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ABSTRACT

The purpose of this study was to analyze data collected from participants in the Pennsylvania Governor's School for the Arts (PGSA) in terms of their relevance to science education. Its objective was to investigate relationships between variables common to the arts and sciences as a means for hypothesizing alternative approaches for growth in scientific attitudes and skills. A group of PGSA students were administered four test instruments: the Biographical Inventory, Form R; the Sixteen Personality Factor Questionnaire; the Torrance Tests of Creative Thinking, Figural Test; and the Pennsylvania Department of Education's Education Quality Assessment Goal VII Test of Creative Performance. Statistical procedures used to analyze the data included analysis of variance, intercorrelations between variables, and regression. Although the data analysis was incomplete when this summary was prepared, these conclusions were drawn on preliminary results: (a) Positive relationships exist between certain art and science education constructs; and (b) Some affective skills appropriate to the development of artistic talent are related to some personality profile factors of research scientists. (Author/MH)

THE POTENTIAL FOR IMPROVING SCIENCE EDUCATION THROUGH TRANSDISCIPLINARY INTEGRATION WITH ART EDUCATION

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1. Objectives and Theoretical Rationale for the Study.

The Pennsylvania Governor's School for the Arts (PGSA) is a five-week summer program for Pennsylvania's most artistically talented and gifted high school students. The PGSA includes five instructional departments--art, music, dance, theater, and photographic arts--all of which stress a related arts approach. Integration of the arts across disciplines in a "living and learning" format has been the planned approach of the PGSA during the three years of its existence..

There is some concern that, although the present screening procedures for selecting participants have demonstrated their effectiveness in the selection of highly competent, and very talented youngsters for the PGSA, other procedures could be implemented to improve the efficiency of the selection process. Unfortunately, however, no instruments are known to exist that could assist with the identification of artistic talent (RISE, 1975); thus, there is a need to identify functional and valid tests for helping to identify these talents. An analysis of appropriate test instruments as potential means to effect greater efficiency, while at least maintaining the effectiveness of the present identification system, was the initial purpose of the original study to improve the identification and selection processes for the PGSA program. Of primary concern was the analysis of single or allometric scores representing concurrent validity for the identification of artistic talent and those representing predictive validity for the selection and anticipation of participant success in the arts enrichment program of the Pennsylvania Governor's School for the Arts.

Other studies, primarily exploratory, were designed as parallel, yet independent, analyses of the obtained data. These descriptive studies can be valuable for identifying trends, suggesting hypotheses, and supporting or refuting the further identification of alternative hypotheses and the development of formal research in a given area. Such was the intention of the work reported herein.

Many educators recognize the multi-disciplinary and interdisciplinary nature of science. Since science includes such a complex interaction of things, any attempt to effectively educate children about science must be comprehensive, incorporating processes and concepts from all appropriate fields of knowledge and appropriate instructional methods.

Transdisciplinary integration attends to this multi-disciplinary and interdisciplinary nature of science. All of the traditional classroom disciplines can and must contribute to an understanding of science; but they should be seen and studied in terms of integrated systems rather than in terms of the traditional confines of disciplinary schema. To illustrate, an interdisciplinary approach to environmental education was demanded by the editors of seven journals in a declaration published in the February, 1975, issue of The Science Teacher. Not only environmental education, but other science instructional areas, too, could benefit from an integrated, interrelated, interdisciplinary, and interfluent learning approach.

The purpose of this study was to analyze data collected from participants in the PGSA in terms of their relevance to science education. Its objective was to investigate relationships between variables common to the arts and sciences as a means for hypothesizing alternative approaches for growth in scientific attitudes and skills (Can instructional activities in art areas help develop necessary science skills and attitudes?).

2. Methodology and Design.

The larger PGSA study was designed as a two-year comprehensive validity study of several instruments possessing apparent face validity for the identification of artistically talented youngsters. This separate study was designed as a descriptive study to analyze data with a proto-theoretical view toward increasing educational productivity.

