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Designing an educational program to foster environmentally responsible behavior and use by teachers

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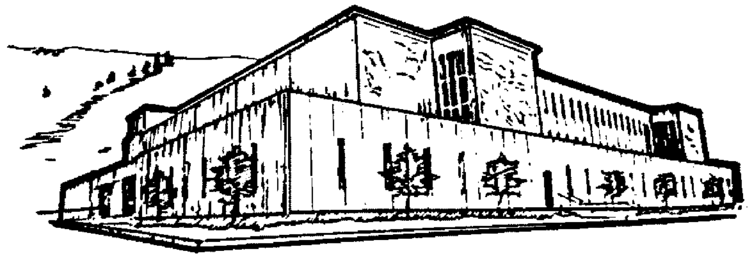

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Date: 9/9/93

DESIGNING AN EDUCATIONAL PROGRAM TO FOSTER ENVIRONMENTALLY RESPONSIBLE BEHAVIOR AND USE BY TEACHERS

by

Peggy Dybvig Schmidt

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Designing an educational program to foster environmentally responsible behavior and use by teachers

Director: Lee H. Metzgar

Improvement of Missoula's air quality depends largely upon individual lifestyle changes because individuals rather than industry contribute the greatest portion of Missoula's air pollution. *Air Care* is an interdisciplinary unit on the subject of air pollution in the Missoula Valley. The unit aims to foster learner participation in measures that protect air quality through incorporation of strategies developed by research on environmentally responsible behavior. It also aims to achieve maximum utilization by meeting the curricular guidelines of a major local school district, meeting students' and teachers' needs, and through provision of a kit that contains visual aids and hands-on materials.

Acknowledgements

I would like to thank the members of the Missoula City/County Air Pollution Advisory Council, who initiated this project and provided valuable feedback on the lesson plans. Special thanks go to council member Dr. Gerry Brenner, who put a great deal of time and effort into reviewing both my professional paper and the *Air Care* unit. I thank all the educators, fellow graduate students, and fifth grade students who commented on *Air Care*.

I am grateful to Mike Christiansen, Ray Somerset, Dorothea Lowe, and Carole Addis, who allowed me to test a pilot version of the unit in their classrooms. Thanks also to the teachers who presented the material in their classrooms during the 1992-93 school year.

Many thanks to Jim Carlson, Ken Anderson, and Ben Schmidt at the Missoula City/County Health Department, each of whom was always ready to answer my questions. Thanks also to Greg Oliver. His unit, *Living in Missoula*, provided the foundation on which *Air Care* was built.

Faculty and staff of The University of Montana Environmental Studies Department always went out of their way to support me and my fellow students in any way possible. I am proud to have been a part of that department.

Finally, I would like to thank the members of my professional paper committee: Drs. Doug Beed, Ralph Allen, and Lee Metzgar. Their comments helped me to improve my professional paper by leaps and bounds. Most of all, I extend special thanks to Lee Metzgar, my committee chair, for going the extra mile to help me improve my Environmental Protection Agency grant application and for making time to answer my questions.

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I. Introduction

Air Care is an interdisciplinary unit on the subject of air pollution in the Missoula Valley of Montana. It was developed through the Missoula City/County Health Department with funds from the United States Environmental Protection Agency (U.S. EPA). Those funds also provided for a set of educational kits to accompany the unit. Each kit contains hands-on materials, visual aids, lesson plans, a teacher's reference guide, and virtually everything a teacher requires to present the unit.

II. Need for the Project

Missoula is the largest urban population in North America completely surrounded by the Rocky Mountains. Its mountain valley topography leads to frequent temperature inversions during the winter. These inversions stagnate air for days at a time and trap pollutants in a relatively thin layer of cold air near the valley floor. EPA classifies Missoula as a "non-attainment area" for particulates and carbon monoxide. A "non-attainment area" fails to meet federal air quality standards.

Before 1977 Missoula's death rate from chronic obstructive pulmonary diseases stood at 49% above the national average. Several other areas of the state with poor air quality also had elevated death rates from respiratory ailments (Johnson 1980). In response to this, and because few studies on the health effects of air pollution applied to Montana's meteorology and terrain, the state legislature funded the Montana Air Pollution Study (MAPS) in 1977.

One section of the study compared the pulmonary function measurements (PFM) of children from Missoula, Anaconda, Billings, and Butte to those of children from a city with relatively clean air, Great Falls. Results showed that Great Falls children had the best pulmonary function, while Missoula and Anaconda children had the worst. The highest and lowest community PFM averages differed by as much as 9.4 percent. In another study, repeated PFM-tests revealed a consistent negative correlation between particulate air pollution and PFM.

Researchers also studied several adult residents of Missoula who suffered from chronic obstructive pulmonary diseases. Tests showed a significant negative correlation between forced expiratory volume over one second and weekly average particulate counts (r unreported, $p < 0.05$). Tests also revealed a negative relationship between peak expiratory flow rate and particulate counts ($r = 0.374$). When members of the MAPS team studied the daily diaries of these patients, they found positive correlations between respirable particulate count and shortness of breath ($r = 0.065$), coughing ($r = 0.139$), wheezing ($r = 0.203$) and self-treatment of lung problems ($r = 0.339$). Patients became less active as particulate counts rose ($r = 0.198$) (Johnson 1980).

Missoula's air quality has improved since 1977, as shown in Figure 1. However, the rate of population growth in the Missoula Valley requires continued reductions of per capita air pollution emissions or a possible return to past air pollution levels and associated health risks.

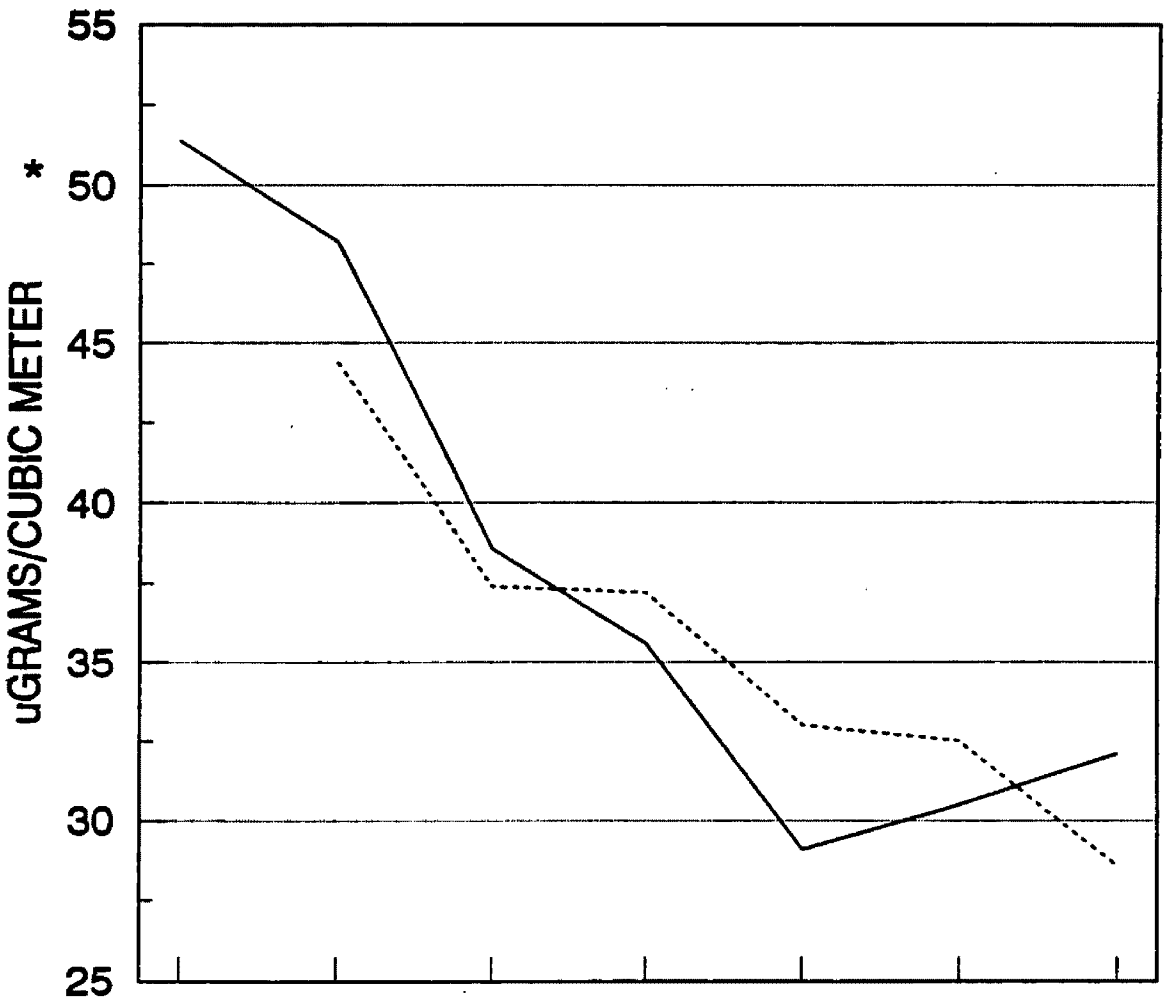
Education plays an essential role in reduction of per capita emissions. First, educators must raise awareness about the sources of

FIGURE 1: Average Annual PM-10 Concentrations in Missoula, MT.

MISSOULA PARTICULATE LEVELS (PM-10)

1986 - 1992

ANNUAL AVERAGE



YEAR		1986	1987	1988	1989	1990	1991	1992
BOYD PARK	—	51.4	48.2	38.6	35.6	29.1	30.5	32.1
HEALTH BLDG.	---		44.4	37.4	37.2	33.0	32.5	28.6

Source: Missoula City/County Health Department, Environmental Health Division.

Missoula's air pollution. Many local residents demonstrate misconceptions regarding this subject. Evidence of this lies in comments received by the Missoula City/County Health Department. Although the department has no quantitative data on the comments it receives, environmental health specialists report that they regularly field telephone calls from citizens who are misinformed about the sources of Missoula's air pollution. Some callers say that industry contributes the largest portion of Missoula's air pollution. The health department should therefore enforce stricter regulations on industry, they suggest. Automobiles do not threaten air quality, insist some callers. One person said that automobiles pollute, but wood stoves do not.[1] In fact, health department data show that industry contributes only 5% of the particulates and 9.6% of the carbon monoxide during the winter. As shown in Figures 2 and 3, the largest sources of Missoula's particulate air pollution are road dust and residential wood stoves; vehicles contribute the largest portion of carbon monoxide. Thus, *individuals* must take responsibility for the greatest share of Missoula's air pollution. Substantial air quality improvement depends upon individual lifestyle changes.

Air pollution education provides a means to inform citizens of the sources of Missoula's air pollution and to relate other important information such as the health effects of polluted air. Most importantly, research has shown that environmental education can promote environmentally responsible behavior (Ramsey and Hungerford 1989).

