reason for students' use of everyday thinking and everyday language in the context of solving science tasks or questions could be that science (school science) is often taught (and hence perceived by students) as dull and uninteresting. This is in contrast to their everyday life which encompasses things which are interesting and full of strong emotions. Thus another approach to alleviating the problem of wrong use of everyday thinking in a scientific context is to inject interest and emotions in school science. Yet another prong of attack is to ensure that the everyday life is brought into school science by emphasising the applications of particular science concepts, principles in the everyday life.

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Thinking for Critical Literacy in the Primary Classroom

Christina Hvitfeldt

I recently gave a paper at a regional seminar in Singapore on the need for introducing argumentative thinking, a vital component of critical literacy, into the primary school language arts programme. During the discussion period which followed, participants from Singapore, Malaysia, India and Indonesia expressed concern that Asian parents and teachers, most of whom expect children to be obedient and deferential, would not welcome such an emphasis in the classroom.

Becker (1991) suggests that this negative attitude toward argumentation in the school setting is at least partially due to the fact that age has generally been equated with authority within Asian traditions. Mr Goh Chok Tong, Prime Minister of Singapore, expressed the view of many parents and teachers when he stated in a recent speech: "We must not unthinkingly drift into attitudes and manners which undermine the traditional politeness and deference Asian children have for their parents and elders." (*International Herald Tribune*, 1994, August 23, p. 3).

Becker also suggests that within traditional Chinese culture, argument is to be avoided because it requires direct confrontation. "Taking opposite sides of an argument necessarily meant becoming a personal rival and antagonist of the one who held the other side . . . If one did not wish to become a lifelong opponent of someone else, he would not venture an opinion contrary to the other person's opinions in public." (p. 236)

Clearly, reading and writing and the ways in which these acts are understood reflect the cultural values and the everyday needs of a society. Langer (1993) calls literacy culture-specific, suggesting that "there is no right or wrong literacy, just the one that is, more or less, responsive to the demands of a particular culture." (p. 201) When a society changes, it is natural that its literacy will need to change as well in order to adapt to new requirements. This is apparent throughout Asia, where the demands of the workplace are rapidly changing due to new technologies and sophisticated information systems. To respond to these new demands, schools are increasingly called upon to put greater emphasis on critical literacy, logical reasoning, problem solving and flexible thinking, skills that are becoming necessary even in entry-level jobs. During a recent interview, Mrs. Kam Kum Wone, Director of Research and Testing for Singapore's Ministry of Education, stated that "our students are very good in memory work and answering recall kinds of questions. But generally, they perform less well in questions that require reasoning or analytical skills. We should build on critical thinking skills. Teachers will have to think of approaches to get our students to think more, analyze more." (*The Sunday Times*, 28 August 1994, p. 14).

Applebee, Langer & Moll (1985) suggest that critical literacy begins when students take an active role in the reading comprehension process. "To foster higher-level literacy skills is to place new and special emphasis on thoughtful, critical elaboration of ideas and understandings drawn from the material students read and from what they already know. They must learn to value their own ideas and to defend as well as question their interpretations in face of alternative or opposing points of view." (p. 8). Norris (1985) emphasizes that, above all, "one must have the disposition to think productively and critically about issues, or else no amount of skill in doing so will be helpful." (p. 40)

The question which remains is whether educators really want their students to think, to question and to argue in defense of their opinions. In most classrooms, teachers continue to favour the children who sit quietly, don't ask too many questions, accept as truth what they are told and give the expected answers. Many teachers express concern that their authority will be undermined if children are encouraged to become more critical and questioning, having concluded that teaching for 'critical literacy' and maintaining 'traditional values' in the classroom are incompatible. Yet I believe that teachers can help students develop their own interpretations of what they read, elaborate upon the ideas and information they draw from their reading, and put forth reasons to defend their points of view in ways which are culturally acceptable. We can help our students to develop critical literacy, including argumentative thinking, using methods which emphasize discussion and collaboration and minimize confrontation.

