ABSTRACT

Diagrams are frequently used to communicate relationships between multiple dimensions of quantitative information. Attempts are usually made to simplify complex information and to reduce to a minimum the elements considered. Here I will discuss a different breed of diagrams: one that addresses the increasing need to confront complex issues in all their complexity, and that, more than serving to communicate already existing ideas, would serve to explore new ways of organizing knowledge. Several educational and cultural implications of this conception are discussed.

DIAGRAMMING AS A WAY OF THINKING ECOLOGICALLY

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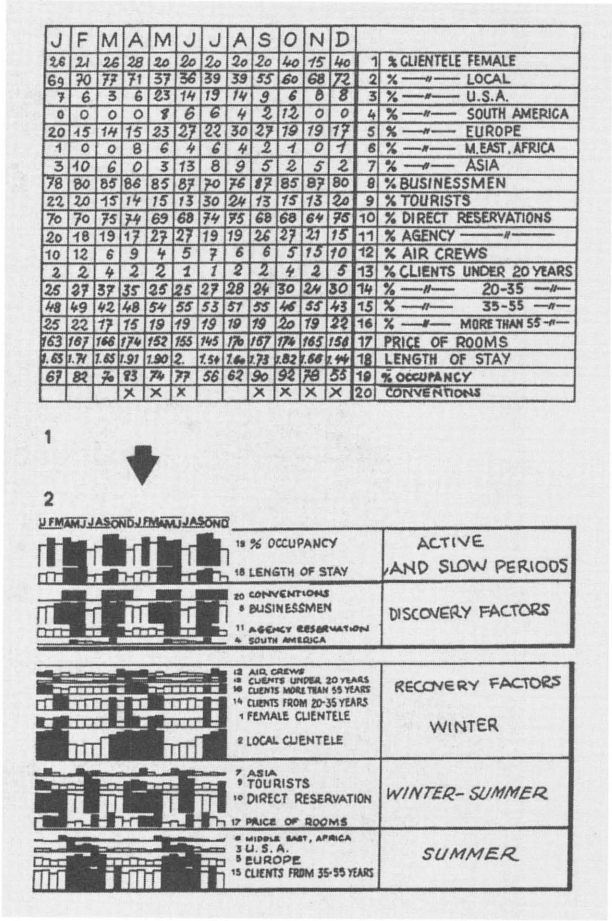
Figure 1



J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —"— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —"— U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —"— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —"— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —"— M.EAST, AFRICA
3	10	6	0	3	13	8	9	5	2	5	2	7	% —"— ASIA
78	80	85	86	85	87	70	76	87	85	87	80	8	% BUSINESSMEN
22	20	15	14	15	13	30	24	13	15	13	20	9	% TOURISTS
70	70	75	74	69	68	74	75	68	68	64	75	10	% DIRECT RESERVATIONS
20	18	19	17	27	27	19	19	26	27	21	15	11	% AGENCY —"—
10	12	6	9	4	5	7	6	6	5	15	10	12	% AIR CREWS
2	2	4	2	2	1	1	2	2	4	2	5	13	% CLIENTS UNDER 20 YEARS
25	27	37	35	25	25	27	28	24	30	24	30	14	% —"— 20-35 —"—
48	49	42	48	54	55	53	57	55	46	55	43	15	% —"— 35-55 —"—
25	22	17	15	19	19	19	19	19	20	19	22	16	% —"— MORE THAN 55 —"—
163	167	166	174	152	155	145	170	167	174	165	158	17	PRICE OF ROOMS
1.65	1.71	1.65	1.91	1.90	2.	1.54	1.66	1.73	1.82	1.66	1.44	18	LENGTH OF STAY
67	82	76	83	74	77	56	62	90	92	78	55	19	% OCCUPANCY
			X	X	X			X	X	X	X	20	CONVENTIONS

Table and graphic presenting the same information, from Jacques Bertin, 1981, vi.

INTRODUCTION

The topic of this paper is diagramming as a way of thinking. I propose that thinking is highly connected to communication, including communication to oneself, and that, when thinking, processes of visualization alternate with processes of evaluation in a pendular sequence of hunches and judgments in order to build knowledge and opinions.