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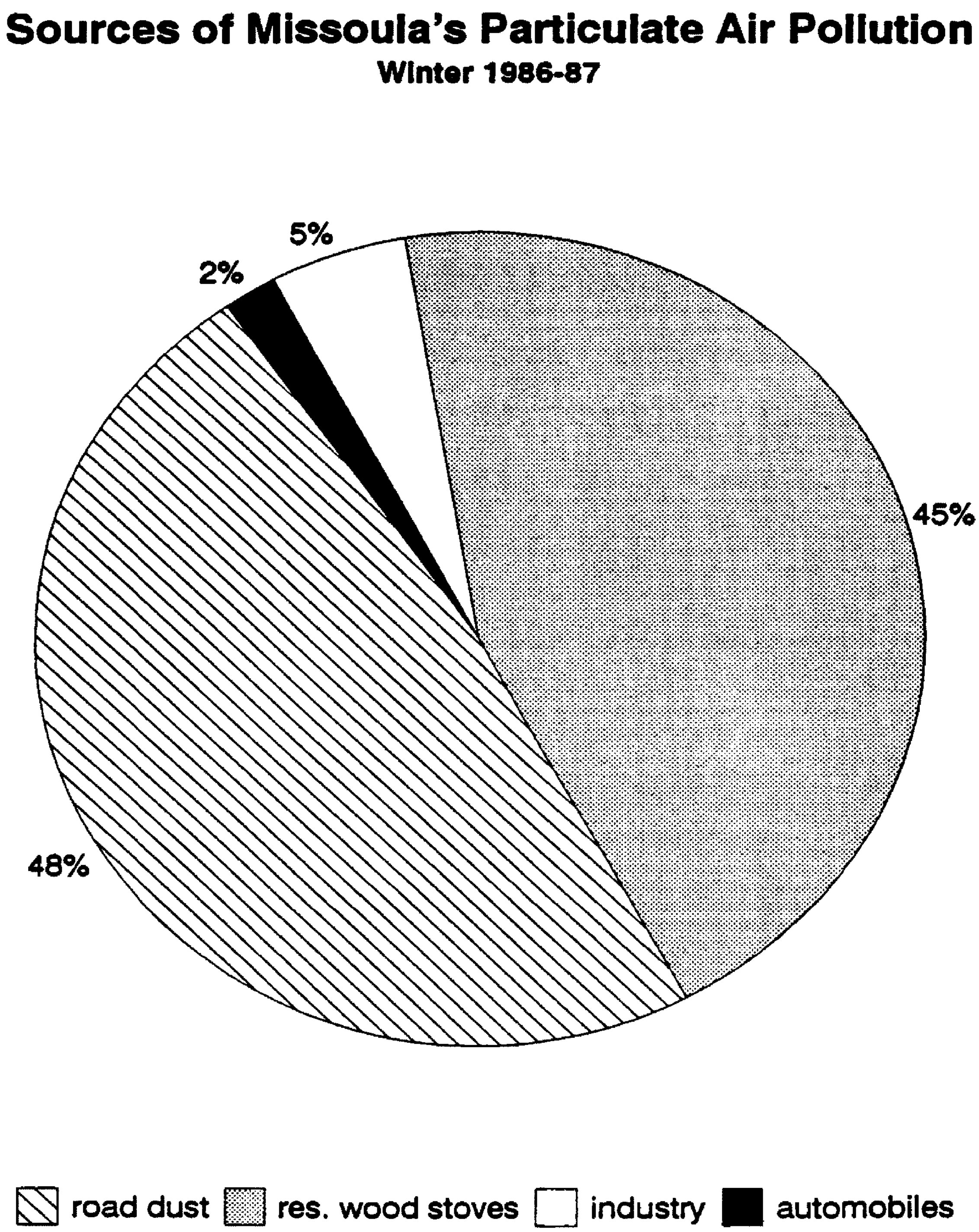
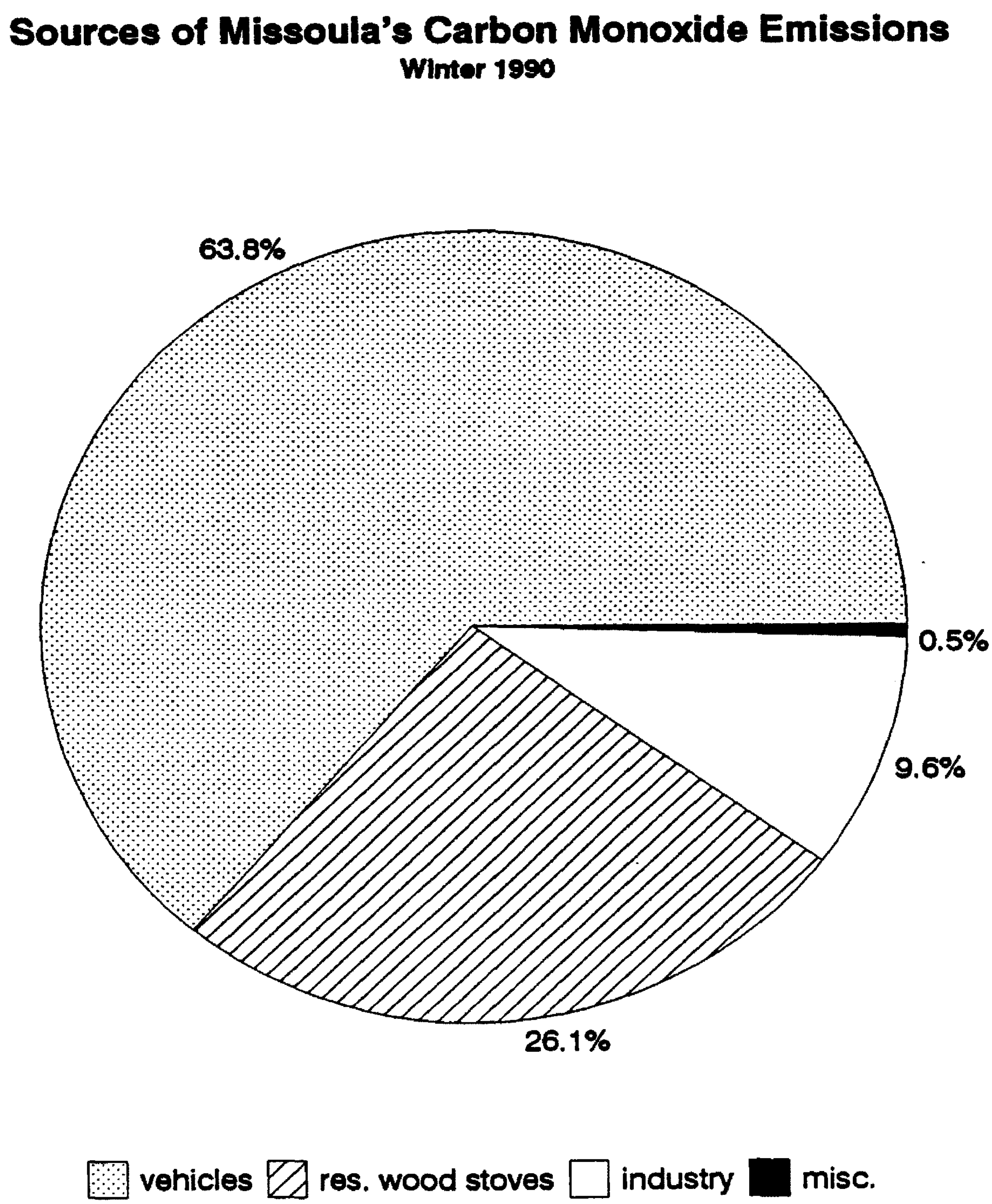
[1] Source: Benjamin Schmidt, environmental health specialist at the Missoula City/County Health Department.

FIGURE 2: Sources of Missoula's Particulate Air Pollution, Winter 1986-87.



Source: Missoula City/County Health Department, Environmental Health Division.

FIGURE 3: Sources of Carbon Monoxide Emissions in Missoula, MT.



Source: Missoula City/County Health Department,
Environmental Health Division.

Thus, education on the subject of air pollution can empower Missoula-area students to make lifestyle decisions that will improve the quality of the air they breathe.

III. Environmental Education and Lifestyle Changes

A. Definition and Goals of Environmental Education

The field of environmental education (EE) came into existence more than twenty years ago. In 1969, Stapp et al. wrote what many people today accept as a definition of environmental education:

> *Environmental education* is aimed at producing a citizenry that is *knowledgeable* concerning the biophysical environment and its associated problems, aware of *how* to help solve these problems, and *motivated* to work toward their solution (Stapp et al. 1969, 31).

In 1977, an intergovernmental conference on environmental education, held in Tbilisi, USSR, took Stapp's definition of EE one step further. Conference attendees compiled a set of goals for EE. They suggested that EE should foster awareness of the environment, sensitivity toward it, attitudes that motivate learners to protect nature, and development of environmental problem-solving skills. The Tbilisi statement entered new ground in its final goal for EE: *participation* in environmental solutions.

Participation is the key component. Environmental education will have no positive impact on the ecological health of the planet unless it convinces learners to participate in solutions to environmental problems (i.e. adapt environmentally responsible behaviors). In 1980, researchers suggested that environmentally responsible behavior should be the "superordinate goal" of environmental education. They said that EE's overall goal should be "to aid citizens in becoming environmentally knowledgeable, and above all, skilled and dedicated citizens who are willing to work, individually and collectively, toward achieving and/or maintaining a dynamic equilibrium between quality of life and quality of the environment" (Hungerford, Peyton, and Wilke 1980, 43). Today, encouraging ecologically responsible lifestyle choices remains a "commonly expressed goal" of environmental education (Simmons 1991, 16).

B. Why EE Failed to Change Lifestyles

Unfortunately, EE has failed to achieve these goals. One can name a few successes in the field, such as heightened awareness of environmental issues, the popularity of recycling programs, and isolated examples of projects that have solved local environmental problems. But EE has not persuaded a large segment of the population to make lifestyle changes. Hungerford and Volk, authors of "Changing Learner Behavior Through Environmental Education (1990)," write:

> " . . . when current reports on environmental quality are considered, we must admit that we have not been successful, on a widespread basis, in convincing world citizens to act in environmentally responsible ways" (Hungerford and Volk 1990, 16).

Many researchers have uncovered reasons for EE's failure to change lifestyles. Gigliotti (1990) states that EE has not taught people how their lives impact the natural world. Citizens do not see that their resource-intensive habits cause environmental problems. People have filtered EE messages and heard only the information that allows them to maintain their way of life. In other words, EE has failed to change people's values (Gigliotti 1990).

The result is a nation of ". . . ecologically concerned citizens who, armed with ecological myths, are willing to fight against environmental misdeeds of others but lack the knowledge and conviction of their own role in environmental problems." (Gigliotti 1990, 9) EE has produced people who readily accuse industrial polluters, but refuse to alter their own lifestyles. As I have indicated, it is possible that the situation in Missoula supports Gigliotti's theory. Callers accuse industry. Those who claim that woodstoves and automobiles do not pollute abdicate personal responsibility for Missoula's air pollution.

Van Matre (1990) agrees with Gigliotti on many points. He argues that EE has focused too heavily on short-term, issue-oriented projects and ignored learners' long-term lifestyle choices. "Thanks to the efforts of our mass media, people are aware of such problems as acid rain, ozone depletion, and toxic waste, but they usually don't see the connection between their own lives and the problems (and no one dares tell them)" (Van Matre 1990, 4).

Another reason why EE has failed lies in "a supplemental, infusion approach instead of genuine, focused educational programs" (Van Matre 1990, 47). The following serves as an example of that failed approach: a class of fourth graders plays a tree game in the autumn, sings a snowflake song a few months later, and studies acid rain in the spring. This will never work. Environmental educators must construct programs with clear objectives and provide activities that build upon each other sequentially to achieve those objectives as in any other subject area

(Van Matre 1990). Van Matre offers an alternative to conventional EE, which will be addressed later.

Hungerford and Volk (1990) argue that the culprit for EE's failure is a faulty model for behavior change that was widely accepted in the past and which still enjoys common acceptance. This model says that increased environmental knowledge leads to improved awareness or attitudes, which in turn lead to behavior change.

I have seen such an attitude toward behavior change in my experience as an environmental educator. The nature center where I served as an intern taught nothing but natural history. A great number, if not *most* attendees of the yearly Montana Environmental Education Association conference adhere to it, judging from workshop presentations and the discussions that follow. Earlier this year, I attended a teachers' in-service presentation on the subject of a fifth grade environmental science unit. The presenter's stated goal was to teach facts. Given the facts, students would take action, she maintained.

"Research into environmental behavior, unfortunately, does not bear out the validity of these linear models for changing behavior," (Hungerford and Volk 1990, 9). Students do not automatically make that leap from awareness to behavior change. EE has failed because its leaders have not provided learners with the skills to bridge the chasm between knowledge and action. Fortunately, Hungerford and Volk advocate a new model for behavior change, which will be discussed in Part Four.

EE has failed to attain its goals because it is "a step-child of education" in the United States and many other countries (Hungerford and Volk 1990, 16). Our leaders treat EE as an after-thought; EE comes *after* reading, writing, and arithmetic. "Relatively few nations have made a commitment to EE programs that involve students throughout their schooling and that utilize a carefully constructed, research-based scope and sequence. Where EE exists, students typically receive incidental exposure to environmental issues, with the emphasis on the ecological foundations and/or awareness levels" (Hungerford and Volk 1990, 16).

Most EE programs are too issue-specific. Even when they offer ideas on how to solve environmental problems, most do not attempt to relate those issue-specific solutions to global environmental issues (Hungerford and Volk 1990). For example, students might learn how to contact elected officials regarding a local environmental problem, but not how to use that same skill in other contexts. Environmental educators have not given learners the opportunity to generalize their knowledge and skills to other issues.

Nature and environmental education centers in this country have not met the objectives of environmental education. Simmons (1991) studied the goal statements of more than 1,200 nature and EE centers throughout the United States to investigate whether these goal statements coincide with the internationally-accepted goals of environmental education. More than half the centers cited encouragement of environmentally responsible behavior as a major goal of their program. However, Simmons encountered little support for and even resistance to goals that Hungerford, Volk, and others have determined are necessary to achieve lifestyle changes. Only 17.5% of the centers listed environmental problem-solving skills as a major goal. The most frequently mentioned goal was nature study (Simmons 1991).

EE has failed to encourage environmentally responsible behavior because nature and EE centers adhere to the outdated behavior change model mentioned earlier. "For the most part, centers are endorsing a behavior model that simplistically links nature study directly to environmental behavior . . . given the research in environmental behavior, one would suspect that those centers providing nature study with the goal of encouraging environmentally sound behaviors are not achieving this goal" (Simmons 1991, 21).

