From Misconceptions to Constructed Understanding
The Fourth International Seminar on Misconceptions Research
(1997)

Article Title: Metacognitive Skills Applied to Planning Environmental Curriculum in a Designated Ecological Emergency Zone; Niznhii Tagil, Russia

Author: Brody, Michael

Abstract: The paper describes an action research study investigating the application of metacognitive strategies; concept mapping and the Vee Diagram, to the design of new environmental curricula in Niznhii Tagil, Russia. The research was conducted over the course of a year and emphasized collaborative planning, execution and assessment of the project. Two teacher inservice workshops helped participants develop a new environmental science education course for teacher training at the Institute Pedagogica and new environmental education curricula at local schools in the city of Niznhii Tagil, Russia. This large industrial city in the middle Ural Mountains is the first designated ecological emergency zone in the Russian Federation. The conferences, meetings, workshops and curriculum development effort helped teachers, those who train teachers, and members of the community learn how they can help young people develop awareness, knowledge, and skills they need to understand their immediate situation, and to become lifelong environmental stewards. Curriculum materials emphasizing interdisciplinary approaches and inquiry oriented lessons were developed for preservice and inservice teacher training as well as high school science students.

Keywords:
General School Subject:
Specific School Subject:
Students:

Macintosh File Name: Brody-Metacognitive
Release Date: 10-20-97 B

Editor: Abrams, Robert
Publisher: The Meaningful Learning Research Group
Publisher Location: Santa Cruz, CA
Volume Name: The Proceedings of the Fourth International Misconceptions Seminar - From Misconceptions to Constructed Understanding
Publication Year: 1997
Conference Date: June 13-15, 1997
Contact Information (correct as of 12-23-2010):
Web: www.mlrg.org
Email: info@mlrg.org

Metacognitive Skills Applied to Planning Environmental Curriculum in a Designated Ecological Emergency Zone; Niznhii Tagil, Russia

Michael Brody
Department of Education
Montana State University
Bozeman, Montana 59717
406-994-5951
uedmb@msu.oscs.montana.edu

Metacognitive Skills Applied to Planning Environmental Curriculum in a Designated Ecological Emergency Zone; Niznhii Tagil, Russia

Abstract

The paper describes an action research study investigating the application of metacognitive strategies; concept mapping and the Vee Diagram, to the design of new environmental curricula in Niznhii Tagil, Russia. The research was conducted over the course of a year and emphasized collaborative planning, execution and assessment of the project. Two teacher inservice workshops helped participants develop a new environmental science education course for teacher training at the Institute Pedagogica and new environmental education curricula at local schools in the city of Niznhii Tagil, Russia. This large industrial city in the middle Ural Mountains is the first designated ecological emergency zone in the Russian Federation. The conferences, meetings, workshops and curriculum development effort helped teachers, those who train teachers, and members of the community learn how they can help young people develop awareness, knowledge, and skills they need to understand their immediate situation, and to become lifelong environmental stewards. Curriculum materials emphasizing interdisciplinary approaches and inquiry oriented lessons were developed for preservice and inservice teacher training as well as high school science students.

Metacognitive Skills Applied to Planning Environmental Curriculum in a Designated Ecological Emergency Zone; Niznhii Tagil, Russia

Introduction

A city of nearly half a million people, Niznhii Tagil is deep in the industrial heartland of the former Soviet Union. The city is studded with smokestacks and besieged with pollution. The local health service says it has the highest rate of lung and stomach cancers in the Russian Federation. Only four percent of the community's children are considered healthy.

In many parts of the world, environmental degradation in the name of technological advancement has been borne by communities of people who suffer both physiological and psychological damage due to the deterioration of the human/ecological condition. This is especially true in Eastern Europe and Russia where a large number of cities and towns have recently been recognized as ecological emergency zones (Environmental Policy Review 1992; Der Spiegel 1994). Typically, People in these areas have lived their entire lives in the same place as their ancestors. Future generations have little chance of migrating, resulting in a distinct gene pool subject to hundreds of years of contamination.

The industrial city of Niznhii Tagil, located in the mid-Ural mountain region of Russia has recently been designated the first ecological emergency zone by the Russian Federation. The 430,000 people living in Niznhii Tagil, including approximately 100,000 students in grade K-12 have the highest incidence of lung and stomach cancer of people in any region in Russia.

Until recently, Niznhii Tagil has been a military city closed to western visitors. Popular belief and limited scientific information indicates that the imbalance of technological advancement and the preservation of human and natural environment is primarily due to the last 400 years of uncontrolled mineral extraction and refining and production of heavy equipment including locomotives and military armaments. These technological developments have all been within and surrounding the city limits of Nizhni Tagil. Toxic contaminants in the soil, water and air are primarily heavy metals from extraction, refining and production activities but also include organic contaminants from the coking operations (Kidd 1992).