Diagrams are traditionally used in visual communications to present information. This has been widely discussed and their advantages for some applications have been proven many times, paradigmatically by Bertin through his classic example of the hotel manager (*figure 1*, 1981, vi). Bertin (1983) recognizes three basic functions for diagrams: to record, to understand and to communicate, extending the value of diagrams beyond their more usual function as communication devices (12). Baigie, referring to the illustrations produced by Descartes for his papers on science and mechanics, ponders: "are they merely to help the reader come to grips with the text or, more substantially, are they involved in some way in the creation of knowledge?" (*figure 2*, 90-91). Much has been discussed about the nature of diagrams, their possible strengths and weaknesses and the cognitive processes involved in both their construction and their decoding.

While diagramming as a way of contributing to the process of thinking has been used quite commonly, little of this has been systematically studied, and certainly even less of this has penetrated general education. As a result, picture making has been relegated

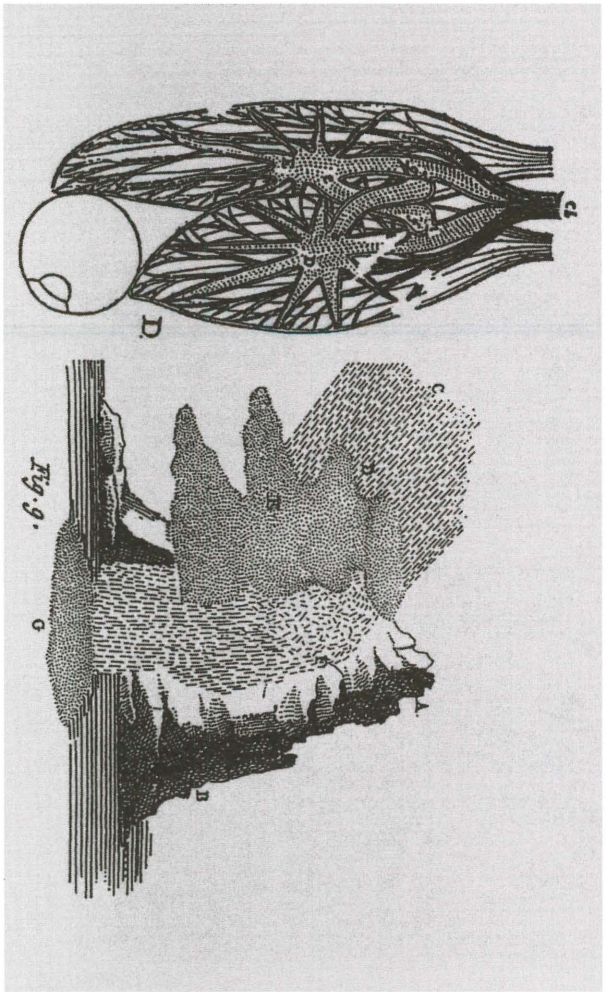


Figure 2

Reciprocal muscle action (René Descartes, 1664) on the left and his 1637 formation of vapors [clouds] on the right as reproduced in Baigre, 1996, 91.

to self expression and recreation, while verbal language has provided the paradigm for thinking, for reporting on science and for general exchanges of information.

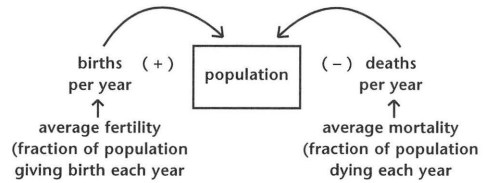
The structure of verbal language, however, offers a limited capacity to convey information. It promotes linear thinking and sequentiality, and is very poor for the presentation of hierarchies, inclusions, simultaneity, distinctions of levels, multiplicity of kinds and complexity of connections. While all this can be described verbally, the nature of verbal discourse does not reflect the structure of what is signified. The development of thinking habits in Western education has concentrated on language, and therefore on sequential and unilinear thinking. In the long run, this has limited our capacity to understand serious problems of a physical or social nature due to verbal language's inability to promote the perception of context, complexity and simultaneity – in other words – due to its inability to promote thinking in terms of ecologies of information.

This tendency has been possibly fostered by the nature of the verbal language structure, but its influence has also been felt in the terrain of graphic presentations, where simplicity, isolation of variables and reduction of data many times have been pursued as strategies to improve the scientific quality of the graphics developed. In this way the attempt was to produce clarity of information.

It is, however, evident, that our world is an integrated system, as can easily be seen now that the natural environment is stressed by human overpopulation, chemical contamination and biological hazards stemming from the need for unprecedented expansion in food production.

