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Problem-based learning: A practical process for a more promising future

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A Practical Process for a More Promising Future

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SCHOOLS' ROLE IN OUR SOCIETY

A perpetual issue in American society is that of the comprehensive goal of its educational system. A prevailing conviction among researchers, teachers, lawmakers, and parents is that the purpose of this country's schools is to cultivate effective thinking in students. In a society that exhibits complex and threatening problems, noted Raymond Nickerson, we cannot afford *not* to develop good thinking (Baron & Sternberg, 1987).

Most Americans prefer living in a democratic society, which, to be most successful, must be composed of citizens who are capable of independently analyzing and synthesizing the information surrounding them. Unfortunately there is disparity between society's ideals and reality. While people want to live in a society that allows them to make their own decisions, they do not exert the effort required to make sound ones. It seems that one of the greatest obstacles to social progress is irrational behavior. This could be due to the fact that many Americans simply do not take responsibility for their actions, or perhaps it is because they are never taught *how* to think competently.

The potent influence the media has in this country is an excellent example of countless Americans' lack of effective thought. Advertisements, politicial platforms, and even news reports are all designed to be extremely persuasive. They are so effective primarily because people fail to be reflective thinkers, due to lack of either initiative or skill. Many Americans' spending habits also exhibit insufficient thinking. Numerous people neglect taking time to analyze and compare products and services; furthermore, they accumulate substantial debts without considering the consequences. Richard Paul suggested that societies such as ours are producing "vulgar and sophisticated but not critical believers" (Baron & Sternberg, 1987, p. 138). America is truly experiencing an age characterized by colloquial expressions such as, "Seeing (or hearing) is believing!" and "Live for the moment!"

Andrew Chrucky attributes much of our citizens' immoral and unwise behavior to our schools' educational practices. He believes too many instructional methods are teacher-

centered and/or promotive of competition and are therefore assisting in the creation of "self-centered, dependent individuals" (Oxman *et al.*, 1991, p. 48). This is unfortunate since mature thinking is all the more necessary in a democratic society whose citizens have the privilege of making so many of their own decisions.

SHORTCOMINGS OF AMERICA'S SCHOOLS

The tendency to take things at face value is evident even within our schools. Present classrooms are often receptacles for students who, in turn, are too often mere receptacles for information. Students frequently fail to realize that just because something is written in a textbook or stated by a so-called or even genuine authority does not necessarily mean it is true. Their false assumptions are certainly natural reactions to teachers who require them to accept and memorize information without question (Shermis, 1992). Clearly, students' lack of critical thinking skills is not solely their fault. It is also due to the failure of teachers to provide opportunities for students to engage in processes that require good thinking, such as solving authentic problems or representing knowledge in a variety of ways (Blumenfeld *et al.*, 1991). Research shows that the majority of the questions teachers pose require very little reasoning. Furthermore, teachers tend to allow students only a few seconds to consider and respond to a verbal question before answering it themselves (Swartz & Perkins, 1990). The result of this is an emphasis on low-level cognitive tasks that leads to students' lack of understanding and poor attitudes (Blumenfeld *et al.*, 1991).

Students come to realize, even during their early schooling years, that achieving superior grades is valued in this society. They become proficient, beginning even in junior high, at utilizing approaches they believe help them to obtain high numerical scores (especially on standardized tests). Such strategies include: *work as quickly as possible, memorize a great deal of vocabulary, practice taking numerous forms of tests, identify the most obvious answer within the list of answer options and move on,* and *try to "psyche out" the test constructor.* None of these tactics fosters a mentality of genuine problem-solving.

Students accumulate so much practice in arriving at quick answers based on information teachers have transmitted to them, that they rarely take time to really think about what they are doing. "What students often learn well -- that school is a place to repeat back what teachers or textbooks say and that to follow the correct steps in the correct order is to get the correct answer -- blocks them from thinking seriously about what they learn " (Barnes, 1992, p. 4). Teachers, textbooks, and tests usually provide very structured problems, which result in students rarely having to even identify or define problems (Court, 1991). Even when teachers try to utilize more complex, high-level activities, they conduct them in a way that decreases the need for student thought (Blumenfeld *et al.*, 1991).

Numerous sources cite more specific examples of students' inability to think critically. Kurt Reusser conducted a study in which schoolchildren were presented with the following problem: "There were 26 sheep and 10 goats on a ship. How old is the captain?" Nearly 75% of the children attempted to give a numerical answer. In another context, Ed Silver asked students to determine how many buses would be needed to take a certain number of people on a field trip. Although many students used appropriate strategies to solve the problem, resulting in answers such as "two and one-third buses," they failed to consider the fact that it is impossible to drive only a third of a bus (Bransford & Stein, 1993). Studies by Mullis and Jenkins in the late 1980's showed that only 7.5% of high school students were capable of making logical conclusions based on detailed scientific knowledge, and only 41.8% of them could comprehend, summarize, and elaborate upon moderately difficult reading texts (Bruer, 1993).

Even when students can recall a great deal of knowledge, they struggle to apply it. Therefore, they possess what is called "inert knowledge." Obviously the people who are most valued in society are *not* those who possess trivial or useless knowledge, but those who can put their knowledge to use in a variety of situations. Knowledge refers to a process or use of skills, not a product or outcome (Bruner, 1966). Fifth-grade students may be able to solve "story problems" on a math worksheet, but they are truly using their knowledge when

they are standing in a grocery store aisle and determining which brand of soup is the best bargain.

Students' lack of ability to apply what they learn points out two particular shortcomings of many educational methods. First, they are decontextualized. Rather than answering a wide variety of prepared problems on black-and-white worksheets, students need to practice solving problems in authentic situations. When they can manipulate tangible objects and clearly understand when and where to employ specific problem-solving tactics, they are much more apt to actually *do* so when they find themselves in real-life circumstances. A second shortcoming was mentioned previously: a number of educational practices do not require students to actually define problems (Bransford & Stein, 1993). A social studies "problem," for example, might be stated, "Imagine you are on a wagon train headed west on the Oregon Trail -- how will you handle encounters with wild animals and Native Americans along the way?" In order for students to actually define the problem, it could be worded as follows: "Imagine you are on a wagon train headed west on the Oregon Trail -- what obstacles will you encounter and how will you deal with them?"

Since teachers are responsible for implementing instructional methods such as those just described, they tend to receive just as much blame for students' lack of critical thinking skills. In some respects, this blame is misplaced. Teachers often have little freedom to experiment with newer teaching strategies due to state and district policies that allow them to make few independent decisions. Many educators have little control over the texts they use and the curricula they must teach, and some of them are required to cover vast amounts of factual information. In addition, they are pressured to raise students' scores on factually-oriented, standardized tests.

However, some teachers' methods have disappointing characteristics over which they *do* have a great deal of control. A survey given to experienced teachers and principals in November, 1990 (Moore, 1991), asked them to evaluate numerous aspects of beginning teachers (graduating after 1988) with whom they had worked. The 500 respondents believed

the areas in which new teachers had the most difficulty were in modeling and expecting correct usage of standard English in writing and speaking and in teaching critical thinking and problem-solving skills. The fact that many teachers do not write and speak well is extremely disturbing, but perhaps one of the leading reasons for students' insufficient thinking skills is that teachers themselves are not critical thinkers and did not graduate from teacher-education programs that emphasized higher-level thinking. Even universities do not require students to be reflective thinkers. For example, future teachers are usually introduced to the taxonomy of skill levels designed by Benjamin Bloom and are often expected to memorize it. Unfortunately, this taxonomy and many of the teacher-education professors who present it fail to help college students understand the attitudes and strategies necessary for cultivating thinking skills at its higher levels. Consequently, although young teachers are often proficient at reciting the levels of Bloom's taxonomy, they are unable to design lessons and activities that require their students to think at the upper levels of this taxonomy; this presents another example of inert knowledge.

HOW AMERICA'S SCHOOLS HAVE TRIED TO REVERSE THESE SHORTCOMINGS

Countless schools have, in recent years, attempted to develop students' reasoning skills by implementing specially-designed, thinking skills programs. According to Edys Quellmalz, however, administrators' commitment to these programs "has been largely rhetorical," so even if such programs *could* be effective, they would have little impact on students' thinking abilities (Baron & Sternberg, 1987, p. 86). Even when employed regularly, these programs merely introduce a number of thinking strategies to students, without helping them understand when to use which strategies or providing practice in using them. Other "quick-fix" approaches to improving students' thinking include raising school standards, adopting site-based management, lengthening the school year, raising teacher and student accountability, permitting open enrollment, and testing more frequently (Bruer,

1993). While there are a number of profitable characteristics to each of these ideas, they have few serious impacts on raising the level of students' reasoning abilities.

THE BEST SOLUTION

Educators have learned from past attempts that adopting innovations in curriculum or instructional methods is extremely difficult. Major changes can only be achieved when numerous factors are taken into consideration, including curricular content and organization, students' psychological characteristics, professional support, and teachers' efficacy (Blumenfeld *et al.*, 1991). Some researchers have proposed returning to old-fashioned courses and methods as a way of meeting the need for critical thinking in schools. One example would be what occurred in turn-of-the-century, rural schoolhouses. These learning environments often utilized activities that have now been found to hinder worthwhile learning, such as memorizing and reciting long lists of facts, writing about topics always selected by the teacher, and reading texts about which students had no prior knowledge (Corey, 1944). However, a few methods that promote critical thinking were practiced by these schools, including peer teaching, supporting one's opinion (often in written compositions), exploring the environment outside the school, and taking time to discuss any questions students raised. Nearly every realm of students' lives required them to employ good thinking skills, for problem-solving had to be done in a variety of situations on the farm, and they had plenty of time while performing daily, rote tasks to do a great deal of thinking. In contrast, many contemporary students spend most of the hours that they are outside of school in front of a television, where they do little (if any) higher-order thinking.

In a truly effective thinking environment, educators themselves strive to be critical thinkers and make use of a wide range of available materials. They incorporate activities that promote good thinking into every aspect of the curriculum, since "thinking illuminates content and vice versa" (Swartz & Perkins, 1990, p. 29). "[E]ducational institutions --

from kindergarten to university -- should be places where relevant and worthwhile thinking is embedded in every activity of the day, not as an exercise or subject matter, but as the way things are done" (Smith, 1990, p. 125). Students in such an environment are engaged in solving problems that allow for multiple interpretations or solutions and that encourage them to explain their thinking and transfer learning from one situation to another. Tishman, Perkins, and Jay (1995) proposed a "classroom culture of thinking," in which language, values, expectations, and habits coincide to express and encourage good thinking (p. 2). "We have to change the way teachers interact with students...and the changes must be grounded in an understanding of how children learn" (Bruer, 1993, p. 7). Restructuring must, therefore, begin within classrooms themselves, not in legislative or even school districts' offices.

THE NECESSITY OF IMPLEMENTING THIS SOLUTION

Few Americans dispute the fact that drastic changes in this country's educational system are sorely needed, as journal articles and polls from all echelons of society consistently portray. Employers and college instructors alike witness the "end results" of schooling and complain of young people's lack of comprehension, communication, and reasoning skills. H. G. Wells once said, "Human history becomes more and more a race between education and catastrophe." Among the contributors to catastrophe in our society are laziness (perhaps due to the number of modern conveniences many Americans possess), poor communication skills, lack of creativity, and an inability to solve problems. In a country where technology and job requirements change so often, business leaders are seeking problem-finders as well as problem-solvers (Kearns & Doyle, 1991).

Pessimists wonder if current educational practices are capable of warding off impending catastrophe. While optimists do not deny the existence of problems, they do see hope for the future as long as the right changes are made. Perhaps the words of Deborah Court, professor of social studies education at the University of Victoria, British Columbia,

(1991, p. 119) describe the situation best:

> For tomorrow's world, which is just around the corner, we need creative, questioning individuals, well informed and literate, who can work together to devise solutions to many problems that face us. These individuals should not be schooled in value-free reasoning but should be actively taught basic values of respect for persons and for the earth and all its creatures.
>
> We need to employ the many useful approaches we have for teaching critical thinking. In addition, we must work to redesign our schools so that they are less authoritarian (but not without guidance) and less examination driven (but not without accountability). If we do this in a courageous and thoughtful way we will produce good critical thinkers.

While this may initially sound utopian, such an educational environment is not all that unfeasible.

Among other vital points Court raised in the preceding quote, the first sentence of the second paragraph poses two implications. First, in the words of a common idiom, we do not need to "reinvent the wheel." Court did not say that we need to *find* approaches that cultivate effective thinking; rather, she encouraged us to use ones that are already in existence. This, of course, does not mean that all of the educational methods of high quality have been discovered, but she believes we *do* have sound approaches that can be adapted. Second, she pointed out the fact that there are indeed approaches that are expendable. In a culture so badly in need of critical thinkers, we must begin by creating discerning educators who make use of only those techniques that are most beneficial.

David Perkins claimed that America is experiencing "a time of ripeness for education." Many teachers, in his words, "find themselves in the midst of ferment: full of will to do something, faced with an abundance of choices, but ill prepared to make those choices well" (Baron & Sternberg, 1987, p. 41-42). Often they are not prepared to determine how to develop critical thinking skills in students because they are unable to pinpoint exactly what such thinking is.

CHARACTERISTICS OF "GOOD" THINKING

Psychologists have failed to agree on a completely satisfactory definition of "effective" thinking. One result of the continuing debate over this issue is the number of adjectives and synonyms that have infiltrated educational journals, university textbooks, and even the media. A list of such jargon would include: "reflective thinking," "metacognition," "critical thinking," "higher order thinking," "strategic thinking," and "creative thinking." Although there are disputable differences among the specific meanings of these terms, they are obviously interrelated.

Metacognition, an aspect of critical thinking that refers to being aware and in control of one's own thinking, is emphasized here because it is often considered to be the highest level of mental activity (Flavell & Wellman, 1977). Monitoring one's thinking and using strategies to direct it are essential in exercising efficient and independent thinking. Basic metacognitive skills include predicting the outcomes of one's own problem-solving actions, checking the results of these actions, monitoring one's progress toward a solution, and evaluating how reasonable one's solutions are. Although metacognition develops with age and experience, research has shown that such thinking can be fostered even in preschoolers. Teachers who introduce young children to metacognitive skills and help them refine these skills are helping them to learn how to learn (Bruer, 1995). This not only leads to children being more independent in learning, but also to becoming lifelong learners.

It would be quite simple to describe a "critical thinker" as a person who utilizes specific skills that perhaps not everyone does. However, numerous authors have cited the fact that truly critical thinkers possess certain dispositions (habits or inclinations), as well. Tishman, Perkins, and Jay (1995) suggest five essential "thinking dispositions" that ought to be cultivated in students: being curious and questioning, thinking broadly and adventurously, reasoning clearly and carefully, organizing one's thinking, and giving thinking time (being persistent). A list such as this implies that only a very fine line, if any, can be drawn

between the abilities and dispositions of a critical thinker; it seems as if they all support one another. The correlation between skills and inclinations is further illustrated in the ideas of Swartz and Perkins (1995), who add the following thinking processes to the list above: exercising keen judgment, challenging assumptions, and maintaining objectivity and balance.

"Good" thinking, then, is not only the ability but also the inclination to be insightful, think innovatively, assess critically, and make sound decisions. Numerous authors have gone beyond this "definition" to note that nearly all of the characteristics of effective thinking are necessary to successful problem-solving. For example, concerning the four attributes just mentioned, insight is needed to identify and define problems, innovative thinking results in creative solutions to problems, and critical assessment helps to evaluate sources of information and judge possible solutions in order to choose the best one. Since problem-solving comprises nearly all aspects of critical thinking, it ought to be a major focus at all levels of education.

Problem-based learning is one instructional method that has been employed primarily at the university and secondary levels in a variety of settings. Only recently has it been introduced to teachers at the elementary level. When conducted properly, this method promotes the development of all of the characteristics of critical thinking mentioned in preceding paragraphs. If youth and adults are expected to possess beneficial problem-solving skills, they must begin to acquire and practice these skills while they are still very young. Consequently, problem-based learning should be an excellent method to use more extensively in elementary schools.

A SURVEY OF PROBLEM-BASED LEARNING

When attempting to describe a concept, it is often just as helpful to understand what it is *not*. Numerous educational techniques have the word "problem" as part of their title or definition, yet they are not problem-based learning. Ross provided two examples of such methods: a problem-oriented method, in which problems are used as criteria for choosing curricular content, or a problem-solving curriculum, which involves providing students with specific training in solving problems (Boud, 1991). Problem-based learning also is not "simply the addition of problem-solving activities to [an] otherwise discipline-centered [curriculum]," as the name might imply (Boud, 1991). Howard Barrows, one of the pioneers of this method, defined it as "...learning which results from the process of working towards the understanding of, or resolution of, a problem" (Barrows & Tamblyn, 1980).

A BRIEF OVERVIEW

One of the most vital issues in understanding problem-based learning is recognizing what constitutes a good *problem*. This word is used in a wide variety of contexts even within schools; for example, different subjects relate to social problems or math problems, and the school atmosphere itself entails disciplinary problems and policy problems. Shermis (1992) described his (and many others') feelings concerning an example of the type of "problems" with which most American students are familiar:

> 'If Train A leaves a station going 90 miles an hour headed north, and Train B leaves the same station, headed in the same direction, one hour later but traveling at 110 miles an hour, when will Train B catch up with Train A?' -- [This isn't a 'problem' -- it's an exercise in converting words to a mathematical procedure.] I never really *cared* if Train B *ever* caught up with Train A. It simply was not *my problem!* (p. 51-52)

In problem-based learning, problems are "ill-structured." A very informal synonym can be used to define this adjective: ill-structured basically implies a "messy situation." The

actual problem is not clearly defined, and not only is there initially no apparent answer, but there also is not a sole, correct answer. As little information as possible is explicitly provided, and the procedure for solving the problem is also not given. The ulitmate goal is for students to experience both breadth and depth in learning. This occurs when they explore multiple points of view of related information and probe extensively into a few of these perspectives. Throughout this process, students often redefine the problem a number of times.

Perhaps the most fundamental attribute of problem-based learning is the context in which problems are introduced and handled. A term of educational jargon would describe such a context as *authentic*, meaning one that is as similar to real life as possible. Obviously everyday living is not separated into areas such as math, science, or writing, so problems are presented and treated with minimal attention to specific disciplines. If problems are of high quality and are processed thoroughly, students generally work in most of the acknowledged subject areas anyway. (This is often referred to as *integration*.)

Whereas in traditional approaches, students presumably have mastered the specific background information needed before they are even presented with a problem, this method requires them to begin with a problem and acquire their own knowledge as they solve it. The problem is introduced ambiguously so that students cannot immediately determine what to do. Rather, resources are made available for them to conceive their own definition of the problem and make plans for dealing with it. Many problems have no specific solution; for instance, students could not be expected to contrive a plan to end global warming. Such is the reason that this method is not called "problem-*solving*." Problem-based learning instead compels students to identify what needs to be known in order to improve upon or at least relieve the enormity of a problem-situation (Boud, 1991).

Usually through collaborative efforts (or *cooperative learning*), students discover what they already know about the proposed problem, identify what they need to know, gather information, and continually reevaluate their hypotheses. Some of their research can be done

independently, but plenty of opportunities to share ideas and new information ought to be provided. The teacher is discouraged from being a major resource in terms of factual content in order to prevent the classroom atmosphere from having a "hierarchy of expertise" (Boud, 1991). Rather, his or her primary role is to facilitate the whole process.

THE ORIGINS OF THE METHOD

The most influential pioneers of problem-based learning taught in the medical schools at Case Western Reserve University in the United States in the 1950's and McMaster University in Ontario, Canada, in the 1960's. At that time, medical education was in the midst of a long era during which it was essentially dictated by a formal lecture approach. In order to allow students to be more active in their learning process as well as to alleviate the stress on first- and second-year students, a problem-based program was instituted in the Schools of Medicine at these two universities. The most significant modifications included more interaction among instructors and students and students' being provided with real-life medical problems to analyze. This led to a much less competitive environment in which instructors and students openly discussed issues and learned from one another.

By the mid-1970's this format was introduced to the medical school faculty at the University of New Mexico. Research at that time showed that students in the problem-based program were learning the basic content of the curriculum just as well as their counterparts in traditional programs. Furthermore, those involved in the new program were more inclined to undertake their own learning endeavors because they felt less threatened by the classroom environment, which indicated that they were apt to become lifelong learners (Aspy, 1993).

During the following decade the Harvard University School of Medicine implemented this method; soon universities across the country and even around the world incorporated aspects of this approach into their teaching practices. Instructors were often opposed to changing what had worked well for them for so many years (the lecture format, for

instance), but after considering the best interests of the students, they usually realized the benefits of problem-based learning. Not only could students receive more training in handling authentic medical problems, but they also did so by collaborating with each other as well as the instructor, instead of expecting the instructor to provide all of the answers.

Once the advantages of this method were noted at universities, it was introduced to teachers at the secondary, and more recently, elementary school levels. This was done with the assumption that if older students master roughly the same amount of material and become more independent learners when they deal with real-life situations, then using this method with younger students should have similar results. Proponents of the method were faced with a new challenge: training teachers in conducting problem-based learning. As this method continues to seep through the realms of education, the issue of teaching people how to manage it is constantly evolving.

