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ABSTRACT

Reported is a study on the measurement of concept attainment for the purpose of developing a measuring system and a model of attainment abilities and establishing relationships between learned concepts and cognitive abilities. Thirty concepts, ten for each of the biological, earth, and physical science areas, were selected from six fourth grade texts and analyzed in terms of the level to which concepts, attributes, and examples were identified. A 12-item test was constructed for each concept. Statistical results from concept and task attainments for boys and girls indicated the highest attainment level on biological concepts, the lowest level in physical science, and subtle differences in the performance of girls and boys. Results from a further simplex analysis of the task attainment scores supported the postulation of a concept attainment hierarchy. Children responded well on tasks dealing with gross perceptions rather than fine distinctions among examples and non-examples of a concept with the gross perception level preferred to the fine perception level. The attainment of a concept was a function of its association with the concrete world. Reexamination of science curriculum, instructional procedures, and children's cognitive abilities in terms of concept learning was recommended. (CC)

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ELEMENTARY SCHOOL CHILDREN'S LEVEL OF ATTAINMENT OF SELECTED CLASSIFICATORY SCIENCE CONCEPTS

by

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Introduction

The assessment of science concept learning continues to be a major research problem due to the lack of refined and agreed upon systems for measurement of concept attainment. This deficiency is of paramount concern in measuring classroom achievement. For example, what levels of concept mastery are attainable by children? Answers to such questions are pertinent to the establishment of curricular content and specification of reasonable learning expectations for school age children. In addition, there are implications for the management of instruction; i.e., whether instructional sequences are designed for individuals, small groups, or large groups. The lack of a system(s) for measurement of levels of concept attainment consistently inhibits progress in the study of science concept learning.

A second deterrent to the improvement of science concept learning is the absence of models of science concept learning. Such a deficiency continues to produce diffuse and diluted research efforts on curriculum and instruction on science concepts.

It is the purpose of this paper to report the progress made in a comprehensive study designed to measure the level of attainment of selected classificatory science concepts. Major goals are developing a system for measuring the level of science concept attainment, developing a model of concept attainment abilities, and studying the relationships among learned concepts and specific cognitive abilities.

Procedure

Test Construction

Master lists of classificatory concepts from the biological, earth, and physical science areas were prepared by analyzing the six fourth-grade science texts available to the teachers in the school system where the concept attainment tests were to be administered. Initially, ten concepts were randomly selected from each of the three lists and analyzed as follows:

1. Supraordinate, coordinate, and subordinate concepts were identified.
2. Criterial, other relevant, and irrelevant attributes were identified.
3. A definition was constructed.
4. Examples and non-examples were identified (Voelker, Sorenson, and Frayer 1971).

Concepts that could not be analyzed using this system were randomly replaced from the master lists until 30 concepts, 10 per area, had been analyzed. (Table 10)

A 12-item test was constructed for each concept. Each test included one item designed to measure performance of these tasks (Voelker & Sorenson, 1971).

1. Given name of attribute, select example of attribute.
2. Given example of attribute, select name of attribute.

3. Given name of concept, select example of concept.

4. Given name of concept, select non-example of concept.

5. Given example of concept, select name of concept.

6. Given name of concept, select relevant attribute.

7. Given name of concept, select irrelevant attribute.

8. Given meaning of concept, select name of concept.

9. Given name of concept select meaning of concept.

10. Given name of concept, select supraordinate concept.

11. Given name of concept, select subordinate concept.

12. Given two concepts, select principle relating them.

These tasks were part of a schema for testing the level of concept mastery (Frayer, Fredrick, & Klausmeier; 1969).*

Pilot Study

A pilot study was conducted to estimate the reliability of the tests and make item indices data available for use in revising the items. In addition, preliminary data were available for estimating the possibility of a hierarchy of concept attainment tasks.