This does not mean that nature study and knowledge of environmental problems play an unimportant role in environmental education. Knowledge is a crucial factor in the equation that leads to responsible lifestyle choices.

IV. Strategies That Lead to Environmentally Responsible Behavior

A. The Hungerford and Volk Model of Responsible Environmental Behavior

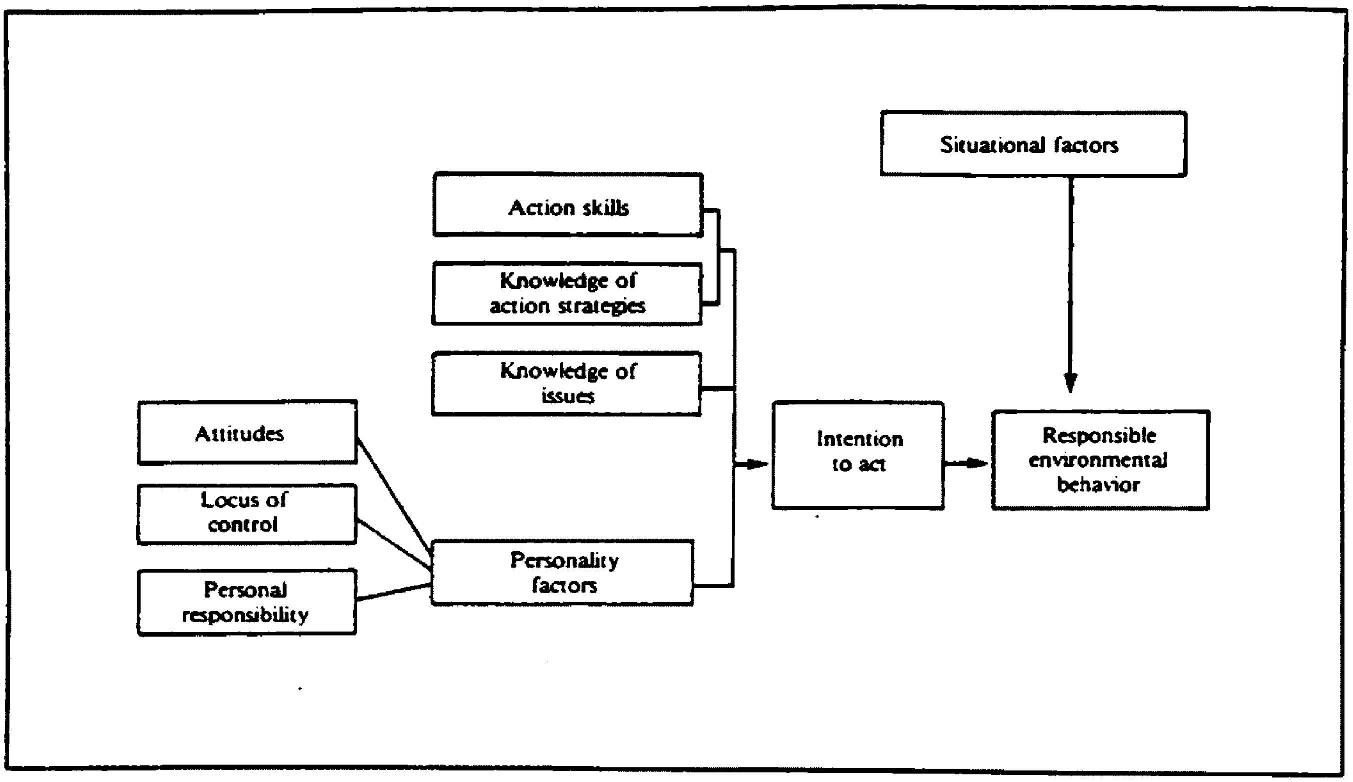
Researchers have studied factors that relate to responsible environmental behavior for at least as many years as the field of environmental education has existed. An exhaustive meta-analysis of research on environmentally responsible behavior was published in 1986-87. Researchers analyzed only those studies that rely on empirical data and which had been completed since 1971. The report includes 128 studies from a wide range of academic fields including education, psychology, sociology, engineering, political science, business, forestry, and communications. The authors used information from their study to design an environmental behavior model, a flow chart of factors that lead to learner participation in solutions to environmental problems (Hines, Hungerford, and Tomera 1986-87). This model is displayed in Figure 4.

Hungerford and Volk (1990) presented an alternate view of that model three years later, as shown in Figure 5. They drew upon the work of Hines, Hungerford, and Tomera (1986-87) as well as other recent studies on environmentally responsible behavior. They looked at a study of attitudes toward technology, pollution, and nature and research on androgyny and environmental orientation. They examined studies on the effects of specific educational methodologies on the environmental behavior of different populations of school-age children. In addition, they drew upon research that identifies predictors of environmentally responsible behavior.

Hungerford and Volk divide the variables that contribute to environmentally responsible behavior into three categories: entry-level, ownership, and empowerment. *Entry-level variables* predict environmentally responsible behavior (which Hungerford and Volk term "citizenship behavior") or relate to it in some fashion. "These appear to be prerequisite variables or, at the very least, variables that would enhance a person's decisionmaking (sic) once an action is undertaken" (Hungerford and Volk 1990, 11).

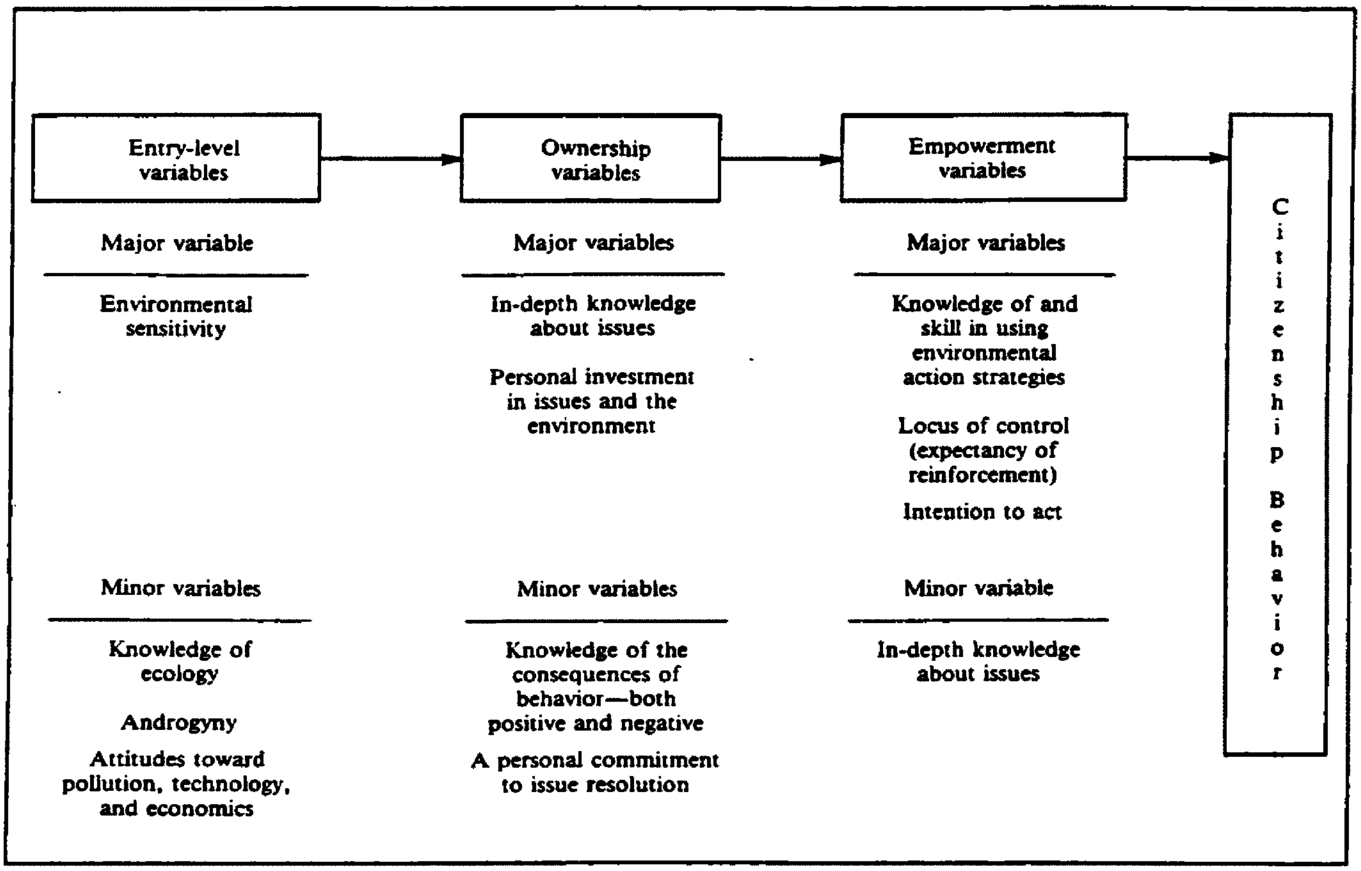
Environmental sensitivity is the only major entry-level variable. Research has shown that it relates strongly to behavior (Hungerford and Volk 1990). Hungerford and Volk define environmental sensitivity as "an empathetic perspective toward the environment" (11). People become sensitive toward the environment when they spend time in nature regularly, over a long period of time. "It appears that 'environmental

FIGURE 4: The Hines, Hungerford and Tomera environmental behavior model



From Hines, Hungerford and Tomera (1986/87).

FIGURE 5: The Hungerford and Volk model of responsible environmental behavior



From Hungerford and Volk (1990).

sensitivity' is a function of an individual's contact with the outdoors in relatively pristine environments either alone or with close personal friends or relatives" (Hungerford and Volk 1990, 14). Recreation such as hunting, outdoor family activities, hiking, time alone in nature, or outdoor activities as part of a youth group act as the strongest precursors to environmental sensitivity. Teacher role-models and environmentally-related mass media contribute to environmental sensitivity in some individuals (Sivek and Hungerford 1989-90). Others have reported that a sense of loss after witnessing the destruction of a favorite natural area led to their environmental sensitivity (Hungerford and Volk 1990).

The environmental sensitivity variable poses a problem in that educators cannot easily address this variable in formal educational settings. Researchers suggest the following strategy:

> It appears as though teachers would have to be willing to serve as strong, environmentally responsible role models as well as to provide numerous opportunities for students to interact with important media and the natural environment itself. It also appears that the nonformal sector holds considerable promise for the development of sensitivity if it can capture learners for long periods of time and put them into aesthetically positive situations (Sivek and Hungerford 1989-90, 38-39).

Knowledge of ecology is the first minor entry-level variable. It provides "an ecological conceptual basis for decisionmaking (sic)" (Hungerford and Volk 1990, 11). Researchers have compiled a list of concepts that will permit learners to make sound ecological decisions. The list includes: individuals and populations, interactions and interdependence, environmental influences and limiting factors, energy flow and nutrient cycling, community and ecosystem concepts, homeostasis, succession, humans as members of ecosystems, and the ecological implications of human activities (Hungerford, Peyton, and Wilke 1980). Teachers need not cover each of these topics over the course of one unit. Learners should first understand each concept in broad, general terms, then gain more detailed knowledge of the concepts as they progress throughout their schooling.

The second minor entry-level variable of Hungerford and Volk (1990), androgyny, characterizes many environmental activists. In other words, people who exhibit citizenship behaviors tend not to adhere to rigid sex-role stereotypes. Hungerford and Volk offer no suggestions for how to address this variable in the classroom. I would argue that teachers address it indirectly when they model androgynous behavior.

Some researchers have found that attitudes toward pollution, technology, and economics (another minor entry-level variable) play a significant role in environmental behavior. Borden (1984-85), author of "Psychology and Ecology: Beliefs in Technology and the Diffusion of Ecological Responsibility" studied such attitudes. He found that as many as 87% of survey respondents believe that technology will solve the earth's environmental problems. As a consequence, people feel less responsible for protecting the environment. Educators must therefore debunk the myth that technology will solve our problems (Borden 1984-85).

Ownership variables make an issue important to the student on a personal level. One major ownership variable is in-depth knowledge of environmental issues. A person must understand an issue and what it means for society and the environment before he or she can deliberately help solve it. Thus, in-depth knowledge of environmental issues makes a person more likely to adopt citizenship behaviors (Hungerford and Volk 1990).

Hungerford and Volk (1990) designate personal investment in issues and the environment as the second major ownership variable. "Here the individual identifies strongly with the issue because he/she has what might be called a proprietary interest in it" (Hungerford and Volk 1990, 12). Economic considerations can lead to personal investment: an individual may decide to conserve energy to save money, for example. Knowledge of ecology and understanding human involvement in environmental problems can lead to personal investment as well (Hungerford and Volk 1990). Personal investment can stem from anything that makes a person care about an issue, including aesthetic considerations, concern for the environment, or human health threats.

