Proposed Scientific Inquiry Capabilities

Fundamental Scientific Knowledge
SIC #1: **USES COVARIATION AS A BASIS FOR INFERRING CAUSALITY**
SIC #2: **USES ABSENCE OF COVARIATION AS EVIDENCE OF NO RELATIONSHIP**
SIC #3: **VARIES FACTORS TO ESTABLISH THE PRESENCE OR NATURE OF A RELATIONSHIP**
SIC #4: **COORDINATES THEORY WITH EVIDENCE**

Theory Building
SIC #5: **GENERATES AND USES ANALOGIES IN CONCEPTUALIZING PHENOMENA**
SIC #6: **APPLIES PHYSICAL INTUITION**
SIC #7: **IDENTIFIES POTENTIAL CAUSAL FACTORS AND GENERATES VARIABLES TO REPRESENT FACTORS**
SIC #8: **FORMULATES COMPOSITE VARIABLES**
SIC #9: **REASONING CONCERNING EXTREME CASES**
SIC #10: **GOAL ORIENTED OBSERVATION**
SIC #11: **RECORDS OBSERVATIONS**
SIC #12: **CONSULTS RECORDED NOTES**
SIC #13: **INNOVATION CONCERNING TASK MATERIALS**

values concerning phenomena and the world
SIC #14: **SEARCHES FOR A NECESSARY UNDERLYING PRINCIPLE**

values concerning methods of approaching the world-
SIC #15: **SEARCHES FOR PARSIMONY**
SIC #16: **INTERNALLY CONSISTENT IN EXPLANATION**
SIC #17: **CONCERNED FOR ACCURACY OF LANGUAGE**
SIC #18: **CONCERNED WITH PRECISION OF MEASUREMENT**
SIC #19: **IDENTIFIES SOURCES OF ERROR IN TAKING MEASUREMENTS**
SIC #20: **USES TECHNIQUES FOR PRECISE MEASUREMENT**
SIC #21: **REACTION TO DISCONFIRMATION**
SIC #22: **CONCERNED FOR VERIFICATION**
SIC #23: **CONSIDERS RELATIVE VALUE OF EMPIRICAL EVIDENCE**

Theory Testing
SIC #24: **CONTROLS VARIABLES**
SIC #25: **MAKES UNSOLICITED PREDICTIONS**
SIC #26: **USES PREDICTIONS TO TEST HYPOTHESES**

Logical Mathematical Operations
SIC #27: **USES PROPORTIONAL REASONING**
SIC #28: **CLASSIFICATION**
SIC #29: **SERIATION**

Proposed Scientific Inquiry capability #1

INQUIRY CAPABILITY: **USES COVARIATION AS A BASIS FOR INFERRING CAUSALITY**

REFERENCES: DKuhnetal (1988, p. 37)

SCALE:

[0] DOES NOT INDICATE SENSITIVITY TO COVARIATION

[1] TREATS COVARIATION AS EVIDENCE FOR INFERRING A RELATIONSHIP BETWEEN VARIABLES

[2] TREATS COVARIATION AS SUFFICIENT EVIDENCE FOR INFERRING CAUSALITY

[3] TREATS COVARIATION AS NECESSARY BUT INSUFFICIENT EVIDENCE FOR INFERRING CAUSALITY

[4] MAKES A GENERAL STATEMENT THAT COVARIATION IS NECESSARY BUT INSUFFICIENT EVIDENCE FOR INFERRING CAUSALITY

EXPLANATIONS:

Proposed Scientific Inquiry capability #2

INQUIRY CAPABILITY: **USES ABSENCE OF COVARIATION AS EVIDENCE OF NO RELATIONSHIP**

REFERENCES: DKuhnetal (1988, p.37)

SCALE:

[0] GIVES NO INDICATION OF TREATING NON-COVARIATION AS EVIDENCE OF NO RELATIONSHIP BETWEEN VARIABLES

[1] TREATS NON-COVARIATION AS EVIDENCE OF NO RELATIONSHIP

[2] MAKES A GENERAL STATEMENT THAT NON-COVARIATION IS EVIDENCE OF NO RELATIONSHIP

EXPLANATIONS:

Proposed Scientific Inquiry capability # 3

INQUIRY CAPABILITY: **VARIES A FACTOR TO ESTABLISH THE PRESENCE OR NATURE OF A RELATIONSHIP**

SCALE:

[0] DOES NOT INTRODUCE VARIATION TO STUDY THE EFFECT OF A FACTOR ON THE PHENOMENON OF INTEREST

[1] VARIES A FACTOR IN ORDER TO STUDY ITS EFFECT ON THE PHENOMENON
(Creates at least two levels of observation of the factor)

[2] SYSTEMATICALLY VARIES A FACTOR IN ORDER TO STUDY THE NATURE OF THE RELATIONSHIP BETWEEN A FACTOR AND THE PHENOMENON
(e.g. studies effects of three or more levels of a factor or varies observations on a factor to test a predicted relationship)

EXPLANATIONS:

Proposed Scientific Inquiry capability # 4

INQUIRY CAPABILITY: **COORDINATES THEORY WITH EVIDENCE**

REFERENCES: DKuhnetal (1988, p.37)

SCALE:

[0] DOES NOT CLEARLY DISTINGUISH BETWEEN THEORY AND EVIDENCE
data is taken as an explanation in itself,
or data is taken as support of subject's theory irrespective of whether it is consistent with the theory

[1] EVIDENCE IS USED TO EVALUATE A THEORY OR A THEORY IS USED TO EVALUATE EVIDENCE

[2] EVIDENCE IS USED TO EVALUATE A THEORY AND A THEORY IS USED TO INTERPRET EVIDENCE

EXPLANATIONS:

Proposed Scientific Inquiry capability # 5

INQUIRY CAPABILITY: **GENERATES AND USES ANALOGIES IN CONCEPTUALIZING PHENOMENA**

REFERENCES: Clement (1988) `Observed methods for generating analogies'

SCALE:

[0] DOES NOT GENERATE OR USE ANALOGIES

[1] FORMS A NON-SIGNIFICANT ANALOGY WITH ONLY SURFACE SIMILARITY TO SOME ASPECT OF THE PHENOMENON

[2] GENERATES A NON-SIGNIFICANT ANALOGY WITH STRUCTURAL OR FUNCTIONAL SIMILARITY TO SOME ASPECT OF THE PHENOMENON

[3] GENERATES AND/OR APPLIES A SIGNIFICANT ANALOGY

[4] USES ANALOGY FORMATION AND APPLICATION AS PART OF AN INTENTIONAL TECHNIQUE FOR THEORY BUILDING
e.g. "Now what do I know that is like this?"

EXPLANATIONS:

DEFINITIONS:

Significant analogies -- part of serious attempt to generate or evaluate a solution

Non-significant analogies -- offered in passing and not applied to the problem

Surface similarities -- unrelated to the problem at hand (e.g. referring to floating and sinking cubes "These remind me of building blocks." [similarities may be perceptual, structural or functional]

Proposed Scientific Inquiry capability # 6

INQUIRY CAPABILITY: **APPLIES PHYSICAL INTUITION**

REFERENCES: Clement `Nonformal reasoning...'

SCALE:

[0] NO EVIDENCE OF PHYSICAL INTUITION BROUGHT TO BEAR ON THE TASK

[1] APPLIES A PHYSICAL INTUITION BROUGHT TO THE TASK

[2] MAKES A GENERAL STATEMENT CONCERNING THE ROLE OF PHYSICAL INTUITIONS IN SCIENTIFIC ENQUIRY

EXPLANATIONS:

A Physical intuition is a perceptual-motor schema used to represent some aspect of a phenomenon of interest. It is to be distinguished from verbal, logical, or mathematical representations. It is to be distinguished from an immediate sensory experience.

Proposed Scientific Inquiry capability # 7

INQUIRY CAPABILITY: **IDENTIFIES ONE OR MORE POTENTIAL FACTORS TO ACCOUNT FOR THE PHENOMENON**

REFERENCES: Inhelder and Piaget (1958)

SCALE:

[0] DOES NOT IDENTIFY FACTORS TO ACCOUNT FOR THE PHENOMENON

[1] IDENTIFIES ONE OR MORE POTENTIAL FACTORS

[2] EXPLICITLY USES THE TERMS `FACTOR/S' OR `VARIABLE/S'
e.g. "I think there are three **variables** operating here."