There is an increasing global awareness that the people in communities such as Niznhii Tagil need help to bring their ecology into human, environmental and

technological balance. Any strategy for the correction of this situation must involve work with industry, government and education. In fact, Niznhii Tagil was identified at the Earth Summit in Rio de Janeiro (1992) as one of the most critical areas in the world in need of international help to correct these problems. It is recognized widely that in order to work cooperatively to overcome these problems, that in-depth understanding of peoples' culture, values and knowledge is essential to helping design effective educational programs (Brody 1994).

Old Sable

The Nizhni Tagil Environmental Education Project, named by Russian participantsOld Sable after the city's mascot, was funded by USAID and USEPA as part of a multi-component environmental management project.

Old Sable was part of a three year initiative in the city of Nizhni Tagil, a formerly closed (to foreigners) military industrial city of 440,000 in the southern Ural Mountains that was designated Russia's first environmental emergency zone due to severe industrial pollution. The project was designed to demonstrate new methods of local environmental management and decision-making practices involving diverse sectors of society to stimulatelong-term results. In addition to environmental education, the project also included identifying and ranking environmental and health risks, implementing low-cost solutions to environmentalproblems, strengthening local governmental institutions, and developing cost-effective strategies for public investments. This research focuses on the educational portion of this large scale community project.

Constructivism

Constructivism is at the root of empowering students to create new meaningful knowledge and has been described in the environmental education literature as a model for the development of teaching and learning (Klein & Merritt 1994). As such, it forms a solid foundation for the development of innovative environmental curricula. The main components of this constructivist approach are the introduction of real life problems (relevance and interdisciplinarity), student centered instruction (emphasis on the individual) and production of new knowledge by the students (inquiry and social perspectives). Constructivism was the basis for the teacher workshops conducted in Niznhii Tagil.

Real life problems for the people of Niznhii Tagil are embedded in the long standing cultural, economic and social conditions of the city which have led to the degradation of the ecological and human condition. The human health issues are extreme and require a focus on the local ecological situation. This situation requires and interdisciplinary approach integrating the various conditions of the city. This is a complex situation. Teachers previously trained in traditional dogmatic techniques and discrete disciplines do not consider themselves to have the skills to help students learn in such complex and meaningful ways.

Before all else, teachers must find ways to encourage and help students to ask appropriate questions and design ways to go about answering them. Asking questions and finding answers has not been the traditional Russian approach to educating children. Asking questions and finding answers places an emphasis on the learner's existing understanding of the situation and the construction and assimilation of new knowledge (Ausubel 1960). This is derived from the traditional Piagetian (1969) conception of constructivism.

Working with secondary science teachers in the workshops required an emphasis on the construction of new reliable and valid environmental knowledge based on scientific reasoning and integrating the accepted conceptual and methodological aspects of various disciplines. The constructivist approaches to educating children presented in the workshops held great potential for helping students learn with more depth of understanding through the practice of doing science. New knowledge was seen as derived from experience and characterized by its congruence with the real world. This approach shifts the emphasis towards students structuring and restructuring their own experiences in relation to the natural world. This construction of knowledge is facilitated by the use of heuristics to help them to reflect on the learning process and its eventual outcomes.

Metacognitive Skills

Two heuristic devices which hold great potential for constructivist teaching approaches and development of curricula are concept maps and the Vee diagram. Concept mapping was designed to represent the relationships between concepts in graphic ways thus emphasizing interrelationships and integrated thinking (Novak & Gowin 1994). Meanings are expressed through propositions formed by connecting two concepts with a line and labeling this line with a linking word. When large numbers of concepts are interconnected they form a

map which can be used to express complex interrelationships between concepts related to ecological issues (see Figure 1 below, Brody 1994).

The concept map when constructed by students helps to illustrate that we use language labels to construct concepts and propositional relationships about a domain of knowledge. The concept map serves as a tool to illustrate the hierarchical, conceptual/propositional nature of knowledge. It also serves as a tool to help teachers and students organize their cognitive frameworks into more powerful, integrated and metalearning tools.