Critical literacy through stories

Fisher (1987) calls a good story "a kind of investigation, an adventure in thinking and imagination" and claims that "all stories need thinking about, need to be recreated in our own imaginations. The response we have to stories tells us as much about ourselves as it does about the story; it offers us clues about our own lives." (p. 42) He suggests that fairy tales, in particular, appeal to children because they often have turning points where the main character must make crucial decisions that seem to be wrong at the time but somehow turn out right at the end.

In *Sleeping Beauty* one of these turning points concerns the decision of the parents - should they tell their daughter about the danger of spinning wheels in the hope that she will avoid them, or should they not tell her and simply destroy every spinning wheel they can find? This is the sort of question that can fruitfully be discussed at all ages, and one that can be applied to many of life's dangers. In *Jack and the Beanstalk* -- would you have swapped a cow for a handful of magic beans, or climbed a beanstalk into the sky? In *Hansel and Gretel* -- how would you have found your way out of an unknown wood, and would you go into a stranger's house even if it was made of sweets? There is a wealth of material in traditional tales to stimulate discussion and problem solving. Could you, like the *Three Little Pigs*, build houses out of straw, wood and brick and how would they stand up to the wolf's fierce breath? How would you have raised the *Enormous Turnip* from the ground? How would you have rescued *Rapunzel* from the Tower?" (p. 44)

Whatever the story, class discussion which encourages young

An important part of teaching for critical literacy is helping children become responsible for their own thinking.

children to share the thoughts and emotions that their reading has aroused stimulates thinking and enriches the reading experience. Speculating about alternative ways to solve the characters' problems provides an opportunity for children to produce ideas, provide reasons, explore implications and predict outcomes. It also provides a springboard for writing.

Commeyras (1993:489) describes the use of Dialogical-Thinking Reading Lessons in which students read and discuss a story that contains an issue or question that can be considered from more than one point of view. For Sheila Greenwald's *The Hot Day*, for example, the teacher wrote the following on the chalkboard:

Central question: Why did Mr. Peretz run away and never come back?
Side A: Mr. Peretz was scared.
Side B: Mr. Peretz was angry.

The students were then invited to choose one of the positions and explore reasons to support it. They came up with the following:

Side A: Mr. Peretz was scared.
1 Because he thought they were ghosts.
2 Because he thought a bomb went off.
3 Because the children yelled at him.

Side B: Mr. Peretz was angry.
1 Because the children broke into his room and made it cold.
2 Because the children came into his room without permission.
3 Because the children wasted talcum powder.

Class discussion then centered on which reasons were true, which were relevant, and which provided the strongest support for the conclusion. Finally, the children were given an opportunity to say what they believed as a result of all the thinking they had done on the topic, either orally or in writing. Commeyras suggests that children always be allowed to say they have not made up their minds, as knowing when to withhold judgement is an important element of critical literacy.

Mohr, Nixon & Vickers (1988) maintain that a good way to give upper primary children meaningful opportunities to participate in activities that require higher-order thinking skills is to use their favourite books. Their *Thinking Activities for Books Children Love* contains discussion guides for fifteen books chosen as favourites by children in Primary Three through Six. Each guide contains chapter questions which focus on knowledge, comprehension, application, analysis, synthesis and evaluation. The guides present an organized sequence of thinking activities that can be used with the whole class, small groups, paired or independent readers. The guides also encourage creative problem solving, as in the following pre-reading question on Sheila Burford's *The Incredible Journey*:

> A Siamese cat, an old bull terrier, and a young Labrador retriever attempt to travel back home over three hundred miles of Canadian wilderness. They have been purely domestic animals never even attempting to hunt their own food. What will they have to do to be successful in reaching their destination? (p. xiii)

The chapter guides for each of the fifteen books provide excellent models for the formulation of questions which demand various

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levels of thinking. The questions can be used in a variety of ways for discussion or for writing.

