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ABSTRACT

Construct validity of a prototype baccalaureate generic problem solving skills test was explored through a structural analysis. The assessment method used three real-life problem situations crossed by six generic skills, namely Decision-Making, Communication, Analysis, Synthesis, Valuing and Execution. There were six written responses for each skill for each problem situation. The structural model included 18 skill/task observations with 6 latent skill variables, 3 latent trait variables and a higher order general factor (g). A multitrait-multimethod design was employed using a confirmatory factor analysis (LISREL VI). The data set moderately conformed to the model with most of the variation in performance attributed to the general factor. Factor loadings were neither consistent across skills nor across tasks. Therefore, generic skills, as measured by this procedure, possess little independence from the general factor. The weaknesses in the assessment method and implications for test methodology and research in the assessment of generic problem solving skills are discussed. Descriptions of the three real life problem situations are appended. (Author/LMO)

Generic Problem Solving Skills:

Are they Misnomers as Constructs of Educational Outcomes?

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Running Head: GENERIC PROBLEM SOLVING SKILLS

Abstract

Construct validity of a prototype baccalaureate generic problem solving skills test was explored through a structural analysis. The assessment method used three real-life problem situations crossed by six generic skills, namely Decision-Making, Communication, Analysis, Synthesis, Valuing and Execution. There were six written responses for each skill for each problem situation. The structural model included 18 skill/task observations with 6 latent skill variables, 3 latent trait variables and a higher order general factor (g). A multitrait-multimethod design was employed using a confirmatory factor analysis (LISREL VI). The data set moderately conformed to the model with most of the variation in performance attributed to the general factor. Factor loadings were neither consistent across skills nor across tasks. Therefore, generic skills, as measured by this procedure, possess little independence from the general factor. The weaknesses in the assessment method and implications for test methodology and research in the assessment of generic problem solving skills are discussed.

Generic Problem Solving Skills:

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Introduction

While there has been considerable concern regarding the development and assessment of higher order cognitive processes (herein called generic problem solving skills) at all educational levels (NAEP, 1981; Bloom, 1984; Frederickson, 1984; Ennis, 1985; Sternberg & Baron, 1985), there is still controversy over the nature of such constructs and the structures of such abilities (Carroll, 1985; Heartel, 1985). More specifically, there is debate over whether such abilities are domain general or domain specific (Baron, 1982; Keil, 1982), or whether there is a hierarchical configuration including a higher order general factor and lower order specific factors (Gustafson, 1984; Carrol, 1985). Such issues converge at the confluence of cognitive science, psychometrics and education in which the first concerns their structure and development, the second their measurement, and the third the practice of helping individuals acquire them.

This paper focuses on three perplexing issues undergirding the assessment of generic problem skills: 1) What are the structural relationships among such skills?; 2) Are the skills generic across problem solving tasks or are they specific to individual tasks?; and 3) To what degree are generic problem solving skills unique from one another or from a general factor? The answers to these questions may shed light on not only the construct validity of tests purporting to measure such entities, but also whether educational programs may

legitimately claim them as goals or desired outcomes.

Generic problem solving skills may also be referred to as higher order mental processes (Bloom, 1984), critical thinking skills (Ennis, 1985), domain general skills (Keil, 1982), or reflective thinking skills (Dewey, 1933; Baron, 1981, 1982). They are considered as skills as opposed to capacities (Baron, 1982) since they are subject to the laws of learning (cue fidelity, reinforcement, practice, transfer) and can be acquired through educational or training experiences. Such skills are considered generic or ubiquitous in the sense they repeatedly occur in the analysis of skills underlying the resolution of real-life problems (Woditsh, 1977). Moreover, certain skills have been identified in a variety of contexts through a variety of research methods (Peterson & Watkins, 1979; Peterson, 1982). The most frequently occuring skills include Decision-Making, Communication, Analysis, Synthesis, Valuing and Execution. These skills, however, are subsumed under a general intelligence factor which represents the power of reasoning or the "noegensis" of abstract entities (Spearman, 1923), total life learnings (Carroll, 1982), or fluid intelligence (Horn and Cattell, 1966; Gustafson, 1984).

