4-1990

A Logico-Structural, Worldview Analysis of the Interrelationship between Science Interest, Gender, and Concept of Nature

William W. Cobern
Western Michigan University, bill.cobern@wmich.edu

Jane E. Ellington
Austin College

Daniel M. Schores
Austin College

A Logico-Structural, Worldview Analysis of the Interrelationship between Science Interest, Gender, and Concept of Nature
(SLCSP #095)

A research investigation reported at the annual meeting of the National Association for Research in Science Teaching, Atlanta, April 8-11, 1990.

William W. Cobern, Ph.D.
Faculty of Education and Human Services
Arizona State University-West Campus
Phoenix, Arizona

Jane E. Ellington, Ph.D. & Daniel M. Schores, Ph.D.
Department of Psychology & Sociology
Austin College Sherman. Texas

A few years ago I[1] was speaking with a distinguished professor of science explaining to him my concern for the low level of science interest among school level students. I remarked that in my view a major contributor to this lack of interest was the methodology used to teach science. Students forsake science because their own orientation to the world does not allow them to appreciate science as it is typically taught (Cobern, 1989a). The professor immediately added to my sentence "and believed by the vast majority of qualified practitioners." He went on to say that this dropping away of students is a blessing because it leaves science with only those who are truly capable of doing science. What this professor advocated was the natural selection of science students via the survival of the fittest - science education, "red in tooth and claw! "

Purpose of Study

Of course, this scientist's opinion is no longer one popularly held for two good reasons. As Patrick and Remy have pointed out we are confronted with new challenges "associated with the pervasive influences of science and technology in modem American society" (1985, p. 1). The enlightened citizenry needed in a 20th Century popular democracy means a citizenry capable of making informed decisions concerning science and technology. Thus, educators are confronted now more than ever with providing meaningful science education for all students, not just the three percent who will be science majors in college.

Secondly, the natural selection approach to science education rather unnaturally selects for white males of at least middle socioeconomic status. Clearly at issue here is equity. Due to various ambiguous factors, i.e., factors only poorly understood at this point, many individuals are tacitly denied the opportunity for scientific understanding needed in modem society. Furthermore, among those who study the demographics of the American and world labor forces, there is a growing concern that the science and engineering student pipelines are much too small to continue supporting a technologically advanced economy (e.g., Vetter, 1988). Thus, we must improve the involvement in science of those groups traditionally under represented in science as students and professionals.

Women form one such group. To increase the involvement of women in science both as professionals and as enlightened citizens we must ask what it is that currently bars their involvement (e.g., Thomas, 1986). We have a clue in the recent Belinky et al book *Women's Ways of Knowing* that suggests that there is a distinctly feminine world view. As other studies have indicated (Cobern, 1989b) worldview variations potentially interfere with science education particularly when instruction proceeds unaware of the importance of fundamental epistemological structure in learning. The purpose of the research being reported here was to provide information about gender-related worldview structures. This was an exploratory investigation that sought to identify potential presuppositions in a single worldview category, the NonSelf, and specifically that aspect of worldview related to concept of nature. The current literature in women's studies (e.g., Halpin, 1989; Whatley, 1989) suggests that a gender-related concept of nature may conflict with the concept of nature typically found in science and as presented in science instruction. It is envisioned that the findings of this study will subsequently inform more precise worldview investigations.

The significance of worldview research is in its potential for informing instructional design. For example, given that a particular concept of nature is common in science education, students who enter

[1] i.e., Bill Cobern

the science class with a different concept may be at risk (Rosser, 1989). In principle, worldview research will enable science educators to make science more meaningful by developing instruc-tional strategies that build deep bridges to connect with student fundamental presuppositions about the world.