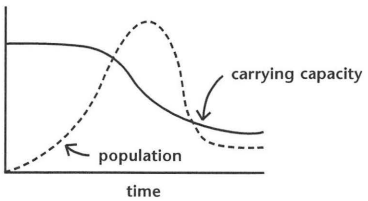
To discuss diagrams as ways of thinking and to propose the relevance of diagrams for the understanding of certain problems, I will offer three examples.

Figure 3



Population dynamics redrawn from The Limits to Growth, *Meadows et al, 1970, 34.*

Figure 4



Population and resource comparison over time redrawn from The Limits to Growth, *Meadows et al, 1970, 92.*

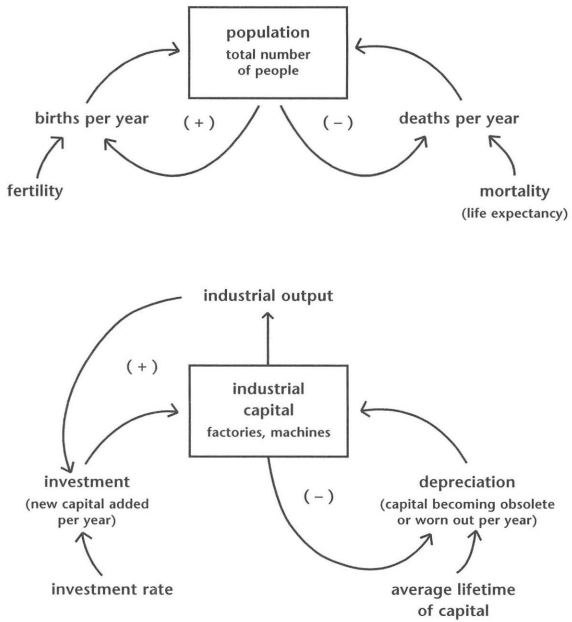
EXAMPLE 1: DIAGRAMS AND THE ENVIRONMENTAL PROBLEM

The Limits to Growth is a 1970 publication produced by the Club of Rome with a view to alerting people about the finite nature of world resources and the rapid manner in which we are heading toward disaster. It presents information about the world situation by using both a series of double entry charts and a series of diagrams that illustrate connections among a wide variety of factors. The series of diagrams begins with a simple one on population in figure 3 (34), followed by a slightly more complex one in figure 4 (92). Then they relate population and industrial capital in figure 5 (95) and propose relations between population, agricultural capital and industrial capital in figure 6 (97).

Other diagrams propose alternative influences, such as the relations between industrial capital, service capital and non-renewable resources, such as seen in figure 7 (100). Finally a full graph of the world ecology is presented in figure 8 (102-103). After carefully building and showing relationships in this case, the viewer sees an insight that cannot be conveyed by verbal language alone.

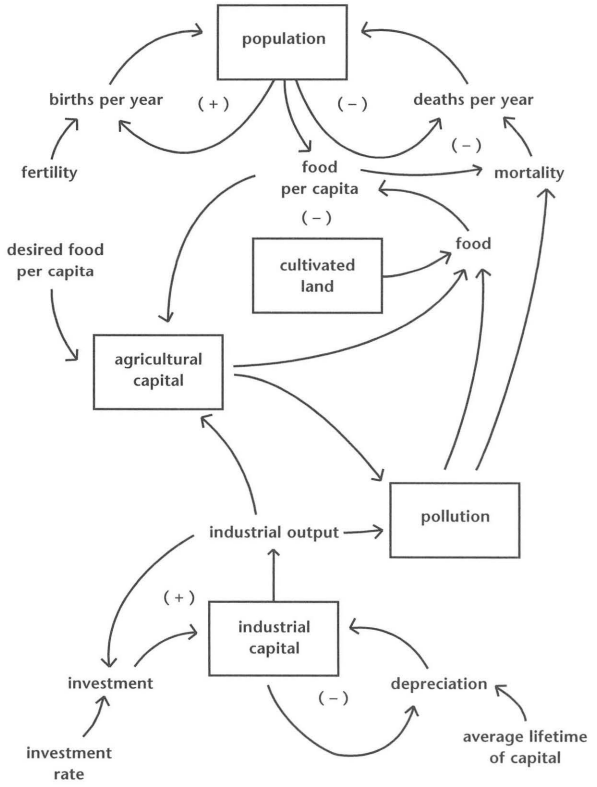
It is obvious that to convey information about something physical, such as the streets of Rome or the muscles of an arm, a visual presentation will be more efficient than a verbal description. In this case, however, I am not talking about physical things but about conceptual constructs, where connections are proposed between economic factors, biological factors, resources, population and pollution – a complex ecology that resists comprehension if one separates its components into discrete pairs.