One method used to assess generic problem solving skills is to measure them across a set of real-life problem situations analogous to the assessment center method (Moses & Byham, 1977). In this technique, an individual is presented with a real-life problem situation (see Appendix I) and set of directive cues, one for each skill, designed to

elicit a written response that can be evaluated in terms of high, medium or low performance (Peterson, 1984). The directive cues were derived from general education competency statements (Peterson & Watkins, 1979) and are presented in Table 1. Such a test, while initially intended to assess the achievement of generic problem solving skills in postsecondary education, also provides an opportunity to investigate theoretical issues pertaining to the nature of such abilities. To date, the construct validity of the assessment center approach (tasks crossed by skills) has already been brought to question using exploratory factor analytic procedures (Sackett & Dreher, 1982).

Place Table 1 about here

A confirmatory factor analytic approach (Long, 1983; Bagozzi, 1981, Gustafson, 1984) is employed in the present study to examine an a-priori hypothetical structure involving generic problem solving skills, a general intelligence factor and task factors as portrayed in Figure 1. According to the generic skills theory, skills should be present across most real-life problem solving situations (herein called tasks). If skills are truly generic, a statistical hypothesis would be that there would be greater common variance across skills than across tasks. Further, a general factor should capture common variance across both skills and tasks. Therefore, there should be consistently higher factor loadings across the skill factors than across task factors if the problem solving skills are generic

rather than task specific.

Place Figure 1 about here

Method

Subjects. A field test of a prototype generic problem solving skills test (Peterson, 1984) included 20 lower division students from introductory Psychology classes, 26 upper division students from Human Relations and ROTC classes and 16 graduate students from the College of Education at a large southeastern university. The lower division students received course credit for research participation, upper division students received a small stipend ($10) and graduate students met individual course requirements.

Procedure. When subjects arrived for the prearranged testing sessions, they were informed they had unlimited time to complete their written responses to the three assessment tasks. Thus the speed factor as an element in the measurement of intellectual functioning was not present (Carroll, 1982). Most students completed their responses to the three problem solving tasks (i.e. situations) within two hours and no student took longer than three. Each task included six questions, one for each generic problem solving skill. The length of the written responses to each question varied from 10 - 250 words.

The Situations. Three real-life problem situations (see Appendix) were developed to represent general academic content domains. For example, Cuban Crisis drew predominantly on perspectives from the social sciences and humanities, Land Development from the social

Table 1. Generic Problem Solving Skills and Directive Cues Used In Real-Life Situations

Skills	Directive Cues
1. Decision-making	Describe which course(s) of action you would recommend in the above situation.
2. Communication	As a _____ (role specific such as a social worker), what is the central issue for you in the above situation?
3. Analysis	Describe the problem from A's perspective (i.e. a player), B's perspective and C's perspective.
4. Synthesis	List as many courses of action that might be taken including ones you woulld not choose to follow.
5. Valuing	What values underlie A's behavior, B's behavior, C's behavior?
6. Execution	For the course(s) of action you recommended (in the decision making stimulus), outline the sequence of actions you would take to implement the solution.