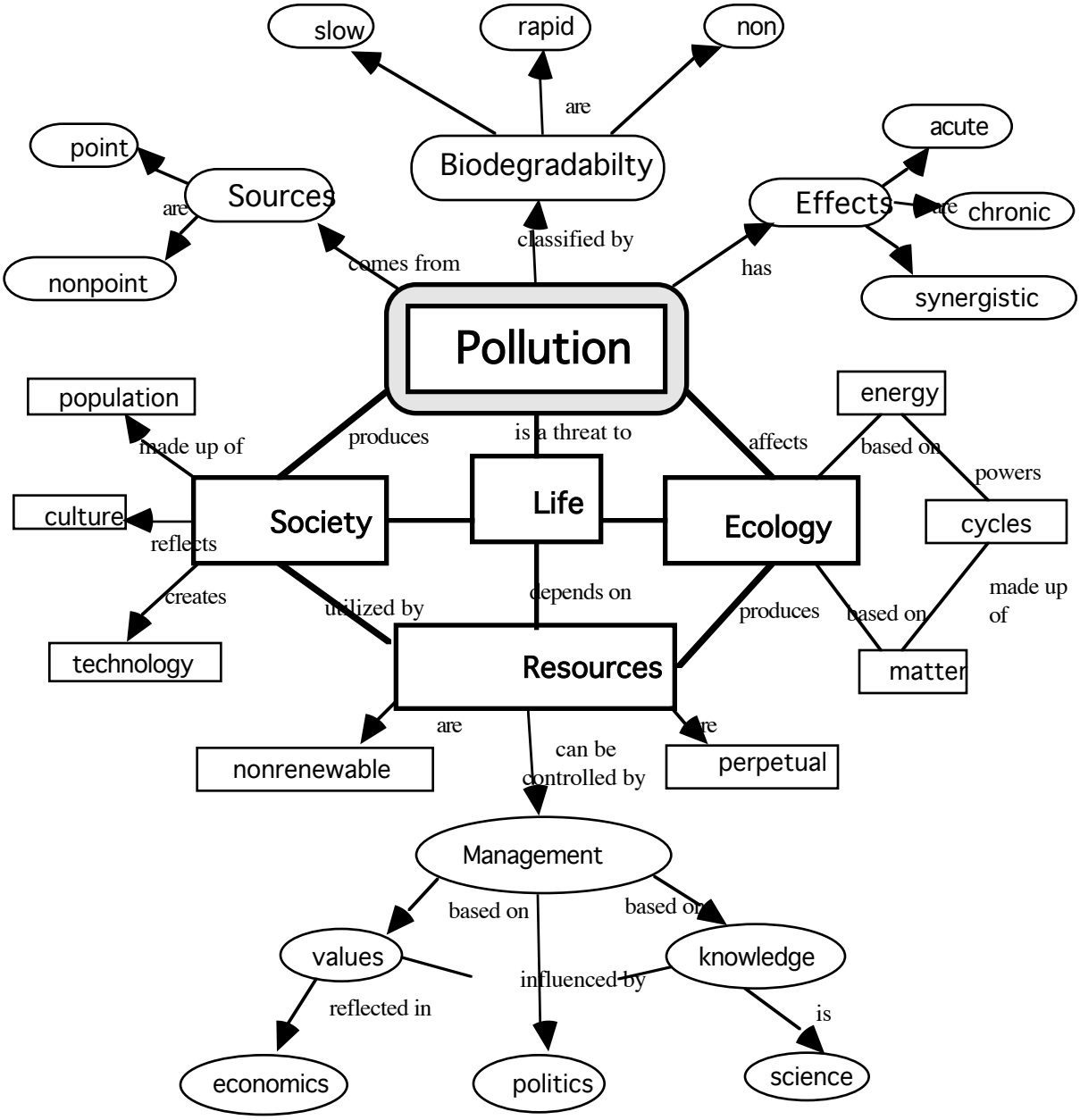

Figure 1. Concept map constructed by research team to define pollution.

The Vee is used to help the learner unpack and construct new knowledge through the interaction of the conceptual and methodological aspects of a discipline (Roth & Roychoudhury 1993). This is emphasized through the identification of the key research questions, the events under consideration, the conceptual structure which underlies the inquiry, the data acquisition and transformation, and the knowledge and value claims which derive from the investigation. The interrelationship of the conceptual aspects including beliefs, theories, principles and concepts with the methods of the investigation and the

results is of key concern in the application of the Vee to extreme ecological situations.