The simplest means of instructing teachers about this approach is to place them in the midst of it. When asked to handle problems that arise from their actual teaching circumstances, they realize how much thinking, analyzing, collaborating, and learning occur on the part of the students in a problem-based learning situation. Once they are trained in facilitating this process and perhaps even in devising problems, teachers feel more comfortable in incorporating problem-based learning into their own classrooms. Through experience and practice, they gradually become more adept at presenting problems, encouraging students to take initiative for their own learning, and assessing students' progress.

NOT JUST ANOTHER EDUCATIONAL FAD

Anyone even moderately associated with the field of education is well aware that various teaching methods come and go with continued research. Some techniques are worthwhile, yet do not adapt to the changing needs of both students and teachers. Problem-based learning is not such a method. In fact, researchers such as Charles Engel believe it is

best described not as a way of teaching, but rather as a means of learning (Boud, 1991). Because problem-based learning has been formally practiced in classrooms for over thirty years and teachers from all echelons of education continue to learn about and implement it into their practices, it can hardly be another passing fad. Furthermore, the fact that highly-esteemed schools, such as the Harvard Medical School and the Illinois Science and Mathematics Academy, have advocated this method portrays many respected educators' beliefs in its value.

Unlike many other instructional methods that tend to "come and go" because they are both supported and opposed by contradictory research results, the research concerning problem-based learning has not shown that it negatively influences students' learning. Gallagher, Stepien, and Stepien have found that students in problem-based learning environments acquire an equal amount, if not more, factual knowledge than those in more traditional programs (Stepien, Gallagher, & Workman, 1993). In a study by Gallagher, Stepien, and Rosenthal (1992), a one-semester course entitled, "Science, Society, and the Future" was taught to twelfth-grade gifted students. The course was designed to improve students' problem-solving skills and engage them in ill-structured, interdisciplinary problems. Comparisons of pretest and posttest results showed that after completing the course, the students worked to define and then proceeded to solve problems much more frequently than they had previously. It has been discovered that students in problem-based programs like school more than those in traditional programs (Kaufman *et al.*, 1989). They also utilize more productive study strategies, resulting in comprehension of material as opposed to merely being able to recapitulate it in various modes. (One limitation of studies in this area is the ambiguity of the independent variable; it is difficult to define a "traditional" program [Hallinger, 1991].)

DETAILS CONCERNING THE PROCESS OF PROBLEM-BASED LEARNING

TEACHER PREPARATION

A teacher who practices problem-based learning spends a great deal of time planning each unit of study long before involving students. Each step of the process must be seriously considered and well-organized in order to be better prepared for how students will handle the problem. The more work a teacher does in preparation, the better he or she will be at facilitating the problem-solving process in such a way that students experience both breadth and depth in the unit of study.

SELECTING THE PROBLEM

An ill-structured problem can be based on current events, real-world problems, or curricular themes. The problem and its implications must be of genuine interest to the students in order for them to become motivated to find solutions (Lepper, Greene, & Nisbett, 1973). Consequently, problems should be adapted so as to meet the needs, interests, and skills of the students at hand. When determining the content of ill-structured problems, Hallinger (1991) proposed considering the following attributes:

-Prototypical *Does this kind of problem occur in real life?*
-Integrative *Does this problem lend itself to studying concepts from several disciplines?*
-Prevalent *Is this type of problem common?*
-Significant *Would a problem such as this influence a large number of people?*

DETERMINING OUTCOMES OF A PROBLEM-BASED UNIT OF STUDY

It is essential that teachers be able to explain the significance of their students' endeavors on problems, so a rationale should be established for each one. After some

preliminary research has been done (thereby identifying possible resources and references), it is helpful to consider how various subject areas and concepts will be incorporated into the unit of study. In a more traditional program, teachers sometimes attempt to cover everything themselves, which is usually an impossible feat. Creating semantic maps not only aids in brainstorming for ideas, but it also helps teachers determine which topics to emphasize. Learning objectives that set parameters for assessment can then be established. It may be advantageous to outline a tentative work schedule, as well, so that the process is thorough but not excessive.

DEFINING STUDENTS' ROLES

Students take on new identities, so to speak, for each unit of study by adopting a particular mind-set. They must assume clearly-defined roles in order to guide their research and discussion and to help them feel more accountable for solving the problem (Stepien, Gallagher, & Workman, 1993). The more specific their roles are, the better. For example, they may be members of a certain political task force, doctors in a particular hospital, or members of a specialized commission; obviously the specifics of the role are determined by the subject of the problem.

DETERMINING THE PROBLEM OPENER

The way in which a problem is introduced to students is crucial in motivating them. In fact, a teacher usually has no more than ten seconds to initially win their interest and draw them into the problem. (This amount of time decreases the older students are.) Problems can be presented in the form of an event, a descriptive statement, or even a set of questions. Means of presenting them include role plays, fictitious or authentic letters, facsimiles, audio tapes, or videos. For instance, Brad Martin, a teacher at La Entrada School in Menlo Park, California, introduced his students to a problem concerning imminent destruction of the planet Earth with an interactive video disc entitled, "The Great Solar

System Rescue." Another example would be a memo from the mayor to the students, acting as chemists, regarding the re-opening of public beaches before the Independence Day holiday after having been closed down for some time by the Environmental Protection Agency (Finkle, 1995).

PREDICTING AND PLANNING STUDENTS' WORK

Once students are engaged in a problem, they need to assess what they already know about it and what information they lack. A teacher must be prepared to guide them through this brainstorming process. After evaluating their prior knowledge, students are ready to create problem statements, which should be anticipated by the teacher during his or her preparation. These statements, developed from the perspective of the roles students assume, are best considered in the following form: "How can we...*(the central issue)*...in such a way that...*(conditions for an acceptable resolution)*...?" Arrangements must also be made for how students will go about gathering and sharing information as well as creating and evaluating solutions. Various opportunities for the teacher to do embedded instruction (a practice that some educators label as taking advantage of *teachable moments*) inevitably arise throughout the unit. Some of these occasions are predictable, so preparations can be made for them ahead of time. Unexpected situations simply require the teacher to recognize suitable opportunities and be flexible in exploiting them. Although these "mini-lessons" can disrupt students' collaborative work, some issues simply must be addressed as a large group. Embedded instruction generally occurs when students need to understand a concept that is either confusing or new to the majority of them. Despite the fact that the teacher takes a more direct role in such situations, students' input must still be encouraged and valued.

DETERMINING THE CULMINATION OF THE PROBLEM

At the onset of the unit, the teacher should inform students of what their ultimate goal is; hence a final product or performance (or perhaps both) that students will prepare

must be planned in advance. This product or performance should be a logical follow-up to their roles and work in the process of solving the problem, and to maintain the authenticity of the process, they should represent real-life products or performances. For instance, a proposal (from the class as a whole) or set of proposals (one from each subgroup in the class) could be sent to a government official, or students could make oral presentations to a panel of experts. Activities such as these not only help each student develop a stake in the problem, but also provide opportunities for authentic assessment. Anecdotal records, concise tests, and other forms of assessment can also be used throughout the unit to evaluate students' mastery of the established learning objectives.

CONDUCTING THE UNIT OF STUDY

It seems as though no amount of planning is ever enough in the field of education. Thus "field-testing" is an essential part of problem-based learning. As with everything else that occurs in their classrooms, teachers must constantly reflect upon reasons for both failures and successes of various aspects of the problems they facilitate.

INITIAL ACTIVITIES

Following thorough preparation on the part of the teacher, executing a unit of study should prove to be quite manageable, for it simply becomes a matter of following what has already been planned. As a class, students are introduced to the problem with whatever has been selected to be the problem opener. The teacher then facilitates as the students, still in a large group, contribute as many ideas as possible to a "Know/Need to Know" chart. This is a two-column chart: in the left column, students list the knowledge they already have concerning the topic of the unit of study, and in the right column, they begin a list of the major questions to which they need answers in order to deal with the problem. The students then attempt to define the problem using the form mentioned previously ("How can we...in such a way that...?).

RESEARCHING AND SHARING

This part of the process is significant in helping students to feel responsible for and guide their own learning. Students work individually or in collaborative groups to gather and share information in a variety of ways. Since little relevant information is provided for them at the onset of the problem, it must be derived from personal interviews, newspapers, books, or any other sources students believe to be worthwhile. (Obviously, it is vital to have a myriad of resources available to students, including people, videos, newspapers, and magazines in addition to books.) What they learn can be shared through reciprocal teaching, the "jigsaw" approach, or any other effective method. With elementary students, it is often best to organize groups "horizontally;" this means that all decisions require a group compromise. They can still rotate the role of a leader (who makes decisions in "vertical" group organization) or recorder, but collaboration should be the primary goal. Regardless of their age or the type of problem, students may want to revise the "Know/Need to Know" chart they developed earlier in the process, and as they acquire new knowledge and/or gain new insights on the problem, they may even want to revise their problem statement. It is also during this time that the teacher carries out embedded instruction as necessary.

WRAPPING UP THE PROBLEM

After possible solutions have been generated and evaluated by students, final products are created or performances are done by individuals or groups. The format of these products or performances ought to encourage students to apply the knowledge and skills learned in the current and previous problems. They must also require students to truly "grapple" with the problem in the context of their role. Finally, students should find themselves "in situations where they experience the consequences of their own actions," such as having one or more experts on the subject critique the products or performances or even select a solution they would implement (Bridges, 1992, p. 98).

DEBRIEFING

The unit concludes with a time of debriefing that benefits both students and teachers. Students are able to process what they have experienced and set goals for solving future problems. Teachers obtain students' feedback, which helps them to specifically determine what worked well and what did not. Krynok and Robb (1995) provide examples of valuable questions to ask students during this time:

> *What did you learn about* (subject of problem)*? How can you apply this to* (broader area of content)*?*
> *What did you learn about your skills?*
> *What did you do well?*
> *What do you need to improve?*
> *What will you do differently next time?*

Other questions pertaining to the problem itself, available resources, and the teacher's role should also be considered.

COMMUNICATION

Collaboration is a cornerstone of a number of newer educational approaches (Blumenfeld *et al.*, 1991), and "the procedures that result in people's getting involved enough to want to talk about what they think are the very procedures that result in people getting involved enough to learn" (Duckworth, 1987, p. 139). Throughout the problem-based learning process, "teachers coach communications -- how we receive, share, and make meaning through reading, writing, speaking, and listening" (Finkle, 1995). Good thinking in the classroom is closely related to how well students and teachers relate to one another (Court, 1991). This is true outside of the classroom, as well; what students learn through their collaboration with others helps them to refine and enlarge their knowledge base, which can later be transferred to new situations (Stepien & Gallagher, 1993).

Many students are unaware of how crucial various aspects of communication are. It can be helpful for them to use the acronym, *MAP*, in determining what they must take into account when presenting *and* receiving information (Bransford & Stein, 1993):

Message *(Is it clear?)*
Audience *(What is their background knowledge? What are their expectations?)*
Presentation medium *(How, or in what form, is this being communicated?)*

Discussion is a vital element of problem-based learning. Contrary to what many instructors and students currently believe, "discussion" is not simply students' responses to questions posed by a teacher (Boud & Feletti, 1991). Such situations are, in actuality, "recitations," in which teachers play an authoritative role and students merely "rehash" concepts that have been transmitted to them and that they are expected to comprehend. A truly reflective discussion is one in which students themselves raise and answer their own questions relating to multiple sources and disciplines and cite evidence they have discovered on their own. Consequently (as aforementioned), students draw upon their own knowledge and expand it by learning from each other. It is important to remember that "pick-up knowledge," or what students "plagiarize from dust in the air," may be used in discussion, but it should be judged just as stringently as any other source (Shermis, 1992).

A primary goal in communication is to help students understand the purposes of asking probing questions: to request clarification or explanation, to bounce ideas off of one another, to seek examples, or to ask for sources of information (Shermis, 1992). One tactic in helping students to not only communicate, but also formulate more explicit ideas is to ask, "Why?" twice in a row. Open-ended questions such as this are most desirable in promoting critical thinking.

An aspect of both communication and critical thinking that teachers often fail to emphasize is that of critical listening. Some characteristics of this kind of listening, such as determining the factual basis of the content of what a speaker says, will be discussed later in conjunction with evaluating a source of information. Mary Bozik suggested that a listener should also consider the speaker's purpose and possible biases and must learn to recognize the effect word choice can have on a message (Hunsaker, 1991).

In any cooperative learning situation, such as that of problem-based learning, controversy is nearly inevitable. Teachers should not attempt to avoid this by declaring certain subjects to be "off-limits." In fact, students can obtain a great deal of practice in being tactful and respectful by working through difficult issues together.

ASSESSMENT

Assessment ought to be done by both teachers and students in a variety of ways, both formal and informal, throughout the entire problem-solving process. Prior to the unit of study, students' prior knowledge, needs, and attitudes can be assessed. Formative evalution occurs during the unit so that changes in instruction, activities, and scheduling can be made. Summative assessment, done after the unit has ended, is used to determine the results and effects of the unit. As part of both the formative and summative types of assessment, self-evaluations and reflections on the problem, the process of solving it, and the resources used should be discussed or written by students and teachers. The value of the problem as well as what does or does not work well during the act of solving it can be considered. Students at the Illinois Mathematics and Science Academy maintain problem logs, or journals, that contain records of their thoughts. For example, in such journals, students can be asked to write a problem definition after their first class discussion, name an especially useful resource, or suggest an initial problem solution (Stepien, Gallagher, & Workman, 1993). Journals, portfolios, and conferences are all excellent means of assessing and communicating with students.

One of the more obvious ways to evaluate students is to critique their final performances or products. This assessment should portray both strengths and weaknesses as well as provide suggestions for future improvement (Bridges, 1992). Many students have a traditional mind-set of wanting to know whether or not their solution is "right." It is important to help them realize that, in life, the only way to discover this is to take action and

then, in some instances, simply wait. The best they can do is to take as much information into account as possible when solving the problem and then attempt to anticipate the results of their solution (Bridges, 1992). Many students may have difficulty making predictions about their solution, so questions such as the following may be of help (Parnes & Harding, 1962):

*What individuals or groups will be affected? How?
*What are the costs involved?
*What concrete objects are involved (materials, equipment, etc.)?
*What abstract ideas are involved (opinions, feelings, values, etc.)?
*What, if any, new problems will arise?
*How would this solution be difficult to put into action?
*What would happen if this solution failed?
*Are there timelines involved?

Perhaps the primary aim of problem-based learning is to foster problem-solving skills, which are difficult to assess. However, Norman argued that problem-based learning is also "about knowledge learned in the context in which it will later be used." This view allows teachers to expect students to gain specific knowledge (Boud & Feletti, 1991, p. 255-56). More formal types of assessment, perhaps in the form of short, criterion-referenced tests, may be applicable in some situations. However, these should never be utilized as the sole form of evaluation, and they should never test isolated facts out of context. They are best used as "checkpoints" throughout the unit of study to insure that students are comprehending important information and meeting the learning objectives established by the teacher; consequently, it quickly becomes apparent which students are struggling, and they can be helped before too much time has passed.

Specific traits and abilities for which teachers can watch are varied, and they should be observed in a class as a whole, as well as in individuals (Baron & Sternberg, 1987). For example, they can note whether or not students select and use resources appropriately and how well students compile knowledge from multiple resources. Metacognitive skills and transfer of learning across various situations can be observed as components of long-term progress.

Teachers learn a great deal about students simply by observing their social interactions during the course of study. Bridges (1992) suggested watching for three specific components of participation: *content* of what is being said, *process* of communication (who is talking and the tone and relevance of what they are saying), and *frequency* of participation. It is important to hold students accountable for making fairly equal contributions to the problem-solving process, and to help them avoid "social loafing" (Bransford & Stein, 1993). A beneficial activity is to ask students to assist in developing criteria for behaviors to observe. This helps them realize what is expected of them and allows them to experience a greater sense of ownership in the whole process. They also gain an awareness of what constitutes effective thinking. Students, especially those age eight and above, can learn a great deal from evaluating each other.

The debriefing period at the culmination of a problem provides another form of evaluation, for it is vital to obtain students' feedback concerning the problem and the process of solving it. Comments of even very young children with whom problem-based learning is done are extremely important in helping a teacher to make adaptations. Students can also submit their opinions of their teacher's role as a coach or facilitator.

A RATIONALE FOR PROBLEM-BASED LEARNING

Vehicle headlights, alarm clocks, and shoestrings were all solutions to different problems at one time or another. Often solutions such as these created new problems (Bransford, 1993). Problems do not necessarily lead to new inventions, however; in fact, they impact nearly every part of daily life. Planning a meal, avoiding a traffic jam, and organizing a presentation are only a few common acts that require problem-solving. Barrows and Tamblyn (1980) believe that adults actually learn a great deal through the course of solving many of the problems they face every day.

This is not a process reserved for adulthood, though. Even infants are "natural and social scientists" and spend a considerable amount of "time and energy investigating and making sense" of the various environments in which they find themselves (Katz, 1993, p. 20). Anyone who has worked with children knows that those from ages two through at least six are *very* skilled at asking questions and thinking about the world around them (Maiorana, 1992). One wonders if America's educational system contributes to the fading of their inquisitive nature when it fails to allow them to research personal interests, ask their own questions, and share their ideas with each other. Students need to be provided with numerous opportunities to exercise their creativity and refine their innate problem-solving skills. Stepien and Gallagher (1993) have described problem-based learning as "apprenticeship for real-life problem-solving."

Students clearly could not be expected to acquire knowledge of all that they would ever need to know while they are yet in school. (Besides, it is doubtful that this nation could ever determine who would make the decision as to what students ought to know.) Consequently, in addition to gaining a general foundation of knowledge, students should learn

how to independently and effectively handle new situations. Problem-based learning, as it encourages students to both acquire and apply knowledge, is ultimately a way of learning to comprehend instead of learning to recall facts (Boud & Feletti, 1988). In other words, problem-based learning helps students learn skills just as much or more than facts. Bruer cited several research studies showing that domain-specific knowledge, for instance, only results from "extensive experience and practice in the domain" (Bruer, 1993, p. 61). While developing and refining their skills through a variety of experiences, students obtain factual knowledge anyway. Equipping them with practical skills will thus enable them to not only adapt to, but also participate in, continual advances in society. As Charles Engel believes, the very nature of knowledge is that it is complex and changing as communities of people respond to it.

Engaged in this method of learning, students are encouraged to take a more active role in their learning by being open-minded, reflective, and critical in their reasoning. These types of thinking can be rehearsed during the problem-solving process as they research and evaluate sources of information and discuss this information with each other. Reflective and critical thinking are also necessary for debriefing (be it the formal session done as a group at the conclusion of a unit of study or even ongoing, spontaneous self-reflections) as students identify and consider how they could enhance their strengths and improve their weaknesses (Boud & Feletti, 1991).

Working collaboratively is central to problem-based learning, as evidenced in the previous description of this method. This provides excellent opportunities to promote social skills such as empathy and appreciation of various points of view. The fact that this method has moral benefits could be supported, as well, since both students and teachers must be respected as people with knowledge, interests, and emotions (Boud & Feletti, 1991). In a growing, ever-changing world, little could be more vital than cultivating citizens who can live together peaceably by communicating with each other effectively.

This approach to learning is both holistic and cumulative. Knowledge is acquired in an integrated manner in real-life contexts, making what students learn more relevant. Barrows and Tamblyn (1980) have found that the relevance and authenticity of this method tend to make it a more natural way of learning (West, 1992). The problems students face also become progressively more complex. This allows them to utilize what they have learned in previous situations each time they approach a new problem. Deeper understanding of content is possible because students must make useful applications of the information they acquire (Blumenfeld *et al.*, 1991).

There is unquestionably a motivational value to problem-based learning (Hallinger *et al.*, 1991), which is due to students' activities being authentic and to their sense of ownership in what they are doing. They may be more committed to learning because numerous aspects of the curriculum are dictated by neither textbooks nor their teachers, but by themselves. According to research, students also find problem-based learning more enjoyable than traditional modes of education (Aspy, Aspy, & Quimby, 1993).

Problem-based learning is an excellent means of addressing three additional characteristics of thinking: creativity, dialogical thinking, and the reality of multiple intelligences. Creative thinking is significant in that there are numerous ways to solve problems, do research, share information, and present solutions to others. Dialogical thinking aids in curtailing children's egocentric natures by promoting a more global mind-set. Howard Gardner's theory of multiple intelligences is also relevant to problem-based learning, because it promotes placing students in roles that foster their strengths and help them develop some skills in and appreciation for their weaker areas. Each of these aspects of thinking is discussed in detail in following sections.

CREATIVITY

Its significance in society. Awareness of the importance of creativity is certainly not a new phenomenon. Nearly forty years ago, Alex Osborn wrote about the history of

civilization essentially being the record of man's creative ability. Imagination, he said, is irrefutably responsible for man's survival and has led him to conquer the world. In his opinion, "It is axiomatic that to think intelligently is to think creatively" (McIntosh & Meacham, 1992, p. 9). This statement has been confirmed through correlational results from independent tests for intelligence and creativity (Resnick, 1987).