Educational productivity, as determined by instructional and other educational processes, is limited by the experiential or "teaching lore" approach prevalent throughout our schools and colleges. If education is to become more productive, then a greater commitment to the science of education must be engendered. Since the most important component of a science of education is its theory base, professional educators sympathetic to the rigors of scientific enquiry must be engaged in theory building. Science educators, with their predisposition and preparation toward the logic of scientific thought and theory, should be the logical source for these professionals needed to build a more scientific base for education.

The need for more serious involvement in theory building is apparent when one surveys the research literature. Jacobson (1975), for example, attempted to synthesize generalizations from 50 years of science education research reviewed in the Reviews of Research in Science Education. Although his report was meant to be suggestive rather than exhaustive, it does stimulate some alarming concerns. If, after 50 years of research, we can only generalize that "we get what we plan and teach for", that "there may not be a 'best way to teach'", or only that achievement is positively correlated with age and IQ, then we must review our methodologies and the functions of theory in research. This must be done in order to re-emphasize the importance of theory development to the construction of a scientific base for general education.

We must ask, as did Jacobson, whether significant and critical problems have been identified and studied, whether our research methodologies have improved, and whether we have tried to systematically build upon the work of others. Satisfactory resolution of these and other related problems will be encouraged by our greater commitment to theory construction.

The value of theory to research can be immense. Novak (1963) has pointed out that science advanced only slightly until the advent of theory development

based on experimentation. Platt (1964) has described strong inference as a theory construct which, as a systematic method of scientific thinking, has produced more rapid advances than other of the research methodologies not planned in a theoretical setting. And Suppes (1974) has stated that success in developing a body of theory can impact significantly on the place of research in education.

Assuming these thoughts to be representative of researchers, then a theoretical foundation has generally been recognized as a prerequisite to meaningful and advancing educational research. However, it has also been generally lacking from our research efforts. Tinto (1975) has described this situation: "In large measure, the failure of past research ... can be traced to two major shortcomings; namely, inadequate attention given to questions of definition and to the development of theoretical models that seek to explain, not simply to describe ...."

Beauchamp (1968) has described three functions of theory--description, explanation, and prediction. A theory must account for observations of the organization of and interrelationships between variables. It must also provide at least tentative reasons for or causes of the described observations. Finally, a theory must be able to allow predictions of observations from the explanations suggested. It is this third function--this power of prediction--that is the most significant function for theory in our schools and colleges, especially as it relates to predicting student achievement in specified learning environments.

Since one of the first functions of a theory is description, a study of the interrelationships of variables which describes organizational relationships is necessary before a predictive system can be established. Careful description is a required component of theory construction since the real test of a theory's validity is the reliability of predictions made from it. Reliable predictions are more likely if they are generated from a theoretical system that has accounted with reasonable accuracy and completeness, many observations from relevant and different situations.

A regression-discontinuity, quasi-experimental design was selected for the original study to compare participant change during the PGSA program to baseline data collected before program involvement. This paper, however, was prepared to report on the investigation of the data from a post-hoc analysis. The legitimacy of post-hoc "data-snooping" has been described by Games (1970); it serves to identify trends, describe inter-relationships, and suggest further research. This kind of activity is necessary in the early stages of the theory-building process.

3. Data and Its Sources.

From an initial applicant pool of nearly 2,000 tenth and eleventh grade artistically talented students from across the Commonwealth of Pennsylvania, 255 were selected for participation in the PGSA and, thus, the original study. Four test instruments were administered to all participants: the Biographical Inventory (BI), Form R; the Sixteen Personality Factor Questionnaire (16 P.F.); the Torrance Tests of Creative Thinking (TTCT), Figural Test; and the Pennsylvania Department of Education's Education Quality Assessment (EQA) Goal VII Test of Creative Performance. In addition, pre and post assessments included individual instructor ratings of student performance in skill areas appropriate to the PGSA.