A simplex analysis (Guttman, 1954) was run on 12 of the 30 concepts. The results indicated the existence of a general progression of difficulty which approximated the organization of the schema tasks used in constructing the concept attainment tests. (Table 1).

*Note that the tasks in this schema are typically used by teachers and researchers alike to measure the level of concept attainment. However, analysis of concept attainment studies reveals an absence of consistency in patterns of use. This lack of consistency raises serious questions about the source(s) of variance in test results.

Table 1

Simplex Analyses for Selected Arrangements of Task Attainment Scores*

	q^2
1. 5 4 3 2 1 7 8 9 10 11 6 12	.8239
2. 3 4 5, 1 2, 6 7, 8 9, 10 11, 12	.8133

*Mixed sample of boys and girls

Results

Factor Analyses

Conventional factor analyses were performed separately for the concepts and the tasks to gain some insight into the interrelationships among the variables of a single mode. The conventional analyses were obtained using three initial factor methods--Alpha (Kaiser & Caffrey, 1965), Harris R-S^2 (Harris, 1962), and Unrestricted Maximum Likelihood Factor Analysis (UMLFA) (Jöreskog, 1967). Tucker's three-mode factor analysis was then used to determine if there are any important concept-task interactions for the idealized persons (Tucker, 1966). (Tables 2-9)

The conventional factor results for the concepts yielded one or more orthogonal factors for the various methods. The concept variables are almost all of complexity two, three, and even greater on these factors, however. The obligue results tend to yield simple structure but the oblique factors are very highly correlated, thus, a main conclusion is that all 30 of the concepts are measures of a single functional relationship existing among the concepts; this holds for both boys and girls.

As with the concepts, the most reasonable interpretation for the tasks is that all 12 of the tasks are measures of a single underlying ability or latent trait. The intercorrelations of the oblique factors are extremely high when more than one factor is yielded.

The results for the three-mode factor analyses support the hypothesis that there are no important concept-task interactions for the idealized persons. Thus, it is reasonable to regard these two modes as being independent.

<u>Concept Attainment</u>

It should be noted that the concern in this analysis is for general patterns and trends rather than a comparison based on statistical inference. This is a function of the evolutionary design of the study.

The means, standard deviations, and estimates of test reliability for the 30 concept attainment tests are presented in Table 10. The results indicate the highest level of attainment on the biological science concepts and the lowest level of attainment on the physical science concepts for both the boys and the girls. These results are not unexpected in terms of the age and development of the children involved and the normal range of school and non-school experiences children have with these concepts.

It is of note that the girls achieved higher mean scores than boys on 25 of the 30 concepts. This general pattern of higher achievement for girls was also evident in each of the three subareas. The least and the most difficult concepts for both boys and girls were identical. The highest scores were earned for mammal and fish, and the lowest scores earned were for invertebrate, cell, molecule, and conductor. The "easier" concepts were both from the biological science area but the most difficult concepts come from both the physical science and the biological science areas.

Those concepts which were easier for the children are associated with common experience, are relatively easy to provide instructional sequences for, and lend themselves to illustration with concrete examples and non-examples. In addition, they are associated with living things which are of major interest to children in the elementary school.

Difficult concepts coming from both the biological and the physical science areas is revealing. The particular concepts can be applied in a classificatory sense but it is not easy to develop instructional sequences to teach them in a classificatory sense. Each of the four concepts are abstractions from derived data rather than perceptual data which could partially explain the lower level of attainment.

Nine of the ten concepts on which the highest science area scores were earned were the same for boys and girls, five from the biological science area and three from the earth science area. Eight of the ten concepts on which the lowest scores were earned were identical for both boys and girls, four from the physical science area and three from the biological science area.

The comments in this and the previous paragraphs indicate that differences in the performance of girls and boys on the attainment of these and possibly other classificatory concepts are apt to be subtle.

The biological science concepts divide themselves into those which are readily learned and those which are not, apparently a function of the degree of abstraction or connection with perceptual and firsthand experience. Generally, low scores were attained on the physical science concepts while scores earned on the earth science concepts are more intermediate, possibly because most are associated with direct perceptual experience.