Many people believe creativity is merely a component of genetic material that only some humans are lucky enough to possess. Actually, David Perkins (1981) found that there are degrees of creativity that different people may have. Furthermore, much research completed by Davidson and Sternberg (1984) during the 1970's and 1980's showed that creativity *is* in fact teachable. If history is to continue the way Osborn viewed it, then creative problem-solving is needed to "[empower] students to take charge of the future" (McIntosh & Meacham, 1992, p. 10).

What is creativity? A definition offered by Bransford and Stein (1993) refers to working in a way that is not only novel to the individual, but also appropriate to the situation. This statement includes a very significant term: "individual." Many young students' novel ideas are discouraged when they are similar to ideas already in existence. However, if a person has no knowledge of a pre-existing idea, or modifies an idea in some way, then their new idea is novel, and therefore creative, at least to themselves.

The abilities and dispositions of a critical thinker were discussed previously. Sternberg and Lubart (1991) believe there are two abilities specifically relevant to creativity: the ability to define and redefine problems and the ability to think insightfully. To these authors, "insight" simply means being observant of and able to connect ambiguous and seemingly irrelevant information. This is not always a matter of finding the right answers, but rather of asking the right questions.

A set of necessary dispositions for true creativity was also suggested by Sternberg and Lubart (1991). They believe a creative person not only enjoys creating new ways of doing things, but also has a global perspective. Such a person possesses a desire to

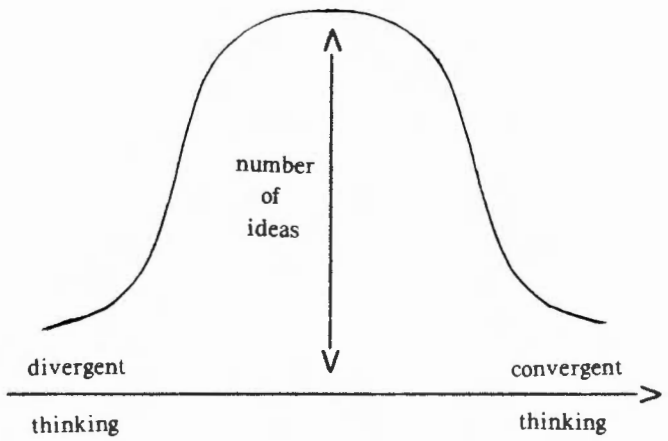
persevere and grow in light of the obstacles he or she overcomes. Finally, a willingness to take risks is essential and is supported by courage and strong convictions.

A common description of creative thinking is that it includes both divergent and convergent thinking. Divergent thinking is fluent, flexible, original, and elaborate. In other words, students must be open-minded, "stretch" their thinking, and avoid judgment of any kind. On the other hand, convergent thinking is more logical and evaluative. When engaged in this latter type of thinking, students critically assess ideas to determine their merit and consequences.

Creativity's value in schools. Few report cards nationwide include a section for portraying assessment of students' creative abilities. Perhaps this is due to the lack of a good definition of creativity and therefore the absence of a dependable way to evaluate it. This is not to say that researchers and schools have not attempted to test for creativity! Countless school districts utilize what they call "tests of creativity" to label students they feel should be involved in so-called gifted programs. Many experts doubt that these tests really show what educators are seeking. Sternberg and Lubart (1991) believe such tests utilize trivial problems; these authors stated, "Better to ask students to think of unusual ways to solve world problems -- or school problems, for that matter -- than to ask them to think of unusual ways to use a paper clip!" (p. 614)

What often *are* indicated on progress reports, however, are teachers' views of the work habits and dispositions of students. Studies have shown that teachers tend to see an "ideal" student as one who possesses attributes that are not supportive of creativity, such as constant efficiency and submission to authority. Many teachers disapprove of students who constantly ask questions, make guesses, think independently, and take risks (Sternberg & Lubart, 1991). Of course this is not always the case, but, as stated earlier, students can not be expected to think and solve problems creatively in the "real world" when they are discouraged from doing it in school.

The use of creative thinking in solving problems. McIntosh and Meacham (1992) suggest that teachers attempt to prevent students from intermixing divergent and convergent thinking during the problem-solving process. Both types of thinking, whose relationship is illustrated below (p. 12), are essential, but when used simultaneously, they can restrict each other.



Common forms of divergent thinking include brainstorming ideas about a general topic or listing attributes concerning specific aspects of a topic. McIntosh and Meacham (1992) describe a checklist that can be used when attempting to lengthen a list of ideas. This checklist utilizes the acronym, *SCAMPER*: substitute (one idea for a previous one), combine, adapt, modify/magnify/minify, put an idea to another use, eliminate and suggest an alternative, rearrange/reverse the list of ideas (p. 24).

McIntosh and Meacham (1992) also suggest specific activities to aid students' convergent thinking, three of which are described here. First, a "musts and wants" activity forces students to develop criteria that their proposed ideas or problem solutions *must* meet and that which they *want* their ideas to meet. Second, students could create an evaluation grid, in which each idea is ranked (not rated) several times, according to various criteria, and total scores help students reach a final decision. Below is an example of how a student

council in an elementary school might utilize an evaluation grid to solve the problem of what type of fund-raiser to sponsor.

IDEAS	CRITERIA					TOTAL
	cheap set-up	attract people	make money	easy set-up	fun	
rummage sale	2	2	1	3	3	→11←
carnival	4	1	2	4	2	13
bake sale	1	4	3	2	4	14
teacher "dunk"	3	3	4	1	1	12

A third way to practice convergent thinking, especially when having to choose between two strong ideas, is to use the acronym: *ALU.* This stands for considering the advantages, limitations, and unique potential of each idea.

Some researchers and educators have even developed specific ways of approaching the problem-solving process that promote the use of creativity. They believe these methods are easier to remember and therefore will be employed more often. One such example, involving six steps developed by Isaksen and Treffinger (1985), suggests utilizing both divergent and convergent thinking at each step of the process. It is outlined below, along with italicized notes concerning its relation to problem-based learning:

1. Mess-finding (Identifying the topic)
   Done primarily by the teacher, taking students' needs and suggestions into account.
2. Data-finding
   Achieved with the "Know/Need to Know" group activity.
3. Problem-finding
   Initially, students may see multiple problems, or more than one way to state a problem.
4. Idea-finding
   Researching, both individually and collaboratively, and beginning to generate possible solutions.
5. Solution-finding
   Compiling proposed solutions and developing criteria to evaluate them.

6. Acceptance-finding
   Compromising to decide upon a solution and predicting what the results of implementing the solution would be.

A second example of a problem-solving approach is the IDEAL method, proposed by Bransford and Stein (1993).

1. Identify problems as opportunities (and consider what those opportunities could be)
2. Define goals (as many as are necessary at this point in the process)
3. Explore possible strategies/solutions (both general and specific)
4. Anticipate outcomes (of solutions) and Act
5. Look and Learn (debrief the experience and set goals for the next one)

DIALOGICAL THINKING

Instruction that promotes dialogical thinking connotes helping students to observe and develop multiple perspectives of an issue. Richard Paul suggested that thinking this way involves empathy and reciprocity, and therefore requires the loss of natural egocentrism that Piaget characterized. As alluded to earlier, students are often led "to believe that there are more or less authoritative answers...for most of the important questions and decisions" in life (Baron & Sternberg, 1987). They often assume the frames of reference of parents, teachers, peers, authors, and other sources of the media.

Problem-based learning allows students to practice discovering various points of view in a non-threatening environment. This can be done by role-playing the thinking of others, justifying opinions, and searching for personal and others' inconsistencies. For example, when evaluating arguments proposed by experts, peers, or authors, students could be encouraged to consider questions such as, *Are the facts accurate?, Is reasoning logical and consistent?,* and *Can underlying assumptions be questioned?* (Bransford & Stein, 1993). A discussion of the ageless tale of *Chicken Little* (Kellog, 1985), for instance, could encourage youngsters to think about the questions just listed from the point of view of the main character. It may seem as though questions such as these are much too advanced for elementary students, but they can be modified to simpler terms.

Students particularly need practice in challenging the frames of reference of books, newspaper articles, and television programs. One way to help them do this is to provide multiple interpretations or accounts of an event. When considering possible causes of an event, for example, students can be encouraged to go beyond simply identifying possibilities; they can also gather and critique evidence to make hypotheses about which causes are more probable.

Kevin O'Reilly, a Massachussetts high-school teacher, suggested having students evaluate sources of information in terms of whether they are primary or secondary, whether or not the author would have a reason to distort information, and whether or not there is other evidence supporting what an author states (Baron & Sternberg, 1987). Students ought to be led to realize that there could be some truth to conflicting evidence, since various sources blend personal ideas with different combinations of information. Promoting dialogical thinking must go beyond simply "unmasking" the biases of, or differences among, various sources. Students should also assess these differences and work together to form conclusions concerning the information they have gathered.

MULTIPLE INTELLIGENCES

A great deal of research directed by Howard Gardner (1983) led him to believe that there are at least seven specific intelligences, or ways of knowing the world, of which every human has varying combinations. These intelligences are linguistic, logico-mathematical, spatial, musical, kinesthetic, interpersonal (understanding others), and intrapersonal (understanding oneself). Recently, Gardner has been considering adding environmental intelligence to this list.

The current educational system and its standardized tests emphasize linguistic and logico-mathematical skills and dispositions, thereby "assum[ing] that everyone can learn the same materials in the same way and that a uniform, universal measure suffices to test student learning" (Gardner, 1991). As a result, countless students may be incorrectly labeled as

"failures." For instance, a student whose report card consistently portrays failing work in nearly all of the traditional subject areas may be extremely gifted spatially, kinesthetically, and interpersonally. However, if there are few opportunities to exhibit these intellegences at school, he or she may not have many experiences with success, if any, and would consequently receive little positive feedback.

If teachers are to build upon students' prior knowledge, then multiple intelligences must certainly be taken into account (Bruer, 1993). A problem-based learning environment maintains respect for the diverse skills and dispositions individuals possess. Through the course of identifying problems, researching, sharing information, and reaching conclusions, students can utilize these skills in various ways. For example, when attempting to find a solution to a problem, one student may need to talk over the issues with another. A different student may want to draw a diagram of the information that has been assembled. Another may simply need to spend time alone thinking over the problem. Yet another student might have to write out his or her thoughts in order to organize them. As students share their interests and knowledge with each other, it is difficult for them *not* to view situations from new perspectives, so encouraging an acknowledgement of multiple intelligences also promotes dialogical thinking.

ARGUMENTS AGAINST CRITICISMS OF PROBLEM-BASED LEARNING

"TOO MUCH TIME IS REQUIRED FOR PREPARATION AND STUDENT WORK"

First, if teachers are truly committed to helping students develop good thinking and problem-solving skills, then time should not be the major factor in determining the amount of effort given to preparing for classroom work. Time is a critical issue for teachers, as many of them vow they never have enough of it. With practice, however, planning for problem-based learning should become less demanding not only because *any* task done with repetition becomes easier, but also because the time and mental energy required in the transition from modes of traditional instruction to this method will already have been made. Second, as long as student work is productive and progresses toward general and specific learning objectives, it is time well spent. There are occasional circumstances when teachers must impose time limits upon and/or create other boundaries for students. Otherwise students become so engrossed in some problems that they could work on one problem for weeks. Teachers must also keep in mind that the first few problems students attempt to solve will take much longer than subsequent ones. Initial problems not only prepare them for the process of solving later ones, but knowledge of subject matter is also transferred from early problems to later ones (Barrows & Tamblyn, 1980).

"KNOWLEDGE BECOMES RELEVANT ONLY TO SPECIFIC PROBLEMS"

Years ago, educators believed general mental abilities could be trained through courses such as Latin and logic, but much research has shown that transfer of knowledge across various situations usually does not occur automatically. However, a great deal of further research suggests that transfer is quite likely, as long as instructional techniques

promote high-road transfer. High-road transfer (or "far" transfer) involves making a conscious effort to apply prior knowledge to new situations; low-road transfer (or "near" transfer) happens more spontaneously, usually because the context resembles the one in which the knowledge was acquired.

Students often learn numerous strategies for solving different kinds of problems, but they are not always encouraged to consider how to apply such strategies in diverse situations. In other words, "practice does *not* make perfect" -- students who solve mathematical problems very well in school may not necessarily be able to shop wisely or balance their checkbooks. Transfer is critical, since one of the major objectives of education is to prepare students to apply what they learn while in school to current or future situations outside of that building. Teachers must help students realize how what is being learned can relate to or be used in other circumstances within the same subject matter, in different subject matter, and in life outside of school (Tishman, Perkins, & Jay, 1995). The younger they are, the more help they need in noting similarities among situations. When students possess metacognitive skills that enable them to connect previous learning to new contexts, transfer will occur fairly easily and regularly.

Tishman, Perkins, and Jay (1995) suggested an excellent way of modeling the value of transfer, which disproves the common assumption that transfer extends outward from classroom work. Teachers must recognize and respect students' prior knowledge and transfer this knowledge *into* discussions. This is very easy to do in problem-based learning, since so much student-centered communication occurs. Many studies conducted by Brown *et al.* (1988) have shown that transfer "does take place, even among three- and four-year-olds, when...learning takes place in a social context...whereby justifications, principles, and explanations are socially fostered, generated, and contrasted" (Perkins & Salomon, 1989, p. 22).

"PROBLEM-BASED LEARNING IS TOO ADVANCED FOR ELEMENTARY CHILDREN"

Young children naturally have limited reasoning skills (as proven by Piaget), but with effective instruction that is well-rooted in their own experiences, researchers such as Edys Quellmalz have found that they "are quite willing and able to engage in challenging tasks" (Baron & Sternberg, 1987, p. 99). They can even display metacognitive skills, such as reflecting on their own thinking, but the key determinant of this is the appropriateness of the learning environment (Tishman, Perkins, & Jay, 1995). Researchers at the College of William and Mary and the Illinois Mathematics and Science Academy have found this method to be extremely motivating for elementary students (Stepien, Gallagher, & Workman, 1993).

Rudimentary literacy skills of very young children present obstacles in terms of explaining ideas and information and carrying out assessment, so most of their reasoning must be done primarily via discussion. Discussions, which are integral to problem-based learning, generate occasions to develop speaking and listening skills, as well as dialogical thinking. Children can be aided in comparing differing sources of information as well as in putting their own ideas into words. Their metacognitive skills can even be enhanced if teachers help them guide and evaluate their thinking in simple terms, through such activities as setting goals and reflecting on their own work.

"THIS METHOD DOES NOT TAKE CHILDREN WITH SPECIAL NEEDS INTO CONSIDERATION"

One of the major advantages of activities done within the context of problem-based learning is their adaptability. No two classrooms are alike, so problems must be tailored to fit each group of students. The fact that students work together so much when attempting to solve problems creates excellent opportunities to incorporate students with special needs. Such children can be expected to participate in discussions, do research, and complete culminating activities, but teachers must obviously be flexible. For instance, if reading is too difficult for a particular child, he or she could conduct several personal interviews to

obtain information; or, a culminating activity that involves creating a product could be tape recorded if writing is impossible.

"TEACHERS HAVE LESS CONTROL OVER STUDENTS"

An environment of effective problem-based learning never allows students to become "out of control." This is because teachers design and coach activities in ways that set parameters of which students are often not aware. They usually feel quite autonomous and are not cognizant of the control the teacher still possesses. When a teacher "checks in on" a student who is doing independent research, for instance, the student may sense that he or she is simply answering the teacher's questions and informing the teacher of what he or she is researching. However, a competent teacher may be using such questions and suggestions to subtly help the student focus or redirect his or her work.

"THIS METHOD RELIES TOO MUCH ON EFFECTIVE GROUP DYNAMICS"

"[G]roup work can diminish thoughtfulness by encouraging reliance on others as resources, thereby decreasing personal responsibility and independent thinking" (Corno & Mandinach in Blumenfeld *et al.*, 1991, p. 377).

Although dependency on one another is very beneficial in problem-based learning, a few unmotivated students can negatively influence an entire group or class -- especially if they are quite verbal. This tends to decrease over time. The more problems students complete, the more they realize the importance of fulfilling their individual responsibilities. When groups are changed periodically, peer pressure often encourages negligent students to do their part (Krynok, 1995). During group work, teachers can incorporate all students into a discussion without controlling its content. Teachers must give individual grades instead of group grades, so that students who put forth a great deal of effort are not penalized for their classmates' procrastination (Krynok, 1995).

"CONTENT IS NOT COVERED AS WELL AS IN TRADITIONAL PROGRAMS"

In fact, problem-based learning encourages students to acquire just as much or more content knowledge than programs in which it is simply transmitted to them by teachers and and/or textbooks. One example of when this was found to be true was in an informal study conducted by Krynok and Robb (Robb, 1995). In this study, four biology classes took a test after completing a unit on genetics. Two of the classes had been involved in problem-based learning, while the other two experienced a more traditional approach. The quantitative scores for the problem-based learning classes were slightly higher than those for the traditional classes.

Teachers can base problems on the subject content their administrators or texts require them to cover. Textbooks certainly do not become obsolete, but are considered to be one of many resources used during research. Students become very active in the process of discovery, and as a result, they often begin to view subject matter as being of extreme importance to helping to generate and assess possible solutions. The more they value content knowledge, the more they will want to acquire.

"THE OUTCOMES OF LEARNING WITH THIS METHOD ARE TOO UNPREDICTABLE"

"... [W]ouldn't such an approach...lead only to an occasional, random piece of learning by only a very few students?" (Don Margetson in Boud & Feletti, 1991, p. 46)

There are many ways in which a teacher can carefully organize and provide for specific results during a unit of study. In general terms, students can be expected to develop systematic approaches or plans of action for discovering information. Even persons such as Magellan, Columbus, the originators of the atomic bomb, and Thomas Edison made their discoveries while adhering to specific plans. In addition, students' collaboration will help them expand their knowledge as they combine what they share with each other with their prior knowledge. Fear of students' not acquiring subject knowledge can be eased if clear learning objectives are established for each unit of study. If students are held accountable to these objectives, then they can be expected to master a considerable amount of content.

"ASSESSMENT MAY NOT PORTRAY STUDENTS' CAPABILITIES OR ACHIEVEMENTS"

This concern is the impetus for the use of varied types of assessment several times before, during, and after the problem-solving process. If different modes of both formal and informal evaluations are utilized, then observations of students that are of most importance will be made. However, teachers must be prepared and willing to put a great deal of effort into designing, adapting, and using suitable assessment methods (Nuffield, 1984).

INTEGRATING PROBLEM-BASED LEARNING WITH CHILDREN'S LITERATURE

The number of superior-quality works of children's literature has seemingly exploded during recent years. Artists and illustrators alike are discovering ways to maturely handle issues that are interesting to children and have a great impact on their lives. Good literature not only initiates the use of all four of the language arts (reading, writing, speaking, and listening), but it also provides an excellent introduction to or background for problem-based learning situations.

One of the reasons literature-based problems work so well with children is that literature involves so much emotion. Children, by instinct, are first curious about something and then want to know more about it (Shermis, 1992). This contrasts with numerous textbooks' attempts to interest children with factual information. For instance, an eight-year-old is awestruck by a peacock's beauty before needing to know its biological name, *Pavo cristatus*. In addition, young children's imaginations allow them to make numerous observations in stories and explore countless extentions from them that teachers never would. This results in dynamic discussions and activities related to books.

Children's literature embraces a gamut of topics, so basing problems on them does not sacrifice learning in other disciplines. In fact, integrating subject matter seems to occur naturally when working with a book of high quality. Furthermore, integration usually leads to covering topics in more depth, therefore making them more meaningful and relevant to children (Drake, 1993).

The following pages contain examples of problems that are based on works of children's literature. Countless books can obviously be used, so this is a mere sampling of how problem-based learning can be integrated with children's literature. Some of the

problems "grow" out of the theme of a particular story, while others are extensions of an idea on only one page of the story. The ideas listed are only initial frameworks. Numerous aspects of how a problem is handled are dependent on the variables of individual situations, such as the teacher, students, and community. The plans presented here would have to be modified a great deal in order to adapt them to the classroom in which they were used, but the "aspect of individuality in procedures and outcomes is one of the most exciting things about problem-based...instruction" (Cordeiro, 1990).

These examples include problems that would take varying amounts of time and research. Some of them could actually be solved, while others would simply encourage students to determine what they believe to be the best possible solution. They are arranged in order of increasing difficulty, but this order is debatable, since problem selection depends upon specific characteristics of each group of students.

A similar format is followed for the three-page presentation of each problem, which portrays several steps of a teacher's planning process. The first page lists the role students could take, a possible problem opener, and a problem statement similar to one students might compose. Several of the problems also include one or more problem log ideas. These are items or situations that are introduced to students during the course of their work on a problem and that can affect or change how they will attempt to solve it. The second page shows a semantic map portraying how a teacher might introduce concepts or conduct activities that integrate various subject areas. The third page is also a semantic map, but it is designed to show relations among the concepts students may consider as they work on the problem.