Theoretical Framework

Worldview is a construct that refers to the fundamental organization of the mind. A worldview is an organized set of fundamental, cognitive presuppositions about reality. It is a culturally dependent, interpretive structure. By definition, worldview is a highly stable structure. Nevertheless worldview has an adaptive function and thus there is change and evolution. Cobern (1989a) recently reviewed the extant worldview research in science education and presented a model for continued research endeavors. This model is an adaptation of Kearney's (1984) logico-structural model of worldview, a structural composite of seven, basic cognitive categories or universals: Self, NonSelf, Relationship, Classification, Causality, Space, and Time. Logically related presuppositions are the content of the universals. Kearney likens this logico-structure to the diagnostic categories used by physicians:

> Although the doctor is confronted with a variety of patients, he can presumably describe the most significant medical facts about them in terms of... features common to all patients, e.g., blood pressure, pulse, respiration" (p. 65).

In principle groups of people and even individuals can be identified by worldview variations that result from the presuppositional variation in worldview universals. In other words, where students are usually considered culturally-uniform, most presuppositions within the seven universals will be shared by most students. However, variation exists because some presuppositions are shared by only a few. The distinction between worldview and worldview variation or worldview variant may be likened to the distinction between language and dialect. Thus while most American children operate, within an American worldview (which itself is a variant of a Western worldview), there are many variants due to social, economic, religious, gender, ethnic and other cultural influences (Cobern, 1989a). With regard to science education, it behooves one to speak of students with American worldview variants that range in science compatibility, *less to more.* For example, students who are inclined to accept scientific styles of explanation have a worldview variant that is scientifically-more compatible than students who are not so inclined (Cobern, 1989b). This logico-structural approach to worldview differs significantly from the monothematic approach of Pepper (1942) whose work is foundational for Kilboum (1994) and Proper, Wideen & Ivany, 1988). The strength of logico-structuralism is its sensitivity to intra-worldview variation, and thus its avoidance of artificiality.

Logico-structural theory may be used to investigate some of the vexing issues in science education such as the gender issue. Recent feminist research suggests that there exists a gender-related worldview that must be considered in science education (e.g., Belinky**,** et al, 1988; Halpin, 1989; Whatley, 1989). The logico-structural position would be that there exists a gender-related, worldview variant. The problem is first to identify and describe this variant, and then to investigate ways of effectively using this knowledge for the improvement of science education**.**

Methodology

Logico-structuralism captures the complexity of worldview while simultaneously providing approachable subdivisions. Thus, the model facilitates research by allowing one to attend first to smaller units while guarding against oversimplification. The focus for this study was the NonSelf universal. Specifically, the researchers investigated concepts of nature among college students potentially related to gender. Logico-structuralism however, reminds one that concept of nature, as an aspect of the NonSelf, is influenced by presuppositions in the categories Relationship, Classification, and Causality. Thus, while we may begin the exploration of student understanding of nature by focusing on concepts of nature, eventually research must extend to these three other worldview categories.

The methods of worldview research vary, but primarily researchers use a technique called *reading back* (Jones, 1972). From observations, one reads back to underlying worldview presuppositions. The presuppositions are thus inferences drawn from observations. We chose to use Jones' (1961) technique of conceptualizing presuppositions as bi-directional vectors. For example:

> Simplicity/Complexity: a preference for the obvious or a preference for the devious, rich, and esoteric.

Jones' proposal is that behavior in an individual or in a society can be analyzed into specific configurations of such vectors. There will be a noticeable central tendency among behaviors since an individual's actions will be strongly influenced by the magnitude of each vector. In this study, concept of nature was observed as student response to a direct question about nature. From these responses the researchers inferred potential, underlying presuppositions, the presuppositions being stated as vectors.

At this point, it is important to note that there is a distinction between presupposition, and simple belief and opinion (Cobern, 1990; Jones, 1972). In brief, presupposition refers to a more stable, more basic and general level than simple belief or opinion. For example, it is an opinion that summer is preferable to winter. It is a presupposition to view nature as fundamentally capricious.