The results suggest that the nature of these concepts is such that they cannot be readily classified by area or within area and that the level of attainment of a concept is a function of its association with the concrete world. This is not a startling finding. Rather it lends credibility to postulations of Piaget and others who study the psychological development of the child and his ability to form concepts and classes of concepts.

Task Attainment

Means, standard deviations, and estimates of test reliabilities for the 12 concept attainment tasks are found in Table 11. The girls achieved higher levels of concept attainment on all 12 tasks. No estimate of the existence of a significant difference is made but it is noteworthy that the pattern holds across all 12 tasks.

A simplex analysis was run on the task attainment scores (Table 12). These results indicate a similar pattern of attainment on the tasks for boys and girls, the correlation between the orderings being .879. If the girls do have an edge, it appears to be marginal.

Table 12

Simplex Analysis for Task Attainment Scores
Boys and Girls*

													q^2
Boys	4	3	5	1	2	10	8	11	9	6	7	12	.9129
Girls	4	3	5	2	1	8	10	9	11	6	12	7	.8948

*Correlation between boys and girls ordering = .879

The results of the simplex analysis lend support to the postulation of a concept attainment hierarchy. While the tasks are not in the same order as listed in the procedure (p. 2), there is a pattern which approximates that postulation. A notable exception is that questions dealing with examples and non-examples rank lower than questions dealing with attributes. Questions dealing with relevant and irrelevant attributes. of concepts are at a higher level than initially postulated. Scholars in the discipline and/or learning theorists may deem it necessary to be able to identify specific attributes of concepts that can be classified and applied but children are not behaving as predicted. They appear to deal more with gross perceptions of concept examples and non-examples than with subtleties of attributes and their relative distinctions and groupings.

Further examination of the concept attainment tasks shows the same pattern of response between boys and girls on example and non-example questions but there is a reversal in the results when they are asked to select examples of attributes rather than select names of attributes.

There are also shifts between questions related to definitions of concepts and supraordinate and subordinate concepts. This pattern seems to be a reflection of whether there is an attempt to relate the concept to something more inclusive such as a supraordinate concept or to relate it to something less comprehensive such as a subordinate concept. These results are not readily explained and deserve further analysis. Another shift from the posed hierarchy was in the identification of relevant and irrelevant attributes and relationships between concepts. The fact that these occur at the "highest" level of attainment tends to indicate that the tasks represent subtle ability to distinguish properties of objects and materials, skill in the higher levels of concept formation approaching problem-solving.

Discussion

The fact that the reported results are part of a continuing study leads to discussion of "things to ponder" rather than attempting to draw firm conclusions. Findings give rise to many pertinent questions about the nature of children's learning, from the standpoint of the child's psychological development as well as conditions of school learning. Such questions relate to the effects of teaching behaviors on children's learning styles and the attainment of selected levels of concept attainment, and the compatibility or incompatibility of the structure of a discipline with child development.

Little is to be said about the general level of concept attainment nor that by area. The results confirm that the biological science concepts found in the elementary school science curriculum are easier to learn than the physical science concepts. Examination of the 30 included concepts suggests that "easier" is apt to be a function of the extent of concrete experience the children can be provided in their school learning environment and their experience with the natural environment; also the ease of the developing instructional sequences. Past research has indicated that children's interests influence what they learn. Children are far more interested in tangibles than ideas (concepts) derived from secondary data and abstractions.

The results shed some light on the inclusion of certain concepts in the elementary school science curriculum. More biological science concepts would be appropriate for inclusion because the children did so well on those included and the fact that such concepts lend themselves more often to hands-on, concrete experiences. At the lower levels of the science curriculum a larger proportion of biological science concepts might be appropriate.