Another approach is taken by Matthew Lipman and his colleagues at the Institute for the Advancement of Philosophy for Children, who have produced a series of children's story books and teachers' guides to help children develop cognitive skills within a reading, reasoning and language arts programme. The beginning book, *Pixie* (Lipman & Sharp, 1989), is geared to a Primary Three reading level. It begins:

Now it's my turn! I had to wait so long for the others to tell their stories! I'll start by telling you my name. My name is Pixie. Pixie's not my real name. My real name my father and mother gave me. Pixie's the name I gave myself.

How old am I? The same age you are. (p. 4)

The teachers' guide for *Pixie* (Lipman & Sharp, 1989) provides discussion questions and exercises to stimulate thinking about each chapter. The discussion plan for chapter one focuses on names and includes the following:

1 Do you have more than one name? Explain.
2 Do your parents call you by the same name as your friends call you?
3 Do you use your name when you talk to yourself?
4 If you didn't have a name, would it matter to you?
5 If you had a different name, would it matter to you?
6 If you had a different name, would you be a different person?
7 Can you think of a name you would rather have than the one you have?
8 If people wanted to, could they re-name everything in the world?
9 Can people's names be bought and sold?
10 Is it possible that, as people grow older, they get to look more and more like their names? (p. 4)

The teachers' guide provides good models for the development of questions that have no single correct answer. These questions give children an opportunity to develop their own opinions and come up with reasons to support their points of view either orally or in writing.

Critical literacy through talk about thinking

An important part of teaching for critical literacy is helping children become responsible for their own thinking. To help them become aware of their own thinking and that of others, we need to teach them how to *talk* about thinking. Fisher (1987) suggests that talking about thinking can help children to avoid some of the following problems:

- errors of perception (it's right because part of it is right)
- egocentric thinking (it's right because I think it is right)
- trusting first judgments (it's right because it looks right)
- trusting others' judgments (it's right because he/she says so)
- distrusting others' judgments (it's right because you're wrong)
- errors of logic (faulty arguments, arguing from the irrelevant) (p.12)

In order to engage in critical literacy, children must learn to recognize their own biases. We can help students to see what they already know by encouraging them to share ideas through discussion and develop criteria for evaluation of their opinions through collaborative group work. Block (1993) contends that group work is particularly important in the development of critical literacy because it provides students an opportunity to talk about reasoning and, in doing so, uncover their own metacognitive processes. She suggests that group collaboration helps students to identify their own errors in reasoning by giving them the chance to see how their reasons differ from those of their peers. Students are then in a position to develop strategies to 'repair' their thinking.

Critical literacy through reflective writing

Although the writing of narratives is the most common form of writing in the primary school, children should also be encouraged to use writing to explore their thinking and develop their abilities to reason and solve problems. This kind of writing demands processes such as abstracting general principles, making inferences and deductions and speculating on possible causes, effects and reasons. To provide opportunities for this kind of thinking and writing, Fisher (1987:71) recommends questions which prompt speculation, such as: What if

- plants started to walk?
- you were turned into a frog?
- the oceans all dried up?
- you were really given three wishes?
- you were allowed to run the school?
- you discover your best friend is a thief?

Bicknell (1987) suggests the use of "Think Books," in which children are encouraged to write about their own concerns and ideas. In his experience with middle primary students, Bicknell has found that they most often write about the things they don't understand or have just discovered. He offers the following example from the Think Book of Alan, age ten:

> I don't understand why black people are black and white people are white. I think it might be because when we were cave men that some of them lived in hot parts of the world and others lived in cold parts but I thought that the world was cold then, so why are some people different colours to other people? (p. 66)

In addition to encouraging writing about thinking, Think Books provide opportunities for teachers to suggest to children how they might go about finding answers to the questions they raise, helping them to develop strategies for problem solving.