In an approach similar to Rejeska (1982), students were asked to complete the following sentence so that it accurately reflected their opinions:

> The physical, natural world around me is_____________, and should be___________
> (one word only)

The "is" and "should be" design of this question was intended to provoke a personal response to the question rather than a recitation of something learned in school. The researchers read each student's response and independently placed the responses into categories. To maximize the unbiased review of responses, the researchers read the responses without knowledge of the demographic and science interest information concerning the subjects. After reviewing the data, disagreements among the researchers were settled in conference, though in fact only about 10% of the responses were placed in conflicting categories.

Only one category was set prior to reviewing the data. Taken from the German, *Naturwissenschaft* was used for a response that implied the importance of the careful, scientific study of the physical world. The researchers looked for key words such as "explored," "studied," and "investigated." Thus, as a beginning, responses were marked as either *Naturwissenschaft or Other.*

The data review however, suggested that the responses in the catchall *Other* category could be further divided into six additional categories. For example, some responses alluded to the importance of studying nature, but in the context of an aesthetic view of nature which distinguished these responses from the *Naturwissenschaft* responses. These responses were categorized as *Geistewissenschaft.* The responses in four other categories were marked by their lack of any reference to the study of nature. A sixth category was reserved for non-interpretable responses. The five interpretable categories were defined as follows:

Natur: emphasis on knowledge about nature derived from investigation; e.g., "scientific-cause and effect, every problem has a concrete answer."

Geiste: emphasis on an aesthetic view of nature but with recognition of the importance of knowledge; e.g., "incredible-*explored*, enjoyed, protected by everyone so we can *understand* without destroying" (emphases added).

Aesthetic: a view emphasizing the wonder, awe, excitement of nature; e.g., "beautiful-taken care of to retain is natural beauty for future generations."

Preservation: emphasis on the need to preserve nature or on the disgraceful polluted state of nature; e.g., "deteriorating-preserved- however, we are destroying our world and are going to have to expect our own self-destruction if we do not change."

Chaotic: a view emphasizing chaos or change in nature; e.g., "changing."

Sacred: a view emphasizing the sacredness of nature; e.g., "inexpressible - worshipped."

Subsequently, the categories were subjected to cross-tabulation, frequency analyses using the independent variables gender and science interest. Most importantly, the categories formed the basis for inferred presuppositions.

Subjects in the Study

The researchers used a self-reporting format for gathering information from 146 students at two colleges in the southwest. One was a private, liberal arts college, and the other a large state university. The students were registered in the researchers' courses in education, sociology, and psychology. The researchers initially assumed that roughly equal numbers of men and women would enroll in these courses. However, of the 146 students, the actual count was 112 women and 34 men. On one hand, this was not a problem. Given the exploratory nature of the study it was never the researchers' intention to generalize from the data. On the other hand, a larger sample of men may have yielded evidence of other presuppositions. The gender imbalance is to be redressed in future research.

To avoid stereotypic responses (i.e., "I'll tell them what I think they *want* to hear from a woman, not what I really think), the self-reporting of sex was cloaked in a group of demographic questions such as age. Interest in science was estimated by asking students to report two or three potential majors of high interest and two or three of low interest. The two questions were combined with a label of "1" for science being checked on the first list but not the second, "0.5" for science not being checked on either list, and "0" for science being checked on the second list but not the first. The students were thus divided into three groups, those with science interest, a non-committal group, and those with little or no science interest. This was a survey approach to science interest rather than a more formal testing for science interest. Since a more formal assessment of science interest was not required in the study, this approach was chosen for its ease of use and quickness. The interest of the students was about what one would expect. While 30% indicated an interest in at least one science subject, 53% listed at least one science subject as a least-likely major. The cross-tabular, frequency analyses are presented in Tables I to 7.

Description of Data

In the overall review of data, and the examination of the categories by gender and science interest, the researchers found a number of interesting features.

1. Even during the first review of the data one could not help but notice a profound interest in nature as expressed by the responses. The uninterpretable responses and those responses of only a word or two composed no more than 15% of the data set. The other 85% were expressive indicating that students had warmed to the topic, that nature was an important concern.

