The Gaia Hypothesis: an approach to problem solving in the environment.

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Contents of Curriculum Unit 97.07.02:

To Guide Entry

This teaching unit begins with a conceptual sketch of the Gaia Hypothesis, followed by a way of thinking about teaching found in John Dewey's philosophy of education that meets the challenge of Gaia in the classroom. There follows an outline of how Dewey unites scientific and moral problem solving for developing social policy which is, in turn, made applicable to solving problems in the environment. These ideas are translated into lesson plans, a course outline to integrate the unit into a course in ecology and biodiversity and finally, analytical scoring rubrics.

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1. The Gaia Hypothesis

Up until the last decade, few had thought of planet earth as in any sense alive. True in ancient Greece, Gaia was worshipped as the Goddess of the earth and pantheistic tribes had comparable deities of the earth that magically controlled their lives. An important step in this direction came from ecology where self-sustaining systems were discovered in which energy flowed and a delicate balance was maintained between all the organisms in the local environment. A meadow, a pond or forest were described as ecosystems. The abiotic factors were the inorganic or nonliving entities essential to the biotic factors or community of life that sustained each other the producers, the consumers and decomposers. Subseguently, James Lovelock in his Gaia Hypothesis suggests that the entire earth is one large ecosystem, homeostatically controlled. Furthermore, he shows that the environment was both created to meet life's needs as much as it has adapted to the conditions of the environment. Indeed life and the non-living are inseparable entities rather as the mind is to the body (1). It was more correct to say that the earth as a whole is self sustaining, self-renewing and self-creating. The earth is a living planet. Since life is sacred and encompasses both the biotic and the abiotic, the term Gaia seemed appropriate for the living earth.

We are used to the adage, think globally and act locally. Gaian thinking is really this idea in the fullest sense of its meaning. It is thinking through policies of management of the earth as a whole and to look at all other problems as sub sets of this. It is a cybernetic approach to global village management where the problem is basically humans and culture, not nature. It is recognition that in our rape of mother earth, Gaia may dispose of us in the process of a planetary selfcorrecting homeostatic mechanism before we get to destroy Gaia.

As James Lovelock points out in Ages of Gaia, the central concept in the Gaia Hypothesis is homeostasis in which microbes, plants, soil organisms and aquatic life play an integrated role. They control the flow of carbon, nitrogen, water and other elements that go to make up life with the sun turning the cycles at the homeostatically corrected temperature for life and by life. Life started taking control of the environment with the development of the double helical nucleotides and these genes have driven the experiment of life with the environment as its encompassing cloak. (2)

The key example worked out by Lovelock was thermostatic control of the earth's surface temperature. He used the Daisy World model as theoretical construct to demonstrate his theory. In simple outline Gaia Hypothesis attributes the creation of earth's peculiar atmosphere to (A) the stratospheric Carbon Dioxide blanket. When thick temperatures rise; when thin it cools. The ocean acts as a sink for Carbon Dioxide along with the rocks. Trees and cyanobacteria also absorb the gas and generate moisture. The Carbon Dioxide blanket above the stratosphere

also keeps the oceans from evaporating away.

(B) For surface temperature to be around 13 degrees Celcius, the preferred average temperature for planetary life, it is necessary to have a correct mix of atmospheric gases. Air has the correct balance of 79% Nitrogen, 20% Oxygen and 0.003% Carbon Dioxide (all other planets have very high Carbon Dioxide and minimal Nitrogen and Oxygen). The Oxygen content comes from photosynthetic activity, the Nitrogen from decomposers (protists, fungi and bacteria). Oxygen forms ozone in the ionosphere and neutralizes ultraviolet radiation to protect life.
(C) The luminosity of the earth is lower and controlled by forest and vegetation (micro/macroflora) on land and in the oceans. When darker the temperature cools and when light the temperature rises (the Albedo factor). (3)

The gene flow of information that we call life, to an evolving experimentation problem solving creation and adaptation to the environment, has an exponential history of development. It is Gaia's own self-development leading from the origin of the universe as bare energy leading up to higher levels of awareness. The levels of Gaia may be represented in powers of 10 from 4.5 billion years ago to the present generation born 45 years ago. The boxes are different by x10 to the power of 2 years. In the final box we have the highest level of self awareness, a level that has the power to destroy Gaia'see the diagram opposite and the graph above it describing another exponential development, the human population explosion. We humans, though having evolved to an unprecedented level of selfawareness, have become a cancerous growth'a part of Gaia that is reproducing itself uncontrollably and fast killing its living host'Gaia.