As a whole, this set of problem examples, a few of which have already been tested in classrooms, provides a more practical view of problem-based learning. It shows how this method can be utilized in the early grades -- a practice which, to date, has not seen widespread use. Finally, the examples add a new component to problem-based learning: basing problems on children's literature.

Lunch

by Denise Fleming
New York: Scholastic, ©1992

· Students' Role:

city council members

· Opener:

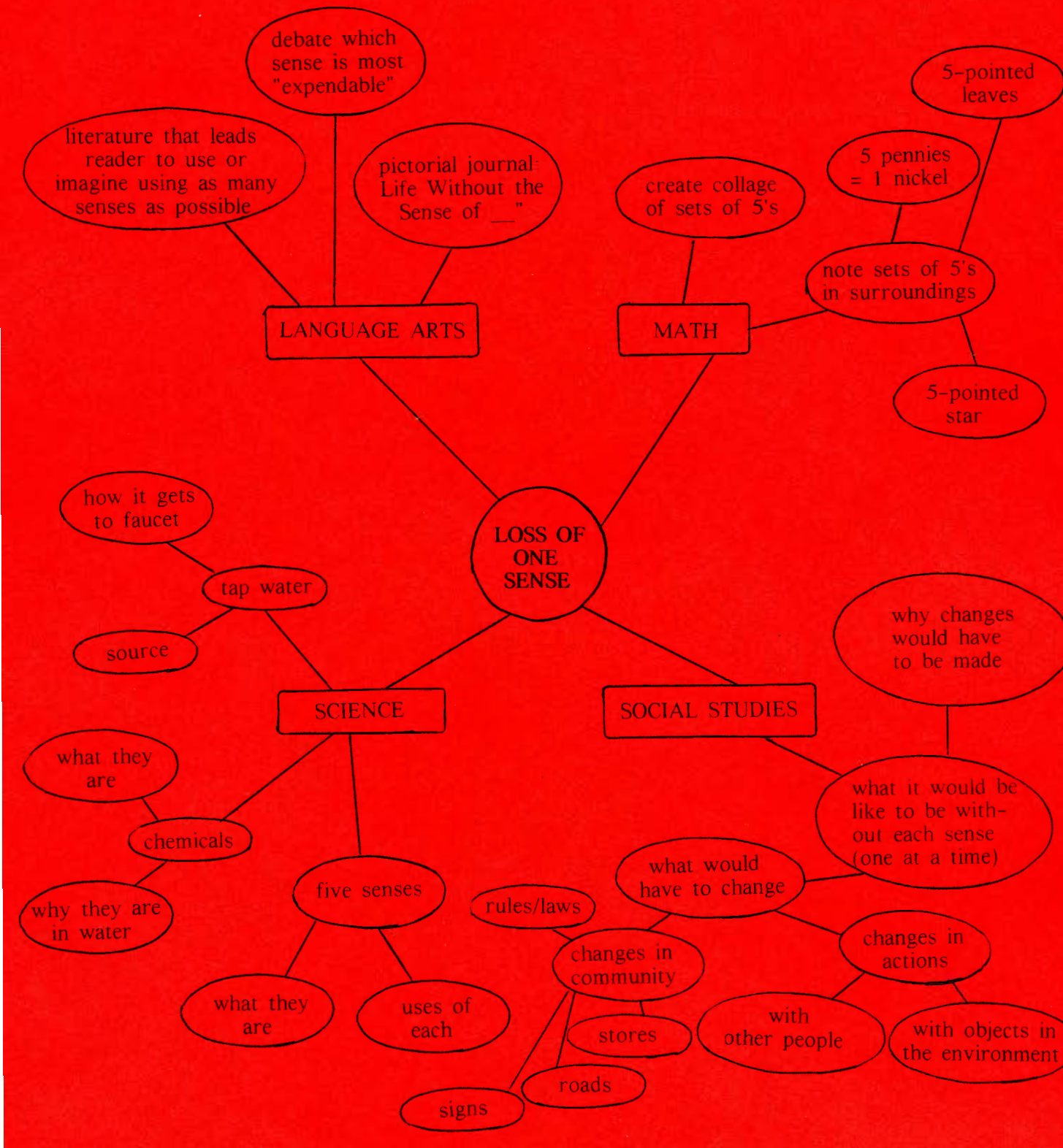
At a city council meeting, the local water plant director announces that a chemical found in the city's water supply may cause humans to lose one of their five senses. Scientists will be able to control which sense it will affect.

· Problem Statement:

Which four senses are most necessary for humans to enjoy life to the fullest?

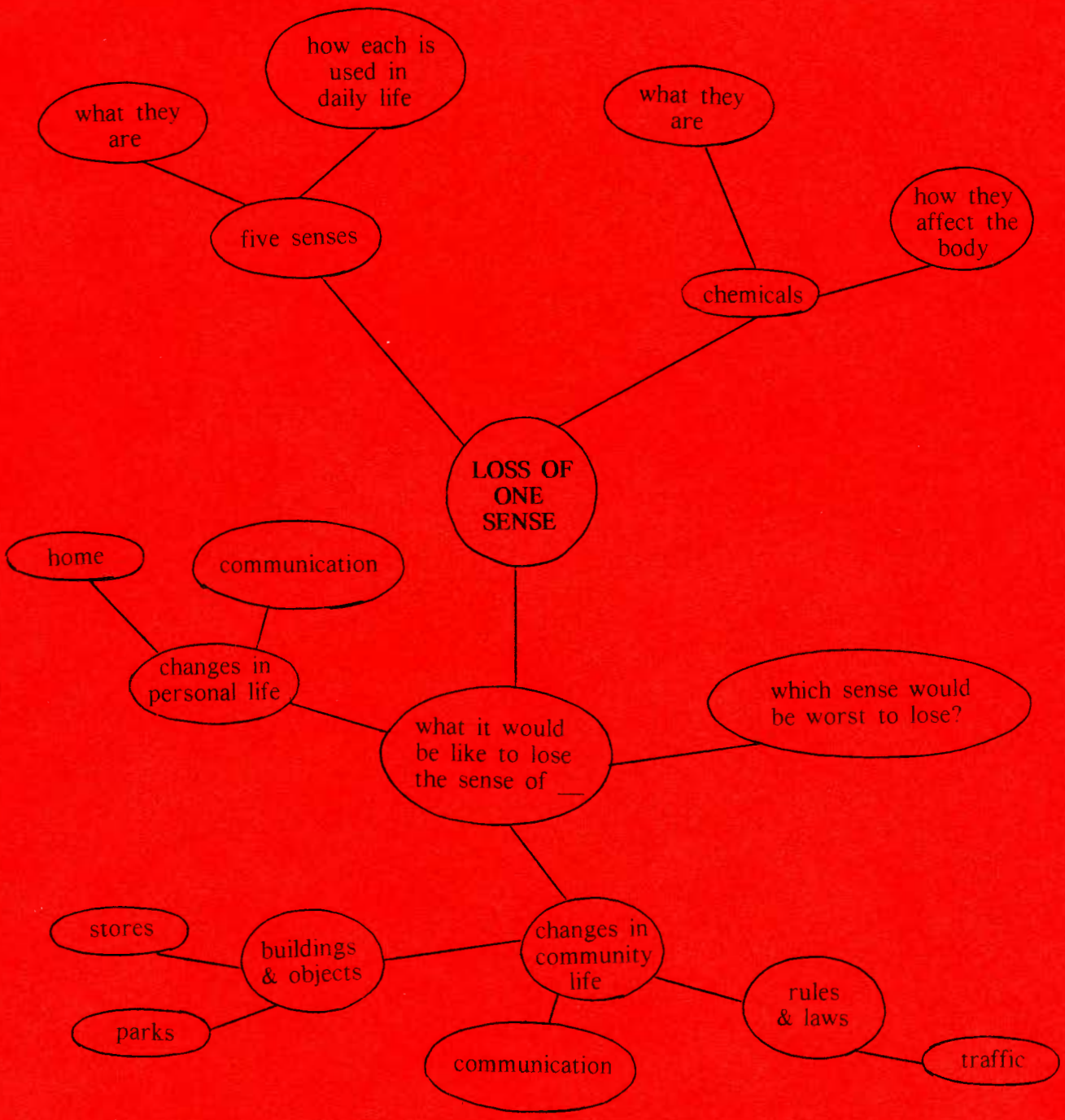
Lunch

TEACHER'S CURRICULUM MAP



Lunch

STUDENTS' CONCEPT MAP



Sanji and the Baker

by Robin Tzannes
New York: Scholastic, ©1993

· Students' Role:

members of the state legislatures of two fictitious islands that are just off the coast of and under the jurisdiction of a nearby mainland

· Opener:

Students are told a story similar to the following one about these islands:

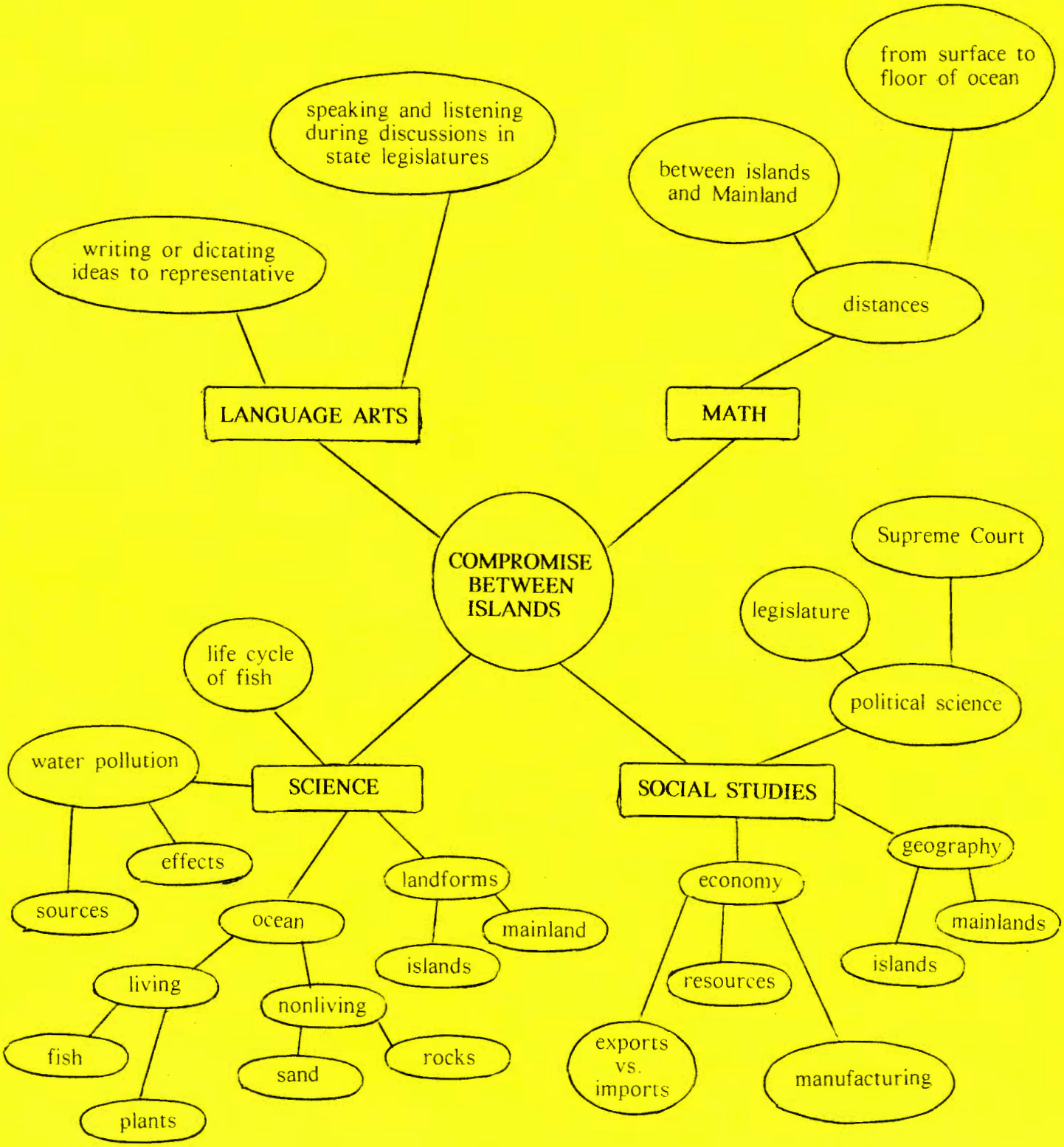
The people living on these two islands, Carp and Trout, are quite poor and very similar: they have similar homes, clothing, and their only resource used to be the special fish they caught and sent to the Mainland for the people there to eat. However, the Mainland was polluting the waters in that area, and so many fish were dying that both islands could not support themselves this way. The Carpans discovered that the sand on the bottom of the ocean could be used to manufacture a special kind of sandpaper that people on the Mainland would buy. They quickly realized, though, that the fish they used to catch (and the Troutans still catch) lay eggs in this sand. They know they should not crush all the eggs, and broken eggshells cannot be in sandpaper anyway, but they do not have enough people or time to dig out all the eggs. The Carpans and Troutans have been debating about what to do for quite some time, and now the Mainland Supreme Court must decide what will happen. The justices on this Court want to hear both sides of the story, so they have sent a representative to listen to what both state legislatures believe should be done.

Problem Statement:

How can we compromise so that each island can make money?

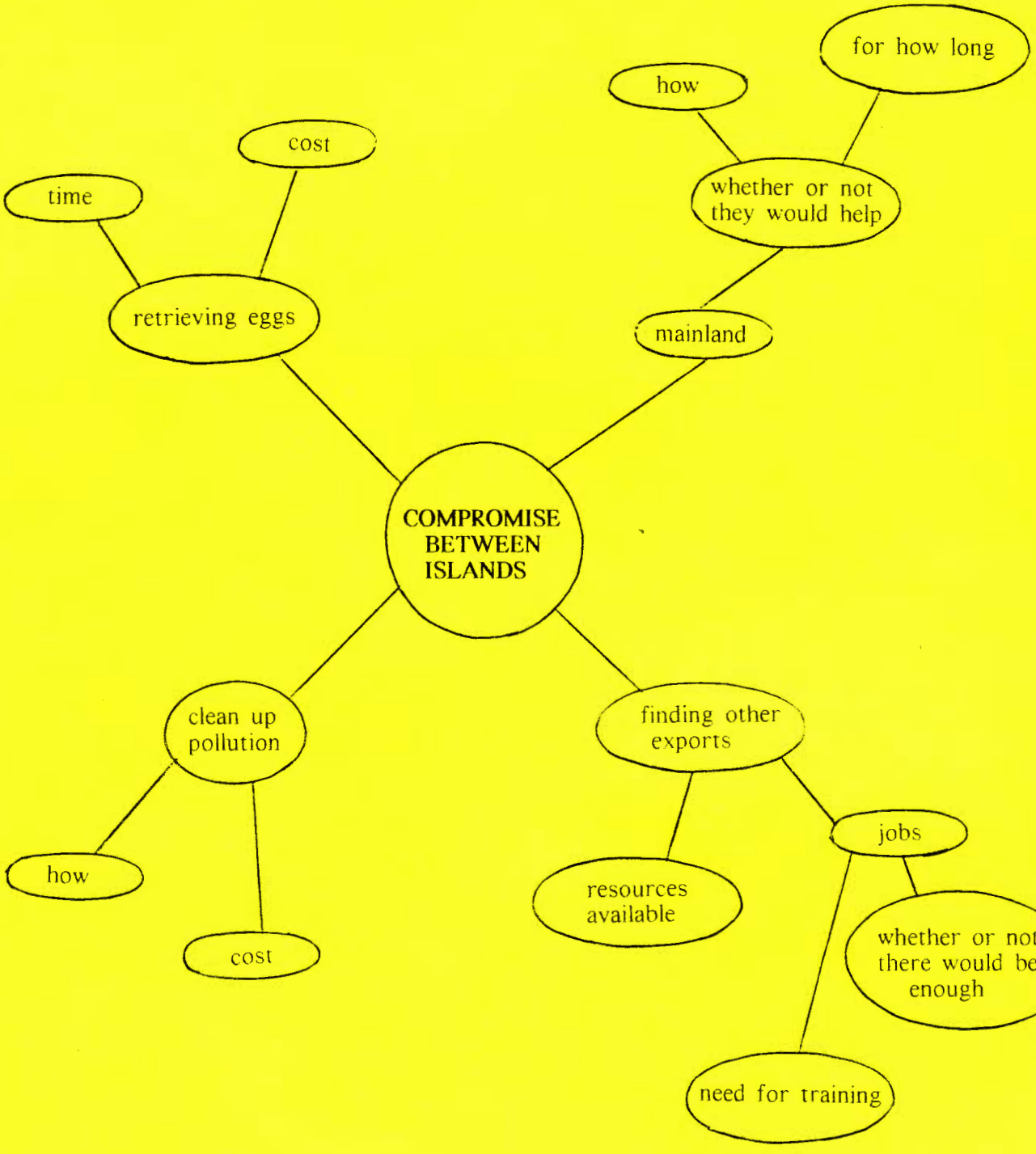
Sanji and the Baker

TEACHER'S CURRICULUM MAP



Sanji and the Baker

STUDENTS' CONCEPT MAP



Bear Shadow

by Frank Asch
New York: Scholastic, ©1985

· Students' Role:

school grounds committee

· Opener:

Your committee receives a letter from the PTA, explaining their interest in purchasing as many of one beautiful type of plant as possible for the playground. This particular plant can only receive three to six hours of sunlight a day.

· Problem Statement:

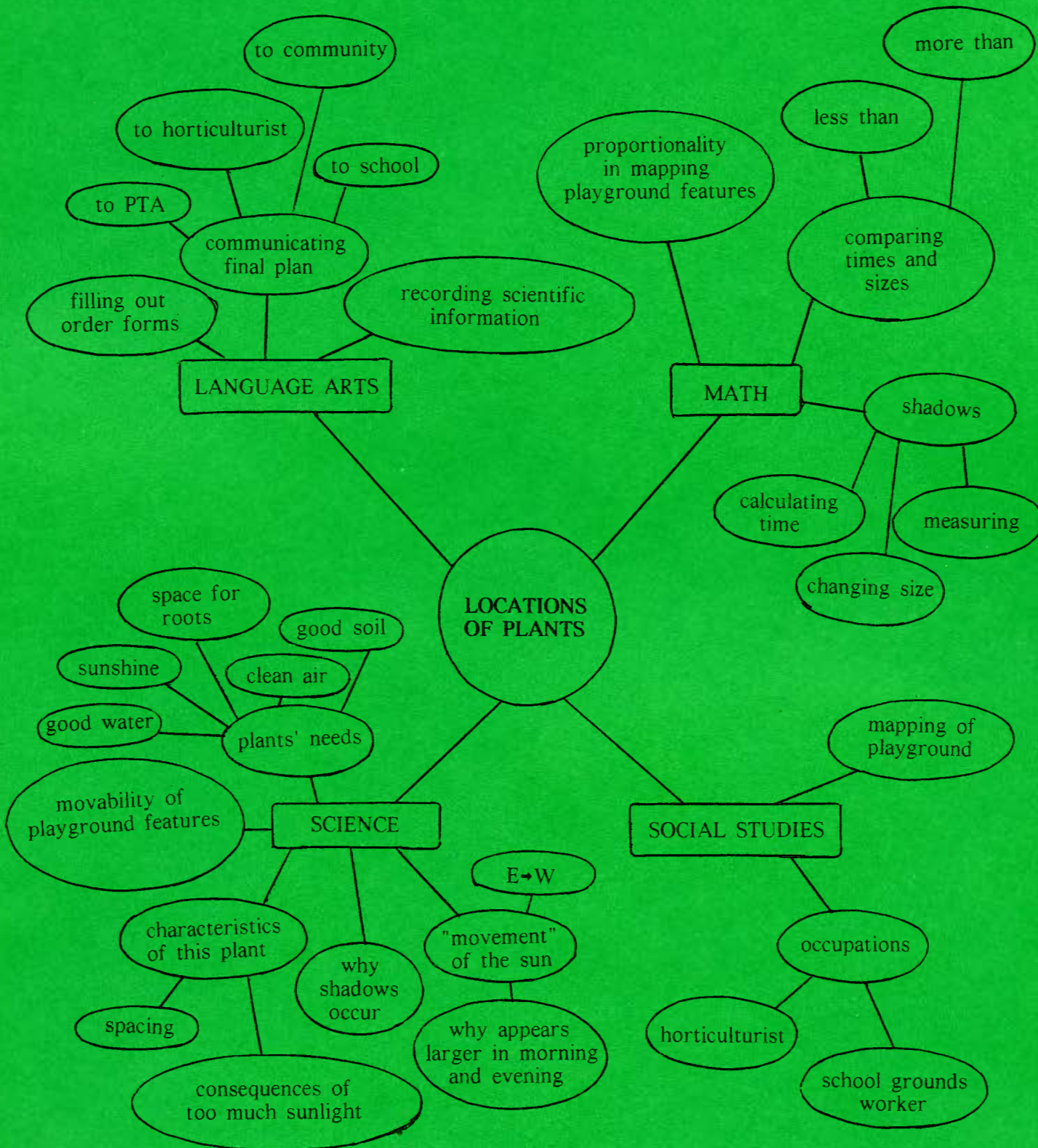
How can we plant as many of these plants as possible in such a way that each one has the greatest chances of survival?