The fact that the earth science concepts do not align themselves one way or the other in terms of difficulty indicate a neutral stance. Thus, it might be justifiable to postulate that the "second line" of concepts for the elementary school curriculum would be from the earth science area. And last, because of the relative proportion of abstraction, concepts from the physical sciences might be relegated to the upper level of the elementary school curriculum.

Possibly, there is need of a new approach to science curriculum development that would graduate concept inclusion from biological to earth to physical science to parallel children's development of concrete to abstract. This postulation cannot be taken as an absolute but there is a similarity between the concepts in the three subareas and the psychological development of the child. The results of this study indicate that the curricular content should be based on what children can learn, not only the structure of the discipline. And if a spiral approach to curriculum development is used then data are needed on the initial point of inclusion of particular concepts. We should question whether the revolving topical organization of curriculum is appropriate when we include concepts from all three areas at the same level. Concepts are developmental. Children develop <u>their</u> concepts over time.

Other questions are in reference to the concept attainment tasks and their groupings. Children responded well on those concept learning tasks which deal with gross perceptions rather than fine distinctions between and among examples and non-examples of the concept. The ability to identify attributes of a concept appears to be more difficult than being able to distinguish between examples and non-examples of a concept. Also concept attainment tasks dealing with definitions and relationships between and among concepts are easier for the children than distinguishing between relevant and irrelevant attributes. This further substantiates that children are more able to deal with gross perceptions than fine distinctions. This is probably a funct..on of the child's development but one would suspect that it is also a function of the nature of the teaching act. Particularly, in terms of the ways in which instructional materials and instructional sequences are designed. Are we trying to <u>force</u> the "impossible" on the child or if the child has not established a learning pattern, are our teaching behaviors favoring a particular set? Research (Siegel and Siegel,1965) indicates that young children early adopt a posture of being either fact learners or concept learners. It is highly probable that our teaching behaviors control children's patterns of concept learning which in the long run could restrict the child's capabilities in concept acquisition.

There is some indication that selecting names of concepts when given attributes is more difficult than identifying concept attributes when given the concept name. The notable factor is the reversal in results between the girls and the boys. Also, it is possible that concepts are taught by example and non-example rather than attempting to teaching them by attribute identification and discrimination. Much research has been conducted on the manipulation of attributes of concepts in presentation of concept example and non-examples but children may be receiving the wrong message. They may be ignoring the fact that the examples and non-examples illustrate various combinations of attribute presence or absence and rather, are distinguishing between the example and the non-example at the gross level, totally missing the developer's intended message.

One also suspects that children's classification abilities are poorly developed in the elementary school, possibly because of teaching sequences but also because of an inability to comprehend. classification, a skill that "defies training", one that must develop over time. The research would tend to indicate that children in the elementary school operate at the gross perception level than the fine perception level.

Further examination of the hierarchy indicates other differential abilities. Selecting names of concepts appears to be "easier" than selecting the meaning of the concept when given the name. But do we teach the opposite? Also, it appears easier for children to identify subordinate concepts than supraordinate concepts. Is this because it is difficult for children to relate pieces to the whole or because there is no attempt at relating parts to wholes in our instructional programs? Is this a reflection that our teaching moves from definitions or highs to lows which in fact creates a learning climate which works against us when we attempt synthesis?

One further observation is the tendency for children to succeed when working from the positive rather than the negative. This could be a function of child development but there is also a suspicion that the behavior is enhanced or inhibited by the nature of teaching.

The previous discussion has raised more questions than it has formulated conclusive generalizations. However, this is consistent with the stage of evolution of the study. The results are not startling but they do indicate that children learn better those things closely related to observable phenomena. Our apriori classification of concepts as easy or difficult or as classificatory or theoretical may be too stringent. As far as children are concerned there are aspects of the same concept which fall in both the classificatory and theoretical realm. This study deals with "learned" concepts. Do our assessments of concept attainment measure a combination of factors including teaching behaviors, organization of instructional strategies, and the learning development of the child? Are we actually measuring learning pattern, response to teaching behaviors, or is it more probable that we are measuring combinations where the interactions are so subtle that our research is really dealing with questions too large and gross?