Block (1993) suggests that biography and autobiography can be used to good advantage in the development of critical literacy. She recommends that children read about famous people who were born on their birthdays, then discuss or write about what it would have been like to have been that person's best friend. The students then write their own autobiographies, using parents and grandparents as sources of information. Next, the children pair up with a friend and each writes a biography of the other. When they compare the autobiographies to the biographies, the children are asked to explain the differences between their own perceptions and the perceptions of others and the consequent differences in the autobiographical and biographical genres.

Conclusion

To help students develop the critical literacy skills they will need to meet the demands of a changing world, we must encourage them to think for themselves. We can begin by asking them to reflect upon their own ideas and present those ideas to their peers. We can promote thinking by asking questions which require students to examine their assumptions or extend their thinking into new areas. When discussing stories, we can ask questions to help students interpret information and generate hypotheses. We can ask them to state opinions, give reasons for those opinions and come up with criteria for evaluating their reasons. We can talk about thinking and help students to monitor their own reasoning. When students write, we can encourage the thoughtful elaboration of ideas, the consideration of cause and effect, and the application of principles to new situations. We can do all this in an atmosphere of collaboration, where children work together to reason things out.

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Culture Influences Thinking: People's Conceptions of Creativity

Tan Ai Girl

This article intends to highlight the influence of culture on thinking. The first part examines connotations of the word "thinking" in English, German and Japanese languages. Japanese language emphasizes both the affective and cognitive aspects of thinking, whereas English and German languages consider the latter. The second part discusses the position of "thinking" in psychology. It is believed that thinking processes should be investigated in relation to the daily life. The third part reviews people's conceptions of creativity in Germany and Japan. Laypersons' conceptions of thinking may provide useful information about cultural influences on thinking.

The Word "Thinking"

"**Think** is the general word, and can refer to any use of the intellect to arrive at ideas or conclusions" (Funk & Wagnalls, 1979, p. 618, bold in original text). Specific terms describing "thinking" or "to think" are such as "to cogitate" (to think seriously or continuously), "to reflect" (to look back in a thoughtful way), "to reason" (make logical or empirical generalizations based on evidence) and "to speculate" (to theorize on the basis of little or no evidence). These words refer to the process of setting "the mind to work in order to seek an understanding of something, solve a problem or get at the truth." (p. 618) Idea, concept, conception, impression, thought and notion are products of thinking. These terms denote "something that exists in the mind during the processes of perceiving, thinking or willing" (p. 283). Thinking is a covert process. Thus, most of the time one may not realize when thinking takes place and how it performs. According to French and Roger (1992), thinking occurs in every moment in life (active). It requires prior knowledge and language to formulate. It expresses thoughts and is the ability to develop representations of knowledge and concepts. Thinking is a recursive process. The thinker prepares to think, thinks, rethinks, checks, rechecks, and concludes at least at that point in time. With new information or in a new situation, the process may begin again. All human beings, children, adults or elderly people, think. Thinking is a natural process, and occurs in a context. Thinking process is influenced by the society. According to Wundt, thinking is "a kind of social psychological problem best studied naturalistically" (Dominowski & Bourne, 1994, p.5).

The Word "Thinking" Across Cultures. Connotations of the word "thinking" of different languages may provide some understanding of thinking across cultures. The word "thinking" in Japanese is "omou" that is represented by a vertical combination of two characters "field" and "heart". "Omou" according to a Japanese dictionary consists of the following connotations (Matsumura, 1989):

1. To evaluate and judge in the *kokoro* (heart), forming a person's opinions.

2 To bring events and thoughts that appear in the *atama* (brain).
3 To have attention and be conscious.
4 To concern about someone's future.
5 To miss the beloved or someone of the home country.

"Thinking" in English according to the Oxford English Dictionary (Simpson & Weiner, 1989) comprises the following connotations:

1 To conceive in mind, exercise the mind.
2 To call to mind, take into consideration.
3 To be of opinion, deem, judge etc.