· Problem Log Idea:

memo from horticulturist saying that the plants must be 6 inches apart

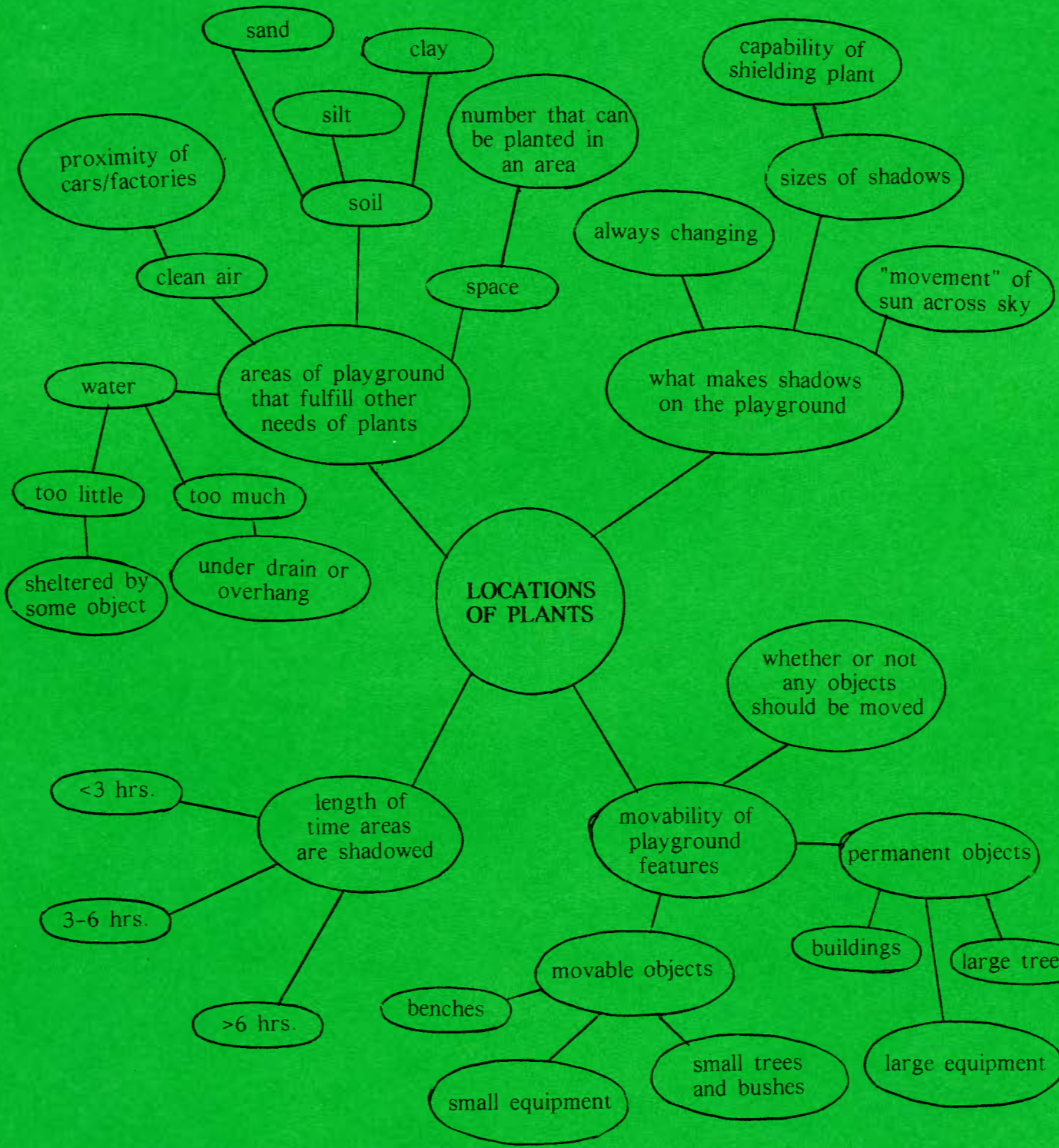
Bear Shadow

TEACHER'S CURRICULUM MAP



Bear Shadow

STUDENTS' CONCEPT MAP



The Wall

by Eve Bunting
New York: Trumpet, ©1990

· Students' Role:

U.S. Department of the Interior, National Park Service

· Opener:

Members view a videotape of people exhibiting disrespectful behavior while visiting one or more of the monuments or memorials in Washington, D. C.; or, members receive a number of letters from concerned veterans.

· Problem Statement:

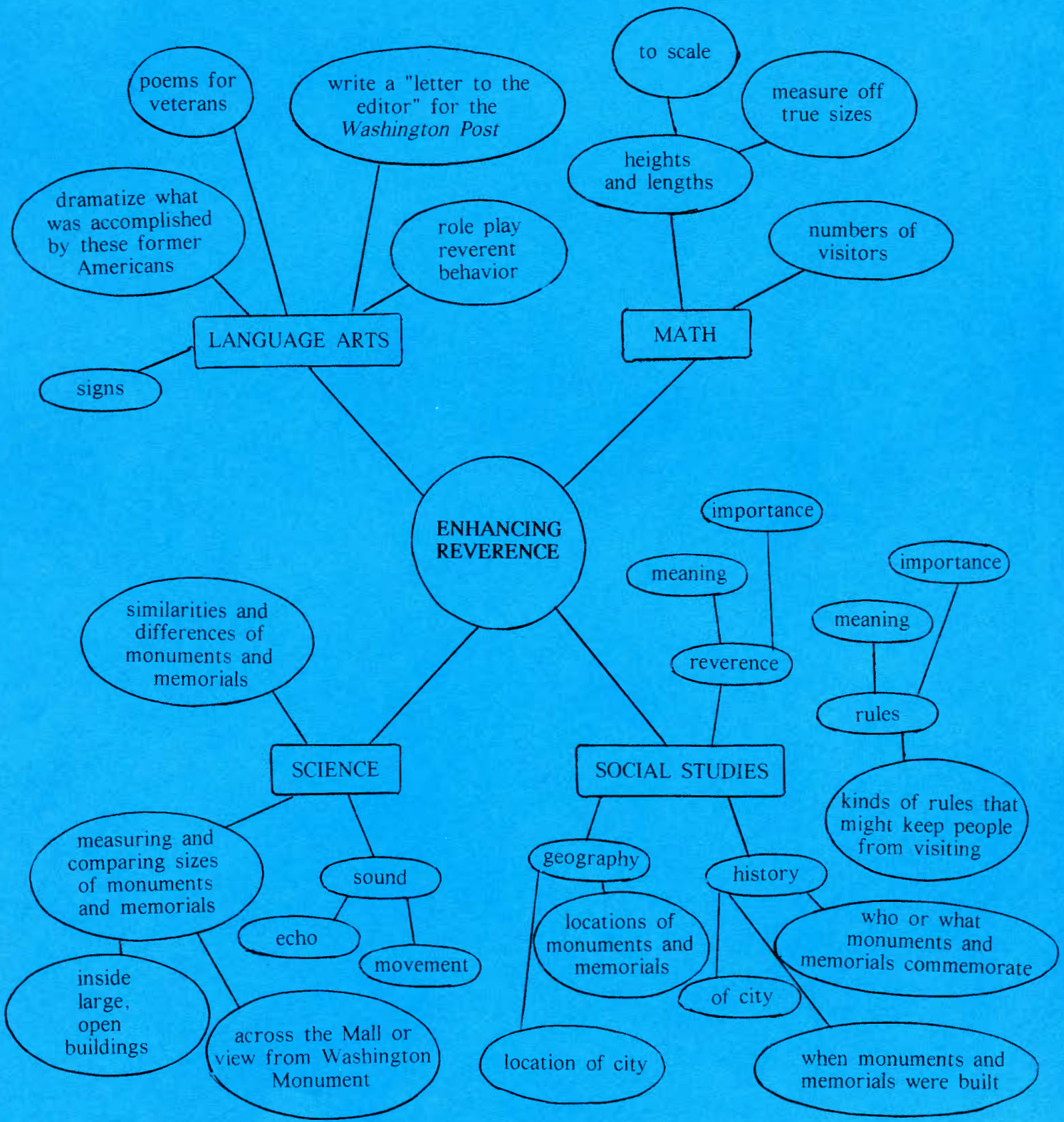
How can we make the monuments and memorials in Washington, D. C. more "reverent" sites in such a way that does not keep people from wanting to visit them?

· Problem Log Ideas:

- memo saying there is no money available to create signs
- phone message saying there is no money available to pay extra security guards

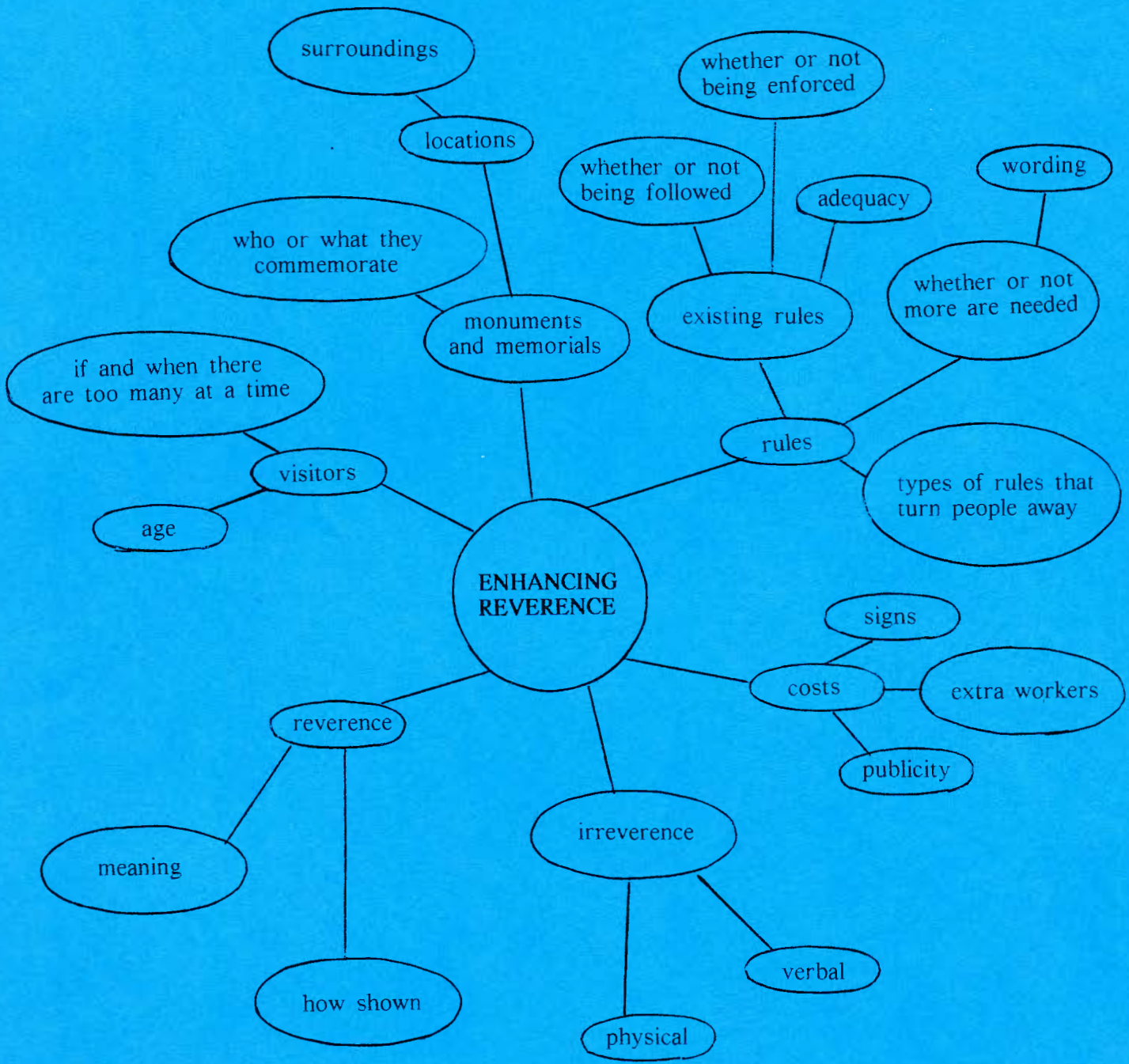
The Wall

TEACHER'S CURRICULUM MAP



The Wall

STUDENTS' CONCEPT MAP



Old Henry

by Joan W. Blos
New York: William Morrow & Co., ©1987

· Students' Role:

members of local Parks and Recreation Commission

· Opener:

You receive a fax notifying you that at their recent meeting, the city council passed a motion to hold a community-wide celebration of the elderly on Grandparents' Day. They also nominated your commission to organize this family-oriented event.

· Problem Statement:

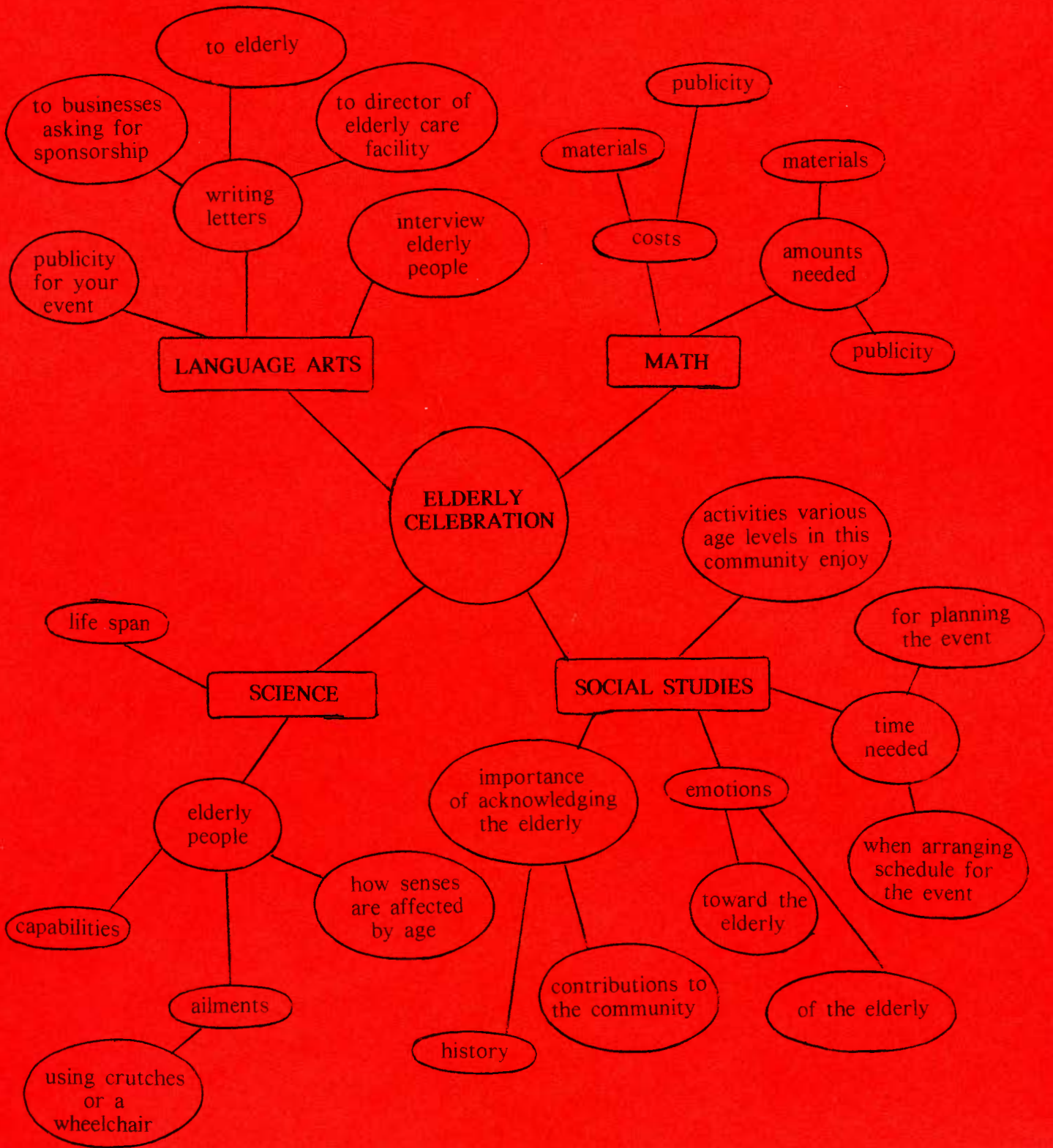
How can we organize a family-oriented celebration that acknowledges the elderly and includes all generations?

· Problem Log Ideas:

- local business backs down as a major financial sponsor
- weather forecast for Grandparents' Day predicts rain

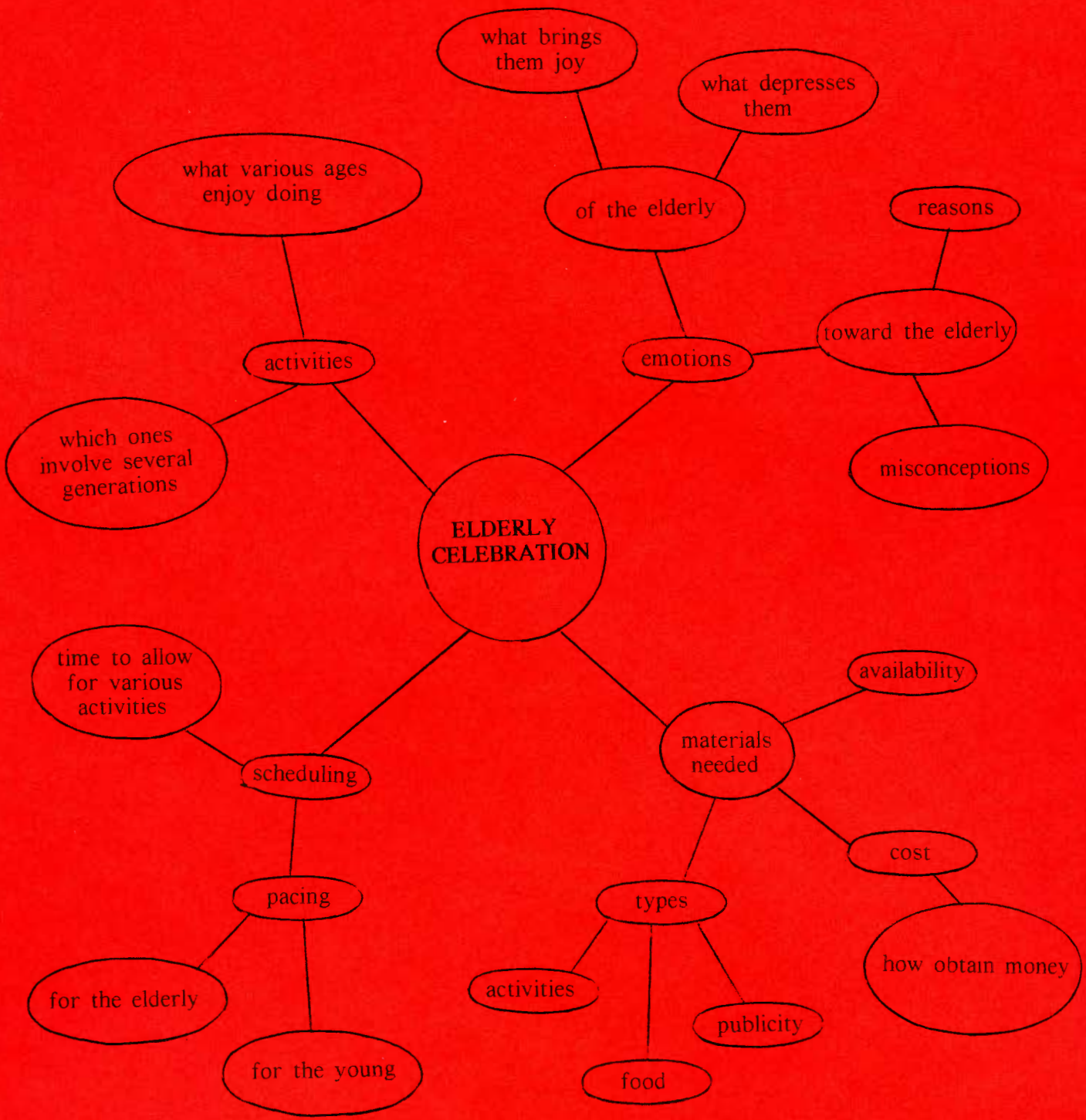
Old Henry

TEACHER'S CURRICULUM MAP



Old Henry

STUDENTS' CONCEPT MAP



Wilfrid Gordon McDonald Partridge

by Mem Fox
Brooklyn, NY: Kane/Miller, ©1985

· Students' Role:

members of local historical society

· Opener:

The historical society receives a newspaper article or memo concerning the recent discovery of a time capsule in or near the community. Many members of the community have contacted the historical society expressing their interest in creating a new time capsule that could be prepared and buried for future opening.