It is the point of view of this teaching unit that Gaia protection is the fundamental starting point for all problem solving in the environment. Norman Myers points out in 'Atlas of Future Worlds', that protection of Gaia needs to be embedded in international law and all human behavior subjected to such a law (4). All other environmental and human problems pale by comparison. Accepting the axiom of the inviolability of Gaia would also help prioritize and suggest acceptable solutions to environmental problems, many of which are being sidetracked because of lack of agreement about what constitutes environmental moral culpability. The following unit then takes this as its a priori and seeks to involve students in the Gaia principle in any and every environmental problem that concerns them. Before developing the practicalities of such an undertaking, it seems necessary that we rethink our pedagogy to make sure that it is adequate to deal with the holistic mode of thinking required by the Gaia hypothesis, and rethinking John Dewey's educational philosophy is our place to begin.

(figure available in print form)

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2. Gaia and Education.

John Dewey has had a profound influence on American education. The present reforms in science education are almost pure Deweyan. Those earlier reforms instituted in his name were not as successful as hoped but with research and creativity, the integrity of his ideas have been practically realized. However the fundamentals of his philosophy of education have far-reaching implications that this unit seeks to include.

The first significant relevance is Dewey's own all encompassing metaphor that he carried to all his ideas about education i.e. the metaphor of life itself. Life is self renewing, self-adaptive, systemic and social; hence education must have these characteristics to be effective.

'The most notable distinction between living things and inanimate things is that the former maintain themselves by renewal.'(5) Education is such a process of renewal and transmission of resources that also includes ideas, skills and so forth for the purpose of continuing life in the environment. Education communicates habits (skills) in doing, thinking and feeling from generation to generation. The whole range of life's experience is passed on to individuals that enlarges their private experience. The individual 'goes out' of the self to find points of contact with that wider experience, the life of the species. (6)

Education manipulates meanings that have been called for the by the need to interact and solve problems, those problems given by history, the present and the challenge of the future. The ability to respond is natural to us'not an extrinsic capacity to be forced on the unwilling. It is not an act of conditioning but a learning to see how ideas come together in a dynamic interplay to achieve some goal. The example Dewey gives to make his point is a baseball game. The game cannot be taught by memorizing rules or sequences of events. These may be used in the process of learning the game, but nothing is learned until the idea of the game is learned. Each of the parts have to come together so that it all makes sense. The test is whether the information works for the individual and they can be creatively used. When this is achieved the individual can demonstrate it and see how all the parts of the game are systemically interconnected to achieve the goal of winning and so forth. In this unit, problems will be thought through in such a 'feed back' loop.(6)

At the heart of education is the idea of growth and this is equally characteristic of life as it moves from inception to death. Dewey's key ideas in this respect are 'reorganizing, reconstructing and transformation'.

Education by contrast is not static and not extrinsic. It is about taking the past into the future with thought, inventiveness and initiative.(7) Gaia problem solving challenges us all to break out of the static 'business as usual' ways of thinking.

The relevance to Gaian thought is that education must be taken out of its abstract and past orientation so as to apply past knowledge to the present and future. We need to move out of the Newtonian universe and move into the contemporary world of nonlinear physics, holistic math, creative chaos and global cultural dialogue. Education must transcend meeting the interests of the status quo, class (business) privilege, or nationalist self interest, for the purposes of all life, all of humanity, and for responding creatively to the environment. (8)

As Gaia is sacred and has its own ends and meanings, so also education provides its own interests, its own intrinsic ends. What is intrinsic, however, is open ended, flexible, responsive, a shared activity, personal and problem solving. It is intelligent and springs from the students own natural intelligence. It is its own discipline.