The BI, published by the Institute for Behavioral Research on Creativity (1973), was initially selected by Pennsylvania Department of Education and PGSA staff to provide documentary support for selections made through an audition-interview process. The Seventh Mental Measurements Yearbook (Buros, 1972, hereinafter referred to as the Seventh Yearbook) includes a reference to the Alpha Biographical Inventory from which the BI was derived--reservations were expressed for its use as a standardized test in terms of the need for clarification of validity and reliability. The use of the test was recommended primarily for research purposes.

The 16 P.F., published by the Institute for Personality and Ability Testing (1967), was selected as a base measure to gather data for determining content, construct, and criterion-related validity of the BI, and as a potential predictor of student performance in the PGSA. The Seventh Yearbook includes references to over 20 years of research with the 16 P.F. Any test, however, that purports to measure personality factors may be criticized in its attempt to make tangible the intangible; the 16 P.F. is no exception. It has, however, been referred to as "the best personality inventory there is", (Rorer, 1972).

The TTCT published by Personnel Press, Inc. (1966), was selected also to provide a possible alternative in the analysis of selection potential and to provide baseline information for an investigation of the validity of the BI. The Seventh Yearbook suggests that the TTCT can be useful as a basis for further research related to creativity and new educational programs. Since creative aptitude and artistic talent seem to be positively related, the TTCT was selected as a potential instrument for the identification of artistic talent.

Finally, the EQA test, published by the Pennsylvania Department of Education (1974), was selected as a base measure to determine the performance potential of PGSA participants and to provide further information in the investigation of BI validity. The EQA scales represent an attempt to appraise certain cognitive and affective skills identified by the Pennsylvania State Board of Education as priority areas for the state's educational thrusts. Goal VII states, "Quality Education should give every child opportunity and encouragement to be creative in one or more fields of endeavor". The EQA scale for Goal VII attempts to assess student-expressed interest in participating in creative activities and the extent of recognition gained through active involvement.

The BI yielded scores for five variables. The male and female grade point average (MGPA and FGPA) were constructed to predict GPA's for high school and college students. Scientific Creativity was developed across a number of studies of adult scientists and engineers. Leadership was constructed to predict leadership ability. Artistic Talent was constructed to predict student performance within and across the major areas of music, visual arts, dance, and theater. This biographical instrument was administered only as a pretest.

The 16 P.F. provided scores for 16 variables, including such personality factors as Reserved versus Outgoing (Factor A), Dull versus Bright (Factor B), Expedient versus Conscientious (Factor G), and Self-assured versus Apprehensive (Factor O). The 16 P.F. was given as both pre and post tests.

The TTCT figural test was designed to measure four variables, including flexibility (variety of type of response), originality (unusualness), elaboration (adding ideas for a more complete and exciting story), and fluency (voluble and glib). The TTCT was administered as pre and post tests.

The EQA test yielded scores for five variables. The notion of creativity used in the construction of the test encompassed the identification of activities initiated and pursued on one's own. Four categories of activities define the four variables--visual arts, performing arts, writing arts, and science activities; the fifth variable was defined as a composite score of the first four. This biographical battery was only administered as a pretest.

Finally, rating sheets constructed by PGSA staff were used to record artistic performance ratings before and after participation in the five week program.

The only participants included in the analysis were those for whom complete data were available. If any data from any of the instruments were missing from an individual's scores, none of the recorded scores for

that individual were analyzed. Thus, from an initial pool of 255, complete data sets were available for 105 participants.

4. Results and Conclusions.

The resultant 52 scores were analyzed using standard product-moment correlation computations. Intercorrelation analysis determined the degree of covariation between several variables. Table 1 presents the correlation coefficients between those variables more relevant to the sciences and those more relevant to the arts.

Insert Table 1 about here.