· Problem Statement:

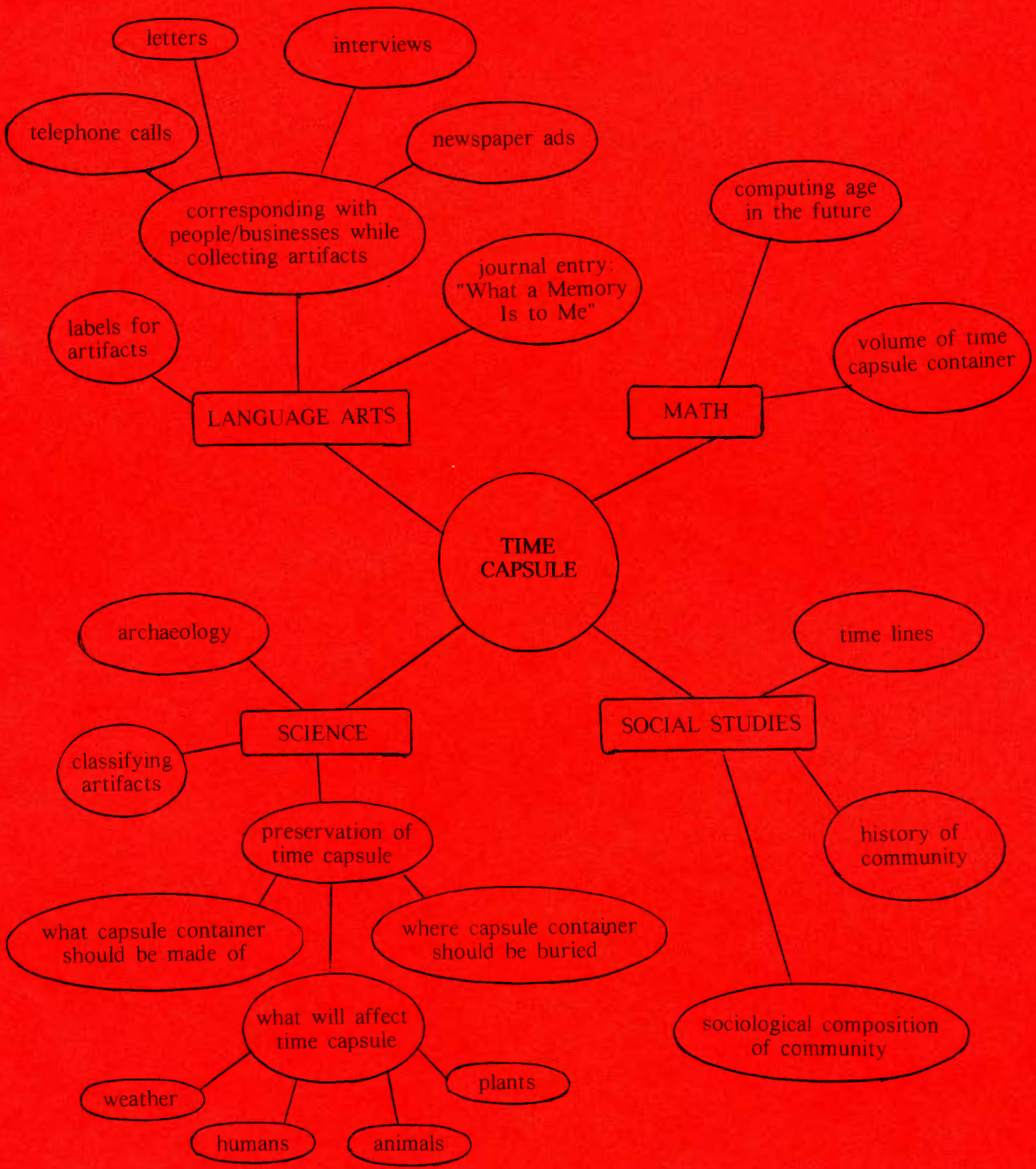
How can we create a time capsule that best portrays our community?

· Problem Log Ideas:

- mailing of material from a large industry in the community, some of which its executives want included in the capsule
- "letter to the editor" from a small business noting concern that only a few businesses will be represented in the capsule
- personal letter from the local nature reserve, asking that the capsule include information or artifacts about the natural characteristics of the community

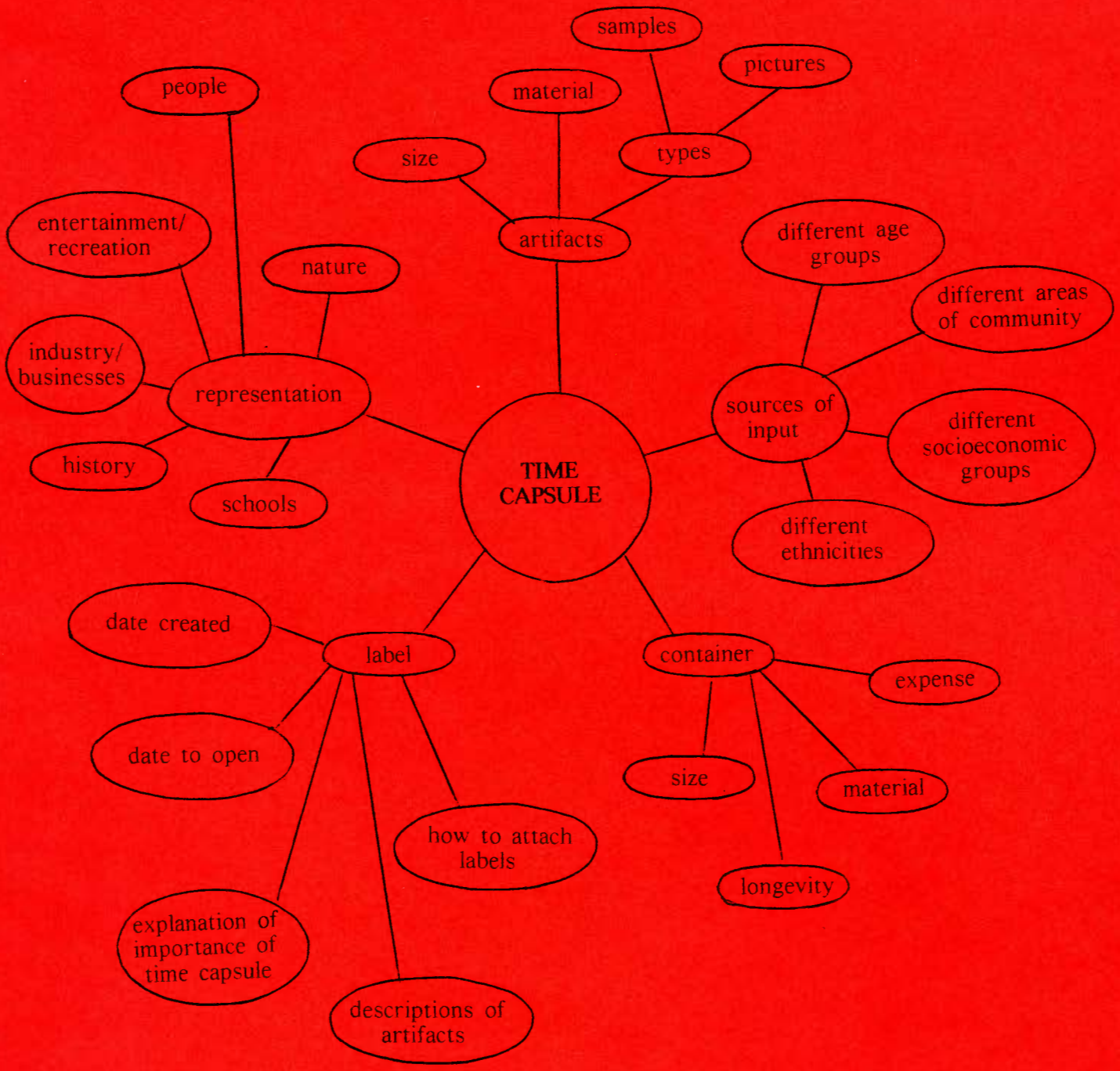
Wilfrid Gordon McDonald Partridge

TEACHER'S CURRICULUM MAP



Wilfrid Gordon McDonald Partridge

STUDENTS' CONCEPT MAP



Night Tree

by Eve Bunting
New York: Trumpet, ©1991

· Students' Role:

members of school council

· Opener:

Give students a memo from the principal, telling them that he/she wants them to plan how the school will observe various holidays throughout the school year. Then...

...have students take a walk around the school property and make observations about its conditions.

OR

...provide students with statistics of what is thrown away throughout the school building.

· Problem Statement:

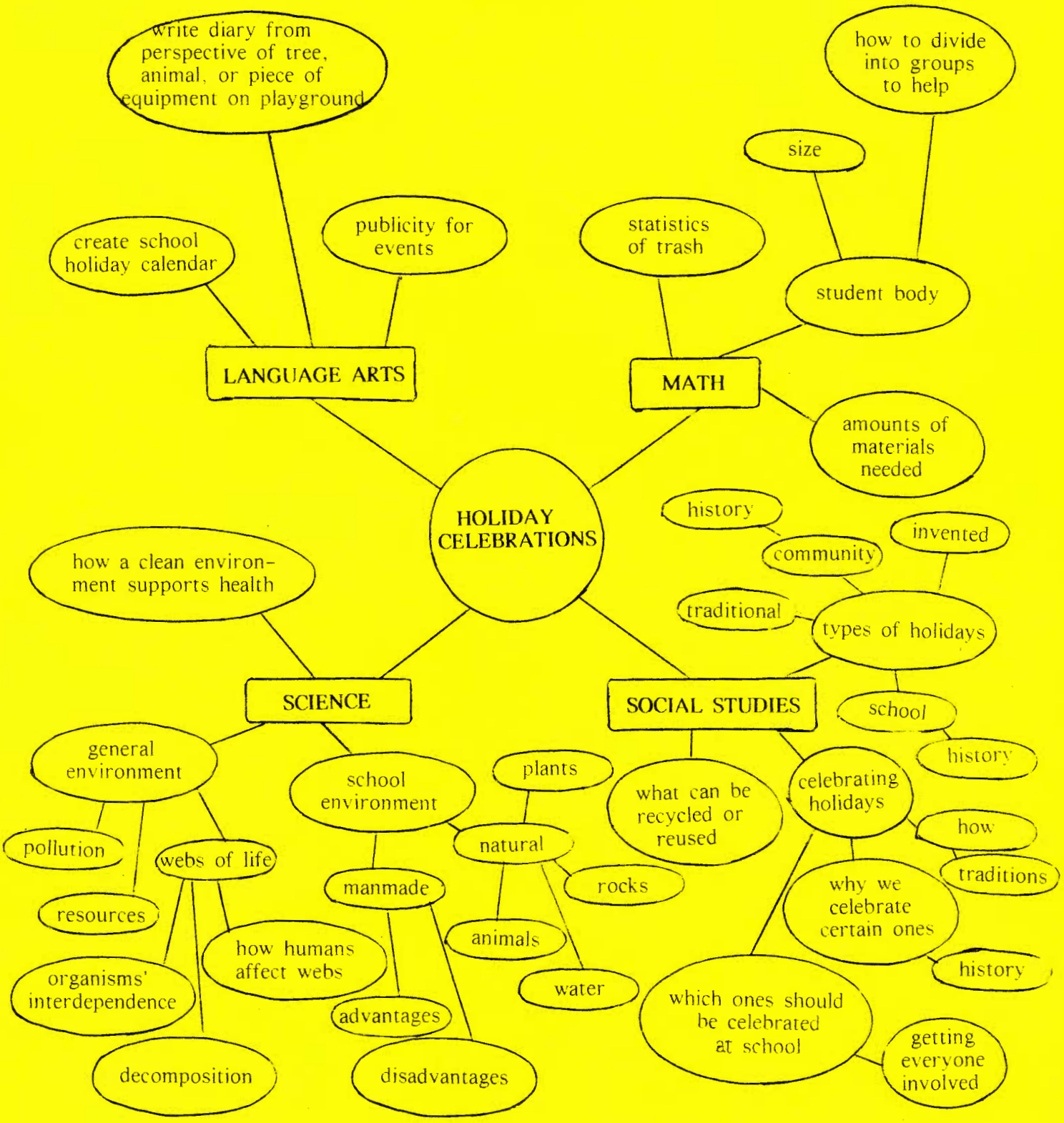
How can we celebrate various holidays at our school in ways that are friendly to the environment?

· Problem Log Ideas:

- letter from a specific subculture (i.e.: Jehovah's Witnesses, Hindus, etc.) expressing concern about how a holiday will be celebrated
- memo from janitors explaining where collection bins (i.e.: trash, recycling, etc.) can be located

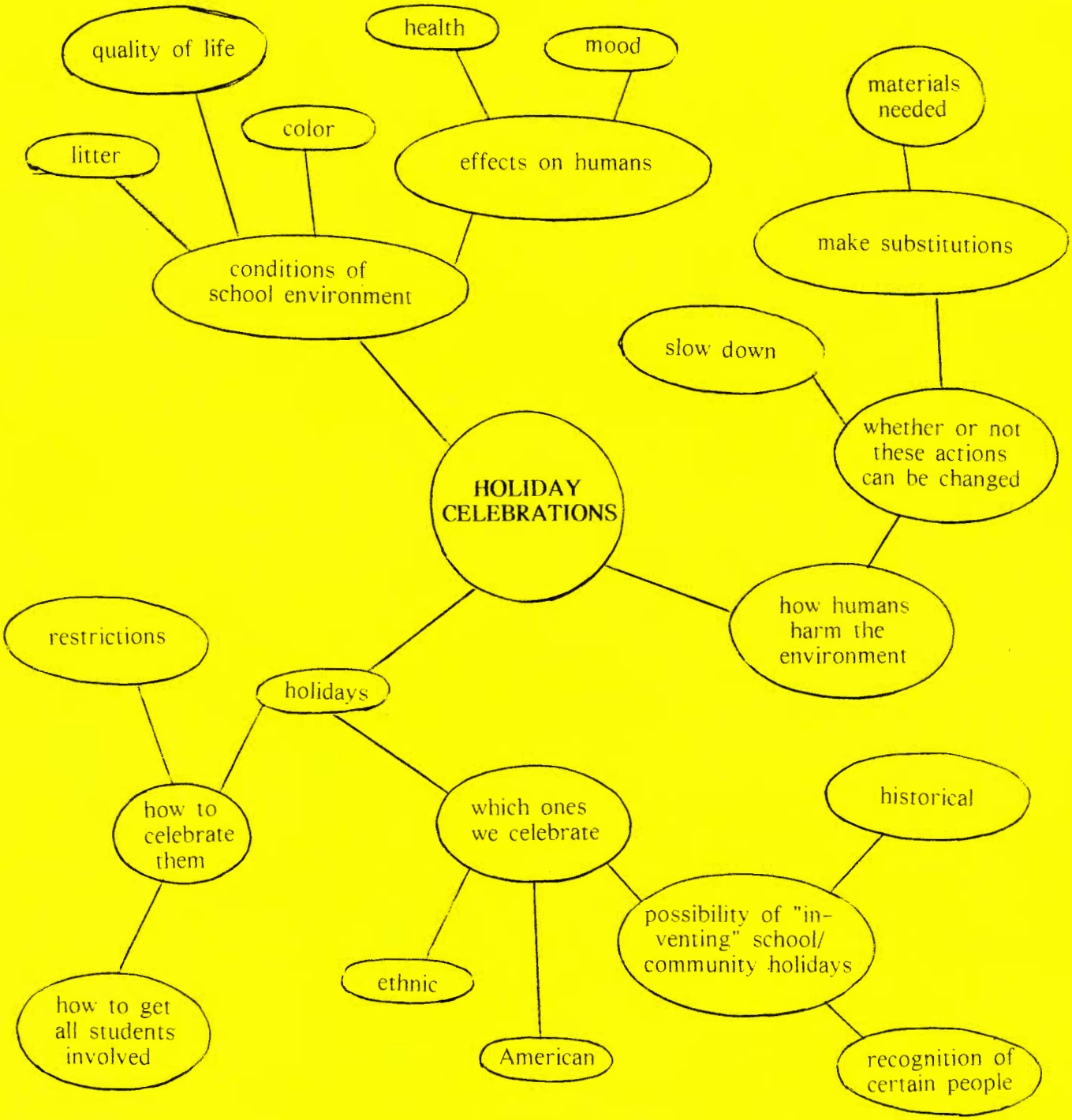
Night Tree

TEACHER'S CURRICULUM MAP



Night Tree

STUDENTS' CONCEPT MAP



Possum Magic

by Mem Fox
New York: Trumpet, ©1983

· Students' Role:

tour guides

· Opener:

Tour guides receive a letter from a group of retired people who are interested in taking a trip to Australia that lasts about three weeks.

· Problem Statement:

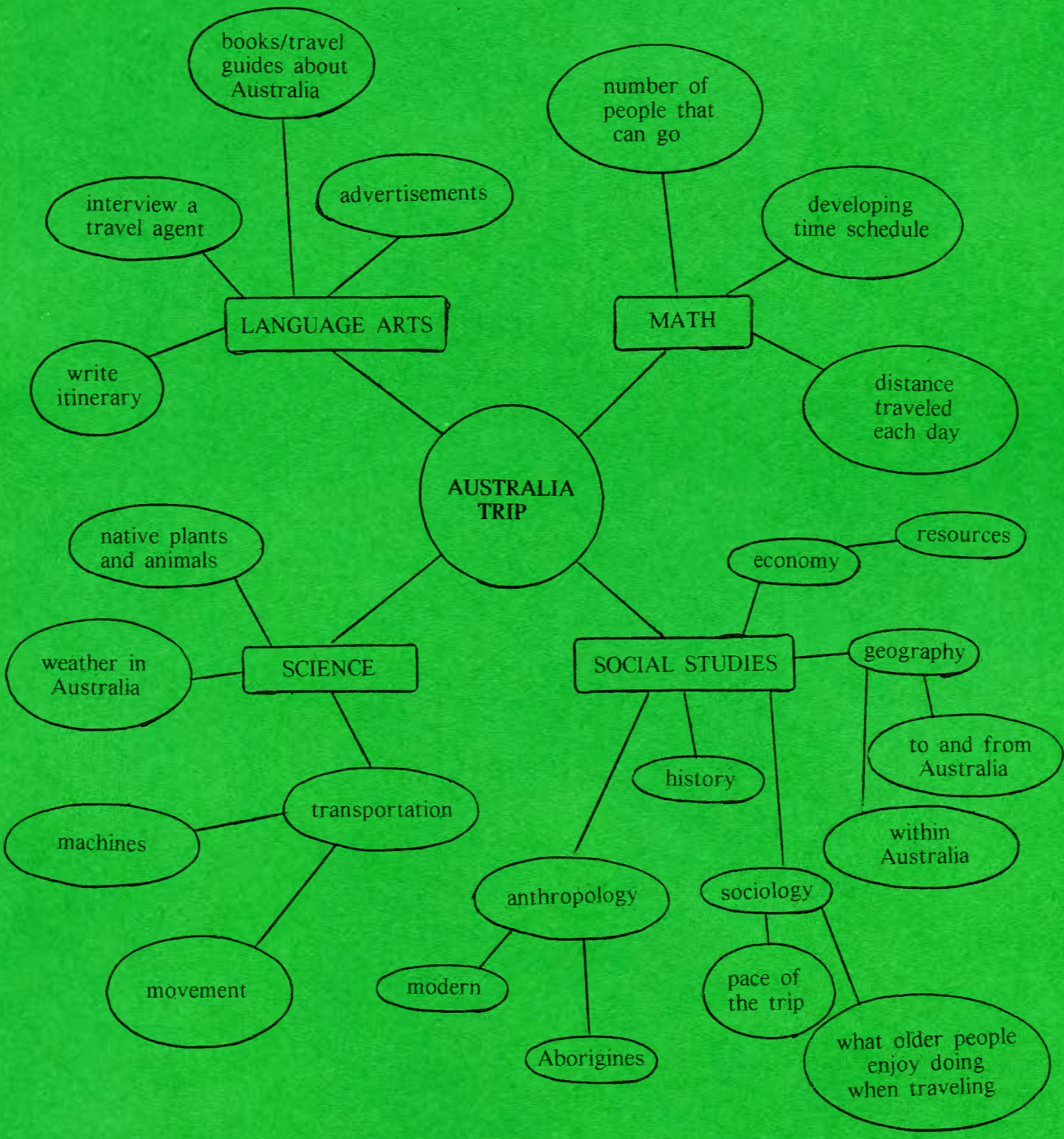
How can we plan a three-week tour that allows retired travelers to see the most important sites in Australia?