Minor ownership variables include knowledge of positive and negative consequences of behavior and a personal commitment to issue resolution. Hungerford and Volk provide no details on these variables. With regard to the personal commitment variable, pledge certificates may help solidify learners' commitment to issue resolution. A pledge certificate is a written promise to carry out some specific environmentally responsible behavior for a certain period of time. The decision of whether to sign the certificate rests with the student.

Finally I will address the *empowerment variables.* "Empowerment seems to be the cornerstone of training in environmental education" (Hungerford and Volk 1990, 12). The first major variable is knowledge of and skill in the use of environmental action strategies. Hungerford and Volk list the knowledge and skill components together because knowledge of action strategies precedes skill. Knowledge by itself does not predict citizenship behavior as powerfully as skill does. One of the very best predictors of citizenship behavior is *perceived* skill in the use of action strategies (Hungerford and Volk 1990). A learner who feels certain he or she knows how to write to elected officials will more likely do so than one who doubts his or her skill in this area.

Hungerford and Volk do not mention *how* to teach citizenship skills. They describe such skills as "fairly easy to teach" and say that "Training in action skills . . . results in improved students' self-concepts and a belief that they have been more fully incorporated into society" (Hungerford and Volk 1990, 12). They refer to two educational methodologies that address this variable, which I will describe later.

Locus of control, the second major empowerment variable, refers to a person's belief regarding his or her ability to make a difference in the world. A person with an external locus of control believes that forces outside him or herself, such as random chance, God, or the government, cause change. Someone with an internal locus of control, in contrast, expects to succeed in creating change. This individual will more likely engage in citizenship behaviors than the person who believes that he or she cannot make a difference.

Teachers who wish to address the locus of control variable should allow students to investigate issues they have a good chance of resolving. They must also teach effective action skills and encourage an appropriate level of group action (Sivek and Hungerford 1989-90). Parents and teachers who want to improve students' locus of control should give children a say in matters that affect them, encourage them to make their own decisions, and encourage them to critically evaluate other people's opinions (Newhouse 1990).

The last major empowerment variable is intention to act. This means simply that a person will more likely work toward resolution of an environmental problem if he or she intends to do so. However, intention to act does not guarantee action. Hines, Hungerford, and Tomera (1986-87) show in their behavior model that situational factors such as economic constraints can get in the way of positive intentions. Other situational factors such as economic incentives and legal obligations can reverse negative intentions.

We must leave the "intention to act" variable in the hands of the learner. "Ultimately, people need to be able to make their own moral decisions about environmental matters. The job of educators is to ensure that everyone has all the tools necessary to make responsible environmental decisions" (Newhouse 1990, 31).

Hungerford and Volk (1990) identify in-depth knowledge of issues as the only minor empowerment variable. They fail to explain why this variable falls under both the ownership column and the empowerment column.

The three categories of variables probably act in a linear fashion. Variables within each category do not necessarily operate the same way, however. *All* the variables probably work synergistically. For example, "it would appear unlikely that citizenship skills taught without issue-related knowledge would prompt responsible behavior in individuals" (Hungerford and Volk 1990, 12).

B. A Critique of the Hungerford and Volk Model

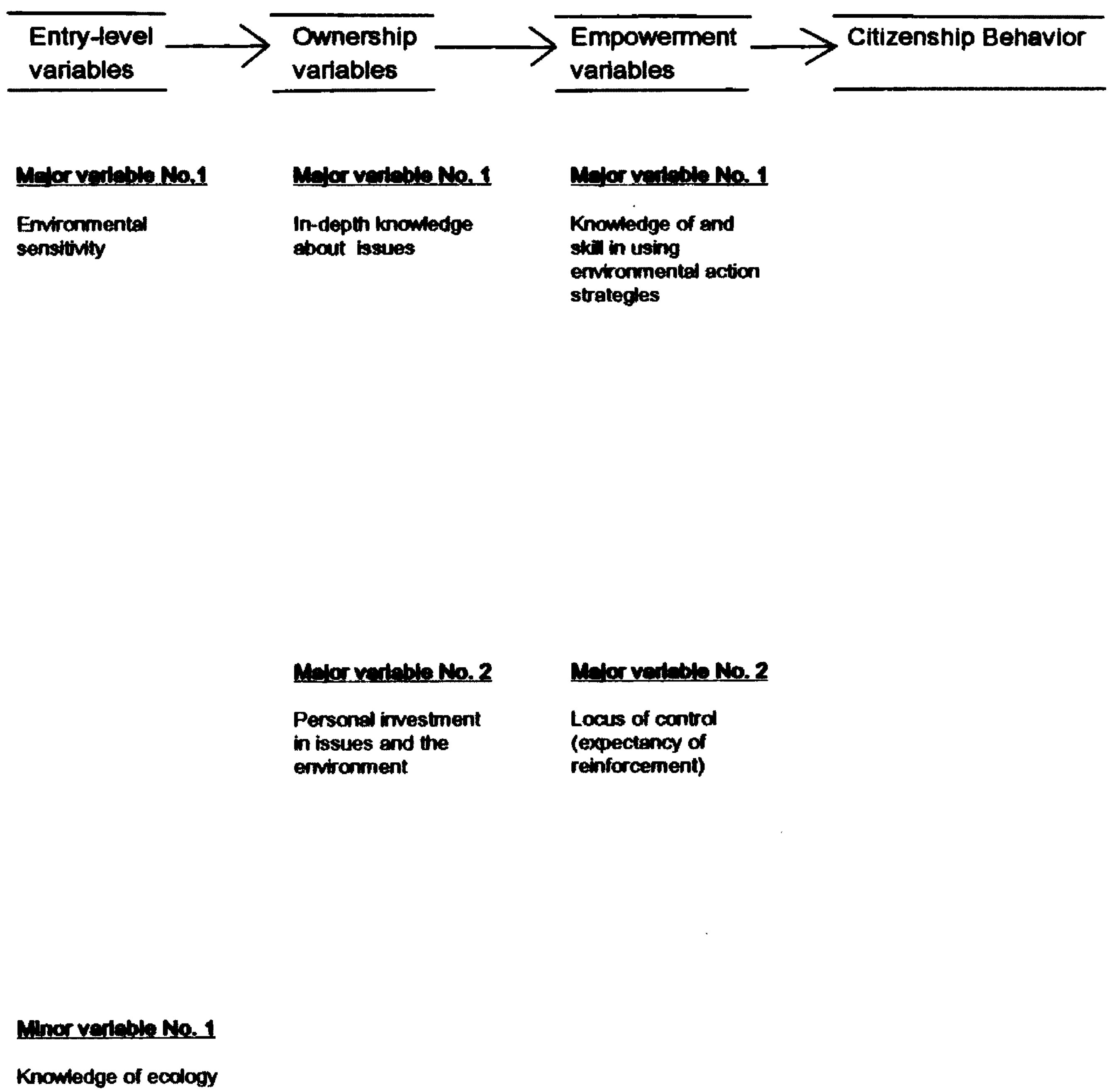
The Hungerford and Volk (1990) model provides a comprehensive, research-based guideline for achieving the superordinate goal of EE: environmentally responsible behavior. It is a tremendous asset to the field. As I have shown, however, Hungerford and Volk provide few or no details on how to accomplish many of the minor variables in the model. They give no information on how to address androgyny, attitudes toward pollution, technology and economics, knowledge of the consequences of behavior, or personal commitment to issue resolution. Hungerford and Volk do not explain why they include in-depth knowledge about issues as both a major ownership and a minor empowerment variable. Finally, educators must leave the intention to act variable up to the student.

I have therefore constructed a modified version of the Hungerford and Volk model for the purpose of this project. It is shown in Figure 6. Later I will discuss how *Air Care* addresses the variables included in this version of the model.

C. Other Strategies That Encourage Environmentally Sound Behavior

Next, I will look beyond the Hungerford and Volk behavior model for strategies that encourage environmentally sound behavior. First, teachers should know students' level of moral development. Kohlberg (1964) identified three levels of moral development: preconventional, conventional and principled (Kohlberg 1964). At the preconventional level, children think through moral dilemmas in terms of what they can get away with. They evaluate cultural labels of good and bad, right and

FIGURE 6: Modified version of the Hungerford and Volk model of responsible environmental behavior



wrong, with regard to the consequences they will face as a result of a particular moral decision. At the conventional level, people strive to fulfill social expectations for good behavior. They respect conventional rules and regulations. Individuals at the principled level devise their own system of moral values based on what they feel is right. Citizens at this level of development work to define their own moral values and principles that have validity apart from the authority of those in power (Kohlberg 1964).

A discussion at the principled level with a group of students who operate at the preconventional level will probably confuse learners. However, a discussion one step above students' level of moral development can stimulate moral development and may increase the instructor's ability to foster responsible environmental behavior (Newhouse 1990).

Examining all sides of an environmental issue has proven more effective in attitude change than issue investigation from a single viewpoint. Since attitudes influence behavior, educators who aim to encourage citizenship behavior should consider this. Newhouse (1990) cites Kopalla (1984) who compared the effectiveness of one-sided communication, which presents only positive arguments with regard to an issue, to the effectiveness of two-sided communication, which presents arguments for and against an issue. Two-sided communication worked better for both advanced and non-advanced students. Self-generated thoughts had a larger impact on people's attitudes than another person's arguments did. Educators must therefore encourage learners to think for themselves (Newhouse 1990).

Van Matre (1990) calls his alternative to conventional environmental education "earth education." Van Matre and other members of The Institute for Earth Education, an international non-profit organization founded in 1974, developed the earth education programs. The programs include sets of focused, painstakingly constructed activities. They address many of the Hungerford and Volk flow chart variables through inclusion of three main components. First, earth education programs teach basic ecological concepts. Van Matre believes educators must focus more on "big picture" concepts such as energy flow and nutrient cycling, and less on species identification and nature trivia. The second component of an earth education program fosters appreciation of and care for nature. One could translate this as the "environmental sensitivity" component. To foster this love of nature, the programs afford learners many opportunities to spend time alone or in small groups out of doors. Third, every earth education program teaches learners how to implement lifestyle changes that protect the environment. This component matches with Hungerford and Volk's action skills variable.

Earth education programs employ inventive techniques to capture learners' imaginations and motivate them to participate in measures that protect the earth. In one program, for example, a mysterious package that arrives in the classroom a few weeks before the unit begins piques students' interest in the program. In another earth education program, children climb inside a gargantuan leaf to see how photosynthesis works. Earth education programs use all sorts of experientially rich formats that make activities fun for students, a technique that all environmental educators could use to increase their programs' appeal.

Based on their review of literature on environmentally responsible behavior, Hungerford and Volk (1990) recommend two educational strategies that address the in-depth knowledge variable and teach action skills. The first strategy is called the "issue investigation and action model" (Hungerford and Volk 1990, 15). This model teaches students the difference between environmental problems and issues. Students learn how to identify environmental issues and write research questions. They use, compare, and evaluate secondary sources of information and write surveys and questionnaires to obtain scientifically valid information. They record data, interpret it, make inferences, and draw recommendations from their inferences. Next, each student chooses an issue that interests him or her, investigates it in detail and prepares a report on the topic. Students then learn action strategies to resolve their issues. They examine the effectiveness of individual vs. group action, create action plans, and evaluate the implications of their plans. At this point, learners decide whether to implement their plans. If a student chooses to implement his or her plan, the instructor facilitates environmentally responsible behavior. This methodology applies to grades six through twelve.

The second curricular strategy that Hungerford and Volk recommend is the "extended case study model." It applies to grades one through twelve. Here, students learn some of the same skills, but the class studies a predetermined issue, chosen either by students or by the instructor. Hungerford and Volk offer few details on how to use this strategy. Perhaps this is because "The research indicates that the extended case study model, although successful, is not as powerful an instructional model as the issue investigation and action model" (Hungerford and Volk 1990, 15).

Ramsey and Hungerford (1989) report on the issue investigation and action model's effect on the environmental behavior of seventh grade students. They found that the model did promote environmentally responsible behavior among students at that grade level. Another study came to the same conclusion for eighth grade students (Ramsey, Hungerford, and Tomera 1981). Thus, the issue investigation and action model works in a variety of groups and settings.