The results also indicate that children may have difficulty in identifying the properties of objects and things. Their classifying behavior is relatively poor. This could, of course, reflect an inability to do this as a function of many factors, but it could also be a reflection of poor preparation in this area. An examination of instructional materials would reveal an assumption that children can classify solely because they can distinguish between apples and oranges. These results imply that the ability to classify is apt to be more a function of the ability to identify attributes of concepts and distinguish between and among relevant and irrelevant attributes, singly and in combination. In terms of design of instructional materials and children's ability to classify, we are probably expecting too much of the elementary school child in classifying and applying classification skills to concept learning.

The results of the study lend credibility to the postulation of a hierarchy of concept learning tasks. This has major implications for the selection of curricular content and the design of instructional sequences.

Last but no least, these data lend credibility to two contentions. One, touted by Raven (1968a,b, 1970) for some time, is the lack of compatibility between the structure of the discipline and psychological development of the child. Children do not think like adults and cannot rediscover what scientists have. Therefore we need a careful examination of the nature of science curriculum and instructional procedures. And as Norvel Scott (1970) has indicated we have totally inadequate information on children's cognitive abilities and their connections to science concept learning.

Table 2

Numbers of Initial and Derived Factors for Concept Scores: Boys and Girls

Factor Method	Initial Factors		Derived Orthogonal Factors						Derived Oblique Factors					
			Common		Specific		Null		Common		Specific		Null	
	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Alpha	1	1	1	1	0	0	0	0	1	1	0	0	0	0
Harris R-S[2]	17	17	8	7	1	2	8	8	8	7	0	0	0	0
UMLFA	2	3	2	3	0	0	0	0	2	3	0	0	0	0

Table 3

Numbers of Initial and Derived Factors for Task Scores: Boys and Girls

Factor Method	Initial Factors		Derived Orthogonal Factors						Derived Oblique Factors					
			Common		Specific		Null		Common		Specific		Null	
	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Alpha	1	1	1	1	0	0	0	0	1	1	0	0	0	0
Harris R-S[2]	5	4	2	2	0	1	3	1	2	2	0	0	0	0
UMLFA	3	3	3	3	0	0	0	0	3	3	0	0	0	0

TABLE 4

Oblique Common Factor Results for Science Concepts: Boys*

	Alpha	Harris R-S²								UMLFA	
Concept	A-1	H-1	H-2	H-3	H-4	H-5	H-6	H-7	H-8	U-1	U-2
Area: Biological Science											
1 Bird	77	93								63	
2 Cell	74			65							97
3 Fish	82	46	50			-34				131	-47
4 Heart	84		42							54	32
5 Invertebrate	73							75		60	
6 Lens	77	-36	109								73
7 Lungs	86	63								94	
8 Mammal	77	37							62	96	
9 Muscle	82		47		56						58
10 Pore	83	43			41					45	40
Area: Earth Science											
11 Cloud	86	31							33	33	54
12 Core	80				99					60	
13 Fossil	83	52					64			99	
14 Glacier	81	115	-32							92	
15 Meteor	80						96				72
16 Moon	81	33									77
17 Planet	83									37	47
18 Sedimentary Rock	75		45	31						39	36
19 Volcano	84	50	75							74	
20 Wind	84	72			32					80	
Area: Physical Science											
21 Conductor	71			67						-33	105
22 Evaporation	83										98
23 Expansion	82								83		95
24 Friction	76	-54						37	57		64
25 Liquid	77								108		53
26 Melting	81										52
27 Molecule	74					60				-40	115
28 Solid	83	67							65	49	35
29 Sound	81						73			34	48
30 Thermometer	81		63		31			-35	39	66	
Intercorrelations of factors 2		93								95	
3		81	84								
4		91	91	79							
5		75	79	78	75						
6		91	92	82	90	79					
7		86	88	76	87	68	84				
8		95	93	86	92	80	92	87			

* Includes those variables which have coefficients greater than .30 (absolute). Decimals have been omitted.