Thinking or "Denken" in German, according to Brockhaus Encyclopedia involves higher recognizing abilities. It links with the visible objects, words or figures. Productive thinking consists of opinions that are organized in order, and that has treated a problem for a long duration. Thinking is not only an innate language. Ongoing thinking is supported by impressions. Invisible thinking always showed through body languages.

The word "thinking" in Japanese emphasizes more the affective than the cognitive aspect compared to that of English and German. One may interpret this to the emphasis of Japanese culture on affection and dependency. Thinking in the Japanese context performs in the *kokoro* heart and the *atama* brain. The emphasis on the affective aspect may be associated with the norm to maintain harmonious human relationships. In German and English languages the word "thinking" is purely related to cognition. For them, the brain is the organ that manipulates thinking processes.

"Thinking" in psychology

Thinking is a mental activity that a person performs, when information is gathered and used. The result of thinking is "thought". Thoughts are integrated information of a person's knowledge of a certain field or topic and of his (or her) experiences. In psychology, thinking is not only investigated from its products (thoughts), but also from its processes (how does thinking occur), components (what constitutes thinking), as well as from its influence on human beings' behaviors.

The study of thinking is one of the essential topics of psychology. Much knowledge of thinking can be found under the field "cognition". Thinking is also related to other fields such as learning and development. According to Koch and Leary's (1985) classification, cognition is one of the fields of psychology like sensory processes and perception; learning; motivation, emotion and value; development; personality; and social psychology. With the rapid development of communications, computer technology, and mathematics of systems, as in game theory and operations research, the study of thinking has gained its acknowledgment after 1950s (Newell, 1985). During this time there was a shift of attention to information-processing models. Segall and his colleagues (1990) claimed that "the study of cognitive activity is fundamental to psychology and to education" (p. 91). They introduced the study of everyday cognition. Cognitive ability related to our daily usage provides a link to understand thinking in various cultural settings. An example of this type of research is the study of practical intelligence (see Sternberg & Wagner, 1986). This study focuses on the kind of intelligence that is often used in daily life and/or on the jobs. Other examples are the investigation of lay theories in psychology (see Furnham, 1988), people's conceptions of creativity (see Tan, 1994 & 1995a), intelligence and wisdom (see Sternberg 1985).

People's Conception of Creativity Across Cultures

"Culture and individual are inseparable and that culture is the way we think, feel and behave." (Kim & Yamaguchi, 1994) Triandis's (1972) subjective culture is defined in terms of the way a person perceives his environment. "By subjective culture we mean a cultural group's characteristic way of perceiving its social environment." (p. 3) According to him, people who share a common language and who do similar activities have high rates of interaction. These frequent interactions provide the opportunity of the existence of similar norms, attitudes and roles. Similarities in physical type, sex, age, religion, place of residence and occupation increase such interactions, and induce a similar subjective culture.

In-Group Behaviors and Self-Disclosure. The Japanese subjective culture is collectivist (Hofstede, 1980) that emphasizes views, needs, and goals of the in-group rather than that of an individual (Triandis, 1990). In-group is a group whose norms, goals and values shape the behavior of its members. Social norms and duty of a collectivist society are defined by the in-group. Beliefs are shared. There is a great readiness of the people to cooperate with the in-group members. Team work and group reward are the two important characteristics of the Japanese (Suzawa, 1985). Outstanding personal achievement under the influence of strong in-group behaviors may be perceived as a life event that brings forth not only eustress (pleasant stress) but also hyperstress (overstress) (Tan, 1995b). One confronts with the principle of commonality of a group if one performs different from others. Strong conformity to the in-group norms may discourage a person to voice his (or her) opinions orally before knowing the consensus. Kawakita-Jiro (K-J) developed a brainstorming method in Japan. Participants organize their creative ideas with cards. Cards help to reduce the insecurity of an individual to express different ideas in a group.