Figure 5



Population growth and capital growth feedback loops redrawn from The Limits to Growth, *Meadows et al, 1970, 95.*

Figure 6



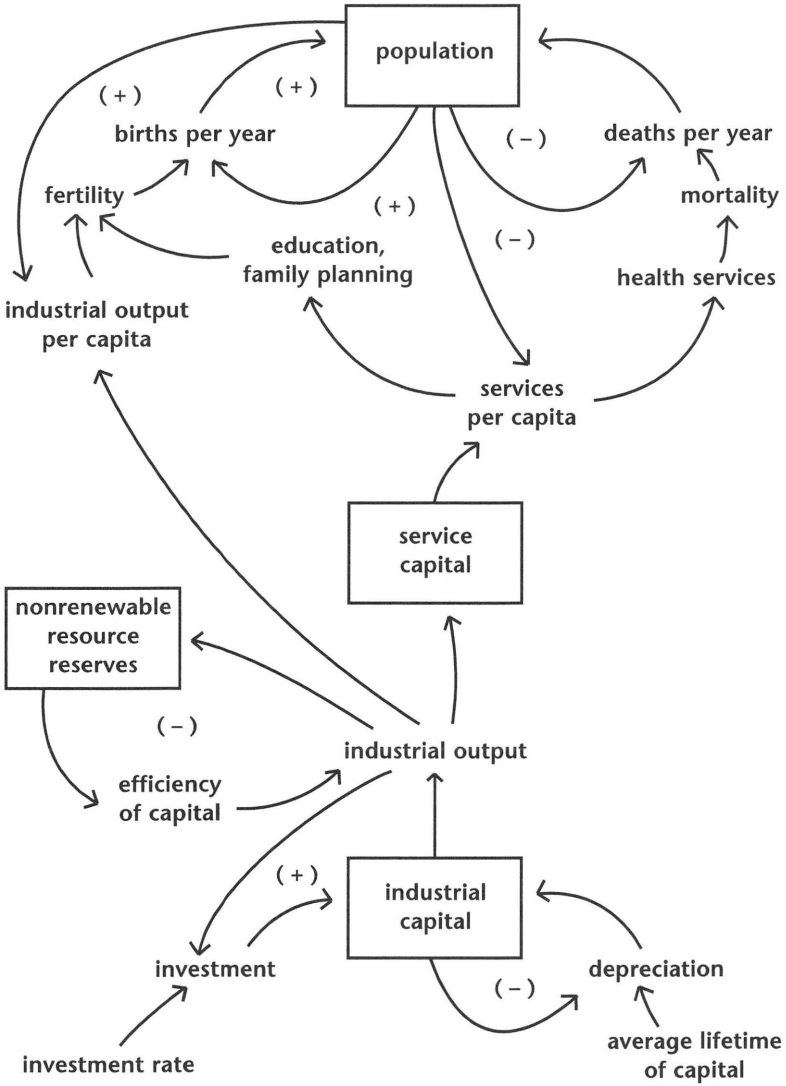
Feedback loops of population, capital, agriculture and pollution redrawn from The Limits to Growth, *Meadows et al, 1970, 97.*

While we could argue about the fitness of the specific connections outlined by the authors of the publication, the graph successfully drives home the notion that the problem is not simple, and that the possible solution to a complex problem cannot be based upon breaking it down strategically into its component problems, because these cannot be addressed independently.

I would like to suggest that the disastrous environmental situation we are facing today is in part due to the endless greed of some people; but it is also in part due to an education that compartmentalizes and isolates information, allowing for egocentric decision-making processes to ignore negative consequences that effect other people and other places. I would argue in favor of an education that would contextualize and integrate information in meaningful wholes. Instead, the specialist education that the dominant culture has promoted fosters a decontextualization of knowledge. The business obsession with efficiency and competitive performance looks at immediate actions and immediate returns, and disregards long term effects and distant consequences. Garbage is exported or buried, as if it would disappear when it is sent around the globe and out of the sight of the originators. Air and water are invisibly polluted by chemical factories, industrial processes, energy generation and transportation. Legislation is constantly developed to protect short term interests of business and governments. Nuclear waste is disposed in containers of uncertain reliability. Lack of planning affects many fields, including heath and safety; as an example, as I write this paper, virus-infected pigs are being killed and buried by the hundreds in Malaysia, without regard for possible contamination of soil and watertables and in total ignorance of the long term effects of hundreds of carcasses fermenting four meters underground in hundreds of sites to accommodate the estimated one million pigs that have to be eliminated. Cheap labor is exploited in developing countries while unemployment affects 10% of the industrialized world, creating medieval poverty in lands of plenty; and cheap people are imported to industrialized countries to perform dirty jobs that the locals do not want to perform. All this is the result of putting economic success at the top of the hierarchy, and of keeping information separated in isolated clusters so that decision-making groups can ignore the long term consequences of their actions.