TABLE 5

Oblique Common Factor Results for Science Concepts: Girls*

	Alpha	Harris R-S²							UMLFA		
Concept	A-1	H-1	H-2	H-3	H-4	H-5	H-6	H-7	U-1	U-2	U-3
Area: Biological Science											
1 Bird	68			109							84
2 Cell	65		82							86	
3 Fish	78			52				40	75	-43	49
4 Heart	78							96	74		
5 Invertebrate	67					51					
6 Lens	64	97							79		
7 Lungs	84	32						62	116		
8 Mammal	76	40		66					44		58
9 Muscle	72		37			33			33	62	
10 Pore	80				50	39			74		
Area: Earth Science											
11 Cloud	80					39	41	-32		39	
12 Core	74	50							75		
13 Fossil	80			70							85
14 Glacier	76					35			63		
15 Meteor	78		50							76	
16 Moon	80		41		37					98	
17 Planet	81				52				37	56	
18 Sedimentary Rock	69	87							90		
19 Volcano	76								38		
20 Wind	78							53	100		
Area: Physical Science											
21 Conductor	66		32							90	
22 Evaporation	81				38	31				73	
23 Expansion	79				81					52	
24 Friction	73				107					74	
25 Liquid	80				38				41	32	
26 Melting	78						91			39	
27 Molecule	65					100			35	33	
28 Solid	79						63		37		
29 Sound	80	-40		58			56				97
30 Thermometer	70						76		40		

Intercorrelations of factors								
2	80						93	
3	89	82					92	91
4	90	85	90					
5	90	84	89	91				
6	92	83	92	93	91			
7	92	80	90	87	90	90		

* Includes those variables which have coefficients greater than .30 (absolute). Decimals have been omitted.

TABLE 6

Oblique Common Factor Results for Science Tasks: Boys*

	Task	Alpha A-1	Harris R-S² H-1	Harris R-S² H-2	UMLFA U-1	UMLFA U-2	UMLFA U-3
1	Given name of attribute, select example.	89	79		120		
2	Given example of attribute, select name.	92	72		69		
3	Given name of concept, select example.	83	112		46	54	
4	Given name of concept, select nonexample.	79	74		39		
5	Given example of concept, select name.	90	97			116	
6	Given concept, select relevant attribute.	91		102			105
7	Given concept, select irrelevant attribute.	87		98			93
8	Given definition of concept, select name.	93		75			78
9	Given name of concept, select definition.	92		99			105
10	Given concept, select supraordinate concept.	93	34	60			61
11	Given concept, select subordinate concept.	91		77			76
12	Given two concepts, select relationship.	86		106			108
Intercorrelations of factors:	2		91		91		
	3				93	87	

* Includes those variables which have coefficients greater than .30 (absolute). Decimals have been omitted.

TABLE 7

Oblique Common Factor Results for Science Tasks: Girls*

	Task	Alpha A-1	Harris R-S² H-1	Harris R-S² H-2	UMLFA U-1	UMLFA U-2	UMLFA U-3
1	Given name of attribute, select example.	88	35	51	102		
2	Given example of attribute, select name.	89	63		101		
3	Given name of concept, select example.	86	85		37	53	
4	Given name of concept, select nonexample.	77	103			96	
5	Given example of concept, select name.	86	84		52	44	
6	Given concept, select relevant attribute.	89		99			79
7	Given concept, select irrelevant attribute.	83		106			90
8	Given definition of concept, select name.	91		82	49		56
9	Given name of concept, select definition.	93		87			87
10	Given concept, select supraordinate concept.	92		78			80
11	Given concept, select subordinate concept.	88		81			94
12	Given two concepts, select relationship.	86		96			107
Intercorrelations of factors:	2		91		90		
	3				94	83	

* Includes those variables which have coefficients greater than .30 (absolute). Decimals have been omitted.