We know, therefore, that environmental education *can* foster environmentally responsible behavior. Teachers must reinforce such behavior if they want students to maintain it, however. Three years after Ramsey et al. (1981) finished their study on the effectiveness of the issue investigation and action model, Ramsey did an unpublished follow-up study (cited in Hungerford and Volk 1990) on whether students continued to exhibit citizenship behaviors. He trained people to interview students that had participated in the original study. He did not tell interviewers which students had been part of the experimental group. Nonetheless, interviewers could pick out which students experienced the environmental action skills training. Students from the experimental group exhibited more environmentally responsible behaviors than their counterparts. "However, it was clear that the original behavior observed in the eighth grade had eroded over time" (Hungerford and Volk 1990, 14). Hungerford and Volk conclude that one-shot programs will not suffice. Educators must provide reinforcement throughout students' schooling. Next, I will describe how *Air Care* aims to foster environmentally responsible lifestyle decisions through inclusion of many of the strategies discussed so far.

V. *Air Care*

The overall goal of *Air Care* is to contribute to improvement of air quality in the Missoula Valley. Toward that end, *Air Care* has two sub-goals. The first is to foster learner participation in measures that protect air quality through incorporation of many of the above-mentioned strategies. The second is to persuade as many local teachers as possible to implement the unit in their classrooms. To achieve the latter sub-goal, the unit aims to meet the curricular guidelines of a local school district and the needs of fifth grade students and teachers.

Members of the Missoula City/County Air Pollution Advisory Council initiated this project. I began work on *Air Care* under their guidance. I designed the unit for the fifth grade level because the curriculum guidelines of Missoula School District One (the largest school district in the valley) call for an environmental science unit at that grade level. In addition, the fifth grade is the most appropriate age level for the concepts I wanted to cover. Next I had to determine the unit's scope. Based on my educational philosophy, which writers such as Hungerford, Volk, and Van Matre have influenced, I felt that every student should gain three things from *Air Care*. First, learners should come away with basic knowledge of the causes and effects of Missoula's air pollution. Second, every student should gain the ability to protect air quality. Third, students should have the opportunity to examine different sides of the issue.

I drew from an educational unit entitled *Living in Missoula: Air Quality and Energy Concerns* in the early stages of *Air Care's* development. Greg Oliver, then with the Air Quality Unit of the Missoula City/County Health Department, designed *Living in Missoula* in 1982. This unit and the teacher's reference guide that accompanies it were valuable resources. With Oliver's permission I borrowed many ideas and activities from *Living in Missoula*. As I describe each lesson, I will note which activities and ideas I adapted from *Living in Missoula* and other sources.

Air Care differs from *Living in Missoula* in many ways. First, I revised outdated information. When Oliver wrote *Living in Missoula*, for example, the health department measured particulate air pollution in terms of total suspended particulate, or TSP. The department now measures it in terms of PM-10, particles less than or equal to ten microns in diameter.

Air Care targets the fifth grade level, whereas *Living in Missoula* targets grades four through eight. I reasoned that if *Air Care* met the exact needs of one grade level, a large number of those teachers would choose to implement the unit. Restriction to only one grade level also eliminates the possibility that some students would cover the same material several different times throughout their schooling. This strategy does not, however, take into account the need for reinforcement in later grades.

Oliver's unit offers a wide variety of lesson plans from which teachers may pick and choose to suit their needs. *Air Care*'s core lessons, in contrast, include only essential information and skills. Because of this and because later *Air Care* lessons build upon earlier ones, the unit is designed to be presented as a whole made up of sequential parts. This more compact form should make it easier for teachers to fit the unit into their classroom schedules, especially given that *Air Care* includes concepts that fifth grade teachers must cover during the school year anyway.

A number of people provided feedback on the first draft of *Air Care*, including Missoula-area members of the Montana Environmental Education Association, faculty and fellow students at The University of Montana, and members of the Air Pollution Advisory Council. I tested a pilot version of the unit in four area classrooms. Those teachers provided feedback, as did teachers who borrowed *Air Care* kits through a lending program which I will discuss later. I received further comments from attendees of three teacher in-service presentations that I conducted through Missoula School District One. Environmental health specialists at the Missoula City/County Health Department lent guidance along the way and I received feedback from one class of fifth grade students.

A. How *Air Care* Incorporates Variables that Lead to Citizenship Behavior

Lesson One addresses the environmental sensitivity variable because it features a slide presentation. As I have documented, environmentally-related media contribute to environmental sensitivity in some people (Sivek and Hungerford 1989-90). Many of the slides in the *Air Care* presentation came from *Living in Missoula*, although the order of slides as well as the presentation's written narrative have changed. The presentation features local scenes. I chose to develop a slide show rather than a video program because teachers say that whereas students tend to sit passively during a video, a slide presentation generates discussion. One can easily pause between slides for questions.

I placed this lesson at the beginning of the unit because I felt that it would allow learners to understand the big picture of air pollution before they analyze cause and effect. The slide presentation acts as an advance organizer, something that presents information prior to a lesson to make the lesson content more meaningful and easier to understand. It provides general information on the topic at hand to help learners integrate new material into their existing cognitive structures. An advance organizer may precede an individual lesson or, as in this case, an entire unit (Dembo 1991).

At the end of Lesson One, students set up an experiment that they will carry out over the course of the unit. For this experiment, which I adapted from *Oregon's Skies*, students place petri dishes in various locations on the school grounds, inside the school, and at different locations around town. A few drops of vegetable oil in each dish trap particles of air pollution. At the end of the unit (ideally after two or more weeks), students collect the dishes and examine them under a microscope. By placing a piece of grid paper under each dish, students count the number of particles per square unit that corresponds with each sample location. Learners compare indoor vs. outdoor air pollution and compare results from different locations around town.

Lesson Two addresses the in-depth knowledge variable. In this lesson, the instructor provides information on the sources of Missoula's particulate and carbon monoxide air pollution. He or she then asks learners to graph that information, either individually or as a group. Independent of the instructor, students must employ their knowledge of graph construction and determine what type of graph they wish to make. The idea for this activity came from *Living in Missoula*.

Lesson Three teaches students about valley temperature inversions and thus addresses the knowledge of ecology variable. The teacher explains scientific concepts involved, then demonstrates the inversion process using dry ice vapor, a large steel bowl that represents the Missoula Valley, and a light bulb that represents the sun's heat. The dry ice vapor settles on the bottom of the bowl. The instructor then lowers the light bulb into the bowl, whereupon the vapor begins to disperse. The instructor points out that inversions are natural phenomena. Students discuss how pollutants might affect plants and animals in other areas after winds carry Missoula's air pollution out of the valley. The director of the Environmental Health Division of the Missoula City/County Health Department explained how to conduct this demonstration.

Lesson Four covers the health effects of Missoula's air pollution. Students review the respiratory system. They discuss results of the Montana Air Pollution Study and measure their own lung capacity by blowing into a balloon as much air as they can in one breath. They measure the volume of their balloons in a graduated cylinder filled with water, record the data, and discuss factors such as air pollution that lead to decreased lung capacity. They examine air filters from the Missoula City/County Health Department's air quality monitoring program. I adapted the activities in this lesson from *Living in Missoula*. This lesson addresses both the in-depth knowledge variable and the personal investment variable. Earlier I documented that personal investment can stem from anything that makes a person care about an issue. Air pollution's threat to human health may give rise to concern about the issue and lead to personal investment in a resolution to Missoula's air pollution problem.

Lesson Five, "Solutions," addresses the action strategies variable. In preparation for Lesson Five, the instructor places a series of stations around the classroom. Each station describes specific actions that learners can take to protect air quality. This lesson also addresses the locus of control variable, since most of the actions mentioned are things that fifth grade students can do on their own to fight air pollution. Some of the items, however, would require adult permission or assistance. Throughout the period, students visit each station in search of clues to answer the questions on their worksheets. The lesson plan suggests how the teacher can provide opportunities for students to practice the action strategies they have learned. I placed the solutions lesson here so that students would know by this time *why* they should protect Missoula's air quality.

I adapted "Role Play--No Easy Answers" from *Living in Missoula*. In this lesson, students explore different sides of the air pollution issue in a mock city council meeting. The instructor divides learners into five groups: lung patients, industry representatives, woodstove owners, concerned citizens, and city council members. The teacher displays a set of proposals for council members to consider. Students may vote to revise the proposals before they begin the meeting. Each student receives a card that indicates his or her role. The card also provides a "statement idea" and asks what the student's position will be. If time permits, the instructor asks students to research their roles. Knowledge students have gained in previous lessons aids in preparation for the debate. Students must state their positions in their own words. They do not have to use the "statement ideas" on their cards. Above all, the instructor encourages students to respect other people's opinions. At the end of the debate the city council casts its vote. Lesson Six addresses the in-depth knowledge variable because students learn about different sides of the issue. It also addresses the action strategies variable since students look for creative solutions to Missoula's air pollution and learn how to participate in local government.

Lessons One through Six make up the core unit of *Air Care*. *Air Care* also features three supplementary lessons for teachers who wish to pursue the topic of air pollution further. Students write and perform their own commercials on how to protect air quality in the first supplementary lesson, which is adapted from *Living in Missoula*. In the second, they create brochures on how to minimize air pollution from wood burning. Students learn how urban design affects the environment and then design their own cities in the third supplementary lesson.

Figure 7 provides a summary of how the unit addresses each of the variables in my version of the model for responsible environmental behavior. To better address the environmental sensitivity variable, I encourage teachers who use *Air Care* to act as environmentally responsible role models. In addition, teachers should provide as many opportunities as possible for students to spend time in natural areas. Because school budgets allow for fewer and fewer field trips, this variable may have to be addressed mainly in nonformal settings and through the media.

B. How *Air Care* Will Achieve Implementation by Teachers

Implementation by the greatest possible number of area fifth grade teachers is *Air Care*'s second sub-goal. Success of the project depends on this objective. Regardless of how well the unit may encourage environmentally sound lifestyle decisions, *Air Care* will have no impact on air quality in the Missoula Valley if teachers do not use it in their classrooms.

Elementary school teachers are asked to teach a greater number of subjects every year. They must cover everything from drug abuse to AIDS awareness to computers in addition to basic subjects. Therefore, a new unit of study stands little chance of implementation unless it does the following. The unit must meet curricular guidelines of the local school district and cover material that students are supposed to learn that year. Otherwise the unit would take time away from teachers' classroom schedules, rendering implementation less likely. In addition, a new unit has to meet student needs. It must take into account student interests and the means by which children learn best at the targeted age

FIGURE 7: How *Air Care* addresses the modified version of the environmental behavior model

Entry-level variables → Ownership variables → Empowerment variables → Citizenship Behavior

Entry-level variables	Ownership variables	Empowerment variables
Major variable No.1	**Major variable No. 1**	**Major variable No. 1**
Environmental sensitivity	In-depth knowledge about issues	Knowledge of and skill in using environmental action strategies
***Air Care* lesson that addresses this variable:**	***Air Care* lessons that address this variable:**	***Air Care* lessons that address this variable:**
Lesson One, Slide Presentation	Lesson Two, Sources of Missoula's Air Pollution Lesson Four, Health Effects Lesson Six, Role-Play	Lesson Five, Solutions Lesson Six, Role-Play
	Major variable No. 2	**Major variable No. 2**
	Personal investment in issues and the environment	Locus of control (expectancy of reinforcement)
	***Air Care* lesson that addresses this variable:**	***Air Care* lesson that addresses this variable:**
	Lesson Four, Health Effects	Lesson Five, Solutions
Minor variable No. 1		
Knowledge of ecology		
***Air Care* lesson that addresses this variable:**		
Lesson Three, Inversions		

level. Finally, a new unit must meet teachers' needs. Teachers should find it accessible, well organized, and easy to use. It must not demand an excessive amount of teachers' limited preparation time.

Air Care meets District One curriculum guidelines. As mentioned earlier, these guidelines call for an environmental science unit at the fifth grade level. The district science guide emphasizes integration of science with other disciplines (District One Science Curriculum Guide 1990). *Air Care*'s core lessons integrate science with mathematics, health, and social studies. The guide also calls for a hands-on approach to elementary science. The oil drop experiment, the graphing exercise in Lesson Two, and the lung capacity activity all employ a hands-on approach. I plan to change Lesson Three, "Inversions," from a demonstration to a hands-on activity with funds from a second EPA grant which I will describe in the next section. District One's science guide further states that students should learn how to identify local sources of air pollution. Lesson Two accomplishes this objective.

With regard to mathematics, the district guide states that "In grades 5-8, the mathematics curriculum should include explorations of statistics in real world situations" (*District One Mathematics Curriculum Guide 1991*, 10). The guide identifies construction, reading, and interpretation of tables, charts, and graphs (as in Lesson Two) as objectives for this grade level.

Through activities such as debates and panels, "students will learn to listen and reflect, participate and contribute, present their own feelings and respect the viewpoint of others" (*District One Social Studies Curriculum Guide 1987*, 6). The role-play in Lesson Six fulfills this objective. An ideal social studies curriculum should, according to the guide, incorporate emerging issues such as environmental concerns.