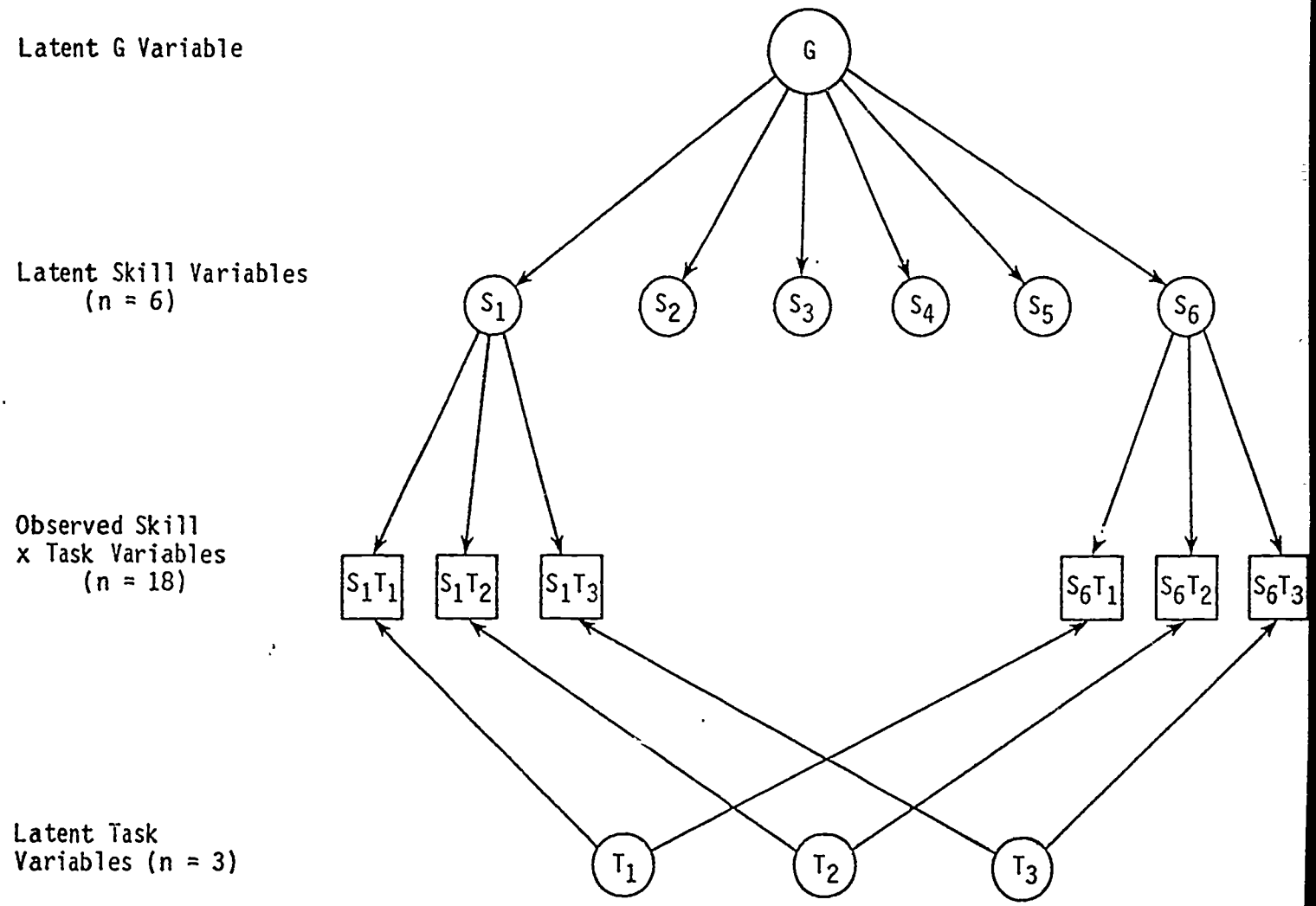

Figure 1. Confirmatory factor model for the structure of generic problem solving skills.

sciences and natural sciences and Token Economy from the social sciences (especially Psychology) and professional schools. In each situation, the subject assumes a responsible social role such as a social case worker, a county commissioner, or a schoolboard member. The respective scenarios were intended to engage student interest and to be sufficiently challenging and complex so that the highest level of all six skills could be demonstrated. While not intending, the situations varied in degree of difficulty for four of six skills excluding Decision Making and Valuing (Peterson, 1985). The full range of performances (1-5) were demonstrated for each skill for every task.

Rating Procedures. For each of the three problem solving situations (tasks), there were six written responses, one for each skill directive. Each response was rated holistically on a 5-point continuum with anchors describing low (1), medium (3) and high (5) performances based on the works of Piaget (see Flavel, 1963), Kohlberg (1971), and Perry (1970). Each written response (18 per subject) was rated by 3 trained ABD doctorial students in Counseling Psychology. The interrater product moment correlations for 18 skill/task performances ranged from .35 to .73 with a mean of .53. The alpha reliability estimated for 3 pooled ratings for each of the 18 performances ranged from .63 to .89 with a mean of .76 (Peterson, 1984).