In a cross-cultural study (Tan, 1995b), Japanese engineering students' conceptions of technical creativity (N=109, average age=21.3) were compared with those of the German engineering students (N=80, average age=23.3). Subjects were requested to disclose whether they attended technical courses, possessed self-confidence to create something and which type of social supports they would seek if they would realize an invention. Results showed that Japanese students disclosed less than their German counterparts (see Table 1). Less than one-third of the Japanese students gave a positive answer to questions regarding attendance of technical courses and confidence to create compared to more than three quarters of the German students. German students were more keen to seek social supports from various sources than the Japanese students. German students who live in an individualist society would seek supports through reading book (first rank), discussing with fellow student (rank 2) and would realize the invention themselves (rank 3). Japanese students, on the other hand, would seek knowledge from the book (rank 1) and journal (rank 2) before they consult their fellow students (rank 3.5), tutor (rank 3.5) and professor (rank 5). Professor was not a significant resource of social supports for the German students (rank 7). The Japanese students who have collectivist behaviors did not consider using their own efforts as an important means to realize the invention (rank 9, the lowest rank). Living in a society which emphasizes the harmonious relationship between seniors and juniors, the Japanese were fond of getting advice from their superiors (for example, professors).

The industrialized culture of a society influences the people's conceptions of creativity. Convenience and newness are two creative features of technical products that the Japanese students were more concerned than their German counterparts (see Table 2). German students on the other hand showed a greater favor of economic features. The Germans are proficient manufacturers for machinery tools, whereas the Japanese are fine manufacturers of electronic goods, semiconductors and computer (Okurasho, 1994). Machinery tools are meant to accelerate the production. Time, work and cost reduction are important features. Compact and new are two essential characteristics of electrical and electronic products. Though there is no significant difference between the German and Japanese perceptions of beneficial features of technical products, the German students showed a higher concern of this aspect. The Green Peace activity has stimulated the German society's consciousness in protecting the natural environment. For the German engineering students besides the economic characteristic, technical products should consist of features that are not destructive to the environment.

Summary

The concept of thinking is examined from various perspectives. Connotations of thinking in various languages show that some cultures emphasize the affective aspect of thinking and

Table 1. Self-Disclosure Across Cultures

	German (n=80) No. (%)		Japanese (n=109) No. (%)	
Attended technical course	77 (96.3)		17 (15.6)	
Had confidence to create something	60 (75.0)		31 (28.4)	
Source of social supports for realizing an invention:		Rank		Rank
Book	47 (58.8)	1	51 (46.8)	1
Student	37 (46.3)	2	25 (22.9)	3.5
Self	36 (45.0)	3	6 (5.5)	9
Journal	26 (37.5)	4	37 (33.9)	2
Tutor	19 (23.8)	5	24 (22.0)	3.5
Patent	15 (18.8)	6	9 (8.3)	7
Professor	14 (17.5)	7	22 (20.2)	5
Database	13 (16.3)	8	8 (7.3)	8
Checklist	12 (15.0)	9	14 (12.8)	6

Table 2: People's Conception of Creative Products

Creative Features of Products	German (n =80) Mean (SD)	Japanese (n=109) Mean (SD)
Economic features (eg time, work and cost reduction, marketability)	5.23 (0.91)***	4.56 (1.15)
Beneficial features (eg environmentally friendly, energy saving)	5.64 (1.17)	5.30 (1.43)
Newness (eg interesting, unconventional)	4.27 (1.46)***	5.04 (1.17)
Convenience (eg handy, compact, no maintenance)	3.98 (1.30)***	4.87 (1.24)

Note: ***$p < 0.001$

some emphasize the cognitive aspect. Thinking is an important theme in psychology. Creativity is investigated in Japan and Germany. In Japan, strong conformity to the in-group reduces the willingness to disclose different opinions and behaviors from the group. Japanese conceptions of creative products reflect the success in electronic and semiconductor fields. On the other hand, German conceptions of technical products reflect their prevailing strength in machinery sectors and concern of environmental problems.

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