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ABSTRACT

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A Technique for Measuring the Expected Amount of Mental Work Delivered by College Professors in the Classroom[1]

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Abstract

A set of scale values representing the expected number of Structure-of-Intellect cells (mental work) delivered by college-level psychology teachers in the classroom, on each of eight jobs, was developed from magnitude estimations of psychology teachers and students from the U.S.A. and Germany.

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A Technique for Measuring the Expected Amount of Mental Work Delivered by College Professors in the Classroom

Purpose

The purpose of the study here reported was to relate the intellective structure of the psychology professor's classroom teaching job to his probability of effective teaching performance in order to develop a scale of teaching effectiveness based on the expected number of Structure-of-Intellect cells delivered by teachers in the classroom (expected mental work). It was hoped that the definition of mental work developed by Pfeiffer (1970) could be thereby redefined as an expectation and applied toward the development of posttraining performance evaluation schedules for assessing classroom teaching performance. The measure here proposed introduces a weighting scheme for jobs of varying intellectual complexity.

Method

The scale values representing the intellective structure of the teaching job were taken from Pfeiffer (1970) and the probability of effective teaching performance data were taken from Pfeiffer, Lehmann and Scheidt (1970). In the present study corresponding elements from these two data sets were multiplicatively combined to yield a scale of the expected amount of mental work delivered by teachers in the classroom.

Stimuli

Four sets of stimuli were required to complete the present study.

One set of stimuli, representing the 120 cells of the Structure-of-Intellect model and associated definitions, was taken from Guilford (1967).* The second set of stimuli consisted of the following eight teaching performance factors (Pfeiffer & Rosbach, 1969): knowledge dissemination (KD), information dissemination (ID), advisory guidance (AG), teacher-student feedback (TSF), teacher dynamism (TD), control of student behavior (CSB), environmental regulation (ER), and classroom administration (CA).* The third set of stimuli consisted of eight German university-level teachers of psychology whose classroom teaching effectiveness was rated by their students on each of the eight teaching performance factors. Similarily, the last set of stimuli consisted of eight American college-level teachers of psychology whose effectiveness was rated by their students.

Subjects

Three American and three German groups of Ss from an American and a German psychology department served as raters.

Americans. One of the rater groups consisted of 17 third and fourth year undergraduate psychology students from a city college in the Delaware Valley. These Ss made separate performance effectiveness estimations on each of eight teachers in their department. A second group of six fourth year psychology students served as controlls by making these same estimations on the same teachers by a slightly different procedure. A third group of eight students, taken from the group of 17, made estimations of the number of Structure-of-Intellect cells at least moderately involved in executing each of the eight teaching jobs.

* Appendices A and B

Germans. Fourteen German university-level teachers of psychology at a medium-sized university in the Ruhr Area made estimations of the number of Structure-of-Intellect cells in the same manner as the American students. Similarily 14 third, fourth and fifth year Vordiplom psychology students from the same department also made these estimations. A separate group of 17 German psychology students from the same department and with essentially the same level of training as the other group of German students made teaching performance effectiveness estimations for eight of their psychology teachers in the same manner as the group of 17 American students.

Development of Job Performance Measures

Intellective complexity of eight teaching tasks. These scale values (taken from Pfeiffer, 1970) were based on the equally weighted magnitude estimations of the three samples of teachers and students of the number of Structure-of-Intellect cells at least moderately involved in executing each of the eight classroom teaching jobs.

Teaching performance effectiveness. These data (taken from Pfeiffer, Lehmann and Scheidt, 1970) were based on the effectiveness the teachers achieved on each of eight jobs in their main subjects during one semester as estimated by their students on a 0 to 100% scale. A constraint was introduced in that the effective (e) plus ineffective (i) estimations of performance had to equal 100 for each teaching performance factor. The teaching performance effectiveness measure was then defined by summing across Ss judgments as follows: $Pe = \Sigma e / \Sigma(e+i)$. Pe was then accepted as a probability value. However, the acceptance of Pe as a probability is unnecessary for the development of the performance measure here described. Sixty-four such pe-estimates were developed

separately in the German and American samples, one for each of the eight teachers on each of his eight classroom teaching jobs. The data are presented as Table 1b and 2b. Whitlock (1963) has established the validity of such Pe-estimates.