The test. As a comprehensive measure of generic problem solving skills, the test was able to differentiate levels of educational attainment. There was a step wise progression from lower division to

upper division to graduate level. The alpha reliability estimates for the six skill dimensions (9 ratings) were from .73 & .85 with a mean of .80. The range of intercorreltaions between skills was from .33 to .66 with a mean of .55. Thus while there was a high degree of covariance among the skills, they would appear to be independent constructs possessing a substantial degree of discriminant validity. Generalizatibility coefficients for 3 tasks and 3 raters were from .51 to .74 with a mean of .64 (Peterson, 1985). At this point, if there is a potential weakness in the test, it may be that the universe of problem solving situations was not adequately sampled (low generalizatibility coefficients) to affirm that generic skills scores derived from the test adequately sample a universe of scores.

Method of Analysis. A multitrait-multimethod matrix was created with three tasks crossed by six skills. There were 18 observed skill/task variables. The structural model as proposed in Figure 1 was tested using a confirmatory factor analysis approach (Long, 1983). In this analysis, a general factor was designated as a latent variable as well as the six generic skill variables and three task variables. A confirmatory factor analysis permits the imposition of constraints on the data set by specifying which pairs of common factors are to be correlated and which observed variables and common factors are to be associated. The LISREL VI program (Joreskog & Sorbom, 1983) was used to conduct the analysis.

It must be acknowledged, however, that the first order variables

of skills and tasks contain specific variance after the variance accounted for by the second order J factor has been partialled out. Different, but potentially viable, models could emerge when the latent J factor is omitted. Therefore a post hoc confirmatory analysis was conducted to determine whether the data also conforms to a model comprised only of tasks crossed by skills.

Results

One can note from the intercorrelation matrix presented in Table 2 that the 18 skill/task performances are intercorrelated to a fairly high degree. Intercorrelations span from .58 to -.06 with a mean correlation of .32. Factor loadings (i.e. LISREL estimates of maximum likelihood) for the confirmatory factor analysis of proposed model are presented in Table 3. The goodness of fit for the whole model was $X^2 = 114.36$, df = 103, $p = .210$, goodness of fit index of .841. These results suggest that the data set moderately conforms to the proposed model. The strongest and most consistent loadings occured on the general factor. Loadings of skills across tasks generally (with the exception of the Communication skill) entailed one high loading accompanied by two low loadings suggesting that these skills are <u>not</u> generic once the variance associated with the G factor is partialled out. Task factor loadings were also inconsistent indicating that tasks alone do not consistently account for levels of performance. The interpretation of this analysis is that skills interact with tasks such that the effect of skills is not the same across tasks nor is the

effect of tasks the same across skills.

Place Table 2 about here

Place Table 3 about here

Since the J factor appears to account for the major source of variation, a post hoc confirmatory analysis was conducted to determine whether a tasks crossed by skills alone model without the higher order J factor would be viable. The goodness of fit this model was $X^2 = 239.66$, df = 121, p = .000, goodness of fit index of .712. Therefore, the tasks by skills model was not confirmed by the data set.

Discussion

The present study sought to determine the structural relationships among generic problem solving skills, tasks and a general factor in response to real-life problem solving situations. The results of a confirmatory factor analysis indicated that dimensions of generic problem solving skills or higher order mental processes may not possess a high degree of independence from each other or from a general factor once variation due to a general factor has been partialled out. Differences in levels of performance across 18 observed performances (6 skills x 3 tasks) can not be predicted from tasks crossed by skills alone. Therefore the conclusion is that there is little evidence to support that there are psychometically meaningful constructs as generic problem solving skills independent of the general factor in real-life problem solving situations. Only the constructs communication (what is the central issue?) and Execution (list steps to implement a solution)