Students should learn how to determine environmental factors that may affect a community, identify pollution sources and human activities that cause pollution, and discuss how to prevent and control environmental problems (District One Health Curriculum Guide 1986). *Air Care* incorporates each of these.

Air Care addresses student needs and interests. At this age level, students are at what Piaget (1967) defined as the concrete operational stage of cognitive development. Children at this stage use logic to solve concrete problems, but still cannot understand abstract material such as hypotheses and verbal propositions (Piaget 1967). This explains why elementary science activities should use a hands-on approach and why *Air Care* includes such activities. With regard to student interests, the feedback I received from a class of fifth grade students indicates that students enjoy the activities in *Air Care*, especially the science activities and the role-play.

The kits that accompany *Air Care* aim to meet teachers' needs. An EPA environmental education grant paid for kit materials. Each kit contains everything a teacher requires to present the unit except dry ice and ordinary school supplies. This saves time for the instructor. The trunks that house each kit are Rubbermaid brand "Totelockers." They have handles, secure latches, and a hasp that fits standard locks. A list of each trunk's contents is shown in Table 1.

TABLE 1: *Air Care* kit contents

Lesson One:
- slide carousel
- 37 color slides
- 5 scratch-resistant petri dishes
- high-powered magnifying glass
- bottle of vegetable oil

Lesson Three:
- 13-quart steel bowl designed to look like Missoula Valley
- 5-quart steel bowl
- low wattage light bulb
- extension cord
- leather gloves
- hammer

Lesson Four:
- Laminated color poster of the human respiratory system
- sponge to represent human lung
- 10-inch round balloons (one for each student)
- unbreakable four-liter graduated cylinder
- 2 measuring tapes
- air filters from health dept. air quality monitoring program

Lesson Five:
- 5 laminated color posters
- "clues" for different forms of nonmotorized transport
- examples of reduce, reuse, and recycle
- 8 miniature split logs
- 5 Velcro-backed "energy saver" cards

Lesson Six:
- 25 laminated role cards
- 5 place cards

Also:
- 3-ring binder containing lesson plans and a teacher's reference guide that includes background information in the form of charts, diagrams, articles, and pamphlets

The EPA grant funded a lending program which I administered through the Missoula City/County Health Department. Teachers borrowed *Air Care* kits free of charge for one to three week periods throughout the 1992-93 school year. During that period, one Girl Scout leader, three fourth grade teachers, four high school teachers, and sixteen fifth grade teachers from a dozen different schools in the Missoula Valley borrowed *Air Care* kits from the health department. The kit reservation schedule filled nearly to capacity during the months December through April.

In January 1993, Missoula School District One purchased three of its own kits from the health department to give teachers in that district greater access to *Air Care* kits. In future years the original set of kits will thus be more readily available to non-District One teachers and private schools in the valley. District One uses *Air Care* as a supplementary unit. The district curriculum office handles administration of its kits. To date, six teachers have used District One kits. Thus, a total of 22 of 61, or 36%, of fifth grade teachers in the Missoula Valley presented the unit in their classrooms during the 1992-93 school year.

A second EPA grant will expand this project. The grant period will begin in July of 1993. The budget will provide for addition of new materials to all six kits. These materials will include a set of high quality puppets. Students will write their own scripts for a puppet show on how to protect Missoula's air quality and perform the show for children in lower grades. The grant will also pay for a set of stackable containers and safety gloves so that pairs of students will have the opportunity to create their own model inversions (transforming Lesson Three from a demonstration to a hands-on activity). In addition, it will pay for better packing materials to protect the kits' contents as they travel from school to school.

The Montana Natural History Center, a Missoula-based non-profit organization dedicated to natural history education, has agreed to take over administration of the *Air Care* lending program at the beginning of the 1993-94 school year. The center owns a library of environmental education kits which its members would like to expand. The most recent EPA grant will allow the Natural History Center to offer these kits free of charge during the 1993-94 school year. After that period, the center will rely on other funds to support administration of *Air Care* kits or charge a user fee.

VI. Conclusion

The *Air Care* lesson plans are printed in the appendix. They are not in their final form. I will make changes to account for the addition of puppets and inversion tanks after the second grant period begins.

Several areas for further study present themselves. First, how could educators most effectively reinforce knowledge and skills that learners gain from *Air Care*? Science instructors at Missoula's Big Sky High School teach a unit on air pollution. Possibly other secondary teachers throughout the valley could implement that unit and incorporate strategies from the issue investigation and action model.

Faculty and staff at The University of Montana Division of Biological Sciences and School of Education are in the planning phase of a project that could not only reinforce *Air Care* but go far beyond the scope of the unit. The group seeks financial support for a set of environmental education learning modules or trunks which would be mailed to contracting schools in the northern Rocky Mountain region. The modules would cover four major content areas in addition to air: energy, water, earth, and life.

Second, what reaction do students, teachers, and administrators have to *Air Care*? Additional feedback from them would tell whether *Air Care* works effectively and provide insight on how to improve the unit.

Third and most important, has learner behavior changed as a result of *Air Care*? What are the unit's short- and long-term effects, if any, on students' lifestyle decisions?

In conclusion, environmental education programs *can* have a positive impact on learners' lifestyle choices and thus the ecological health of the world in which we live. The challenge for educators is to design programs that address variables proven to foster ecologically sound behavior. *Air Care* incorporates many of those variables. The unit will prove successful if it fosters environmentally responsible behavior and if the Montana Natural History Center's *Air Care* reservation schedule fills to capacity in the coming years.

APPENDIX:

AIR CARE

a fifth grade unit on air pollution in the Missoula Valley

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July 1993

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Lesson One: Slide Presentation

OBJECTIVES: Students will learn two reasons to protect air quality in Missoula:
1) human health
2) health of the natural world

SUBJECT AREA: Science
METHOD: Students watch and discuss a slide presentation and set up an experiment.
TIME: 40 minutes
MATERIALS: Slides, carousel, projector, vegetable oil, 5 petri dishes
NOTE: This lesson serves as an advance organizer for the unit; later lessons will cover these concepts in greater detail.

SLIDE PRESENTATION NARRATIVE

1) This is our home, the Missoula Valley. Don't you wish it always looked like this?
2) You can see how polluted Missoula's air can become during a winter inversion.
3) Inversions have always trapped air in this valley, even before humans settled here. They are a natural phenomenon.
4) Problems arise when we add pollutants to the trapped air, such as road dust,
5) wood smoke,
6) automobile exhaust, and
7) industrial pollutants.
8) Our bodies have many natural defenses against air pollution. Too much air pollution can overload these defenses.
9) Air pollution is especially unhealthy for children.
10) The Montana Air Pollution Study showed that Missoula-area children have poor lung function in the wintertime compared to children from other areas of Montana that have cleaner air.
11) The study also showed that Missoula's air pollution is dangerous for people with heart and lung diseases such as chronic bronchitis, asthma, and emphysema.
12) Pregnant women, the elderly,
13) and people who do a lot of outdoor exercise are also at higher risk.
14) One type of pollutant found in Missoula's air, known as carbon monoxide, can cause nausea and headaches. Particulate air pollution can cause cold-like symptoms and serious health problems.
15) During an air pollution alert, more people visit the clinic and emergency room with lung problems. Medication sales rise.
16) Not everyone agrees on how we should solve the problem. Here are some possible solutions.
17) The use of liquid de-icer instead of street sanding materials cuts down on road dust.
18) Proper burning techniques reduce the amount of pollution given off by wood stoves. First, cut the right kind of tree.

19) Split and stack your wood so that it will dry out better.
20) Keep firewood sheltered from rain and snow.
21) Don't overload your stove.
22) Use small, dry kindling.
23) Keep your damper open enough to have a hot, clean fire.
24) Check your chimney for creosote build-up.
25) Go outside to check your chimney for smoke. After the first fifteen minutes a fire has burned, you shouldn't see much smoke.
26) We also protect air quality when we ride a bicycle,
27) walk,
28) or ride a bus rather than drive.
29) We could pass even stricter regulations on industry.
30) We reduce air pollution from factories when we reduce, reuse, and recycle.
31) Here we see downtown Missoula during an inversion.
32) Ahh. . . the wind has swept the inversion out of the valley. What happened to the pollution? Did it disappear?
33) No. It went somewhere else: into mountains,
34) forests,
35) and rivers.
36) One reason to improve air quality in Missoula is to protect our health.
37) Another reason is to protect the environment. In this unit, you'll learn more about air pollution in Missoula and how to protect air quality.

OIL DROP EXPERIMENT

Students capture particles of air pollution with drops of oil that are left out for several days. They later examine the particles under a microscope. By placing oil drops in different locations, students can compare types of particulates found in different areas. The following are suggestions for sample locations:

1) in the classroom with lid on (control)
2) in the classroom (indoor air pollution)
3) elsewhere in the building (indoor air pollution)
4) on school grounds (where it will remain dry and undisturbed)
5) off school grounds (where it will remain dry and undisturbed)

If the class sets up this experiment at the beginning of the unit, students can examine their results during Lesson Five. This activity works best if the oil drops are left out for two or more weeks.

*Slide presentation adapted from *Living in Missoula*, by Greg Oliver.
*Oil drop activity adapted from *Oregon's Skies*, published by the Oregon Dept. of Environmental Quality.

Lesson Two: Sources of Missoula's Air Pollution

OBJECTIVES: Students will learn the major sources of Missoula's air pollution. Students will apply graph construction skills in a real-world situation.
SUBJECT AREA: Mathematics
METHOD: Students graph sources of Missoula's air pollution.
TIME: 30 minutes (15 if the graph is assigned as homework)
MATERIALS: A five foot sheet of newsprint taped to the blackboard, colored markers. (If the graph is assigned as homework, the instructor will need one sheet of graph paper for every student.)

BACKGROUND

We have two main types of outdoor air pollution in Missoula:

1) Particulates: tiny pieces of pollution in the air (e.g. dust, wood smoke). Particulate air pollution affects the entire Missoula Valley.

Sources of Particulate Air Pollution in Missoula, Winter 1986-87

Road dust:	48%
Residential wood burning stoves:	45%
Industry:	5%
Auto exhaust:	2%

2) Carbon Monoxide (CO): an invisible, odorless, poisonous gas. Areas of Missoula where CO levels are highest: Malfunction Junction, downtown.

Sources of Missoula's Carbon Monoxide Air Pollution, Winter 1990

Automobiles	64%
Residential Woodburning Stoves	26%
Industry	9%
Other	1%

Procedure

Write the sources of Missoula's particulate and carbon monoxide air pollution on the board. Include the percentage from each source.

Review the concept of a graph. Ask students to name several different types.

If you choose to do this as an in-class activity (rather than assign it as homework):

The students' job is to graph the sources of Missoula's particulate and carbon monoxide air pollution. Allow students to vote on which kind of graph they will make.

Ask someone to give an idea for how to start. Allow a different person to suggest each step in making the graph.

Involve as many students as possible.

Erase the list of sources from the board.

Ask another teacher to enter your classroom. Ask that person to examine the graph to see if he or she can learn the sources of Missoula's air pollution from it. If so, let students know that they did a good job of conveying information on a real-world graph.

***Lesson adapted from *Living in Missoula*, by Greg Oliver.**

Lesson Three: Inversions

OBJECTIVE: Students will learn how an inversion works.
SUBJECT AREA: Science
METHOD: The instructor conducts a demonstration using dry ice vapor.
TIME: 30 minutes
MATERIALS: a pound of dry ice (available at Albertson's, Buttrey, Rosauer's and Tidyman's for an average cost of $.99/lb.), one medium and one large steel bowl, a quart of very hot water, leather gloves, a hammer to crush the dry ice, an extension cord and a night light.

BACKGROUND

Definition of "inversion": A mountain valley traps a layer of cold air beneath a layer of warmer air.

Missoula is the largest city in North America completely surrounded by the Rocky Mountains. That is why we have more severe air pollution problems than most other cities the size of Missoula.

PROCEDURE

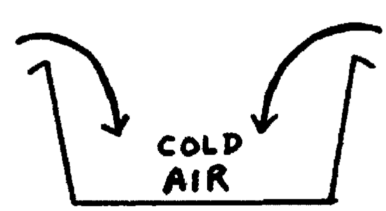
Draw a diagram of the Missoula Valley:

Ask students, if hot air rises (as in a hot air balloon), what does cold air do? (It sinks.)

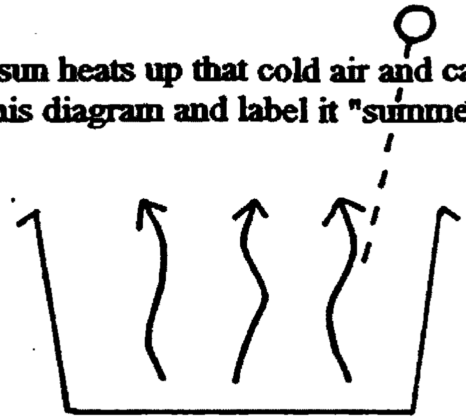
Demonstrate this: Place a few tablespoons of crushed dry ice in the smaller bowl. Add some hot water. Pour the dry ice vapor out of the bowl. It will sink to the ground. (Be sure to use gloves when handling dry ice.)