EXPLANATIONS:

Proposed Scientific Inquiry capability # 8

INQUIRY CAPABILITY: **FORMULATES COMPOSITE VARIABLES**

SCALE:

[0] DOES NOT PROPOSE COMPOSITE VARIABLES

[1] PROPOSES COMPOSITE VARIABLES

[2] SUGGESTS THE NATURE OF THE RELATIONSHIP BETWEEN COMPOSITE VARIABLES (e.g. a ratio)

[3] FORMULATES AND USES COMPOSITE VARIABLES

EXPLANATIONS:

Composite variable = A variable which is a function of two or more other variables.
Examples:
Density = mass/volume
Torque = mass * distance

see ERKE 17:00

Proposed Scientific Inquiry capability # 9

INQUIRY CAPABILITY: **REASONING CONCERNING EXTREME CASES**

REFERENCES: Clement (1988) `A method of limits' p. 575, second example.

SCALE:
[0] DOES NOT GIVE EVIDENCE OF REASONING CONCERNING EXTREME CASES

[1] GIVES EVIDENCE OF REASONING CONCERNING EXTREME CASES

[2] MAKES AN GENERAL STATEMENT CONCERNING THE METHOD OF LIMITS OR USE OF EXTREME CASES

EXPLANATIONS:

See Galileo in Giancolli

Proposed Scientific Inquiry capability #10

Inquiry capability: **GOAL ORIENTED OBSERVATION**

REFERENCES: Norris (1984, 1985), Norris & King (1984)
Clement (1989) `Learning via Model Construction &....' -- Three sources of hypotheses: induction, observation guided by goal orientation, analogies

SCALE:
[0] DOES NOT MAKE GOAL ORIENTED OBSERVATIONS

[1] MAKES GOAL ORIENTED OBSERVATIONS

[2] MAKES GENERAL STATEMENT CONCERNING THE ROLE OR IMPORTANCE OF GOAL ORIENTED OBSERVATION IN SCIENTIFIC ENQUIRY

EXPLANATIONS:
Goal Oriented Observations = Observations made to build or test a specific hypothesis, model or rule

Proposed Scientific Inquiry capability #11

Inquiry capability: **RECORDS OBSERVATIONS**

REFERENCES: Norris (1984, 1985), Norris & King (1984)

SCALE:
[0] DOES NOT RECORD OBSERVATIONS

[1] RECORDS OBSERVATIONS

[2] RECORDS OBSERVATIONS IN A SYSTEMATIC FASHION

Proposed Scientific Inquiry capability # 12

INQUIRY CAPABILITY: **CONSULTS RECORDED NOTES**

SCALE:

[0] DOES NOT RECORD OBSERVATIONS

[1] SPENDS LITTLE OR NO TIME CONSULTING NOTES ONCE THEY HAVE BEEN MADE

[2] CONSULTS NOTES TO RECALL FINDINGS

[3] REGULARLY CONSULTS NOTES AND/OR REFERS TO NOTES WHEN PRESENTING HYPOTHESES AND ARGUMENTS

EXPLANATIONS:

Proposed Scientific Inquiry capability # 13

INQUIRY CAPABILITY: **INNOVATION CONCERNING TASK MATERIALS** (organizes task materials in new ways in order to investigate the phenomenon, going beyond the procedures and set-up used by the guide)

SCALE:

[0] DOES NOT USE THE MATERIALS UNLESS INSTRUCTED TO BY THE GUIDE

[1] USES MATERIALS AS DEMONSTRATED BY THE GUIDE

[2] MAKES INNOVATIVE USE OF THE MATERIALS
e.g. rearranges the lab, asks for new materials or equipment, introduces a new procedure, alters the setup created by the guide

(ADD AN ADDITIONAL POINT EACH TIME AN ADDITIONAL INNOVATIVE ACTION IS OBSERVED AND NOTE THE INNOVATIVE ACTION IN YOUR DIARY)

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EXPLANATIONS:

INNOVATIVE USE OF THE MATERIALS = Using the materials in a way that is not immediately obvious or typical.

Proposed Scientific Inquiry capability # 14

INQUIRY CAPABILITY: **SEARCHES FOR A NECESSARY UNDERLYING PRINCIPLE**

REFERENCES: Clement (1989 p. 352) [explanatory model =~ search for underlying principle]
Inhelder and Piaget (1958, p. 13-15)

SCALE:

[0] GIVES NO INDICATION OF SEARCHING FOR AN UNDERLYING PRINCIPLE

[1] GIVES INDICATION OF SEARCHING FOR AN UNDERLYING PRINCIPLE

[2] APPLIES ONE OR MORE RULES OR FORMULAS TO THE DATA AT HAND IN AN ATTEMPT TO DISCOVER AN UNDERLYING PRINCIPLE

[3] MAKES AN GENERAL STATEMENT CONCERNING THE SEARCH FOR AN UNDERLYING PRINCIPLE

EXPLANATIONS:

SEARCHES FOR A NECESSARY UNDERLYING PRINCIPLE = Looks for a rule/formula/principle that is not a simple fact given by perception but which accounts for the collection of facts that constitute the phenomena under investigation

COMMENTS: **Individuals who do not seek for and apply underlying principles may be limited to compensations among existing items of information rather than an over-arching rule which subsumes the individual items.**

ANECDOTES:

... When Einstein was five years old, his father showed him a pocket compass. The little boy was deeply impressed by the mysterious behavior of the compass needle, which kept pointing in the same direction no matter which way the compass was turned. He later said he felt that "something deeply hidden had to be behind things."

World Book Encyclopedia (1989) Vol. 6

Proposed Scientific Inquiry capability # 15

INQUIRY CAPABILITY: **SEARCHES FOR PARSIMONY**

REFERENCES:

SCALE:

[0] NO EVIDENCE OF CONCERN FOR PARSIMONY

[1] SHOWS CONCERN FOR PARSIMONY

[2] MAKES A GENERAL STATEMENT CONCERNING THE VALUE OF PARSIMONY

EXPLANATIONS:
The search for parsimony is the attempt to obtain as simple an explanation as possible. Subjects who do not search for parsimony are often left with separate models and rules to account for different aspects of the phenomenon.

Proposed Scientific Inquiry capability # 16

INQUIRY CAPABILITY: **INTERNALLY CONSISTENT IN EXPLANATION**

SCALE:

[0] SHOWS NO CONCERN FOR INTERNAL CONSISTENCY IN EXPLANATIONS OF THE PHENOMENON

[1] MAKES EFFORTS TO CORRECT INTERNAL INCONSISTENCIES IN EXPLANATIONS OF THE PHENOMENON

[2] MONITORS EXPLANATIONS TO ASSURE THEIR INTERNAL CONSISTENCY

[3] MAKES GENERAL STATEMENT CONCERNING THE IMPORTANCE OF INTERNAL CONSISTENCY

EXPLANATIONS:

Proposed Scientific Inquiry capability # 17

INQUIRY CAPABILITY: **CONCERNED FOR ACCURACY OF LANGUAGE**

SCALE:

[0] DOES NOT SHOW CONCERN FOR ACCURACY OF LANGUAGE

[1] MAKES EFFORTS TO IMPROVE ACCURACY OF LANGUAGE

[2] MAKES ACCURACY OF LANGUAGE PART OF A GENERAL STRATEGY FOR THEORY BUILDING AND TESTING/MAKES EXPLICIT STATEMENT CONCERNING THE IMPORTANCE OF ACCURACY OF LANGUAGE AS PART OF A STRATEGY FOR SCIENTIFIC APPROACHES TO PHENOMENA

EXPLANATIONS:
Generates and uses unambiguous names for variables and relations.
Attempts to be precise and consistent in use of language.

Proposed Scientific Inquiry capability # 18

INQUIRY CAPABILITY: **CONCERNED WITH PRECISION OF MEASUREMENT**

SCALE:

[0] DOES NOT USE FORMAL MEASUREMENT

[1] USES FORMAL MEASUREMENT BUT DOES NOT EXPRESS CONCERN FOR PRECISION OF MEASUREMENT

[2] EXPRESSS CONCERN FOR PRECISION OF MEASUREMENT

[3] MAKES A GENERAL STATEMENT CONCERNING THE REASON FOR OR IMPORTANCE OF PRECISION IN MEASUREMENT

[4] SEARCHES FOR A LEVEL OF PRECISION APPROPRIATE TO THE TASK

EXPLANATIONS:

Formal Measurement -- Uses a measurement instrument

Proposed Scientific Inquiry capability # 19

INQUIRY CAPABILITY: **IDENTIFIES SOURCES OF ERROR IN TAKING MEASUREMENTS**

SCALE:

[0] DOES NOT RAISE THE ISSUE OF POSSIBLE SOURCES OF ERROR IN TAKING MEASUREMENTS

[1] RAISES THE ISSUE OF ERROR IN TAKING MEASUREMENTS

[2] SUGGESTS POSSIBLE SOURCES OF ERROR IN TAKING MEASUREMENTS

[2] IDENTIFIES REASONABLE SOURCES OF ERROR IN TAKING MEASUREMENTS

EXPLANATIONS:

Proposed Scientific Inquiry capability # 20

INQUIRY CAPABILITY: **USES TECHNIQUES FOR PRECISE MEASUREMENT**

SCALE:

[0] MAKES NO FORMAL MEASUREMENTS

[1] MAKES FORMAL MEASUREMENTS

[2] CHECKS MEASUREMENTS TO VERIFY THEM

[3] TAKES MULTIPLE MEASUREMENTS

[4] USES AN AVERAGE TO REPRESENT A COLLECTION OF MEASUREMENTS MADE ON THE SAME OBJECT

[5] USES MORE ADVANCED (UNUSUAL) TECHNIQUES FOR MAKING PRECISE MEASUREMENTS

EXPLANATIONS:

Formal Measurement -- Uses a measurement instrument

Proposed Scientific Inquiry capability # 21

INQUIRY CAPABILITY: **REACTION TO DISCONFIRMATION**

SCALE:

[0] NO INDICATION OF THEORY MODIFICATION BASED ON DISCONFIRMING EVIDENCE

[1] RECEIVES DISCONFIRMING EVIDENCE AND MODIFIES THEORY

[2] SEEKS DISCONFIRMING EVIDENCE AS PART OF STRATEGY OF BUILDING AND TESTING THEORY

[3] MAKES A GENERAL STATEMENT CONCERNING THE USE OF DISCONFIRMATION AS PART OF SCIENTIFIC ENQUIRY

EXPLANATIONS:

Disconfirming evidence in this item must be so in the eyes of the student

Proposed Scientific Inquiry capability # 22

INQUIRY CAPABILITY: **CONCERNED FOR VERIFICATION**

SCALE:

[0] GIVES NO INDICATION OF CONCERN FOR VERIFICATION

[1] SPONTANEOUSLY MAKES EFFORTS TO EMPIRICALLY VERIFY SOME ASPECT OF A THEORY

[2] MAKES A GENERAL STATEMENT ON THE IMPORTANCE OR REASON FOR VERIFICATION

EXPLANATIONS:

Proposed Scientific Inquiry capability # 23

INQUIRY CAPABILITY: **CONSIDERS RELATIVE VALUE OF EMPIRICAL EVIDENCE**

REFERENCES: Deanna Kuhn et al (1988, p.46)

SCALE:

[0] REASONING AND CONCLUSIONS BASED ON SOMETHING OTHER THAN IMMEDIATE EVIDENCE
ex.personal experience:`Every piece of wood I've ever seen floats.'}
authority:`My science teacher said that...'}

[1] REASONING AND CONCLUSIONS BASED ON IMMEDIATE EVIDENCE BUT OTHER THAN COVARIATION
ex.`The yellow things float.'

[2] REASONING AND CONCLUSIONS BASED ON IMMEDIATE EVIDENCE OF COVARIATION OR NON-COVARIATION
ex. `Weight has something to do with it.'

EXAMPLES:

Proposed Scientific Inquiry capability # 24

INQUIRY CAPABILITY: **CONTROLS VARIABLES**

REFERENCES: Inhelder & Piaget (1954, pp. 74-75)

SCALE:

[0] DOES NOT ATTEMPT TO CONTROL VARIABLES

[1] ATTEMPTS TO CONTROL VARIABLES BUT GIVES NO INDICATION OF THE NOTION OF KEEPING ALL OTHER THINGS EQUAL

[2] EXPRESSES THE NOTION OF CONTROLLING VARIABLES BUT IS UNABLE TO PUT IT INTO EFFECT

[3] KEEPS CERTAIN VARIABLES CONSTANT IN ORDER TO INVESTIGATE THE RELATIONSHIP BETWEEN OTHERS

[4] MAKES A GENERAL STATEMENT CONCERNING THE NEED TO KEEP ALL OTHER THINGS EQUAL WHEN CONTROLLING VARIABLES

EXPLANATIONS:

CONTROLLING VARIABLES = attempting to isolate the effect of one variable on the criterion (e.g. period of the pendulum) by holding constant the effects of other variables

Proposed Scientific Inquiry capability # 25

INQUIRY CAPABILITY: **MAKES UNSOLICITED PREDICTIONS**

SCALE:

[0] DOES NOT MAKE UNSOLICITED PREDICTIONS

[1] MAKES UNSOLICITED PREDICTIONS

[2] GENERATES TESTABLE UNSOLICITED PREDICTIONS

[3] MAKES A GENERAL STATEMENT CONCERNING THE VALUE OR REASON FOR TESTABLE PREDICTIONS IN SCIENTIFIC INVESTIGATION

EXPLANATIONS:

Proposed Scientific Inquiry capability #26

INQUIRY CAPABILITY: **USES PREDICTIONS TO TEST HYPOTHESES**

SCALE:

[0] DOES NOT TEST PREDICTIONS

[1] TESTS PREDICTIONS IN A TRIAL AND ERROR FASHION
ex. predictions are made and tested in the course of varying aspects of the phenomenon in order to see what will happen, rather than as tests of hypotheses, models or rules

[2] TESTS PREDICTIONS TO TEST CURRENT CONCEPTUALIZATION OF THE PHENOMENON

[3] MAKES A GENERAL STATEMENT CONCERNING THE ROLE OF PREDICTIONS IN TESTING ONES THEORY OR BELIEF

EXPLANATIONS:

Proposed Scientific Inquiry capability # 27

INQUIRY CAPABILITY: **USES PROPORTIONAL REASONING**

SCALE:
[0] GIVES NO EVIDENCE OF USING PROPORTIONAL REASONING

[1] ATTEMPTS PROPORTIONAL REASONING BUT IS NOT COMPLETELY SUCCESSFUL

[2] SUCCESSFULLY APPLIES PROPORTIONAL REASONING TO THE PROBLEM

[3] SUCCESSFULLY APPLIES PROPORTIONAL REASONING TO THE PROBLEM AND REFERS TO PROPORTIONS EXPLICITLY

EXPLANATIONS:
"A ratio is a comparison of two numbers by division." [General High School Mathematics (1978). Albany, NY: New York State Education Department.]
"ratio...the relation between two numbers or quantities expressed as a quotient." [The American Heritage Dictionary of Science (1986). Boston: Barnhart Books.]
"A proportion is the equality of two ratios." [General High School Mathematics (1978). Albany, NY: New York State Education Department.]
"proportion...the statement of equality between two ratios." [The American Heritage Dictionary of Science (1986). Boston: Barnhart Books.]
"proportional...having the same or constant ratio." [The American Heritage Dictionary of Science (1986). Boston: Barnhart.]

Proportional Reasoning = the application of proportionality to investigation between proposed or established factors of interest and the criterion variable.

Proposed Scientific Inquiry capability # 28

INQUIRY CAPABILITY: **CLASSIFICATION**

SCALE:

[0] DOES NOT ATTEMPT CLASSIFICATION OF OBJECTS OR OBSERVATIONS

[1] ATTEMPTS CLASSIFICATION OF OBJECTS OR OBSERVATIONS BUT IS NOT SUCCESSFUL IN ESTABLISHING MUTUALLY EXCLUSIVE CATEGORIES

[2] IS SUCCESSFUL IN CLASSIFYING OBJECTS OR OBSERVATIONS INTO MUTUALLY EXCLUSIVE CATEGORIES

[3] ATTEMPTS BUT DOES NOT SUCCEED IN ESTABLISHING INTERSECTIONS OF CLASSIFICATION SCHEMES WITH OTHER CLASSIFICATION OR SERIATION SCHEMES

[4] SUCCEEDS IN ESTABLISHING INTERSECTIONS OF CLASSIFICATION SCHEMES WITH OTHER CLASSIFICATION OR SERIATION SCHEMES

Proposed Scientific Inquiry capability # 29

INQUIRY CAPABILITY: **SERIATION**

SCALE:

[0] DOES NOT ATTEMPT SERIATION OF OBJECTS OR OBSERVATIONS

[1] ATTEMPTS SERIATION OF OBJECTS OR OBSERVATIONS BUT IS NOT SUCCESSFUL IN ESTABLISHING INVARIANT ORDER

[2] IS SUCCESSFUL IN SERIATING OBJECTS OR IN INVARIANT ORDER

[3] ATTEMPTS BUT DOES NOT SUCCEED IN ESTABLISHING INTERSECTIONS OF SERIATION SCHEMES WITH OTHER SERIATION OR CLASSIFICATION SCHEMES

[4] SUCCEEDS IN ESTABLISHING INTERSECTIONS OF SERIATION SCHEMES WITH OTHER SERIATION OR CLASSIFICATION SCHEMES