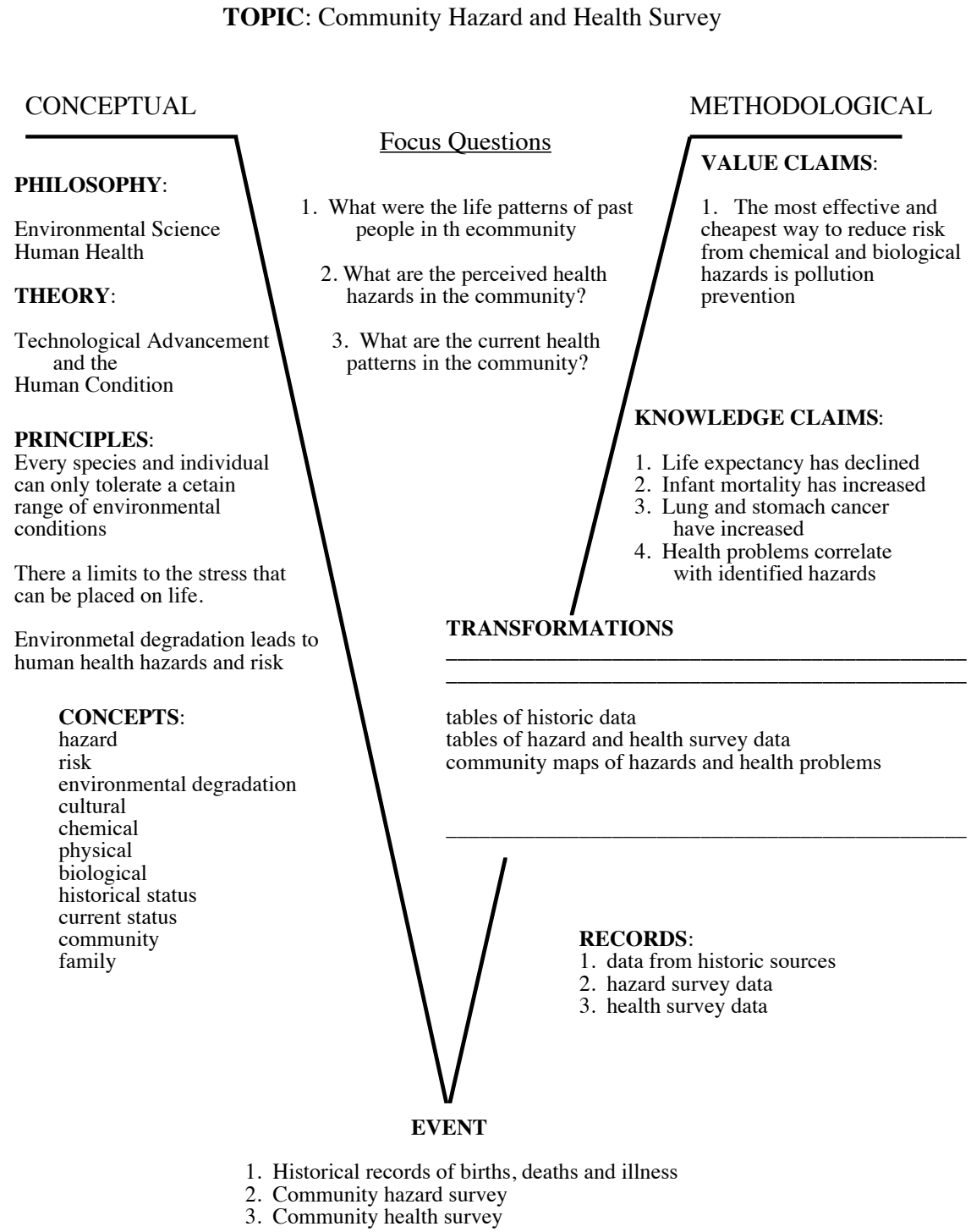

Figure 2. Vee diagram constructed to represent a high school inquiry lesson evaluating the overall health of community members.

Vee Diagrams (see Figure 2) help students construct the interacting set of elements that are involved in knowledge production. Vees serve as a scaffolding or normative device assuring that all of the elements receive due consideration in the process of seeking knowledge and value claims directed by the focus question. Our experience has been that Vee diagramming is more challenging than concept mapping for both students and teachers. This derives in part from the positivist philosophy embedded in most school and college learning, whereas Vee diagramming is rooted in an event-centered, constructivist philosophy now generally accepted by philosophers (C.F. Brown, 1979; K. Popper, 1982; E. von Glaserfeld, 1984).

Both of these techniques have been researched in relation to their ability to help teachers integrate components of the curriculum , plan lessons and design curriculum units (Gurley-Dilger 1992, Martin 1994, McDonald & Czerniak 1994).

Concept maps and Vee diagrams are valuable tools that help students "unpack" the knowledge in text, laboratory or lectures, and they are powerful tools for curriculum designs. These metacognitive tools show promise not only for the improvement of learners, but also for the empowerment of teachers and curriculum planners.

Action Research Context and Focus Questions

During the course of implementing Old Sable, several educational research questions were posed in the context of an action research paradigm. Among the many definitions for action research, (McCutcheon and Jung 1990, Kemmis and McTaggert 1990, Rapoport 1970, McKernan 1991) the Old Sable project is considered from the action research perspective to exemplify "action research aims which contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework" (Rapoport 1970:499 as cited in McKernan 1991:4). The practical concern in this problematic situation is educating young children in an ecological emergency zone. The ethical framework is derived from concern for the human/ecological condition especially as it relates to future generations.