Dewey does not equate education with mere biological life but with reflective thought within the biological process of living in the environment. The essence of education is thinking within experience. Intelligence is not limited to humans. Humans are more adapted to finding a reflective solution to an environmental problem. Reflective experience or intelligent thought may be summarized as follows and is clearly a generalized scientific way of thinking that can be applied to any kind of experience of any kind.

1. perplexity, doubt, confusion in a situation (a problem/question)
2. a tentative interpretation (hypothesis, projected answer)
3. a careful detailed survey or examination of the experience (observations to clarify the problem)
4. hypothesis (rational explanation) stated with independent variables (causes) and dependent variables (effects)
5. test the explanation by effecting a cause to produce an effect or in other words, live the thought within an experience to see if it gives integrity or coherence to the event. (9)

Methodology in teaching is then no more nor less than the method of intelligent thinking. Students cannot learn this unless they participate in an event that requires active reflection. It cannot be isolated from the world but part and parcel of an action that becomes part of a growing world of experience. Books bring that accumulation of global experience to the student but it has to become a direct experience to become meaningful. The task of the teacher is to help mediate "universal" and private experience.

In Dewey's major opus "Democracy and Education", he elaborates the above in terms of the various disciplines"geography, history, humanities, science and so forth (10). He also apples it to the social spirit, the essence of morality. In the following teaching unit, we will focus more of the implication of his educational theory to ethics and problem solving, particularly as they relate to environmental crises of Gaian proportions. The relevance of Dewey's pedagogy above will be highlighted too.

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3. Developing a Social Policy

From the reasoning above, a teaching methodology will develop out of the steps needed to think intelligently when confronted by some aspect of the environment that we experience or live in. It is essentially scientific but since we are developing social policy we are also operating at a moral level of reasoning. Can such a methodology work for moral reasoning? In my teaching unit on genetics (YNHTI 1996), I set out Dewey's arguments for the appropriateness of scientific reasoning when making ethical judgments. His key justifications are as follows:

1. Moral judgments, as science, deals with time and space since both concern antecedents and consequences.
2. In both science and morality, universals are abstracted out of particular events and actual contexts. Both concern universal "laws" that only mean anything as predicators in actual situations.
3. Science and morality both concern judgments on experiences that require reflection and then action to test theoretical understandings. These are tested as events involving some action, the results of which are used to confirm or deny the validity of the prior reflections and judgments.
4. Science demands that reason be subjected to the hard knocks of experience. Similarly morality must justify itself in terms of actual experienced problems. Neither can hide behind appeals to transcendence independent of experience if they are to claim to be true.
5. Both science and morality involve feeling awareness, rational cognition and action to test validity of the relationship between feeling and thought. Feeling awareness in both science and morality is attention to some aspect of the immediacy of experience that calls forth sentient interest, goals and vision of possibilities (in morality, love is an example of this). Cognition consists of logical connections in experience based on cause and effect. Objective thought in morality and science comes from acting out this reasoning within the environment (in morality, moral principles are reasoning within an experience such as love). If the consequences of action meet those expected by reason and those desired by the original feeling awareness (that drew one's attention to this aspect of the environment in the first place) then both science and morality have reasonable grounds for objectivity.
6. Since methodology of making scientific and moral judgments are analogous, then the use of the following scientific or intelligent method of making social policies to solve problems in the environment are legitimated.

To simplify the above, we may use the life-skills problem solving schema described below that all teachers in New Haven Public Schools are expected to use, where applicable, across all academic disciplines. What follows is a practical application of this applied to the population crisis.