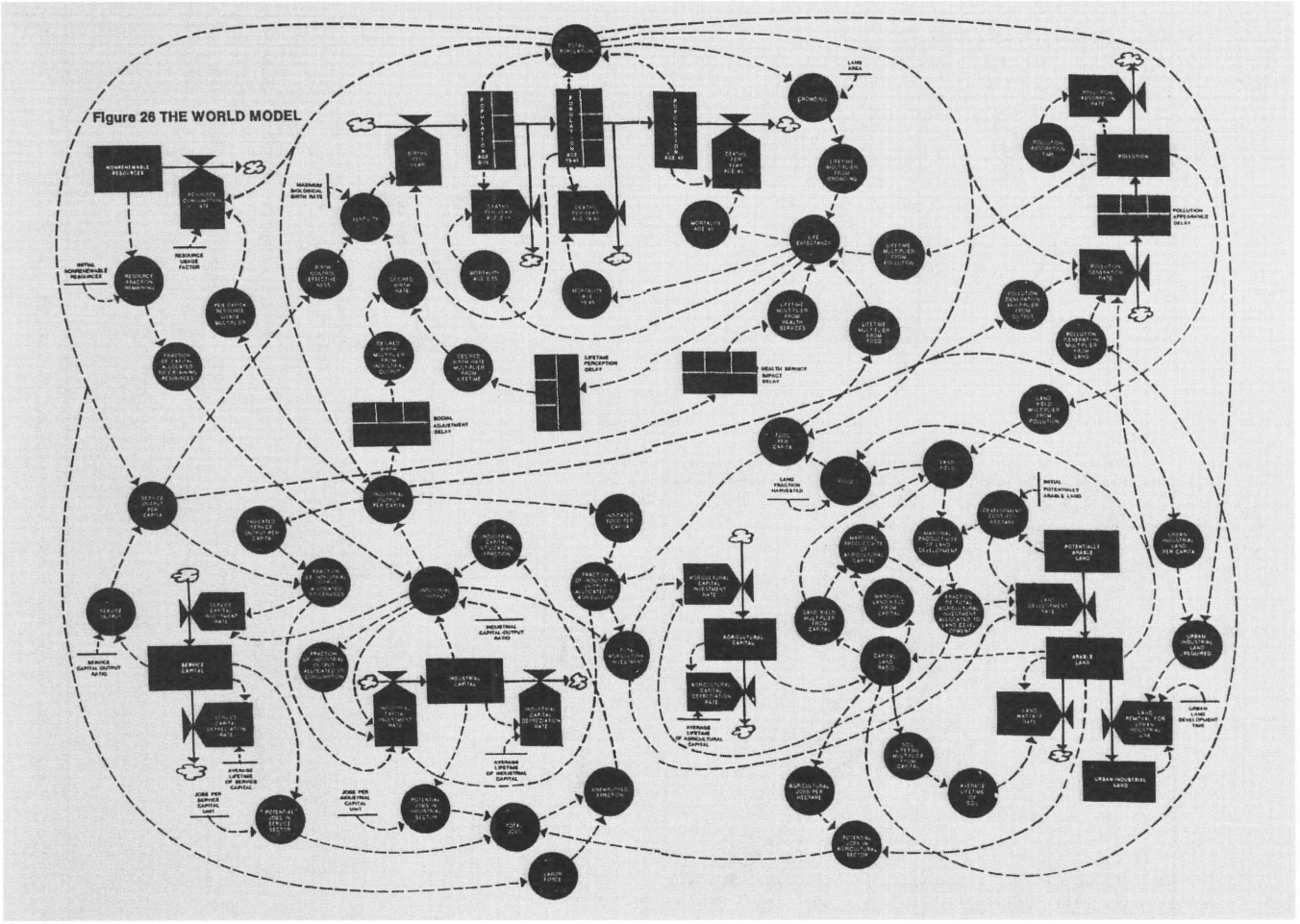
Instead of looking at isolated events in a linear, language-based, binary way, a more responsible and intelligent approach to knowledge would be to look at diagrams as tools that foster the understanding of ecologies of information, and as instruments that assist the development of intelligence. Intelligence involves critical thinking that connects and distinguishes units of information; that generalizes from particulars in careful ways by seeking out patterns; that recognizes in the individual the applicability of the general. It is the ability to discover patterns, hierarchies and causalities. The intelligent person creates taxonomies and uses information to build propositional knowledge to guide action. Because diagrams can synthesize different factors or dimensions of a situation, they lend themselves to exploration of complex interrelationships that would otherwise escape attention.