Grundy and Kemmis (1981 as cited in Grundy 1987) state that there are three minimal requirements for action research. Old Sable incorporated the goals of improvement and involvement which characterized any action research project. The conditions which were set out for the action research project were:

1. Old Sable took as its subject matter the social practice of educating young children, regarding teaching and learning as a strategic action susceptible to improvement;
2. Old Sable proceeded through a cycle of planning, acting, observing and reflecting, with each of these activities being systematically and self-critically implemented and interrelated; and
3. Old Sable involved citizens responsible for each of the activities while widening participation in the project to include others affected by educational practices in Niznhii Tagil (Grundy and Kemmis 1981 as cited in Grundy 1988:353).

Within the action research applied to Old Sable, there are four basic themes: empowerment, collaboration, acquisition of knowledge, and social change. The research process achieves these goals through four major phrases: planning, acting, observing and reflecting (Zuber-Skerrit 1991:2).

Based on the pragmatic nature of Old Sable and the guiding principles of action research the following focus action research questions were posed:

1. Are metacognitive skills (concept mapping and the VEE) transferable across cultures in an environmental science curriculum development project?
2. Do these skills facilitate interdisciplinary approaches and inquiry orientation in a high school science program?
3. How does this orientation to curriculum development facilitate the evolution of schools in a newly democratized and rapidly evolving Russian Federation?

Results

A series of four teacher training workshops were conducted in Niznhii Tagil. The content and methodologies used in the workshops were selected and critiqued and the workshops planned by the author, ISC representatives, PI faculty and practicing teachers during the course of eight two day planning sessions in both the USA and Niznhii Tagil. These negotiations insured the participation, representation and understanding of concerned interest groups in the action research and curriculum development process.

The workshops were attended by the Pedagogical Institute (PI) professors, city-wide teachers,and extra-curricular educators. These workshops were planned in collaboration with a representative sample of the participants at

planning meetings held in both the USA and Russia. According to workshop evaluations the participants found all four workshops to be very valuable and reported that they had either used directly or adapted the workshop activitiesfor use in the classroom. The workshops were titled "Introduction to Community-BasedEnvironmental Education (EE)", Introduction to Community Based Curriculum Development in EE", "Methodology of EE: Learning How to Learn", and EEMethodologies". Ecological topics covered in the workshops coincided with the priority topics identified by participants at planing meetings, the first workshop and the priorities identified by the Old Sable CommunityAction and Implementation project: air pollution, water pollution, and environmental health.

One of the highlights of the workshop series was a residential curriculum development workshop held in March 1995. This successful three day workshop consisted of 36 teachers of all grade levels and subjects, together with 10 science and education professors from the PI, writing approximately 100 lesson plans. Plans were made to distribute the lesson plans to all participants and many of the lessons were included in the final curriculum product. The camaraderie created within work teams of professors and teachers, two groups of people who rarely interact, was remarkable.

Approximately 160 educators attended the workshops (40 per workshop). PIpreservice students, attended the workshop sessions and approximately 10 community members attended the last workshop. Following the curriculum development workshops large forums involving hundreds of community members including teacher educators, preservice students and practicing teachers were held to communicate the results of the workshop development process. Concept maps, Vees and lesson plans were exhibited and shared for participants critique.

The concept maps produced by the participants of the workshops and used in the curriculum development project exhibited a very high level of complexity, integration and clear representations of the multi-dimensional nature associated with educating about ecological emergency zones. A representative concept map constructed by a group of four teachers is found in Figure 3. This map, representing life in an extraordinary ecological situation, has many clear examples of the qualities listed above. The association of ecology, society and the individual expresses the complex nature of educating children who are located in the middle of extreme ecological degradation and who have physical and psychological reactions to it. The inclusion of various societal levels of

organization form the individual to the region expresses the inclusiveness of the map. Complex spatial reasoning is obvious in the layers of inclusiveness. Other maps exhibited extensive use of colors and artistic interpretations of the content which indicated the various levels of representation at which participants were able to share complex meaning in effective and meaningful knowledge representations.