Similarly, cold air sinks every night off the mountains around Missoula.

Add arrows to diagram to show cold air sinking:



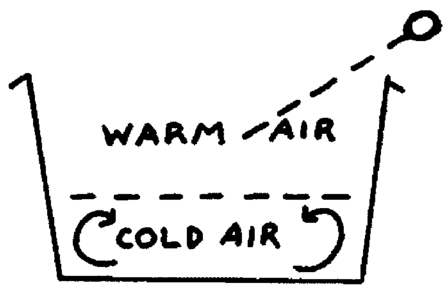
In summer, the sun heats up that cold air and causes it to rise, like a hot air balloon (draw this diagram and label it "summer"):



In the wintertime, we don't get as much sunlight in the valley, because:

the sun is at a lower angle in the sky
we receive fewer hours of daylight
sunlight bounces off white snow on the ground

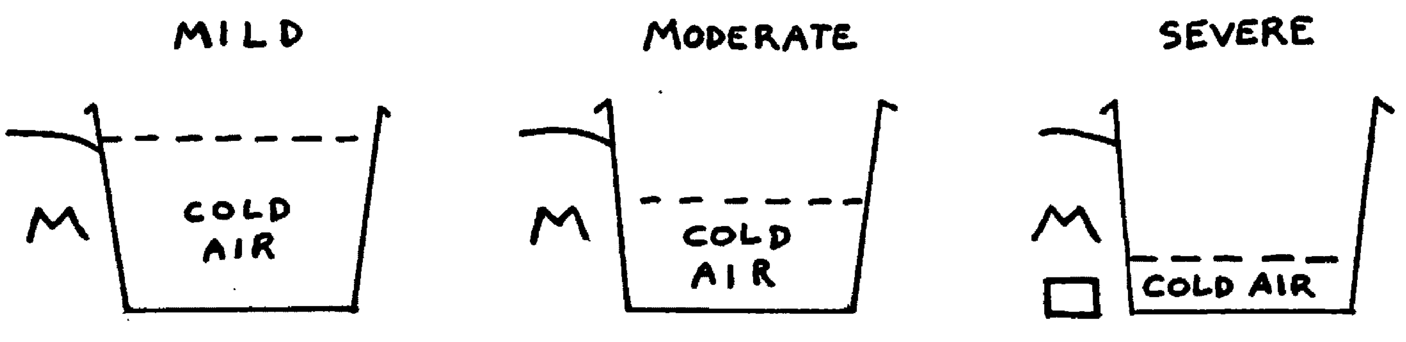
Change the diagram to look like this and label it "winter inversion":



Because we don't get much sunlight during the winter, cold air in the valley stays cold. It rests in the bottom of the valley since it is so heavy. Above it floats a layer of warmer air.

The stronger the inversion, the thinner the layer of cold air we must breathe. During a mild inversion, the layer of cold air reaches as high as Mt. Sentinel. It reaches the "M" during a moderate inversion. During the very worst inversions, the layer of cold air reaches only a little higher than the tallest buildings in Missoula.

Draw the following diagrams to illustrate this point:



Use dry ice to demonstrate how inversions work

Explain that the sides of the large bowl represent mountains surrounding our valley. We live down inside the bowl.

Add several more tablespoons of crushed dry ice and a little hot water to the smaller bowl. If necessary, use a hammer to crush the dry ice into finer particles (this will create more vapor). The more vapor, the better this part of the demonstration will work.

Pour the vapor from the small bowl into the large bowl. If no one breathes into the large bowl, the vapor will settle in the bottom of the bowl.

Explain that this is what happens in the Missoula Valley during the wintertime. A layer of cold air is trapped in the bottom of the valley.

To demonstrate how inversions are burned off each morning in the summertime, plug the night light into the extension cord, turn it on and set it in the bottom of the large bowl filled with dry ice vapor. The heat from the light bulb will cause the vapor to gradually rise and dissipate.

CONCLUSION

Explain that inversions are a natural phenomenon. They happened in Missoula before humans settled in this area. Problems occur only when we add pollutants to the trapped air.

Explain that normally, winds disperse air pollution. During an inversion, however, we must breathe any pollutants that we have put into the air until a major weather system scoops cold air out of the valley (this is the students' cue to blow into the large bowl).

Question for students: Where does Missoula's air pollution go after the wind breaks up an inversion? Does it disappear?

> Answer: As the slide show mentioned, the pollution just goes somewhere else: onto the plains, into the forests, etc.

Question for students: Do you think our air pollution could have a negative effect on plants and animals in these other locations?

Lesson Four: Health Effects

OBJECTIVES: Students review the respiratory system, learn how Missoula's air pollution affects human health and learn how to measure volume by water displacement.
SUBJECT AREA: Health, mathematics
METHOD: The instructor reviews the respiratory system, lists symptoms of breathing polluted air and describes the Montana Air Pollution Study. Students measure their lung capacity using balloons and a graduated cylinder, then discuss reasons for variation in lung capacity. Students examine health department air filters.
TIME: 45 minutes or more, depending on the amount of detail you wish to include
MATERIALS: one 9 or 10-inch round balloon for every student, a large graduated cylinder filled with water, two or more measuring tapes (optional), a sponge, a human lung diagram, a set of health department air filters
NOTE: The teacher may want to cover the respiratory system one day and finish the rest of this lesson another day.

THE RESPIRATORY SYSTEM

Use the lung diagram to explain how the respiratory system works. Name the major parts of the system and how each one functions:

Nose: Hairs inside the nose act as a filter. The nose warms and moistens the air we breathe.
Mouth: We often breathe through the mouth when we work hard, but then we lose the advantage of a filtering system.
Throat: leads to trachea
Trachea (commonly called the windpipe): large tube lined with mucous and cilia
Mucous: a sticky liquid that traps particles of air pollution
Cilia: millions of microscopic, hairlike structures that waft particles back up to the throat and mouth where they can be swallowed or expelled
Bronchial tubes: branch off the trachea. They divide first into two main branches, then into many smaller and smaller branches that look like the branches of a tree.
Alveoli (commonly called air sacs): tiny sacs at the tips of the branches where the exchange of oxygen for carbon dioxide takes place.
Hemoglobin cells (in bloodstream): act like oxygen magnets. They pick up oxygen molecules in the air sacs and carry them to the rest of the body.

Use a sponge to show what the human lung looks like. Students should understand that the human lung does not resemble a balloon.

Discuss the complicated, delicate nature of the respiratory system.

Have students sit quietly for a minute and breathe deeply. Ask them to imagine, one by one, all the parts of their respiratory systems at work in their bodies.

Stress the respiratory system's defenses against air pollution:

1) Nose: filters, warms, and moistens air
2) Mucous: traps particles of air pollution
3) Cilia: waft particles up to the nose and throat

Explain that a high level of air pollution can overwhelm the body's natural defense mechanisms.

HOW MISSOULA'S AIR POLLUTION AFFECTS OUR HEALTH

As mentioned during the graphing exercise, two main types of outdoor air pollution affect us in Missoula: carbon monoxide and particulates.

A. Carbon Monoxide (CO): an invisible, odorless, poisonous gas

CO is 70 times more attractive to hemoglobin cells than oxygen. Compared to a CO molecule, an oxygen molecule doesn't have a chance to be picked up by a hemoglobin cell and get carried through the bloodstream.

When a person breathes CO, less oxygen enters the bloodstream. The heart has to work harder to make up for the reduced level of oxygen. The heart itself then needs more oxygen.

B. Particulates: may lodge deep in the lungs and irritate them

Types of particulates :

1. Dust: not poisonous, but irritates the lungs. Question for students: Who can tell what it's like to breathe in a lot of dust at one time?
2. Wood smoke: physical irritant, like dust. Also a chemical irritant; chemicals in wood smoke bother the lungs. Wood smoke is very similar to cigarette smoke (see teacher's reference for more information).
3. Industrial particulates

Symptoms

	Carbon Monoxide	Particulates
low-level exposure	headache nausea dizziness	reduced lung capacity cough sore throat other cold-like symptoms
high-level exposure	death	further reduced lung capacity damage to cilia emphysema chronic bronchitis increased frequency of asthma attacks cancer lower resistance to infection

Fortunately, we do not experience high-level exposure to carbon monoxide in Missoula.

We do not know the exact *long-term* effects of breathing Missoula's present type of air pollution, since wood stoves became very popular in the valley only 20 years ago.

Groups at Highest Risk

1. people with lung and heart diseases (emphysema, chronic bronchitis, asthma)

   Question for students: Does anyone know someone who suffers from one of these ailments? How does it make them feel? Do air alerts affect them? Must they stay indoors during air alerts?

2. the elderly
3. pregnant women
4. children (A child who weighs half as much as an adult breathes nearly the same volume of air--and air pollution--as the adult.)
5. people who do heavy outdoor exercise
6. smokers

MONTANA AIR POLLUTION STUDY (MAPS)

MAPS study (1980). One goal of this study was to investigate whether children in Missoula are harmed by Missoula's air pollution. In the wintertime, researchers had children breathe into machines in order to measure their lung function. Researchers compared Missoula-area children to children from cities with cleaner air.

Results: Missoula-area children had reduced lung function (reduced lung capacity, for example) compared to children from other areas of the state with cleaner air.

Researchers compared children's wintertime lung function to their lung function at other times of the year. They found that Missoula-area children's lung function was poorer during the winter, but that it returned to normal during the spring and fall.

Researchers also studied adults with lung and heart diseases. They found that Missoula's air pollution had a harmful effect on their lung function (see teacher's reference for more information).

LUNG CAPACITY MEASUREMENT

Students will measure their lung capacity with a balloon and a graduated cylinder filled with water.

Have each student find a partner. Pass out one balloon to each student.

First, allow students to blow up their balloons once without tying them in order to stretch them out. Have students let the air out of their balloons.

Demonstrate the procedure: Take a very deep breath and blow all the air out of your lungs into a balloon. Hold tight to the end of the balloon so that no air escapes. Place it in the graduated cylinder and measure its volume.

One partner will blow up his or her balloon while the other assists with measuring the balloon's volume.

Have students record their data on the board.

E.g.	Volume (cubic cm)	# of students
	1000-1200	1
	1201-1400	3
	1401-1600	2
	etc.	

Alternatively, students could use measuring tapes to measure the circumference of their balloons. If you wish to take this one step further, the circumference of a sphere can be used to calculate its radius. Use the radius to find the sphere's volume:

$$\frac{\text{circumference}}{2\pi} = \text{radius} \qquad \text{volume} = 4/3\pi r^3$$

<u>Question for students</u>: What factors affect how much air a person's lungs can hold?

<u>Answers</u>:

air pollution: a high level of air pollution reduces lung capacity
body size: bigger people have bigger lungs
natural variation in lung size (like natural variation in foot size)
number of years living in an area with poor air quality
having a cold (reduces lung capacity)
having a lung ailment such as asthma, allergies or emphysema
smoking cigarettes
exercise: an athlete will have greater lung capacity than a non-athlete

AIR FILTERS

Show class the health department air filters.

Each filter is placed in an air quality monitoring machine for a period of 24 hours. A vacuum cleaner motor draws air through the filter. When air flows through the filter, particles of air pollution stick to it.

The filters are labeled:

1) **Unexposed (has never been placed in a machine)**
2) **"Good." (from what is called a "good" air quality day)**
3) **"Alert." (from an "air pollution alert" day)**

CONCLUSION:

Discuss the seriousness of Missoula's air pollution problem and how it affects both children and adults.

***Lesson adapted from *Living in Missoula*, by Greg Oliver.**

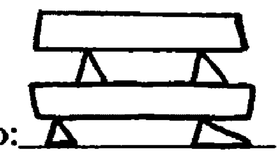
Lesson Five: Solutions

OBJECTIVE: Students will learn four major ways to reduce air pollution in Missoula.
SUBJECT AREA: Social Studies
METHOD: Students visit stations around the room and look for clues to answer the questions on their worksheets.
TIME: 60 minutes
MATERIALS: Set up five stations in advance: Park It!, How You Burn Makes a Big Difference, Energy Savers, The 3R's and the Oil Drop Experiment (see "station set-up," below). You will need one copy of the worksheet for each student, 5 microscopes and five 4x4" squares of grid paper.
NOTE: This lesson provides an opportunity for students to examine the results of the oil drop experiment begun in Lesson One. A square of grid paper under each petri dish allows students to count the number of particles per square unit for each sample.