Figure 7



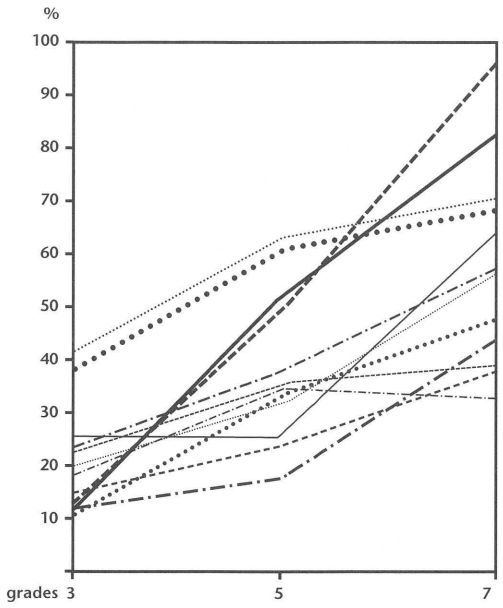
Feedback loops of population, capital, services and resources redrawn from The Limits to Growth, *Meadows et al, 1970, 100.*

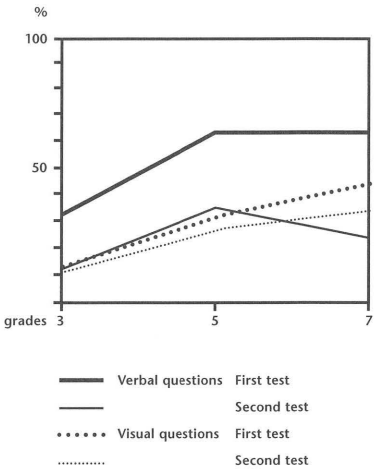
Figure 8



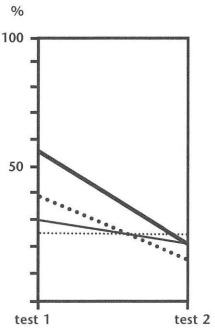
The world ecology model from The Limits to Growth, *Meadows et al, 1970, 102-103.*

Figure 9





	INPUT	KIND OF QUESTION	SEX
------	JIGSAW PUZZLE	Verbal	Boys
——			Girls
- - - - - - -		Visual	Boys
—·—·—			Girls
——	DRAWING	Verbal	Boys
—·—·—			Girls
—·—·—·—		Visual	Boys
- - - - - - - - - - - -			Girls
•••••••••	OBSERVATION	Verbal	Boys
.....			Girls
•••••••••		Visual	Boys
.....			Girls



Input through OBSERVATION Verbal questions
Visual questions
Input through DRAWING Verbal questions
Visual questions

Diagrams to synthesize working data and explore relationships redrawn from Frascara, 1981, 19.

EXAMPLE 2: LEARNING STRATEGIES AND MEMORY

In this example I will report on the instrumental value of diagramming. Some years ago I was interested in studying the relative effectiveness of different ways of acquiring information in relation to short and long term retention. I created three different situations for the acquisition of information, working with school children of ages 7, 9 and 11, males and females, and measuring immediate retention and retention after one week. Once I collected all the results, patterns of comparative performance appeared clearly to me when I produced a diagram that represented all the results and all the variables. In order to make this more understandable, I published the results in three diagrams (*figure 9*). This was not meant to communicate to others the results of my investigation, but was meant for me to be able to have three months of work in front of me so as to draw conclusions and make recommendations. I never had another experience where diagrams demonstrated more clearly their value as tools for analyzing and comparing complex sets of data. At a glance I was able to assess the relative performance of each method of input in connection with the other dimensions of the study, or any other combination of dimensions considered. Even at this low level of complexity, where – unlike in the ecology problem – all the variables involved were discreet and planned, diagramming as a way of presenting research results and analyzing information clearly was more efficient than an alphanumeric presentation of the data.