Table 2 Intercorrelation matrix of 18 skill/task variables (n = 62)

	Dec - Make 1	Dec - Make 2	Dec - Make 3	Com 1	Com 2	Com 3	Anal 1	Anal 2	Anal 3	Syn 1	Syn 2	Syn 3	Val 1	Val 2	Val 3
Decision making 1	1.00														
Decision making 2	.31	1.00													
Decision making 3	.44	.32	1.00												
Communication 1	.58	.46	.34	1.00											
Communication 2	.29	.43	.25	.49	1.00										
Communication 3	.23	.30	.46	.49	.33	1.00									
Analysis 1	.51	.36	.41	.48	.37	.40	1.00								
Analysis 2	.23	.24	.30	.22	.18	.37	.37	1.00							
Analysis 3	.44	.21	.40	.27	.12	.35	.33	.23	1.00						
Synthesis 1	.38	.34	.37	.37	.34	.27	.50	.20	.32	1.00					
Synthesis 2	.36	.39	.24	.25	.26	.28	.18	.43	.26	.19	1.00				
Synthesis 3	.36	.31	.46	.34	.39	.18	.48	.27	.35	.36	.43	1.00			
Valuing 1	.36	.40	.34	.14	.19	.27	.54	.36	.30	.37	.19	.29	1.00		
Valuing 2	.37	.23	.34	.28	.33	.14	.42	.35	.28	.41	.29	.51	.49	1.00	
Valuing 3	.46	.31	.39	.43	.43	.27	.58	.38	.26	.41	.35	.53	.36	.48	1.00
Execution 1	.45	.27	.36	.47	.15	.41	.45	.39	.53	.33	.27	.40	.19	.38	.32
Execution 2	.24	.34	.34	.27	.17	.15	.24	.29	.29	.06	.39	.36	.10	.23	.28
Execution 3	.10	.13	.30	.03	-.06	.31	.34	.39	.25	.20	.13	.26	.39	.30	.34

	Exec 1	Exec 2	Exec 3
Execution 1	1.00		
Execution 2	.37	1.00	
Execution 3	.37	.20	1.00

Table 3 - LISREL Maximum Likelihood Estimates for Task by Skill Factor Matrix, G Factor Included

Observed Tasks	Skills & Task Factors	Decision Making	Communication	Analysis	Synthesis	Valuing	Execution	Task 1	Task 2	Task 3	General Factor
Decision making 1		.117						.451			.599
Decision making 2		.083							.265		.478
Decision making 3		.776								.229	.596
Communication 1			.580					.635			.519
Communication 2			.431						.054		.463
Communication 3			.480							.785	.466
Analysis 1				.188				.105			.783
Analysis 2				.125					.300		.496
Analysis 3				-.588						.228	.529
Synthesis 1					-.064			.071			.597
Synthesis 2					.255				.821		.389
Synthesis 3					.724					-.204	.668
Valuing 1						.766		-.185			.615
Valuing 2						.134			.035		.621
Valuing 3						-.105				-.130	.722
Execution 1							.514	.305			.566
Execution 2							.258		.258		.371
Execution 3							.257			.193	.440

were there factor loadings greater than .250 across all three tasks. Perhaps Carroll (1985) is correct when he stated that factors naturally differ in the range of their applicability to cognitive tasks. Extending this thought, generic skills may function as potential rather than manifest entities as requirements of specific tasks beyond J (Baron, 1982).

However, before adopting a reinterpretation of the notion of generic problem solving skills is noted by many prominent theoreticians (Dewey, Baron, Bloom), there are several issues in the measurement of such constructs that should be considered. The first is that there are inherent biases toward inflating the contribution of J in this method of assessment. The productions are all written responses, and thus, the level of skill performance across all skills could be highly influenced by attributes of general writing ability (eg vocabulary, spelling, syntax, and fluency). Therefore, further research is needed to control for the contribution of general writing ability, possibly by diversifying its method of performances perhaps along the line of Guilford's (1967) Product dimension in his model of general intelligence.