· Problem Log Ideas:

- letter from one of the travelers expressing interest in a particular activity or site on the trip
- long-range forecast predicts several major thunderstorms during the time that the travelers will be in Australia
- phone call message five days before the trip saying that one man has broken his leg but would still like to go on the trip

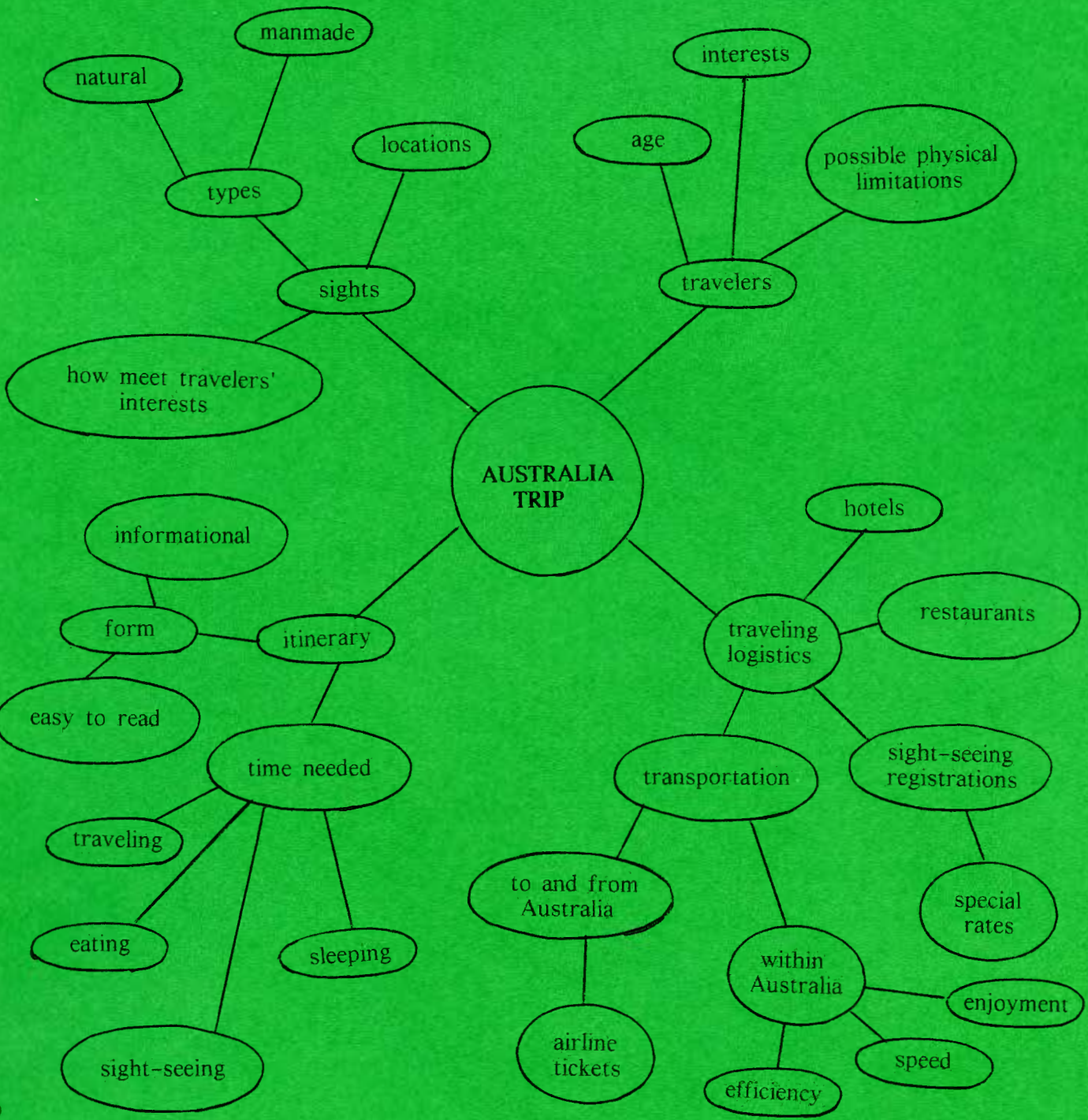
Possum Magic

TEACHER'S CURRICULUM MAP



Possum Magic

STUDENTS' CONCEPT MAP



Letting Swift River Go

by Jane Yolen
Boston, MA: Little, Brown and Company, ©1992

· Students' Role:

employees of local nature reserve

· Opener:

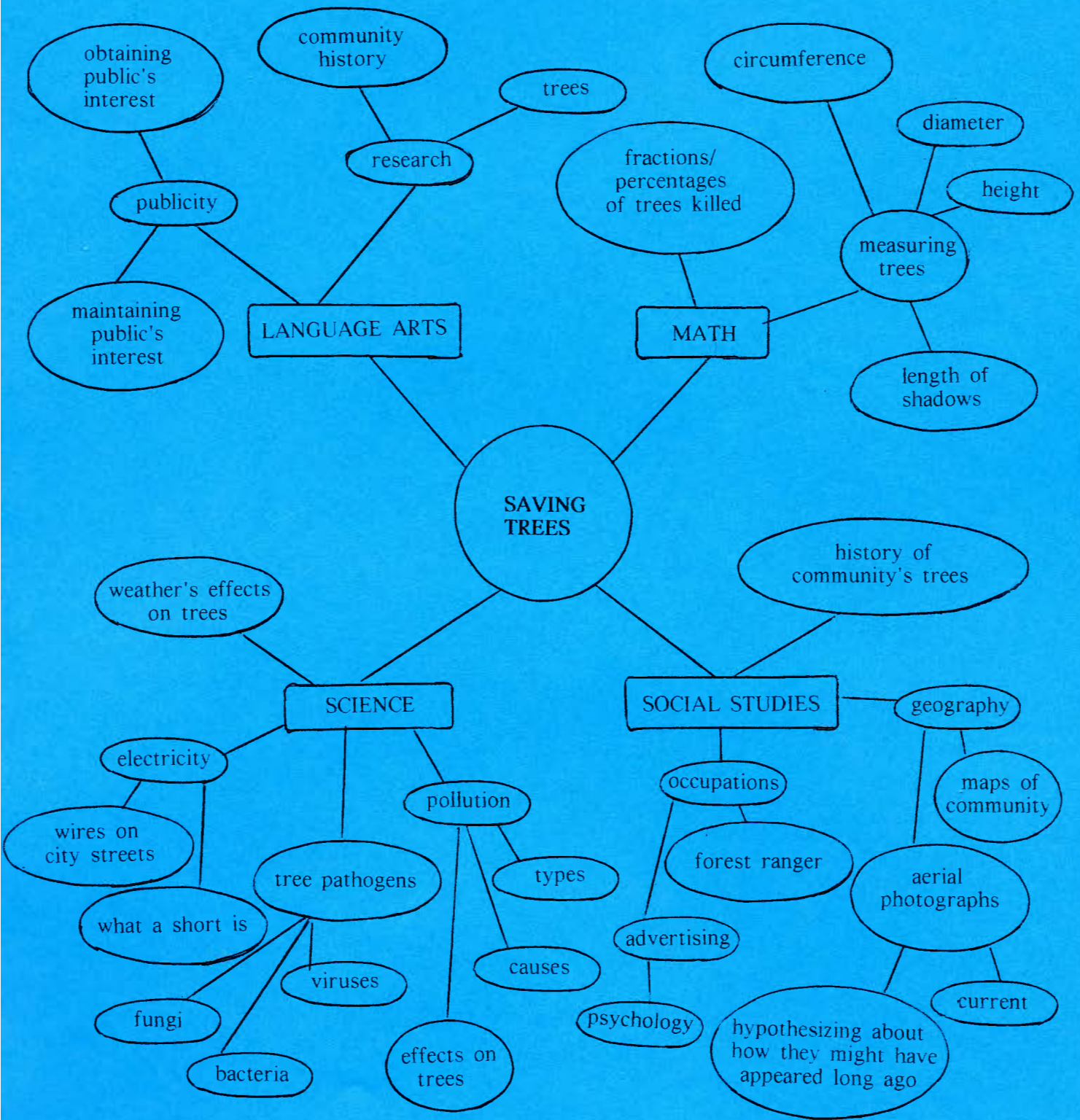
Employees receive a letter from the director of the reserve telling them that the results of their research on the community's trees have been compiled. These results are disappointing: the health and number of the trees in the community are declining rapidly. The director reminds the employees that, despite the necessity of turning this situation around, they will be unable to do it by themselves.

· Problem Statement:

How can we improve the health of our city's trees in such a way that the public is involved?

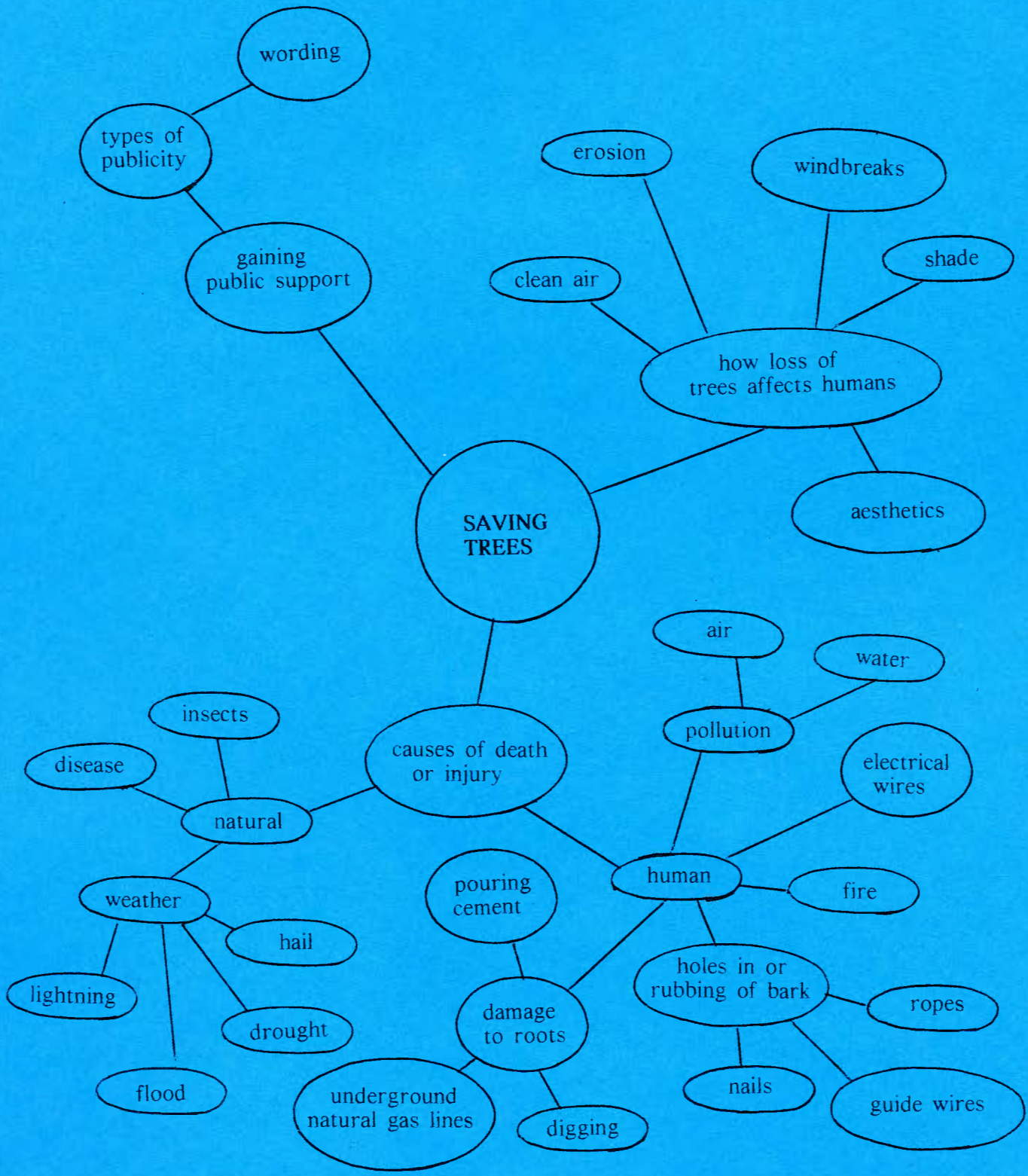
Letting Swift River Go

TEACHER'S CURRICULUM MAP



Letting Swift River Go

STUDENTS' CONCEPT MAP



Something from Nothing

by Phoebe Gilman
New York: Scholastic, ©1992

· Students' Role:

city Zoning and Planning Commission

· Opener:

The commission receives a notice of evacuation concerning an old hospital building that must be torn down. A new hospital is already in operation elsewhere, and the city has purchased the space where the old hospital stands for another use. This notice is accompanied by a memo from the mayor reminding the Commission not to be wasteful.

· Problem Statement:

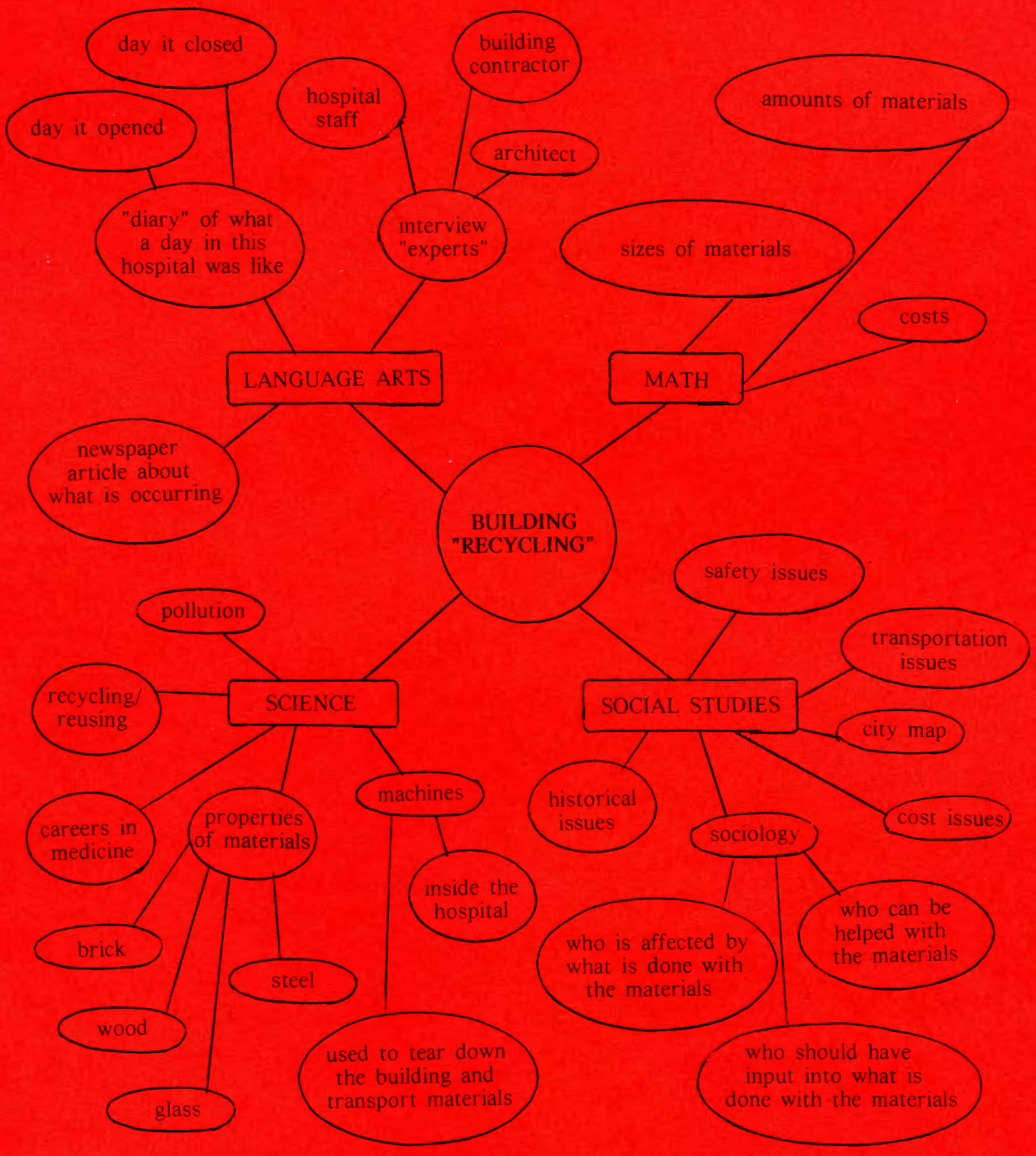
How can we get rid of the old hospital in such a way that wastes as few materials as possible?

· Problem Log Ideas:

- memo from the State Board of Health concerning disposal of materials that could be contaminated
- reminder from local sanitation workers about how and where certain materials can be discarded
- letter from the local American Legion group describing how the original part of this old building was a special hospital for Civil War soldiers; this group does not want this historical fact to be forgotten

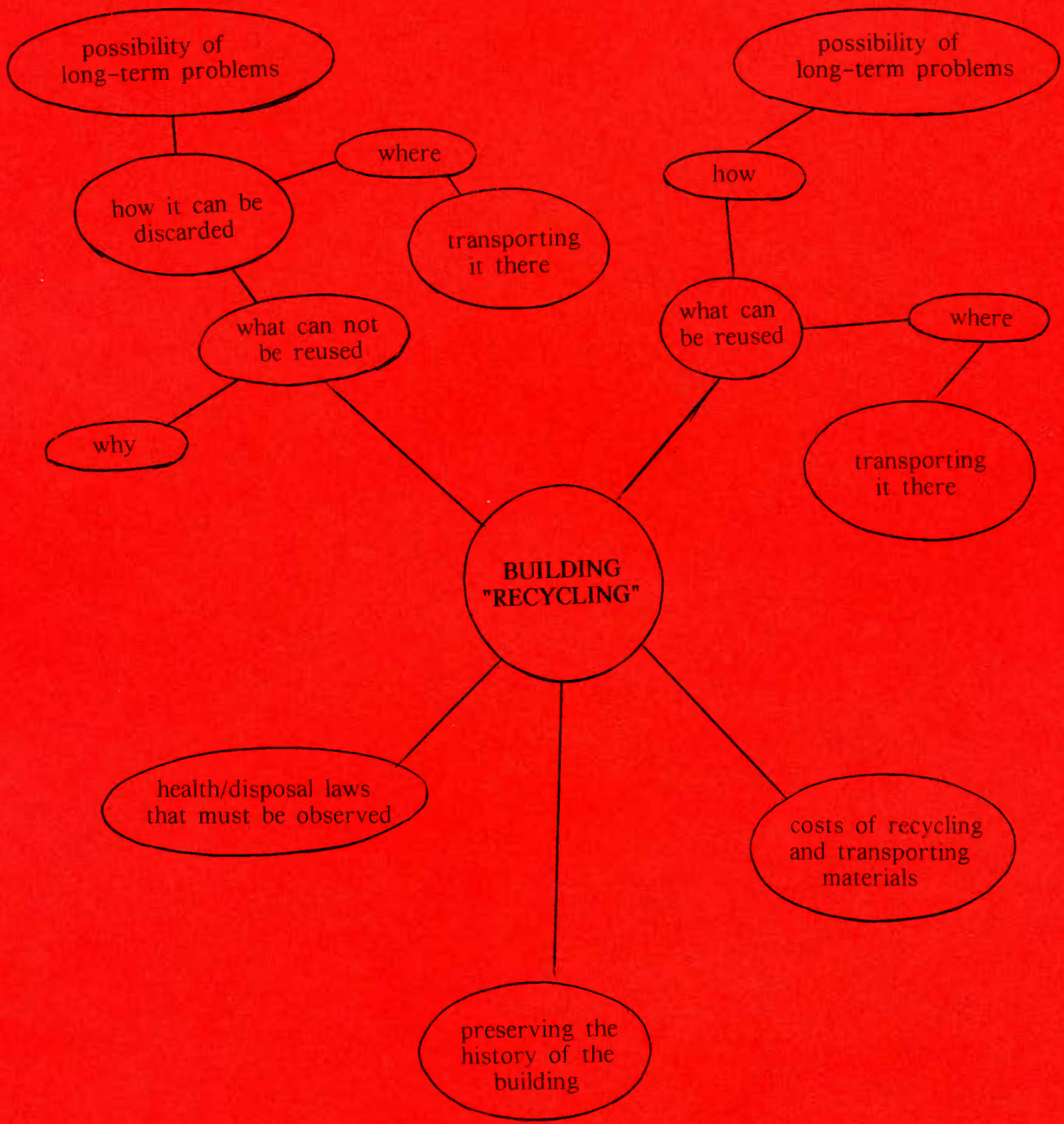
Something from Nothing

TEACHER'S CURRICULUM MAP



Something from Nothing

STUDENTS' CONCEPT MAP



Christmas in the Big House, Christmas in the Quarters

by Patricia C. and Frederick L. McKissack
New York: Scholastic, ©1994

Pink and Say

by Patricia Polacco
New York: Philomel, ©1994

- Students' Role:
  "conductors" on the Underground Railroad

- Opener:
  "Conductors" receive a small piece of wrinkled parchment with a message such as:
  Plez get 16 of us to promist land

- Problem Statement:
  How can we help 16 slaves get to freedom in such a way that neither they nor we get caught?