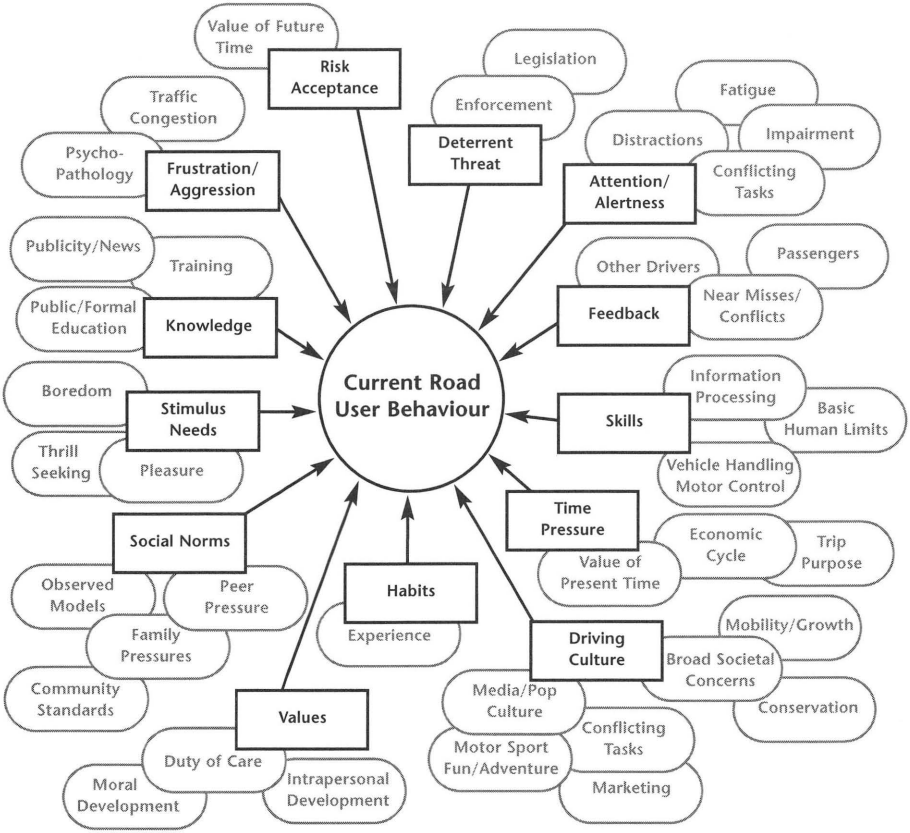
EXAMPLE 3: DIAGRAMS AND TRAFFIC SAFETY

Traffic safety is another supercomplex problem that cannot be addressed properly if one does not look at its totality. While the graphs published in *Mission Possible: the integrated safety initiative for Alberta*, do not intend to represent the totality of the factors that affect traffic safety, they at least show that when looking at the traffic safety problem we have to be conscious of the three basic areas of action that an integrated strategy has to consider: the traffic environment, the road users and the vehicles (*figure 10*, 44).

If we focus in on one of those dimensions, such as in figure 11 (35) and try to ascertain what affects road user behavior for instance, we get an idea of how each one of the dimensions outlined could be further developed in order to present the problem with a high degree of richness. One can get closer to each one of the areas and see how they are constituted by clusters of information that offer possibilities for insight and action. This need for action in the practice of design benefits from diagramming as opposed to verbally describing complex situations. Verbal descriptions challenge memory and imagination, and deceivingly present problems as if they were under control.

The first reaction of people entering traffic safety is to propose solutions that relate to the filter through which they see the problem. If they are engineers, they point at road construction and vehicle safety; if they are policemen, they look at enforcement; if they are traffic education experts they look at drivers' training, etc. In this connection diagramming has to fight the power of personal experience, recent experience and the emotional charge associated with what has been lived as opposed to what has been learned without emotional load.