Expected amount of mental work delivered (EMW). This measure was developed by multiplicatively combining the eight intellective complexity scale values (IC) associated with the eight teaching jobs with the corresponding eight Pe-values associated with a given teacher on each of his eight jobs i.e., Table 1a was developed from Table 1b. Thus EMW for a given teacher on any given job = (Pe)(IC). This procedure of multiplicatively combining probability of effective teaching performance with the number of Structure-of-Intellect cells involved in executing a given job was designed to yield a scale of the expected number of mental work units delivered by teachers in the classroom on each of their eight jobs. This measure assumes that job performance may be assessed by determining the difference between expected and desired number of Structure-of-Intellect cells employed by teachers in the classroom.

Results and Conclusions

Table 1a presents the EMW scale values for the American teachers; table 2a presents the German data. In the first row of Table 1a are the number of Structure-of-Intellect cells necessary to execute each of eight classroom teaching jobs now defined as desired mental work. In the body of Table 1a are the expected number of mental work units delivered by each American teacher on each of his eight classroom jobs. To assess the mental output of each teacher on any job one need only compare his expected amount of mental work with the desired amount of mental work.

Cross-cultural differences and the implications of additive and non-additive EMW matrices for the assessment of job performance and the selection of teaching personnel were discussed.

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Table 1a

Expected Mental Work Defined as the Number of Structure-of-Intellect Cells Delivered by College-Level Teachers of Psychology on Each of Eight Classroom Teaching Jobs

		-Teaching Job -								
		KD	TSF	ID	AG	TD	CSB	CA	ER	
Desired # of S-I Cells		110.5	82.2	70.1	66.2	42.0	40.6	33.2	32.1	Mean
Expected Mental Work Delivered by American Teachers	1	84.5	61.7	51.9	39.0	33.2	22.7	17.4	17.9	41.0
	2	95.7	61.3	56.6	38.7	28.6	29.4	23.1	23.5	44.6
	3	79.3	55.6	52.5	40.3	24.2	23.9	20.1	17.9	39.2
	4	77.9	58.8	44.5	39.2	31.3	25.8	19.1	16.6	39.2
	5	81.9	56.4	50.9	50.3	27.2	24.4	17.3	19.6	41.0
	6	97.0	66.9	61.1	36.7	34.8	30.5	26.2	20.0	46.7
	7	81.6	57.8	47.6	36.5	18.4	24.6	21.8	17.8	38.3
	8	75.1	51.3	48.7	37.2	24.5	26.5	19.0	18.2	37.6
	Mean	84.1	58.7	51.7	39.7	27.8	26.0	20.5	18.9	40.9

Table 1b

Probability of Effective Teaching Performance as Estimated by American Students

		KD	TSF	ID	AG	TD	CSB	CA	ER	
Desired # of S-I Cells		110.5	82.2	70.1	66.2	42.0	40.6	33.2	32.1	Mean
American Teachers	1	.765	.750	.741	.589	.790	.559	.524	.559	.660
	2	.866	.746	.808	.585	.681	.724	.697	.731	.730
	3	.718	.676	.749	.609	.577	.588	.606	.559	.635
	4	.705	.715	.635	.592	.746	.635	.574	.518	.640
	5	.741	.686	.726	.759	.647	.601	.521	.609	.661
	6	.878	.814	.872	.555	.828	.752	.789	.623	.764
	7	.738	.703	.679	.551	.439	.606	.656	.553	.616
	8	.680	.624	.694	.562	.583	.653	.571	.568	.617
	Mean	.761	.714	.738	.600	.661	.640	.617	.590	.665

Table 2 a

Expected Mental Work Defined as the Number of Structure-of-Intellect Cells Delivered by College-Level Teachers of Psychology on Each of Eight Classroom Teaching Jobs

-- Teaching Job -

		KD	TSF	ID	AG	TD	CSB	CA	ER	
Desired # of S-1 Cells		110.5	82.2	70.1	66.2	42.0	40.6	33.2	32.1	Mean
Expected Mental Work Delivered by German Teachers	1	79.0	52.3	47.8	34.1	21.8	16.1	14.4	12.9	34.8
	2	75.0	44.2	55.2	39.5	18.9	21.8	14.1	17.1	35.7
	3	80.9	53.2	52.2	35.0	20.9	21.5	15.8	11.7	36.4
	4	69.8	52.2	47.8	34.7	21.1	23.9	12.8	14.3	34.6
	9	81.5	49.6	53.2	32.1	16.8	20.5	15.0	12.7	35.2
	10	59.8	26.4	38.1	19.9	30.3	19.1	12.7	14.4	27.6
	11	61.4	42.8	43.5	38.9	15.7	13.2	13.0	14.0	30.3
	16	67.6	43.7	43.3	34.5	21.5	16.2	14.0	13.2	31.8
	Mean	71.9	45.6	47.6	33.6	20.9	19.0	14.0	13.8	33.3