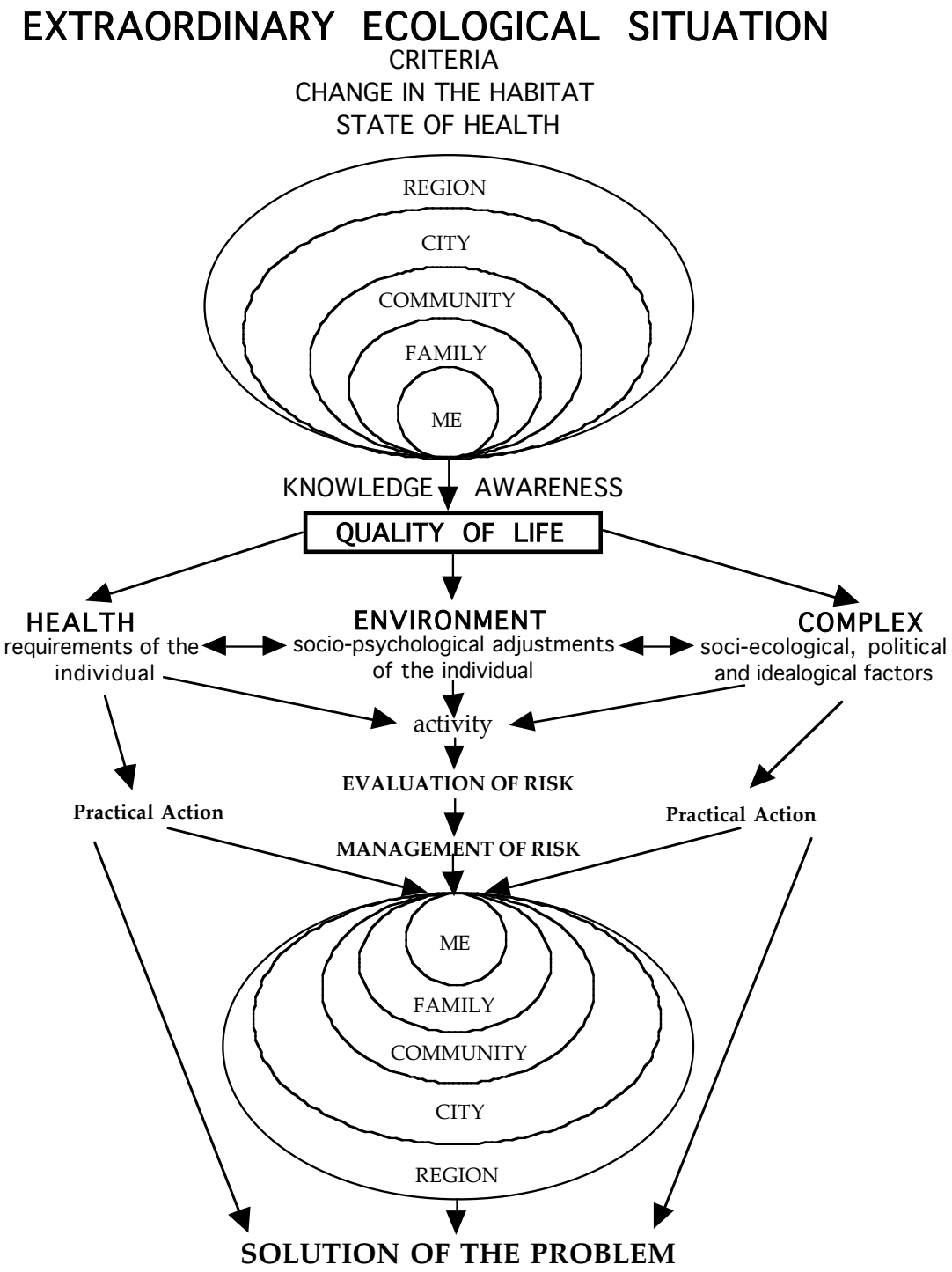

Figure 3. Concept map representing the content of an interdisciplinary unit integrating the individual, ecology and society within an ecological emergency zone.

The VEE diagrams constructed by the participants indicate similar abilities to represent complex knowledge in meaningful ways. Most obvious in these

representations was the systematic organization with which teachers organize their understanding (see figure 3 and 4). Based on the first VEEs constructed by the participants it was clear that the teachers understood the important correspondence of questions, events and claims. In most cases, there were direct correspondence in number and content for each. This indicates a very systematic approach to knowledge construction.

There was also a strong relationship between the conceptual framework and methodological aspects of the investigations they chose to represent. Another consistent trait was the clear explanation of world views and philosophies and there relationship to knowledge claims. These important characteristics indicate the participants rich conceptual understanding of ecology, society and the individual as well as the nature of scientific inquiry.

TOPIC: People in an Extraordinary Ecological Situtation (ESS)