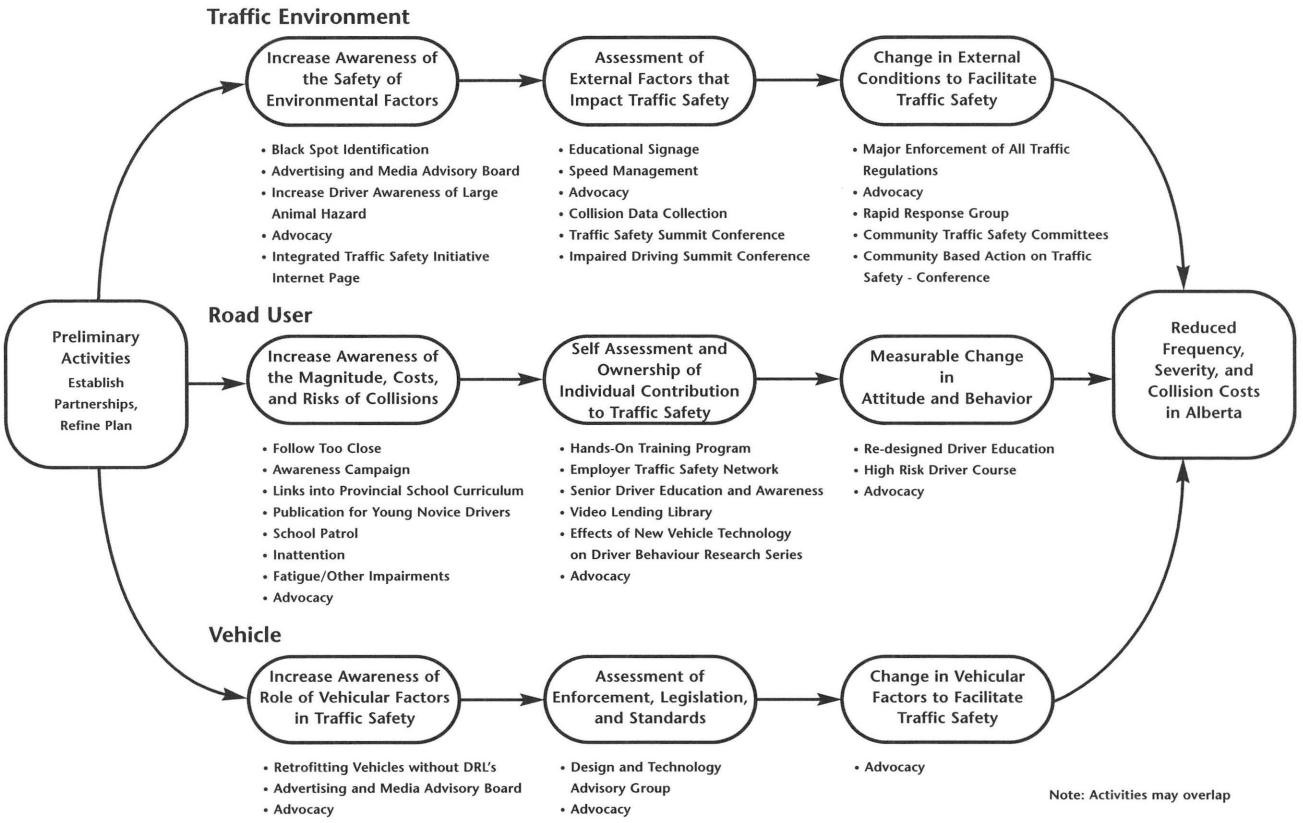
Figure 10



Factors influencing road user behavior redrawn from Mission Possible, the Alberta Motor Association, *1996, 35.*

Figure 11

Integrated Traffic Safety Initiative
Conceptual Overview and Activity Plan



Integrated traffic safety initiative – conceptual overview and activity plan redrawn from Mission Possible, the Alberta Motor Association, *1996, 44.*

AND NOW WHAT?

It remains for us, in general, to ask ourselves: how differently would we think if we had been constantly exposed to diagrams as tools for learning instead of having been bombarded by strings of words in our education? How much better would we be prepared to deal with complex realities? Would we be better prepared to understand the complexity of everything, and, particularly, human relations, life in society and natural ecology?

Given the disastrous reality that surrounds us, from Yugoslavia's war through capitalism gone wild, to the destruction of the natural environment that supports our very species, one can only hope that skill in a more holistic way of thinking could counteract the shortsighted idiocy that rules our lives, deteriorates the general welfare of humanity, affects the health of huge numbers of people and might finally destroy the human habitat.

We have talked enough about the value and the merits and the limitations of diagrams; our time now is to act, to promote the use of diagrams as tools for thinking and to incorporate them in general education as mind-mapping strategies dedicated to integrating knowledge. In this way, our ability to perceive the interconnectedness of events is increased, we become more conscious of the consequences of our daily actions and able to act more responsibly.

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