Table 2 b

Probability of Effective Teaching Performance as Estimated by German Students

		KD	TSF	ID	AG	TD	CSB	CA	ER	
Desired #of S-1 Cells		110.5	82.2	70,1	66.2	42.0	40.6	33.2	32.1	Mean
German Teachers	1	.715	.636	.682	.515	.518	.397	.435	.403	.538
	2	.679	.538	.788	.597	.450	.538	.424	.532	.568
	3	.732	.647	.744	.529	.497	.529	.476	.365	.565
	4	.632	.635	.682	.524	.503	.588	.385	.444	.549
	9	.738	.603	.759	.485	.400	.506	.453	.397	.543
	10	.541	.321	.544	.300	.721	.471	.382	.450	.466
	11	.556	.521	.621	.588	.374	.324	.391	.435	.476
	16	.612	.532	.618	.521	.512	.400	.421	.412	.504
	Mean	.651	.554	.680	.507	.497	.469	.421	.430	.526

APPENDIX A

Definitions of Guilford's Structure-of-Intellect (SI) Categories

1. Intellective Operations Performed on Information

The five major operations or processes which an individual performs on information have been termed cognition, memory, [redacted] divergent production, convergent production and evaluation.

1. Cognition is "awareness, immediate discovery or rediscovery, or recognition of information in various forms; comprehension or understanding" (Guilford, 1967, p. 203, italics deleted). As thus defined, cognition is the operation which includes perceptual acts. Cognition is the process by which external information is acquired by the organism. Cognition should therefore be viewed as the summary word for a group of operations, members of which all involve the input of information, but each member of which differs from the others as a function of particular characteristics of the information. Examples of cognition include filling in missing numbers in arithmetic problems and Verbal analogies such as the Miller Analogies Test.

2. Memory is "retention or storage, with some degree of availability, of information in the same form in which it was committed to storage and in connection with the same cues with which it was learned" (Guilford, 1967, p. 211, italic deleted). Memory is thus restricted to the retention phase of information flow -- it is not intended to mean memorizing, but rather remembering -- and it is most directly analogous to computer memory. Memory may only take place for information which has previously been cognized and, as with each of the operations, it summarizes a group of intellective acts which differ from one another on the basis of characteristics of the information involved.

3. Productive thinking may be accomplished through either of two independent operations. The summary term for a group of operations in which the thinking is directed toward producing quantity or variety of information is divergent production. These intellective acts all involve the organism's attempt to produce as much volume of information as he can, with the specific act defined in terms of the type and form of the information to be produced. Examples of divergent production include such familiar exercises as reciting as many names as one can which begin with a particular letter of the alphabet, specifying all the uses to which some common object could be put, or developing all of the possible explanations for the occurrence of a particular event. Relative to this last example, it should be noted that the divergent production operation is not the one which generates the best explanation for the event; the operation merely extracts from memory all of the possible explanations. A group of output operations are summarized and characterized by "generation of information from given information, where emphasis is upon variety and quantity of output from the same source..." (Guilford, 1967, p. 213, italics deleted); there are postulated to be as many different divergent production operations as there are kinds of information (to be described shortly) involved.

4. The other kind of productive thinking operation is the one in which the thinking is directed toward producing the single best, or right, or most conventional answer. This is termed convergent production, in that the thinking converges toward the most appropriate solution, rather than

diverging in order to produce a range of possible solutions. Convergent production is exactly synonymous with the logician's term "deduction", the drawing of that one conclusion which necessarily follows from the proposition(s). The convergent productions then constitute the polar opposite set of the output operations, with quality rather than quantity distinguishing them from divergent productions; and, as with all SI operations, they subsume a family of intellective acts, each involving a different kind of information.

5. The fifth and last of the major groups of operations is evaluation. Evaluation is "a process of comparing and matching items of information according to ... logical criteria and of making decisions with respect to satisfaction of those criteria" (Guilford, 1967, p. 220). As is the case with the other intellectual operations, there is postulated a somewhat different kind of evaluation for each different kind of information evaluated; however, all of these evaluations involve the same central theme of judging the goodness, the correctness, the suitability, etc. of information which has been cognized, remembered, or produced.