(I) Defining the Problem

a. Population is the root cause of pollution and since population increases exponentially so pollution is increasing exponentially and so necessarily uncontrollably.
b. Pollution of air, water and soil means loss of available resources for the expanding population.
c. Population drives consumption that depletes resources and prevents a balanced or sustainable economy with the environment. It drives the need for synthetics and the need for garbage disposal that further pollutes and cuts back on available land and resources.
d. Population increase drives the need to use mass farming techniques such as mono-genetic crops and pesticides that only increases productivity of crop production on the short term. It increases the risk of loss of protection from pests in the future and toxicity to life in general. In the process further environmental damage threatens the existing level of human population.
e. Population increase means reduction of forests to provide fuel and more cultivated land, more houses and recreational space etc. Loss of forests threatens global homeostatic control of global temperature.

If the temperature goes up there is flooding and increased rate of desertification, if the temperature goes down, there is a movement towards a glacial age. In either case, there is more land lost to farming.

f. Increase in population means increased dependence upon oil and other imported goods that decreases national security and so increases military expenditure that reduces resources available for feeding the population etc.
g. Increase in population ultimately threatens all environmental treaties because the struggle for survival will justify governments to abandon them, that then in turn may lead to qualitative leaps in environmental destruction, and as such possibly lead to death of Gaia or devastating loss of human life to levels below existing population.

(ii)Hypothetical Solutions

a) Give tax and social benefits as incentives to 2 children families and penalties for exceeding this number.
b) Require all synthetics to be either biodegradable or able to be recycled on a sustainable basis.
c) Agribusiness must justify all management and farming policies based upon long term sustainable policies, organic solutions to pest and preservation of genetic diversity in the environment.
d) Enforcement of greenbelts around all forest and woodlands. Cutting of trees must not threaten a complex ecosystem in which they live.
e) Reduce dependence upon foreign imports to reduce military expenditure. Reduce foreign debt by limiting profits that can be made on loans.
f) Support an international economic order that requires foreign trade to be based upon the best use of natural resources consistent with local climate or distinctive biome needs.
g) Give priority to all plans that address issues solving systemic problems.

(iii) Determine what criteria would be used to deem plans/solutions as good/bad or better/worse. (controlling variables).

The task is now to anticipate consequences of the hypothetical solutions that have been imagined. In this case we are interested in:

1) outcomes for the government, state or wider community material or nonmaterial.
2) outcomes for those immediately involved.
3) outcomes for extended family and others directly affected.
4) anticipated outcomes based upon research into comparable situations, for example China.
5) anticipate costs to different sectors of the economy and ways to deal with this.

(iv) Procedure/Materials/Presentation of Data.

Choose the best hypothetical plan and fully write out how it would be implemented with list of resources and costs incurred. Plan data tables, graphs and so forth to determine how outcomes can be measured and presented.

(v) Conclusion

Recommend implementing the plan that appears to offer the best outcomes. Point out limitations and expected arrears for refinement.

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4. *Lesson Plans for using the Gaia Hypothesis as a means to solving problems in the environment.*

Priorities in teaching biology have changed a great deal since the early sixties when I was at high school. There were then only two kingdoms of life. Dissection, classification and anatomy of representative species was taught in terms of evolution. Since then, for good reason, biology has shifted focus either reductively to cell biology, biochemistry and genetics or holistically towards an understanding of species in terms of its ecosystem or

environment. If one thinks of evolution as historical ecology, as indeed it is, then one can weave in the outlines of classification and a study of representative organisms into ecology, just as one previously did for evolution. Hence it is recommended here to use the part of the syllabus found in biological texts on vertebrate and invertebrate phyla/classes and fold them into ecology. The contemporary environmental importance of species diversity is reinforced in this way as a deeper understanding is gained of the inseparable unity between environment and life, which happens also to be the central tenet of the Gaia hypothesis. A study of evolution can be postponed to an integrated course in genetics, sexuality and evolution (see my YNHTI unit for 1996 in Genetics). Your course out-line for students may then look like the one that follows:

a) Course out line for integrating the unit into ecology and biodiversity

Ecology, Biodiversity and the Environment

Students will be working on an ecology project that will consist of two parts. The first will integrate the study of four organisms of your choice with the study of four different biomes. In the second, you will choose and research a particular environmental problem, examine it in terms of the Gaia hypothesis and propose a plan for solving the problem. The project will be written up as a mini-booklet using an analytical scoring rubric as guide for self-grading purposes. You will present your environmental problem and proposed solution to the whole class using a science fair type of presentation board. Deadlines for handing in different parts of the project will need to be met to receive full credit. Each week will include a video, a lecture, reading in the library, writing and drawing in class along with a problem solving test and vocabulary/concept quiz on Fridays. The outline of the project will correspond to the outline of the course.