STATION SET-UP

Park It! Station:
- a) "Park It!" poster
- b) clues: shoe, reflector, bus maps, carpool card, skateboard wheel

How You Burn Makes a Big Difference Station:
- a) "How You Burn . . ." poster
- b) "Use Dry Wood" poster
- c) 8 miniature split logs, arranged like so:



Energy Savers Station:
- a) "Energy Savers Protect Air Quality" poster
- b) 5 Velcro-backed cards

The 3 R's Station:
- a) "The 3 R's" poster
- b) 3 cards labeled "reduce," "reuse," and "recycle"
- c) example of reduce: plastic-wrapped cheese vs. canned cheese
- d) examples of reuse: grocery bag, mug, plastic tub, re-sealable bag
- e) examples of recycle: cans, glass, newspaper, cardboard

Oil Drop Experiment Station
- a) 5 microscopes
- b) 5 oil drop samples
- c) 5 squares of grid paper

Set up the stations before the lesson begins.. Leave as much space between each station as possible.

Alternatively, you could have students make their own solutions posters or games and set them up around the room.

Procedure

Pass out worksheets (one per student).

Explain the assignment: Students should read each poster carefully. They will find answers to their questions at the stations. Some questions have more than one correct answer; encourage independent thinking.

Divide the class into five groups.

Assign each group a station.

After five minutes or so, have groups rotate. Repeat until every group has visited all stations.

Extension: Practicing Skills Learned in Lesson Five

Learners need opportunities to practice the skills they have learned in Lesson Five if they are to adopt these habits in their daily lives. The following are suggestions for how to provide such opportunities.

1) Teach students how to ride a city bus (how to make transfers, read bus maps, etc.), then take a class field trip by city bus.

2) Institute a bike/walk week. During this week, encourage students to find non-motorized means of getting to school, to carpool or to ride the city bus. Students who ride a school bus could be challenged to try an alternate form of transportation after school or over the weekend.

3) Show the class how to apply weatherstripping to doors and windows. If possible, allow small groups of students to weatherstrip doors and windows in the school building.

4) As a group, make curtains for classroom windows to help prevent heat loss during the winter.

5) Institute a classroom program to reduce, reuse, and recycle.

6) Take a walk with the class around the school's neighborhood during the winter months. Identify examples of chimneys that emit the proper amount of wood smoke, as well as chimneys that emit excessive wood smoke. (After a fire has burned for fifteen minutes, one shouldn't see much smoke coming out of the chimney. See "How You Burn Makes a Big Difference" pamphlet in teacher's reference for a photo of what a chimney should look like.) During the walk, you could also identify examples of wood that has been properly split, stacked and sheltered.

A GLOBAL ISSUE

Students should have the ability to generalize the skills they have learned in this lesson to other environmental issues. The instructor can facilitate this by explaining, for example, how energy conservation helps solve many other environmental problems besides air pollution. Energy conservation reduces acid rain, slows global warming, and reduces the number of oil spills that pollute oceans and rivers. Explain how skills learned in *Air Care* apply not only to Missoula's air pollution , but to other environmental problems as well.

Worksheet for Air Care Lesson Five: Solutions

How You Burn Makes a Big Difference

1. Draw a picture of the correct way to stack firewood.

2. What kinds of trees should Missoula residents burn in their wood stoves?

3. It's a good idea to put as much wood into the stove as you can at one time. True or false? (Circle one).

Energy Savers Protect Air Quality

4. ______________________ acts like a blanket for your house.

5. How does weatherstripping help keep your house or apartment warm?

6. Closing the curtains during the winter helps keep your house at a comfortable temperature. This reduces air pollution since you don't have to burn as much fuel. It also saves _________________________.

"Park It!"

7. Cars and trucks contribute 64% of the carbon monoxide to Missoula's wintertime air pollution. Use the clues at this station to think of five ways to cut down on driving. Draw a picture of each one.

"3 R's"

8. **Reducing, reusing and recycling reduce air pollution from ________________.**

9. **Name something that can be reused. Describe four different uses for it.**

Oil Drop Experiment

10. **Draw what you see in each oil drop. For each sample, write how many particles you can find in one square.**

location:__________
# of particles
in one square:_____

location:__________
# of particles
in one square:_____

location:__________
# of particles
in one square:_____

location:__________
# of particles
in one square:_____

location:__________
# of particles
in one square:_____

Lesson Six: Role Play--No Easy Answers

OBJECTIVE: Students will understand different points of view regarding the issue of air pollution in Missoula.
SUBJECT AREA: Social Studies
METHOD: The class stages a mock city council meeting.
TIME: 60 minutes
MATERIALS: 25 role cards, 5 place cards (industry, city council, wood stove owners, lung patients, concerned citizens)

SCENARIO:

Some members of the community feel that Missoula's air is too dirty. They say that the city should enforce stricter regulations on wood burning stoves and industry and make it easier to get around town without a car. Other people say that Missoula residents do not need more laws telling them what to do. They believe that the laws we have now are too strict. The city council has called a special meeting to decide what to do about Missoula's air pollution. Council members must decide which of the following proposals to vote for. They must also consider the cost of each one.

PROPOSAL	COST
A. Do nothing	higher medical bills lower quality of life (some say)
B. Enforce stricter regulations on industry	industry and consumers pay
C. Enforce stricter regulations on wood stoves	wood stove owners pay
D. Enforce laws that say cars must get better mileage	motorists pay
E. Create a better bus system (longer hours, more stops)	taxpayers and passengers pay
F. Build more sidewalks and bicycle lanes	taxpayers pay
G. Provide more $ for de-icer and street sweeping	taxpayers pay
H. Provide incentives to car-pool or ride the bus	taxpayers pay

Ask the class if they have any other proposals to add to the list. Any changes?

Role-play

Have students move their desks into a circle, if possible, to create a meeting-room atmosphere.

Set out place cards.

Pass out role cards. Have students sit with their groups next to their place cards.

Ask students to read their role cards. Students should play the roles written on their cards, but think independently and come up with their own positions. The "statement ideas" are suggestions only.

Give the groups a few minutes to discuss which of the proposals they think the city council should vote for . Students can argue for more than one proposal. Every member of a group does not have to advocate the same proposal(s).

Alternatively, the instructor can have students research their roles and plan arguments and counter-arguments ahead of time.

The teacher, acting as a neutral facilitator, should begin the meeting. Go around the room and have each student state his or her role and list which proposal(s) he or she favors. This activity works best if students use their own words rather than read straight from their cards.

Next, open it up to discussion.

Stress respect for others' opinions.

With ten minutes to go, send the city council out of the room (with a list of the proposals) to make their decision. They may vote for more than one proposal.

Conclusion

Five minutes before the end of the period, bring city council members back in the classroom and have them announce their decision.

Question for students: Does the decision protect the public health? Is it fair? Ask for a show of hands.

*Role-play adapted from *Living in Missoula*, by Greg Oliver.

WRAP-UP FOR THE UNIT:

Administer the quiz.

Briefly review the major concepts covered in the unit:

Sources of Missoula's air pollution

Inversions: 1) how they work
2) how pollution doesn't disappear after an inversion ends

Health effects on adults and children

How to protect air quality

Different sides of the issue

Remind the class of all the things that 5th graders can do to help solve the problem. Kids can make a difference!

Provide opportunities throughout the school year for students to practice measures that protect air quality.

Supplemental Lesson: Media Messages

OBJECTIVE: Students will review ways to improve air quality in Missoula and improve cooperation skills.
SUBJECT AREA: Language Arts
METHOD: Students write and perform commercials on how to protect air quality
TIME: Three sessions:

1) Write script--25 minutes
2) Rehearse--20 minutes
3) Performance/Awards--45 minutes plus time to perform for other classes, if desired

MATERIALS: Paper and pencils, video camera (if available), sticker or award for each student (see "Awards Ceremony")

ACTIVITY:

Divide class into groups of two or three.

Have each group write a 60-second commercial about one way to protect air quality.

Go over these suggestions on how to write a script:

1) **Decide which solution** your group will cover. It doesn't have to be one that the class has discussed in this unit, but if not, the group should check with the instructor.

2) **Decide who you are trying to reach.** Write your commercial especially for that audience. Think about what interests them.

3) **Write your script** . Describe what everyone in the commercial will do and say.

4) **Keep your commercial simple.** Stick to one main point.

During the script-writing period, check with each group to see what solution it has chosen. Write down each group's topic along with the names of group members to help keep students on track during the rehearsal and performance sessions.

Rehearsal:

Check on each group at least once during the session. If possible, have each group perform its commercial for you.

Stress that students will only have 20 minutes to rehearse. Each group should use the full twenty minutes to perfect its commercial, because it will perform in front of the class (and other classes, if the teacher chooses). Students who feel uncomfortable performing in front of the class can take a greater role in set design, making props and stage management.

Performance:

Have groups take turns performing their commercials for the class (and other classes, if desired).

Record each performance on video (optional).

Make notes regarding each group's performance.

Awards ceremony:

Hold an awards ceremony to recognize each individual's contribution to his or her group's performance.

Possible award titles:
- Air Protector
- Most Creative
- Most Original
- Funniest
- Most Professional-looking
- Strangest
- Best Attention-getter
- Best Dialogue
- Best Special Effects
- Best Set Design
- Best actors/actresses
- Best public speaker (for good enunciation, projection of voices, etc.)
- Best script

Each student should receive some type of award.

* Lesson adapted from *Living in Missoula*, by Greg Oliver.

Supplemental Lesson: How You Burn Makes a Big Difference

OBJECTIVES: Students will review how to reduce the amount of smoke produced by a woodburning stove.
SUBJECT AREA: Language Arts
METHOD: Student will create pamphlets on how to minimize pollution from woodburning stoves.
TIME: 60 minutes
MATERIALS: Two pieces of white paper (preferably 8 1/2 x 14) for each student, pencils, erasers, rulers, pens, markers or paints.

Introduction

On the board, list ways to reduce the amount of smoke produced by a woodburning stove (see teacher's reference for more details):

1) Cut the right kind of tree (Douglas Fir, Lodgepole Pine or Larch).
2) Use dry wood (cut early, split, stack in alternating directions, shelter from rain and snow).
3) Start fire with small, dry kindling.
4) Keep air intake or damper open enough to have a hot, clean fire (the fire should not smoulder).
5) Don't overload the stove.
6) Keep chimney clean.
7) Go outside and check chimney for smoke.
8) Don't burn on poor air quality days.*

Activity:

Define any terms from the above list that students do not understand.

Have each student design and create an illustrated pamphlet that explains how to burn properly. Students should include all eight points listed above. Stress that the pamphlets will be evaluated in terms of spelling, neatness, creativity, and educational value.

*Source: "How You Burn Makes a Big Difference," published by Missoula City/County Health Department

Supplemental Lesson: Urban Design

OBJECTIVE: Students will learn several ways in which careful design of a city can reduce air pollution and increase quality of life.
SUBJECT AREA: Social Studies
METHOD: Students create their own model cities.
TIME: 20 minutes plus time to construct model city.
MATERIALS: pencils, white and colored paper, cardboard, paints, markers, scissors, tape, glue
NOTE: This lesson may work best as an independent project for advanced students.

MAIN IDEAS:

Explain that the layout of a city partly determines whether its residents need automobiles to get from place to place.

List examples of how Missoula's layout affects our driving habits:

1) "The Strip." Most people find it difficult to walk or ride a bicycle from their homes to "the strip." People usually drive or take the bus to reach that end of town.

2) Many of the busier roads and bridges in Missoula are unsafe for bicycles. Would you want to ride your bicycle through "Malfunction Junction," for example?

3) Workplaces are often located far from residential neighborhoods; many people must drive to work.

4) There are no sidewalks in some areas of town. There are no bicycle lanes along most streets and highways in and around Missoula.

5) Passenger trains do not serve the Missoula area. Thus, people must drive or fly to distant places.

Ask students how one could solve some of these problems if one were designing a brand new city.

ACTIVITY:

Have students design a city where residents would not have to rely on the automobile for transportation.

Have students work alone or in pairs. Explain that they may use any and all of the materials provided.

CONCLUSION:

Ask each student or pair of students to show their city to the rest of the class and explain how its design helps reduce dependence on automobiles.

Point out that reduced dependence on automobiles curbs air pollution.

Explain the term "quality of life." Ask students if they think quality of life in Missoula would increase if we could make the city more like the cities they designed. Which of their ideas could be used in Missoula today or in the future?

Air Care Quiz

1. **Circle the largest source of carbon monoxide in Missoula:**
   industry
   wood stoves
   road dust
   automobiles

2. **Name one reason why we have more inversions in Missoula in the wintertime than in the summertime.**

3. **What is one of the respiratory system's defenses against air pollution?**

4. **Name two symptoms of breathing too much air pollution.**

5. Name five different ways to protect air quality in Missoula. Draw a picture of each one.

#1

#2

#3

#4

#5

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