- Problem Log Ideas:
  - arrive at a "station" only to realize it is unmanned (there are no food or other provisions waiting for the group as planned)
  - hear a rumor that Confederate soldiers who are looking for fugitives have been hiding in the trees nearby at night

Christmas in the Big House, Christmas in the Quarters

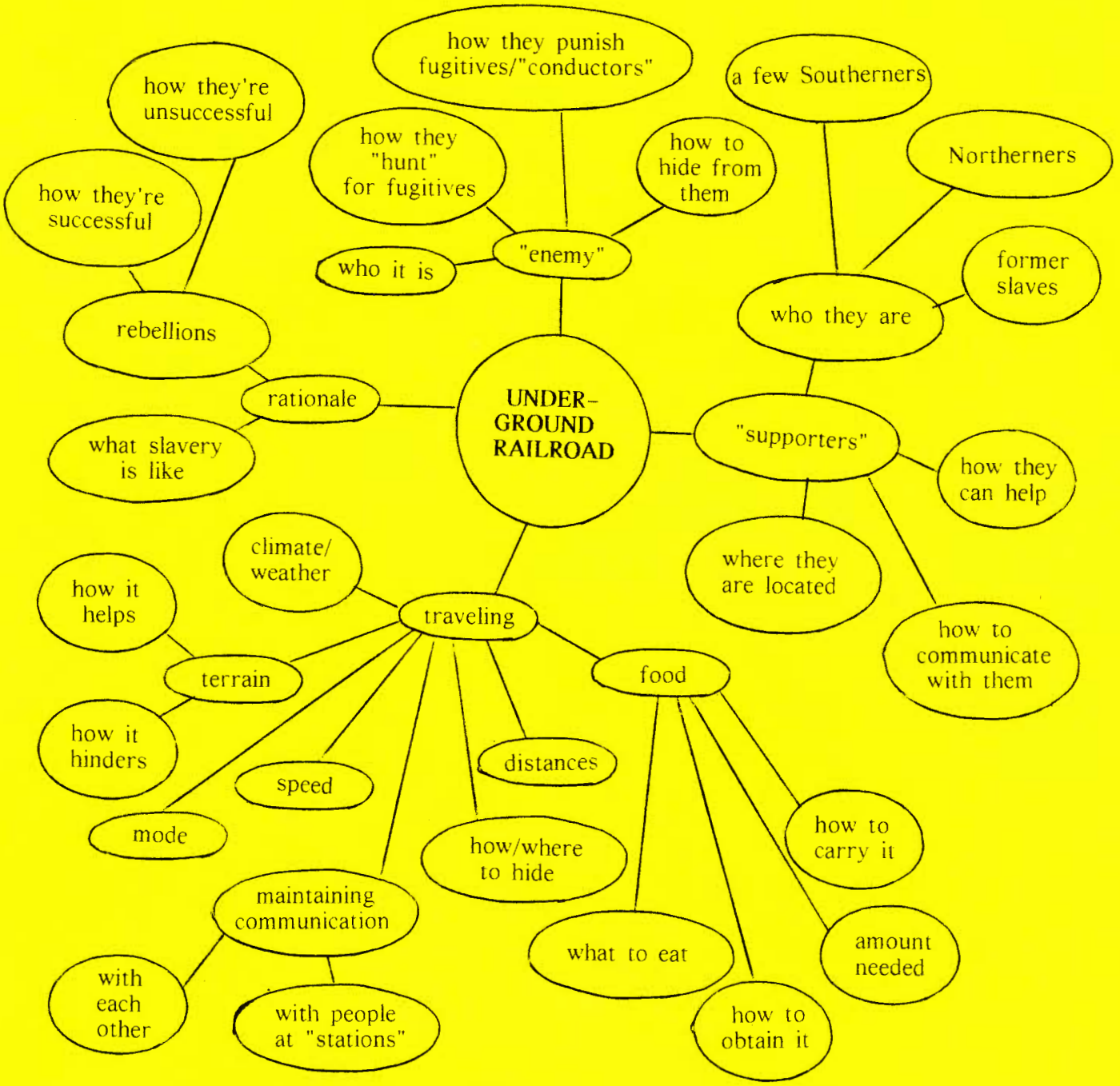
Pink and Say

TEACHER'S CURRICULUM MAP

Christmas in the Big House, Christmas in the Quarters

Pink and Say

STUDENTS' CONCEPT MAP



The Great Kapok Tree
A Tale of the Amazon Rain Forest

by Lynne Cherry
New York: Trumpet, ©1990

· Students' Role:

political activists who are lobbying in the U. S. Congress

· Opener:

A newspaper article describes a bill that is being debated in Congress. If passed, this bill would limit the number of trees that the U. S. could import from the Amazon Rain Forest. As political activists, students must convince senators and representatives to pass this bill. This newspaper article could be followed by a memo or fax reporting that another lobbying group which is opposed to this bill has secured more than half of the senators' and representatives' votes and is gaining momentum.

· Problem Statement:

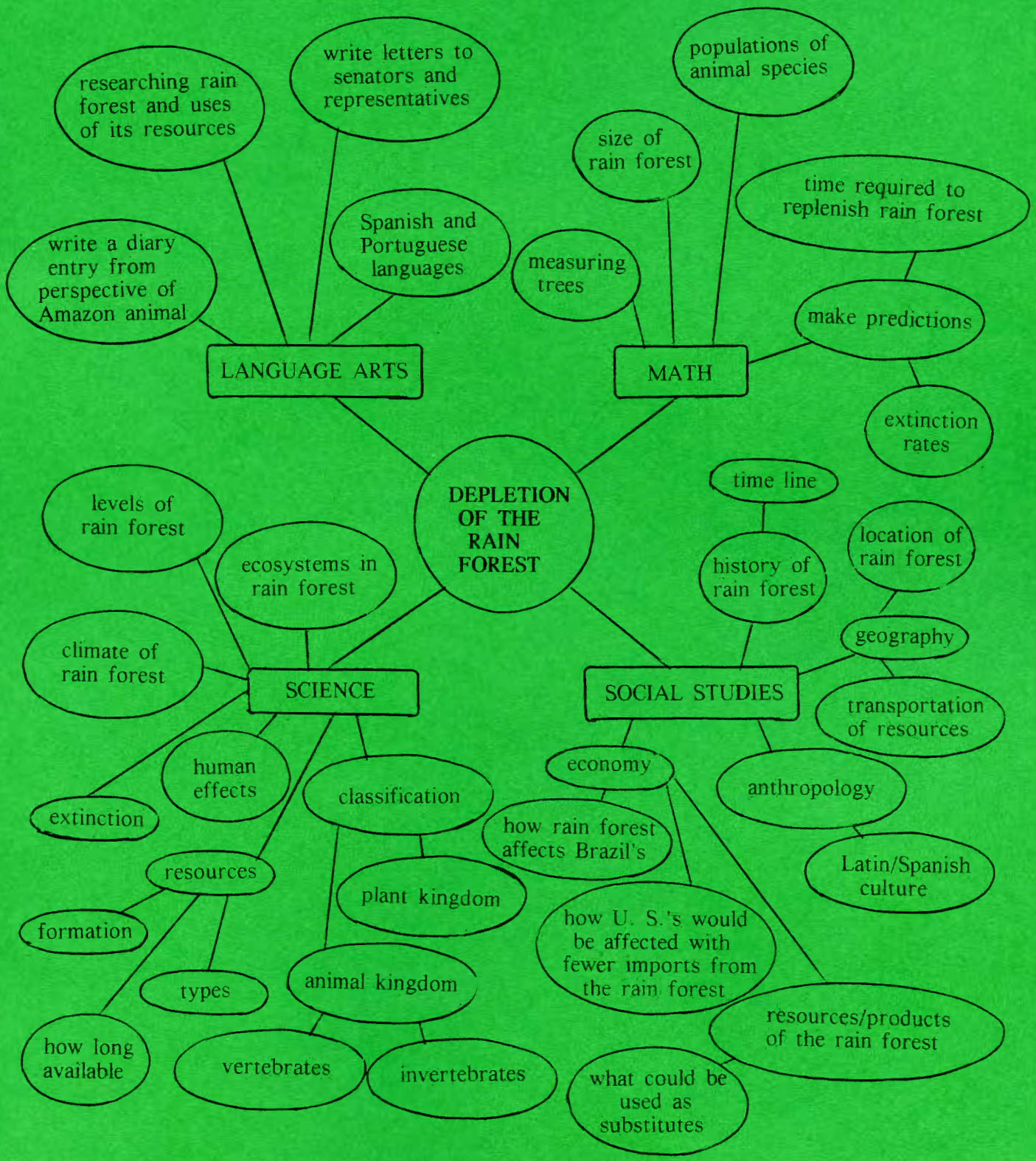
How can we continue to obtain the resources we need in such a way that does not deplete the Amazon Rain Forest?

· Problem Log Ideas:

- editorial in *The Washington Post* describing how the general American public simply does not care much about the Amazon Rain Forest
- letter from a disgruntled American industry that would be severely affected if the U. S. began importing fewer trees from the Amazon Rain Forest

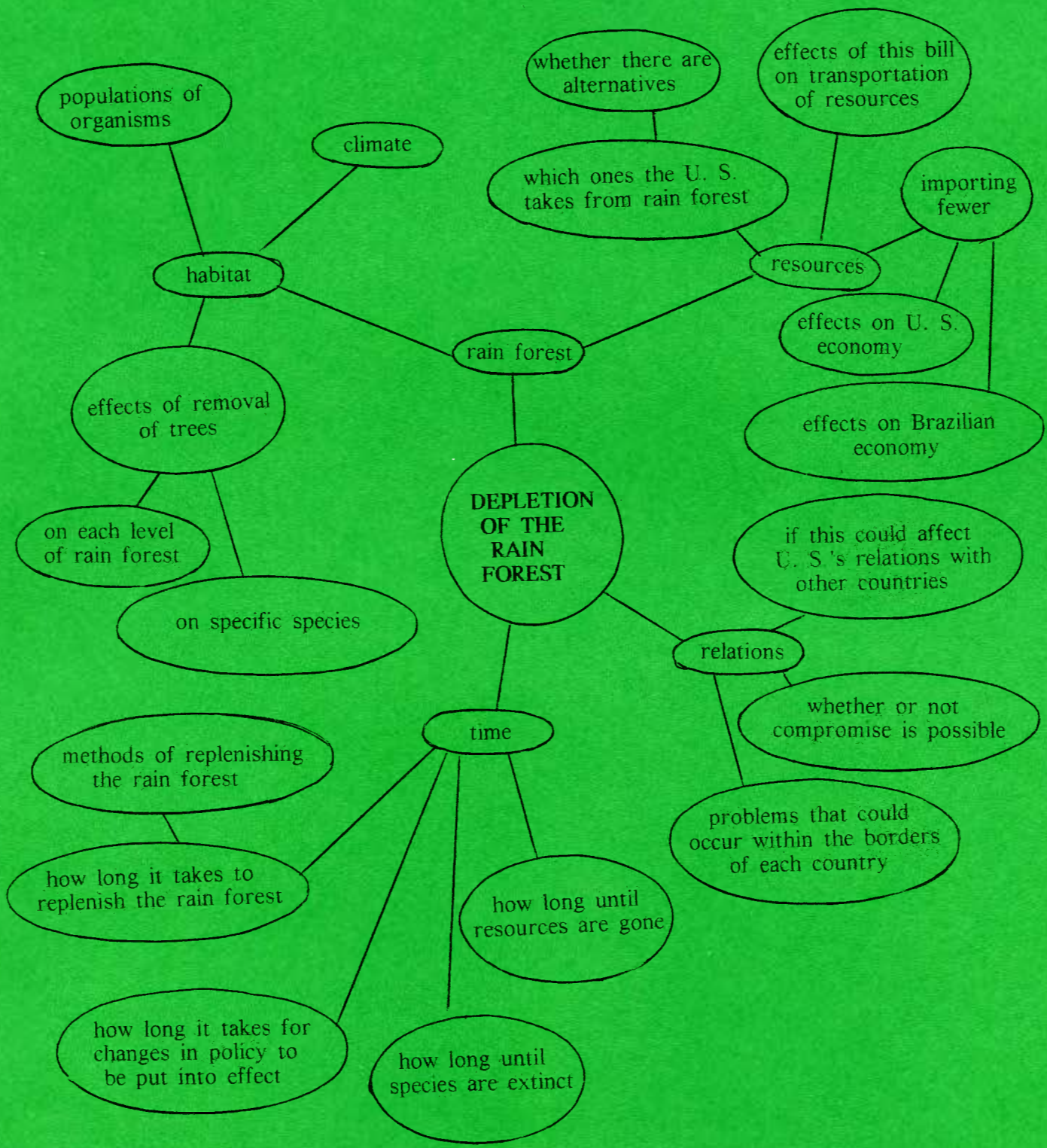
The Great Kapok Tree

TEACHER'S CURRICULUM MAP



The Great Kapok Tree

STUDENTS' CONCEPT MAP



The Great American Gold Rush

by Rhoda Blumberg
New York: Scholastic, ©1989

· Students' Role:

city planners in the Utah Territory in 1849

· Opener:

As a group of people living in Salt Lake City, you have been hearing rumors and reading newspaper reports about all of the men who are dying on the route between your city and Sutter's Mill while on their way to dig for gold in California. You've observed how, if planned well, a town can not only help travelers but also be a money-making venture for the people who build and live in it.

· Problem Statement:

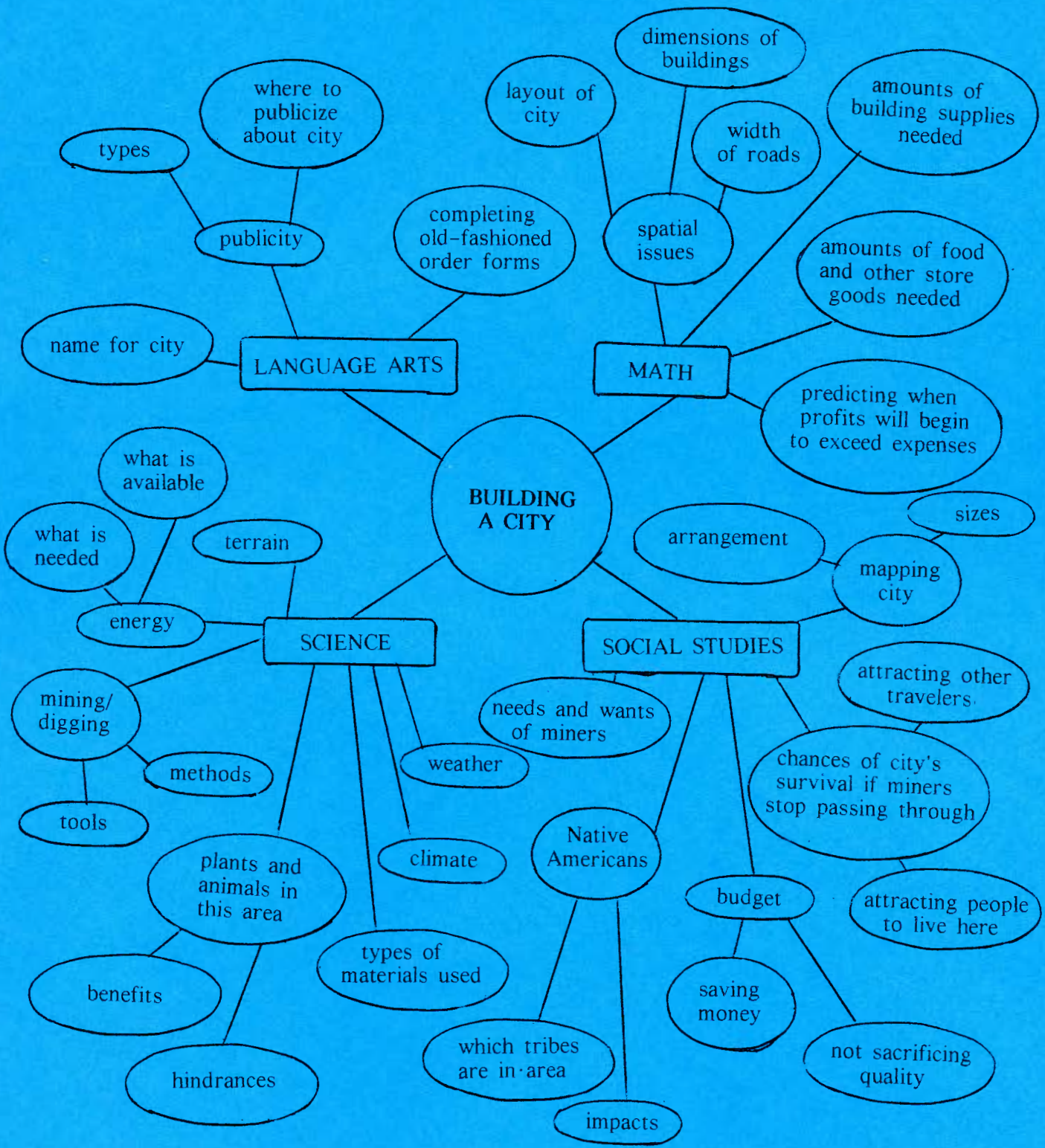
How can we design a city that is both profitable for us and beneficial to miners on their way to California?

· Problem Log Ideas:

- discover that a large portion of the land on which you plan to build contains quicksand
- receive notice of a fire at the lumber mill where you had placed your order
- during construction, there is an outbreak of dysentery among your workers

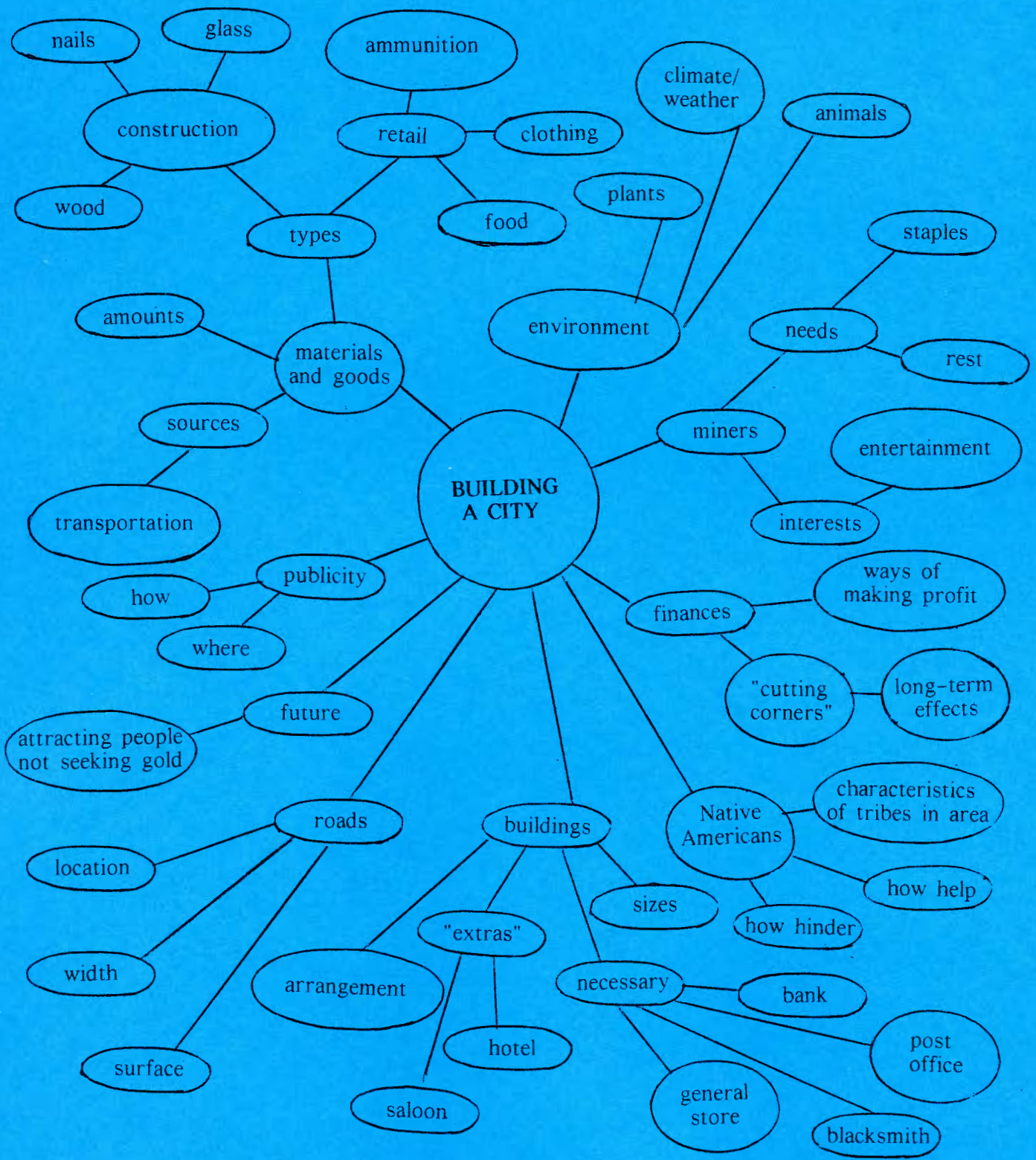
The Great American Gold Rush

TEACHER'S CURRICULUM MAP



The Great American Gold Rush

STUDENTS' CONCEPT MAP



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