TABLE 8

Three-Mode Core Results: Boys

Type I

Idealized Persons	Task* Components	Concept Components: Area 1	Area 2	Area 3
1	1	1.79	1.74	1.79
	2	.75	.63	.73
	3	1.95	2.00	1.87
2	1	.43	.61	.20
	2	.12	.28	.29
	3	-.43	-.39	-.56

Type II

Idealized Persons	Task* Components	Concept Components: 1	2	3	4	5	6	7	8
1	1	1.29	1.20	1.37	.81	.85	1.21	.72	1.10
	2	1.17	1.14	1.05	.77	.60	1.12	.55	.87
	3	1.70	1.70	1.62	.96	1.03	1.73	.97	1.44
2	1	.28	-.09	.18	.17	-.30	.65	.03	.08
	2	.71	.35	.07	-.16	.00	.76	.20	.09
	3	-.25	-.39	-.37	-.25	-.38	-.35	-.14	-.29
3	1	-.20	-.23	-.14	.62	-.27	.05	-.56	.02
	2	-.04	-.20	.45	-.45	.13	.28	-.32	.07
	3	-.01	.07	.31	-.05	.18	-.06	-.13	.13
4	1	-.23	.76	.29	.06	-.04	.02	-.04	-.15
	2	-.11	-.23	.09	.26	.24	.26	-.12	-.49
	3	-.09	.01	-.16	.05	.01	-.04	.12	-.31
5	1	.06	-.04	-.07	.24	.17	.09	.16	-.36
	2	-.08	.21	-.54	-.25	.12	.27	-.45	-.49
	3	.11	.12	-.03	-.10	.05	.22	.04	.06
6	1	-.41	-.13	-.04	-.01	.28	.27	.28	.05
	2	-.11	.05	.01	-.10	.51	-.15	-.08	.04
	3	-.12	-.03	.06	.01	.20	-.14	-.08	.04

* Variables comprising task components:

Type I:
1 - Tasks 1-3, and 5
2 - Task 4
3 - Tasks 6 - 12

Type II:
1 - Tasks 1, 2, and 4
2 - Tasks 3 and 5
3 - Tasks 6 - 12

TABLE 9

Three-Mode Core Results: Girls

Type I

Idealized Persons	Task* Components	Concept Components: Area 1	Area 2	Area 3
1	1	1.00	1.00	1.03
	2	.73	.58	.81
	3	2.31	2.34	2.21
2	1	-.43	-.18	-.28
	2	-.40	-.62	-.38
	3	.13	.18	.52

Type II

Idealized Persons	Task* Components	Concept Components: 1	2	3	4	5	6	7
1	1	2.17	.81	1.32	.27	.35	.84	1.08
	2	1.46	.60	.87	.21	.16	.31	.83
	3	2.32	1.17	1.87	.63	.43	1.06	1.61
2	1	.51	-.15	.27	.56	-.21	-.17	.22
	2	.47	.02	.51	-.19	-.25	-.34	.59
	3	-.56	-.45	-.15	-.14	-.27	-.37	-.19
3	1	.10	.61	-.20	-.04	.07	-.01	.30
	2	-.02	-.52	-.37	.22	.30	-.25	.44
	3	-.13	-.01	-.03	.01	.17	-.06	-.01
4	1	-.15	-.08	-.08	.10	.19	.11	.12
	2	-.06	.54	.10	.07	.45	-.31	.17
	3	-.11	.01	-.05	-.11	.07	.14	.01

* Variables comprising task components:

Type I: 1 - Tasks 3 and 5
Task 4
Tasks 6 - 12

Type II: 1 - Tasks 1, 2, and 5
2 - Tasks 3 and 4
3 - Tasks 6 - 12

Table 10

Means, Standard Deviations, and Reliabilities for Tests of Concept Attainment--Science