2. It was also quite clear that there were qualitatively different expressions of interest in nature. While 29% expressed their interest in nature by speaking of nature's aesthetic qualities for example, another 32% expressed their interest by condemning pollution and advocating preservation (see Table #1).

3. A third striking feature was that only 12% expressed their interest in nature by emphasizing knowledge and investigation of nature, the *Naturwissenschaft* category (see Table #1).

4. There was no indication in the data set of differences between the responses of men and women. As pointed out the disproportionately low number of men in the study precludes any generalizations. Nevertheless, it is interesting to note that there was not even a hint of distinct male and female response patterns (see Table #1).

5. Finally, the researchers noted that students who gave non-Naturwissenschaft responses were also less likely to list an area of science as a probable major. However, students who expressed an interest in a science major were no more likely to be found in the *Naturwissenschaft* category than those who expressed no interest in science majors (see Table #5).

Analysis

As stated earlier, this was an exploratory investigation seeking to identify potential presuppositions in that aspect of worldview having to do with nature. The researchers found in the data set a basis for six presuppositional vectors.

1. It was observed that the group of students who value the study of nature is divided between those who couch this value in an aesthetic or preservationist context, and those who offer no context. Thus the vector:

> Naturwissenschaft/Geistewissenschaft presupposes the importance of knowledge about nature, but on one hand the knowledge of the detached observer while on the other, experiential knowledge.

2. The researchers found many students to have a strong aesthetic view of nature. The opposite would be a nondescript view of nature. Thus:

> aesthetic/amorphous: a preferential understanding of nature as beauty and design or as nondescript matter.

3. For at least one student nature was a reflection of things transcendent or perhaps itself transcendent. The opposite presupposition would be that nature is strictly naturalistic. Thus:

> sacred/profane: a sense that nature is in someway special, transcendent, or a sense of nature as being ordinary.

4. The most frequent comments were that nature is polluted and in need of need protection or preservation. The opposing presupposition is that nature is a resource meant to be used. Thus:

> preservationist/exploitive: a sense that nature is basically something that one preserves and protects, or a sense that nature is a rich resource for humanity.

5. Some students commented on the changeableness of nature and appeared to have a weak sense of order in nature. Thus:

> chaotic/orderly: a sense that nature **is** fundamentally chaotic, or a sense of nature as orderly.

6. As pointed out above, the responses of 85% of the students gave evidence of a strong interest in nature. Thus:

> high view/low view: a sense that nature is important or a sense of relative unimportance.

In principal, these six vectors may be used to define that aspect of worldview relevant to nature, though one must remain alert for the possibility of other vectors. One can now conceptualize this aspect of an individual's worldview as a profile of vector magnitudes. Having identified these vectors, the subject of further research must of course be methods for constructing the profiles. Once the profiles are in hand, one may analyze for relationships with gender and science-related variables such as science interest.

Conclusion

What has been accomplished in this investigation is the identification of six presuppositional vectors concerning concepts of nature. Since these presuppositions were derived from student data there is more to recommend their use in future worldview studies than mere speculative presuppositions. This investigation has thus provided a framework for a partial worldview profile. The next research step is to develop methods for gathering data on students such that these profiles can actually be constructed.

Initially, the researchers felt that in the process of identifying presuppositions there would be a noticeable gender effect. Recognizing the limitations of the data pool, it was still rather surprising to see the level of similarity between men and women students. Less surprising, though of much interest, was the suggestion of some linkage between worldview factors and science interest. In the next research phase, the use of worldview profiles should allow one to address these, two issues with greater precision.

References

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). Women's ways of knowing: The development of self, voice, and mind. New York: Basic Books, Inc.

Cobern, W. W. (1989a). Distinguishing science-related variations in the causal universal of college students' worldviews. Paper presented at the annual meeting of the National Association for Research in Science Teaching ERIC # 304346.

Cobern, W. W. (1989b). Worldview Theory and Science Education Research: Fundamental Epistemological Structure as a Critical Factor in Science Learning and Attitude Development. Paper presented at the annual meeting of the National Association for Research in Science Teaching National Association for Research in Science Teaching.