Part I

1. Introduction to Ecology

2. Organism A and the ocean biome

3. Organism B and the wetland biome

4. Organism C and the desert or grassland biome

5. Organism D and the forest (taiga, deciduous, tropical) biome

Part II

1. The Gaia Hypothesis: A way to solve the environmental problem . . . . . .(name your problem you are interested in solving)
2. Materials used in the class presentation.

To grade the written section of part l, the first of the analytical scoring rubrics (see below) will be used. The second analytical scoring rubric (also below) will be used. A supplementary folder will be used for keeping homework, quizzes and tests in. A grade point sheet will be kept stapled into the folder for recording and calculating grades or quality of work. In both section I and II of your project, it is important that organisms and a problem are chosen that are personally appealing.

b) Devise lesson plans that span a week of instruction.

For several years now I have taught classes that are designed to last a week. Monday is for introducing the theme or topic and includes review of key vocabulary, drawing, photographs, demonstrations, artifacts or a video. On Tuesday, Wednesday and Thursday, independent or small group work or library reading/research sessions are planned that teach the content of the class. Not uncommonly only two of these days are used for student self directed work since some weeks are interrupted by school events, holidays or there is a need to have an added lecture or class discussion on such topics as exemplary student work or unexpected problems or extensions needed for the smooth progression of the course. Since students are given assigned readings with questions for homework that can be difficult for them, they have the option of doing homework in class, in which case assigned class work becomes homework. Fridays are used for checking understanding of content. Questions are devised each week that can be used either as a test or as a basis for whole class discussion. They are generally higher order or open ended questions. For maximum effectiveness, it is best if they are based upon the information type questions that were used by students for homework in assigned areas of reading. Motivation for participation is enhanced when students are promised that these questions or selections of these questions will be used in the final examination. An example of "problem solving", higher order or contextual questions are as follows:

1. What kind of chapter headings would you expect to find in a book entitled: "Human Ecology"?
2. When discussing birth control, a student says that every married couple has a right to as many children as they want. Why not?
3. How could the rain forests be preserved and at the same time, cut down its trees?
4. List some reasons why more is not done to save our natural environment.
5. If the human species does not limit its population growth, list some things that will.
6. An angry person says that government has no right to tell farmers how to farm. Give reasons why people might think government should get involved.
7. Which kind of scientists would be best qualified to write a book entitled, "Death of Planet Earth"?

8. What sort of legal information do you need to know before you go hunting or fishing?

To assist students in part II, four problems in the environment have been worked out in outline (see below). *These outlines are not intended to be comprehensive*. They are merely a demonstration.of the feasibility of the principles discussed in this teaching unit. In the fourth column of the outlines a resource is suggested to assist students develop a detailed execution of a plan once the key issue has been identified in terms of a Gaia perspective. These outlines can be used as individual lesson plans for brainstorming with a whole class on how to solve a particular problem in the environment. It will greatly help if the following, "When you have a problem" sheet is given to all students in the class.