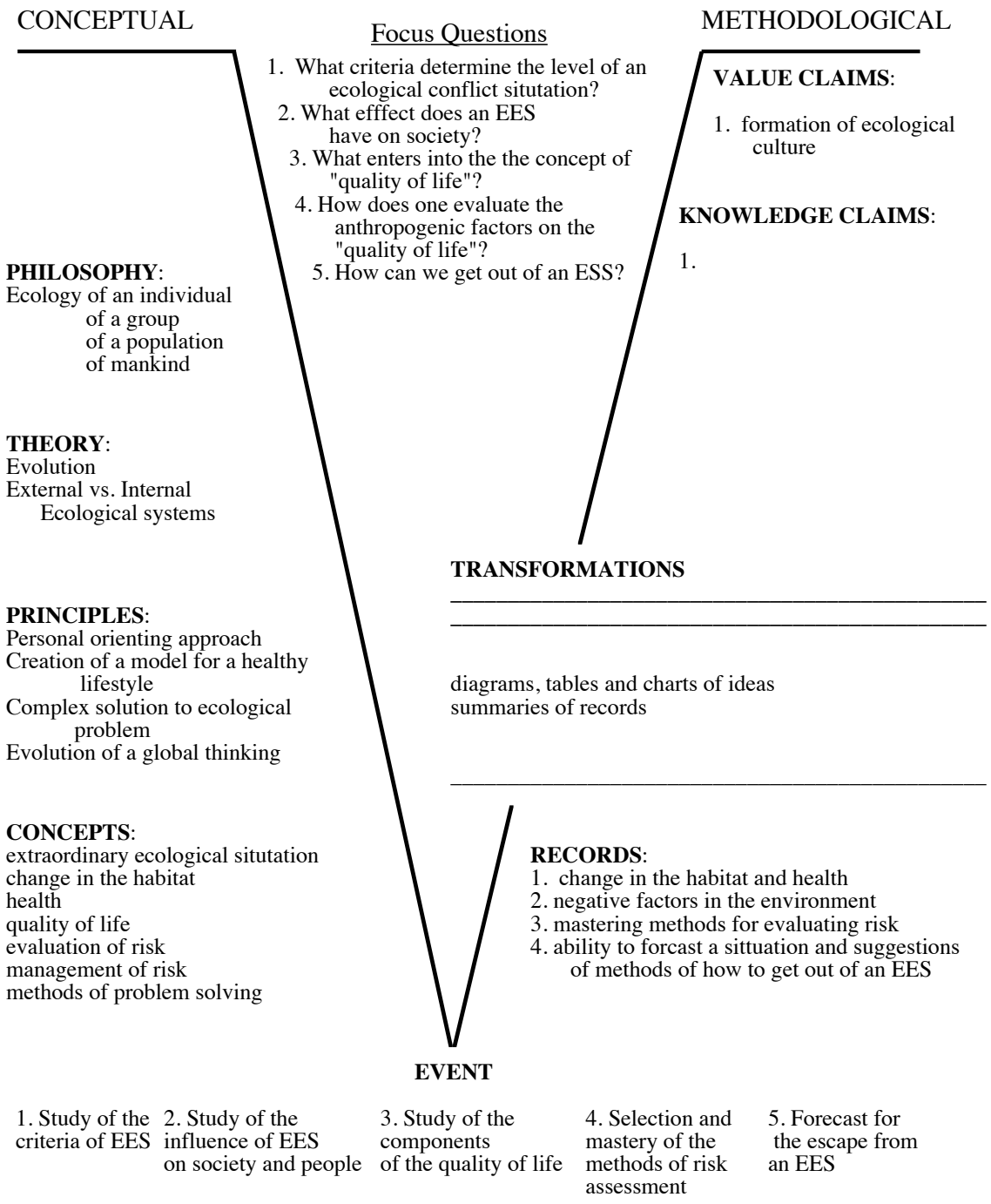

Figure 4. Vee diagram constructed to represent the overal content and structure of a high school interdsiciplinary unit focusing on the relationship of the individual, ecology and society in an ecological emergency zone.

Following the construction of maps and VEEs the groups of participants constructed lesson plans for use in their schools and for publication of materials to be shared with other teachers. These lesson plans were interdisciplinary in nature, reflected a clear understanding of the nature of science and place increasing emphasis on the role of the learner. The lesson plans were collected in units for students and teacher use and have now been published in Niznhii Tagil for use by teachers and teacher educators throughout the city (Niznhii Tagil Pedagogical Institute 1997).

Conclusions

In relation to the research questions posed earlier, we conclude that metacognitive skills such as concept mapping and the VEE diagram are transferable between United States and Russian culture especially as they apply to an environmental science curriculum development project. Comments by participants indicate that the highly cognitive and intellectual approach is positively accepted in Russian culture while the low cost application is particularly easy to assimilate into Russian schools. The cross disciplinary applications and the emphasis on relevance to real life situations was also commented on positively by Old Sable teachers and students.

Based on the results of the research and the development of a variety of curriculum materials we conclude that metacognitive skills indeed facilitate interdisciplinary approaches and inquiry orientation in a high school science program. Many of the lessons designed by the workshop participants incorporated inquiry approaches and were constructed to emphasize both the learner psychological orientation and the epistemological nature of various disciplines.

The metacognitive orientation to curriculum development helps facilitate the evolution of schools in a newly democratized Russia. Participants often commented on the increasing respect and involvement given the learner. A more student centered approach to teaching is highly valued in the new Russia with an emphasis on learner's understanding, the role of beliefs and ideology in scientific endeavors and relevance in the real life situations of the learner.