Halpin, Z. T. (1989). Scientific objectivity and the concept of "The Other". Women's Studies International Forum, 12(3), 285-294.

Jones, W. T. (1972). World views: Their nature and their function. Current Anthropology, 13(1), 79-109.

Kearney, M. (1984). World view. Novato, CA: Chandler & Sharp Publishers, Inc.

Kilbourn, B. (1984). World Views and Science Teaching. In H. Munby, G. Orpwood, & T. Russel (editors), Seeing Curriculum in a New Light. Lanham, MD: University Press of America.

Patrick, J. J., & Remy, R. C. (1985). (Report No. 0-89994-298-9). Boulder, Colorado: Social Science Education Consortium, Inc.

Pepper, S. C. (1942). World hypotheses. Berkeley, CA: University of California Press.

Proper, H., Wideen, M. F., & Ivany, G. (1988). Worldview projected by science teachers: a study of classroom dialogue. Science Education, 72(5), 542-560.

Rejeski, D. W. (1982). Children look at nature: environmental perception and education. Journal of Environmental Education, 13(4), 27-40.

Rosser, S. V. (1989)Teaching techniques to attract women to science: applications of feminist theories and methodologies. Women's Studies International Forum, 12(3).

Thomas, G. E. (1986). Cultivating the interest of women and minorities in high school mathematics and science. Science Education, 79(1).

Vetter, B. M., & Babco, E. (1987). Professional women and minorities: A manpower data resource service. Washington, DC: Commission on Professionals in Science and Technology.

Whatley, M. H. (1989). A feeling for science: Female students and biology texts. Women's Studies International Forum, 12(3), 355-362.

Frequencies: Response Group by Gender

Table 1

Number Row % Column % Total %		F	M	Row Totals
		33	7	
Aesthetic	A	82.5	17.5	40
		30.8	21.9	28.8
		23.7	5.0	
		5	1	
Chaotic	C	83.3	16.7	6
		4.7	3.1	4.3
		3.6	0.7	
		17	1	
Geist-1	G	94.4	5.6	18
		15.9	3.1	12.9
		12.2	0.7	
		12	4	
Natur	N	75.0	25.0	16
		11.2	12.5	11.5
		8.6	2.9	
		8	6	
Not Inter	O	57.1	42.9	14
		7.5	18.8	10.1
		5.8	4.3	
		31	13	
Pollution/Preser	P	70.5	29.5	44
		29.0	40.6	31.7
		22.3	9.4	
		1	0	
Sacred	S	100.0	0.0	1
		0.9	0.0	0.7
		0.7	0.0	
Column Totals		107	32	139
		77.0	23.0	100.0

Frequencies: Response Groups by Science Interest

Table 2

Number Row % Column % Total %		none 0.0	some 0.5	interest 1.0	Row Totals
Aesthetic	A	22 56.4 30.1 15.9	7 17.9 29.2 5.1	10 25.6 24.4 7.2	39 28.3
Chaotic	C	5 83.3 6.8 3.6	1 16.7 4.2 0.7	0 0.0 0.0 0.0	6 4.3
Geist-1	G	7 38.9 9.6 5.1	4 22.2 16.7 2.9	7 38.9 17.1 5.1	18 13.0
Natur	N	8 50.0 11.0 5.8	1 6.3 4.2 0.7	7 43.8 17.1 5.1	16 11.6
Not Inter	O	7 50.0 9.6 5.1	3 21.4 12.5 2.2	4 28.6 9.8 2.9	14 10.1
Pollution/Preser	P	24 54.5 32.9 17.4	7 15.9 29.2 5.1	13 29.5 31.7 9.4	44 31.9
Sacred	S	0 0.0 0.0 0.0	1 100.0 4.2 0.7	0 0.0 0.0 0.0	1 0.7
Column Totals		73 52.9	24 17.4	41 29.7	138 100.0