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ANALYTIC SCORING RUBRIC I

DIMENSION SCORE

Reading Skills

- At least two sources used and cited. 3
- Two or more sources used but not cited. 2
- Only one source used and cited. 1
- No use of sources. 0

Content Skills Required number of pages written have accurate content and are relevant to topic. 3

- Content of topic is only partly dealt with but amount written is adequate and accurate. 2
- Content is appropriate but is less than required. 1
- Content has significant errors. 0

Hands-on Skills There is at least one neat illustration or drawing that is correctly titled, labeled, fills one page and is relevant to the topic. 3

- The neat, suitable visual appropriately fills the page but is partially or inaccurately titled or labeled. 2
- The visual is unclear or only partly fills the page. 1
- The visual is not relevant to the topic or is missing. 0

Writing Skills There are no grammatical or spelling mistakes and the logic of the paragraphs flows smoothly from beginning to end. 3

- There are grammatical or spelling mistakes but the logical development of paragraphs flows smoothly throughout. 2
- There is at least one significant grammatical error or spelling mistake and the order of paragraphs is jumbled or illogical. 1
- There are many errors in grammar or spelling and paragraphs illogical. 0

ANALYTICAL SCORING RUBRIC II

Ethical Problem Solving

DIMENSION SCORE

Problem Problem stated clearly. Underlying problems such as conflict of values, rights or interests are identified. 3

- Problem(s) identified adequately. 2
- Problem and/or underlying issues poorly stated. 1
- Problem not identified or its underlying issues missing. 0

Solutions

- Four or more solutions proposed. 3

- Two or three solutions proposed. 2
- Solutions are unclearly connected to the problem. 1
- Solutions do not address the problem or underlying issues. 0

Consequences - Anticipated consequences or outcomes are identified as desirable or undesirable for 4 or more proposed solutions. 3
- Outcomes identified and evaluated for 2 or 3 solutions. 2
- Consequences unclear as to their desirability. 1
- Outcomes not connected to the proposed solution or missing. 0

Plan, Measures needed to make a Conclusion - A clear outline plan made, listing any resources needed, to implement a solution. Measures are given by which outcomes can be measured and evaluated for purposes of making a conclusion about the adequacy of the solution to the problem. 3
- The plan and measures are adequate to make a conclusion. 2
- Significant information is missing from either the plan, or method of measuring consequences, to make a conclusion. 1
- The plan or measures used are not connected or missing. 0

(figure available in print form)

Teachers Annotated bibliography

Lovelock, James *Ages of Gaia* NY. Norton Co. 1988

The book is mostly very readable and is essential for understanding one of the key and powertul concepts in contemporary ecology and environmental studies.

Myers, Norman *The Gaia Atlas of Future Worlds* Doubleday Press, NY 1990

To understand why the Gaia concept is so powerful and to realize its fullest implications, there is no book that I know that so clearly and concisely fills in the picture. You may find yourself profoundly changed by reading it.

Myers, Norman, Ed. *An Atlas of Planet Management* Doubleday, NY 1993

If you want a broad overview of the key environment issues troubling our planet and you want detailed summaries of data and solutions that are currently being attempted or seriously proposed, there is surely no better book currently on the market. From this unit's point of view it is invaluable as well because it takes a Gaian point of view.

Dewey, John *Democracy and Education* NY, Macmillan 1916

One of the most influential books in education ever to have been written in the USA, still readable and as relevant as it was eighty years ago and as this unit suggests, peculiarly modern if his concept of the environment is given its contemporary meaning and significance.

Wargo, John *Our Children's Toxic Legacy* New Haven, Yale 1996

The value of this book is that it gives an exampie of the complexity of issues when we try to see them holistically and try to translate them to workable solutions. It provides many practical ideas with no starry eyed simplicity as to their workability in the real world of politics and competing values. In my judgment it argues for the importance of taking the Gaia Hypothesis as the point of view for making social policy.

Students Annotated Bibliography

Norman Myers, ed. *Gaia: an Atlas of Planet Management* N.Y. Doubleday 1993

For a comprehensive overview, simply written, this makes an excellent resource textbook.

Endnotes

1. James Lovelock *Ages of Gaia* NY. Norton 1988, p.31-33
2. Ibid 44-45
3. Ibid 52
4. Norman Myers *Atlas of Future Worlds* NY Doubleday 1990, p.60
5. John Dewey *Democracy and Education* NY, Macmillan 1916, p.1
6. Ibid., 6
7. Ibid., 48
8. Ibid., see chapter 4, "Education as Growth".
9. Ibid., 176
10. Ibid., 243 following.