Concept	Mean		Standard Deviation		Hoyt Reliability	
	Boys	Girls	Boys	Girls	Boys	Girls
1. Bird	8.88	9.43	2.20	1.88	.62	.55
2. Cell	7.33	7.29	2.50	2.28	.61	.54
3. Fish	9.42	10.08	2.30	1.86	.71	.65
4. Heart (Human)	8.79	9.36	2.63	2.39	.74	.72
5. Invertebrate	7.40	7.42	2.79	2.63	.73	.69
6. Lens (Eye)	7.87	8.08	2.47	2.19	.68	.60
7. Lungs	8.95	9.45	2.82	2.61	.79	.78
8. Mammal	9.61	10.44	2.48	2.11	.76	.76
9. Muscle	8.07	7.99	2.52	2.69	.67	.70
10. Pore (Skin)	8.26	8.85	2.68	2.73	.72	.77
11. Cloud	8.22	8.67	2.58	2.03	.72	.58
12. Core (Earth)	8.68	8.99	2.66	2.22	.75	.66
13. Fossil	8.81	9.36	2.46	2.08	.70	.62
14. Glacier	8.32	8.69	2.48	2.41	.66	.67
15. Meteor	7.65	7.67	2.76	2.43	.72	.64
16. Moon	8.57	8.34	2.76	2.85	.76	.78
17. Planet	8.32	8.67	2.43	2.36	.60	.68
18. Sedimentary Rock	7.91	8.75	2.68	2.50	.71	.72
19. Volcano	8.78	9.27	2.33	2.08	.65	.60
20. Wind	8.76	9.56	2.56	2.19	.71	.67
21. Conductor	6.62	6.04	2.73	2.60	.68	.66
22. Evaporation	7.99	8.29	2.71	2.53	.71	.67
23. Expansion	7.51	7.80	2.74	2.77	.71	.73
24. Friction	7.69	7.49	2.35	2.16	.62	.52
25. Liquid	8.89	9.22	2.35	2.29	.67	.68
26. Melting	7.75	8.37	2.40	2.16	.65	.62
27. Molecule	6.62	6.99	2.43	2.33	.60	.56
28. Solid	8.58	9.56	2.76	2.21	.77	.69
29. Sound	8.16	8.54	2.49	2.27	.69	.66
30. Thermometer	8.34	8.68	2.54	2.07	.71	.57

Table 11

Means, Standard Deviations, and Reliabilities

for Tests of Task Attainment--Science

Task Number *	Mean		Standard Deviation		Hoyt Reliability	
	Boys	Girls	Boys	Girls	Boys	Girls
1	23.17	24.54	5.14	4.51	.84	.83
2	22.22	23.44	5.74	4.80	.87	.84
3	23.50	24.11	4.46	3.60	.80	.72
4	23.34	23.65	4.20	3.38	.76	.66
5	22.95	23.57	5.36	4.30	.85	.78
6	18.76	20.18	6.10	5.61	.85	.83
7	16.76	18.05	6.30	5.74	.85	.83
8	20.17	21.37	6.81	5.76	.89	.85
9	19.06	20.26	6.48	5.99	.87	.86
10	20.67	21.04	6.50	5.94	.88	.87
11	18.82	19.49	5.66	4.81	.83	.77
12	17.32	17.63	5.90	5.52	.83	.81

*
1. Given name of attribute, select example of attribute.
2. Given example of attribute, select name of attribute.
3. Given name of concept, select example of concept.
4. Given name of concept, select non-example of concept.
5. Given example of concept, select name of concept.
6. Given name of concept, select relevant attribute.
7. Given name of concept, select irrelevant attribute.
8. Given meaning of concept, select name of concept.
9. Given name of concept, select meaning of concept.
10. Given name of concept, select supraordinate concept.
11. Given name of concept, select subordinate concept.
12. Given two concepts, select principle relating them.

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