Frequencies: Response Groups by Science Interest

Women Students Only

Table 3

	Number Row % Column % Total %	none - 0.0	some 0.5	intere st 1.0	Row Totals
Aesthetic	A	20 60.6 34.5 18.7	6 18.2 30.0 5.6	7 21.2 24.1 6.5	33 30.8
Chaotic	C	4 80.0 6.9 3.7	1 20.0 5.0 0.9	0 0.0 0.0 0.0	5 4.7
Geist-1	G	7 41.2 12.1 6.5	4 23.5 20.0 3.7	6 35.3 20.7 5.6	17 15.9
Natur	N	6 50.0 10.3 5.6	1 8.3 5.0 0.9	5 41.7 17.2 4.7	12 11.2
Not Inter	O	4 50.0 6.9 3.7	1 12.5 5.0 0.9	3 37.5 10.3 2.8	8 7.5
Pollution/Preser	P	17 54.8 29.3 15.9	6 19.4 30.0 5.6	8 25.8 27.6 7.5	31 29.0
Sacred	S	0 0.0 0.0 0.0	1 100.0 5.0 0.9	0 0.0 0.0 0.0	1 0.9
	Column Totals	58 54.2	20 18.7	29 27.1	107 100.0

Frequencies: Response Groups by Science Interest

Men Students Only

Table 4

Number Row % Column % Total %		none 0.0	some 0.5	interest 1.0	Row Totals
Aesthetic	A	2	1	3	
		33.3	16.7	50.0	6
		13.3	25.0	25.0	19.4
		6.5	3.2	9.7	
Chaotic	C	1	0	0	
		100.0	0.0	0.0	1
		6.7	0.0	0.0	3.2
		3.2	0.0	0.0	
Geist-1	G	0	0	1	
		0.0	0.0	100.0	1
		0.0	0.0	8.3	3.2
		0.0	0.0	3.2	
Natur	N	2	0	2	
		50.0	0.0	50.0	4
		13.3	0.0	16.7	12.9
		6.5	0.0	6.5	
Not Inter	O	3	2	1	
		50.0	33.3	16.7	6
		20.0	50.0	8.3	19.4
		9.7	6.5	3.2	
Pollution/Preser	P	7	1	5	
		53.8	7.7	38.5	13
		46.7	25.0	41.7	41.9
		22.6	3.2	16.1	
Column Totals		15	4	12	31
		48.4	12.9	38.7	100.0

Frequencies: Collapsed Groups by Science Interest

Table 5

	Number Row % Column % Total %	none 0.0	some 0.5	intere st 1.0	Row Totals
Non Nature	O	51 56.7 77.3 41.1	16 17.8 76.2 12.9	23 25.6 62.2 18.5	90 72.6
Natur	N	15 44.1 22.7 12.1	5 14.7 23.8 4.0	14 41.2 37.8 11.3	34 27.4
	Column Totals	66 53.2	21 16.9	37 29.8	124 100.0

Frequencies: Collapsed Groups by Science Interest

Women Students Only

Table 6

	Number Row % Column % Total %	none 0.0	some 0.5	intere st 1.0	Row Totals
Non Natur	0	41 58.6 75.9 41.4	14 20.0 73.7 14.1	15 21.4 57.7 15.2	70 70.7
Natur	N	13 44.8 24.1 13.1	5 17.2 26.3 5.1	11 37.9 42.3 11.1	29 29.3
	Column Totals	54 54.5	19 19.2	26 26.3	99 100.0

Frequencies: Collapsed Groups by Science Interest

Men Students Only

Table 7

	Number / Row % / Column % / Total %	none 0.0	Some 0.5	interest 1.0	Row Totals
Non Natur	O	10 50.0 83.3 40.0	2 10.0 100.0 8.0	8 40.0 72.7 32.0	20 80.0
Natur	N	2 40.0 16.7 8.0	0 0.0 0.0 0.0	3 60.0 27.3 12.0	5 20.0
	Column Totals	12 48.0	2 8.0	11 44.0	25 100.0