Discussion

The action research approach applied to the development of environmental science curriculum materials in Niznhii Tagil has been an interesting and informative endeavor. Some of the general observations concerning Russian type approaches to teaching and learning are particularly informative. In most cases, we found that Russian teachers have a very insightful analytical approach to construction of knowledge, that is, they are especially organized in regards to their selection of concepts and principles, complete in the analysis and synthesis of ideas into working theories and philosophies and their selection of appropriate methodologies. In general, we found them to be complex and deep in their understanding of ecology, the individual and society.

Despite this depth of understanding however, Old Sable teachers' approaches to science education have been very compartmentalized and didactic. The use of interdisciplinary approaches and inquiry based activities is an innovation that will take time and effort to infuse into their system.

Finally, the interdisciplinary approach and emphasis on the relevance of the local situation were considered to be particularly useful and appealing to the teachers. Simply put, there is nothing so important than the health and well being of children and future generations. In their words, "There is a light of hope in the middle of the ecological darkness associated with our community."

References

Brody, Michael. 1994. Student science knowledge related to ecological crises, *International Journal of Science Education*, 16 (4): 421-435.

Brown, H. I. (1979) *Perception, Theory and Commitment: The New Philosophy of Science* . Phoenix Edition. Chicago: University of Chicago Press.

Der Speigel. 1994. Military Affairs: poisons of the Soviet past, *World Press Review*, October 1994.

Environmental Policy Review. 1992. The Commonwealth of Independent States and Eastern Europe, *Environmental Policy Review*, 6 (1) Spring.

Grundy, S. and Kemmis, S. (1981). Educational Action Research in Australia: The state of the Art. Paper presented at the Annual Meeting of the Australian Association for Research in Education, Adelaide as cited in Grundy, S. (1988). Three Modes Of Action Research in Kemmis, S. and McTaggert, R. (Ed). (1988). The Action Research Reader (3 ed.) Geelong: Deakin University Press.

Ausubel, D. P., (1960). The use of advance organizers in the learning and retention of meaningful verbal material. *Journal Of Educational Psychology,* **51**(5), 267-272.

Grundy, S. (1982). *Three Modes Of Action Research*. as cited in Kemmis, S. and McTaggert, R. (eds.) (1988). *The Action Research Reader* (3ed). Geelong: Deakin University Press.

Grundy, S., (1987) *Curriculum: Product or Praxis London*: The Falmer Press.

Gurley-Dilger, L., (1992) Gowin's Vee: linking the lecture and laboratory, *The Science Teacher*, 59 (3) 51-57.

Kalinin, V. 1994. Creating a new resonance: environmental education in Russia, *Green Teacher*, 41, 8-12.

Kemmis, S., and McTaggert, R., (1990). *The Action Research Planner Geelong*: Deakin University Press, Australia.

Kidd, C. 1992. *Radiation in the Newly Independent States: A Background Paper for IESC Recruiters*, USAID, Washington, DC.

Klein, E. & Merrit, E, (1994) Environmental education as a model for constructivist teaching, *Journal of Environmental Education*, 25, (3), 14-21.

Martin, D., (1994), Concept mapping as an aid to lesson planning: a longitudinal study, *Journal of Elementary Science Education*, 6 (2) 11-30.

McCutcheon, G., and Jurg, B., (1990). Alternative perspectives on action research. *Theory into Practice* ,Volume 24, Number 3 Summer.

McDonald, J. & Czerniak, C., (1994), Developing interdisciplinary units: strategies and examples, *School Science and Mathematics*, 94 (1) 5-10.

McKernan, J., (1991). *Curriculum Action Research. A Handbook of Methods and Resources for the Reflective Practitioner* London: Kogan

Niznhii Tagil Pedagogical Institute, (1997), *Environmental Science Curriculum*, Niznhii Tagil, Russia.

Novak, J. E., & Gowin D.B., (1984). *Learning How to Learn.* Cambridge, England: Cambridge University Press.

Piaget, J., (1969). *The Child's Conception of the World.* Totowa, NJ: Littlefield, Adams & Co.

Popper, Karl. (1982) *Unended Quest: An Intellectual Autobiography* . London: Open Court.

Rapoport, R. N., (1970). Three dilemmas in action research. *Human Relations* 23:6;499. as cited in McKernan J., (1991). *Curriculum Action Research. A Handbook of Methods and Resources for the Reflective Practitioner*, London: Kogan Page

Roth, W-M. & Roychoudhury, A., (1993), Using Vee and concept maps in collaborative settings: elementary education majors construct meaning n physical science courses, *School Science and Mathematics*, 93 (5) 237-244.

von Glaserfled, Ernst. (1984) *"Reconstructing the Concept of Knowledge."* Paper presented at the Seminar on Constructivism, Archives of Jean Piaget. Geneva.

Zuber-Skerrit, O., (1992). Improving Learning and Teaching Through Action Learning and Action Research Draft paper for the HERDSA Conference 1992 University of Queensland.