This completes the coverage of the five major groupings, or kinds, of operations which are performed on information. Now let us examine the different characteristics of information which account for the 24 variations of each operation.

II. Characteristics of Information (Contents & Products)

SI theory indicates that information may be of any of four general types, and that within any one type information may assume any of six specific forms. The general types of information which SI considers operated upon by the intellect are figural material, symbolic material, semantic material, and behavioral material. In turn, each of these types of material may be coded in the specific form of what SI terms units, classes, relations, systems, transformations, and implications. Thus, the complete description of a given item of information must include both its type and its form, and the information item would be referred to as a "figural unit", or a figural "class", or "symbolic relation," or a "behavioral implication", etc.

Intellectual Contents

1. Figural material is material that is concrete in nature; an object, a sound, a texture, an aroma, etc. Because of its concrete quality, appealing directly to the end-organs of sense, Guilford describes figural material as having "sensory character" (1967, p. 72.). Recent SI findings have confirmed the sensory character of many figural materials, to the extent that an additional structure of classification is now necessary for this type of information. The SI model now postulates that the processing of visual figural material constitutes a different intellectual function than the processing of auditory figural material, and it hypothesizes additional different intellectual functions for the processing of figural material which appeals to the other sense modalities. This is an extension of the model beyond the original 120 intellectual functions or,

more specifically, beyond the six variations of each operation performed on figural material. However, for the purposes at hand, it will suffice to recognize (a) the concrete aspect of all figural material, (b) that figural properties for the visual modality are such properties as size, color, shape, etc., and that (c) their parallels constitute the figural properties for the other sense modalities.

2. In contrast to the concrete aspect of figural material, symbolic material is material in the nature of signs or representations "having no significance in and of themselves, such as letters, numbers, musical notations..." (Guilford, 1967, p. 227, italics deleted). This type of information is said to exist not in the concrete stimulus, but in what that stimulus represents. Thus the number "2" has meaning in terms of the concepts "two-ness" or "plural-ness", which it symbolizes, but has negligible meaning in terms of its physical appearance as a sensory stimulus. For example, much of mathematics involves symbolic material, the numbers, signs and letters having no meaning other than in terms of the concepts that they symbolize.

3. Semantic material is verbal content material, spoken or written; it is material in the nature of "meanings to which words commonly become attached" (Guildord, 1967, p. 227). Just as an object is figural and a letter is symbolic, a word -- or more appropriately, the meaning of the word -- is semantic material.

4."Behavioral material is essentially nonverbal, [it is]involved in human interactions" (Guilford, 1967, p. 77), and is associated with feelings, moods, desires, attitudes, etc. insofar as they convey information. Much information is frequently conveyed in human interactions by facial expressions, tones of voice, gestures, etc. as indicators of the "frame of mind" that the other person is in, such as favorableness of attitude, agreement, or disagreement. Although conveyed without words, message content is delivered by the behavioral manner which we observe, and these nonverbal exchanges of information constitute what SI theory terms behavioral content material.

Thus there are four general types of information -- the figural (with its modality variations), the symbolic, the semantic, and the behavioral -- and a specific message of any of these types will appear in one of the six coded forms.

Intellectual Products

1. Units are the most fundamental form in which information may appear. A geometric figure would be a figural unit (of visual type), a tone would be an auditory figural unit, a number or letter would be a symbolic unit, etc.; this definition would also include parallels for semantic and behavioral content material.

2. Classes are groups of units which, by virtue of some common property, "hang together" as a single entity. For example, although the letter a is a symbolic unit, as are the letters e, i, o, and u, the group of these particular letters defines a new entity, the symbolic class of vowels. All 26 letters taken as a group defines another symbolic class, the English alphabet. A square and a rectangle, each of which is a figural unit, together comprise a figural class when they are to be distinguished from a circle and an ellipse.

3. Relations are the relationships among items of information. Analogies are relations, as are synonyms and antonyms, rotated views of figures, mathematical equations, etc. When the information content of a given message is not any of the specific items, but rather, "some kind of connection" (Guilford, 1967, p. 64) between these items, relations are said to be involved. The few examples of relations given above include common figural relations, symbolic relations, and semantic relations, and they have their parallels in behavioral relations. Further, relations may exist either between units --- for example "a and alpha" is the relations between two units, analogous letters in different alphabets --- or relations may exist between sets of units -- "a ... z and alpha ... omega."