A second consideration is that the number of tasks used, three, was too small to allow subjects to demonstrate the "genericness" of their problem solving skills. The results of a generalizitbility study (Peterson, 1985) on the present data set suggest that as many as 10 tasks may be required to achieve generalizatibility coefficients

consistently above .80 across all skills. Third, the study requires replication with considerably more subjects than the present study (n = 62). In confirmatory factor analysis, the risk of Type I error is increased with a small sample size.

Given the fact that the test appears to differentiate levels of educational attainment when IQ was equated (Peterson, 1984), the general factor here may also be indicative of general cultural learning as noted by Carroll (1982) and Undheim (1981) rather than as a pyschologically determined characteristic as fluid intelligence (Gustafson, 1984). General knowledge would appear to be very important in responding to real-life situations.

The question posed in the title of this paper was whether generic problem solving skills are misnomers as constructs of educational outcomes. The answer to this question, based on the present findings, is that they indeed are misnomers given the method of assessment used in this study. It would appear that little is gained over the information a vocabulary test, a general knowledge test, or general reasoning test would provide. Generic problem solving skills may, however, be demonstrated with a greater variety of productions over more problem situations. Until then, one could not claim that generic problem solving skills are being measured much less attained by employing several short essays over several problem situations. The implication for test methodology is that a comprehensive and diverse test battery would be required to demonstrate whether such educational outcomes are being achieved.

First, however, it must be demonstrated that such entities exist beyond the general factor alone.

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APPENDIX

Problem Situations

Cuban Crisis (I)

As a case worker for the Department of Social Services, you have been assigned to work with a young Cuban woman, found beaten and semi-conscious in a Cuban neighborhood. Taken by police to a hospital, she acknowledged that she had been sexually assaulted, but refused to identify her attacker; she became hysterical at the suggestion that she undergo a physical examination to determine if rape had occurred. Her family has refused to cooperate with police attempts to investigate the presumed rape, although the police have been able to determine her attacker's identity by informants in the Cuban community. The girl's father has flatly refused to swear out a warrant, and the girl refused to acknowledge whether that a rape has occurred or her assailant's identity. Frustrated, the police have called you to come to the police station and take over the case.

Land Development (II)

You are a County Commissioner and a special meeting has been called in order to settle a dispute that has occurred concerning the proposed development of 100 acres of land along a primitive river bank. The land in question is 25 feet beyond a marshy area that borders the river. The developer plans to subdivide the land into one acre residential tracts. The site is in a rural county that lies just 7 miles south of a rapidly growing metropolitan area. The river and surrounding areas are noted for their excellent fishing and camping, annually attracting sportsmen and campers statewide and beyond. A major controversy has been raging ever since the developers intentions were made public. Local environmental groups here opposed the development while local businessmen have stressed the need for such a development. The developer had promised to delay the actual construction until environmental groups completed an environmental impact study. The special meeting has been called because several days ago the developer began construction of a road along the river bank and has also begun digging wells and septic tanks. The local environmental groups are demanding an immediate halt to construction. The developer claims that the construction delay is costing him thousands daily and that he intends to proceed with construction until concrete evidence is provided that the subdivision would be other than beneficial to the community.

Token Economy (III)

You are a School Board member in an inner city school district. Disciplinary problems in the 3rd through 6th grades have tripled in the past year. The School Board has received numerous demands from parents to do something to restore order to the schoolrooms. Because of understaffing the classrooms are overcrowded, and it has become increasingly more difficult for teachers to manage the students. Fighting, practical joking, inattentiveness, the use of vulgar language and cheating abound. Several principals have asked the School Board to institute a token economy in all elementary school classrooms within the school district. Since this proposed solution was introduced at the last board meeting a controversy has raged between opposing factions in the P.T.O. Those favoring the institution of a token ecomony claim it is the most efficient way to eliminate undesirable classroom behavior. Those opposing the use of a token economy do so primarily on ethical and moral grounds. The board meets once next month to make recommendations for further courses of action.