4. The fourth form in which information may appear is called systems. Systems are defined as "complexes, patterns, or organizations of ... interacting parts" (Guilford, 1967, p. 64). Systems might be looked upon as families of relations, which taken together comprise some supraordinate organization. Complexity and organization are the features of information in system form which makes it distinguishable from information in the more straightforward relation form. Three examples may clarify the meaning of systems as a form in which information may appear: (1) rhythms and melodies are auditory figural systems; (2) a perspective drawing is a visual figural system; (3) characteristic behavior patterns are regarded as behavioral systems.

5. Information may appear in the form of transformations. Transformations are "...changes, redefinitions, or modifications, /as/ information in one state goes over into another state" (Guilford, 1967, p. 64). Central here is not the information per se, but the change in its state which is the message content. For example, the familiar ambiguous figures are figural transformations, encoding and decoding involve symbolic transformations, while puns and double-entendre statements are semantic transformations.

6. The final form in which information may appear is implications. When certain information immediately implies other information which naturally follows, the other information is said to be an implication. Although an implication which is a property of information may be difficult to differentiate from a convergent production (which is an act performed on information), there is at least a nuance difference. The difference is perhaps best illustrated with symbolic implications, although there are parallels for each of the other four types of information. The given information "2 + 2" immediately implies "4", the given information "10^2" immediately implies "100", without the reader's actualiy going through the arithmetic solution (which would be a convergent production). The extension, or extrapolation, to the "new" information is immediate and is completely given; it is not given explicitly, but it is completely given -- by implication. One parallel, the semantic information, may assist in indicating that parallels do indeed exist. Consider the given information "men, women, and _____." This given phrase immediately predisposes or implies the word "children", i.e., the word children becomes a message in this context, even though it is not presented explicitly. In SI terms, the word "children" would constitute a semantic implication.

III. Representation of SI Model

The complete SI model, consisting of the five operations performed on information and the 24 characteristics of information (i.e., four broad types of information contents and six specific forms (products) within each type), has been assembled in a pictorial representation. The representation is a three dimensional solid figure. The five operations performed on information constitute one of the dimensions, the four general types of infor mation constitute a second dimension, and the six specific forms in which information may appear constitute the third dimension. Figure 1 shows this representation, [redacted] from Guilford, 1967. While each cell in the figure defines a different intellectual function, the complete description requires reference to all three axes. Hence the nomenclature "memory of semantic units", "convergent production of figural classes," "evaluation of symbolic systems," etc. becomes necessary. This nomenclature is merely another way of indicating the basic point made earlier, that a somewhat different intellectual function is involved either if a person processes information in a different way or if he executes the same process, but on information which is configured differently. We also note that there are two ways in which information may be configured differently; (1) it may be a different type of information, or (2) it may be coded in a different form. These variations in process performed on information, and in the information processed, give rise to the 120 cells represented in Figure 1.

Figure 1 (not shown here) was presented to the Ss.

APPENDIX B

Knowledge Dissemination

a. Distinguishes between fact and opinion
b. Presents application of theory
c. Employs textbook and/or prepared notes during lecture
d. Informs about information channels and sources (e.g., library)
e. Conducts research (e.g., collects data in class)

Teacher-Student Feedback

a. Provides feedback on tests and other material
b. Requests students to critique course
c. Conducts question-and-answer periods
d. Gives tests and quizzes
e. Responds to student questions

Advisory Guidance

a. Advises on vocational goals
b. Schedules student consultation

Information Dissemination

a. Gives handouts (e.g., course outline, etc.)
b. Writes on blackboard
c. Gives special instruction and information concerning labs, papers, etc.
d. Assigns outside readings and preparation (other than text)

Teacher Dynamism

a. Gesticulates and/or moves around while lecturing
b. Emphasizes material using humor
c. Gives examples from personal experience
d. Maintains eye contact

Control of Student Behavior

a. Responds to potential or actual emergencies (e.g., student illness, bomb scare)
b. Administers school regulations (dress, smoking etc.)
c. Transmits messages for others (e.g., departmental activities to be attended)

Classroom Administration

a. Assigns seating arrangement
b. Takes roll
c. Assigns grades
d. Establishes range of acceptable classroom behavior

Environmental Regulation

a. Checks physical equipment and environment (temperature, lights, etc.)
b. Operates equipment (e.g., audio-visual aids)
c. Accounts for school funds and property