There were nine science-related variables. Scientific Creativity (BI) and Science Activities (EQA) were identified by definition. In addition, occupational profiles for engineers, biologists, chemists, geologist, physicists, and research scientists identified seven personality factors (16 P.F.) with high and low scores which in combination were unique to the sciences. The 16 P.F. variables thus identified included Reserved (A-low), Bright (B-high), Sober (F-low), Expedient (G-low), Tender-minded (I-high), Self-assured (O-low), and Controlled (Q3-high).

Eighteen variables were identified as art-related variables. Artistic Talent (BI), Visual Arts (EQA), Performing Arts (EQA), Writing Arts (EQA), Flexibility (TTCT), Originality (TTCT), Elaboration (TTCT), Fluency (TTCT), pre-Rating, and post-Rating were identified by definition. Additionally, occupational profiles for artists and musicians identified eight personality factors (16 P.F.) in combination unique to the arts. These variables included Reserved (A-low), Bright (B-high), Assertive (E-high), Expedient (G-low), Tender-minded (I-high), Imaginative (M-high), Experimenting (Q1-high), and Self-sufficient (Q2-high).

Most of the absolute values of r are relatively low (ranging from .21 to .61); however, given the highly selective, homogeneous nature of the group tested, even relatively low values of r can be meaningful. Homogeneity of scores reduces variability, and since there is a mathematical relationship between a correlation coefficient and variance, a low coefficient can be expected when score variability is low. Thus, some meaning can be attributed to statistically significant coefficients even though their absolute values are somewhat low.

From the data presented in Table 1, the following observations can be made:

1) None of the TTCT art-related variables were correlated with any of the science-related variables.

2) BI Scientific Creativity was positively correlated with BI Artistic Talent (r=.61), EQA Performing Arts (r=.29), EQA Writing Arts (r=.29), and the post-Rating (r=.42).

3) BI Scientific Creativity was also positively correlated with several personality factors, including Bright-B (r=.30), Assertive-E (r=.38, r=.27 for post-test), Imaginative-M (r=.46), Experimenting-Q1 (r=.24), and Self-sufficient-Q2 (r=.25).

4) EQA Science Activities was positively correlated with BI Artistic Talent (r=.52), EQA Visual Arts (r=.35), EQA Performing Arts (r=.57), EQA Writing Arts (r=.37), and the pre-Rating (r=.21).

5) EQA Science Activities was also positively correlated with personality factor Assertive-E (r=.31).

6) The pre and post performance ratings were positively correlated with the post test scores for personality factor Bright-B (r=.24 for pre-Rating, r=.38 for post-Rating).

7) Several intercorrelations existed between the various personality factors. Four of these factors were common to both science and art-related variables. Significant correlations of these common variables from the science-related listing related to the group of arts-related variables included Reserved-A with Expedient-G (r=.26) and with Imaginative-M (r=.35) and with Self-Sufficient-Q2 (r=.22); Bright-B with Assertive-E (r=.27) and with Imaginative-M (r=.23, .34) and with Self-sufficient-Q2 (r=.28); Expedient-G with Tender-minded-I (r=-.26) and with Experimenting-Q1 (r=.25, .31) and with Self-sufficient-Q2 (r=.24).

8) Other personality factor intercorrelations included Sober-F with Reserved-A (r=.24, .26, .27) and with Self-Sufficient-Q2 (r=.34, .24, .24); Self-assured-O with Experimenting-Q1 (r=.21) and with Self-sufficient-Q2 (r=-.27); Controlled-Q3 with Expedient-G (r=-.33, -.23, -.51) and with Experimenting-Q1 (r=-.23) and with Self-sufficient-Q2 (r=-.28).

In no way can causality be concluded from correlational data--it can only be inferred, and then only with caution, recognizing the limitations of this method of analysis. Thus it is with this study which had as its purpose the description of interrelationships between art education and science education variables. At least two generalizations can be made from observations of the data, however. First, positive relationships exist between certain art and science education constructs. Second, some affective factors seemingly appropriate to the development of artistic talent are related to some affective factors seemingly appropriate to the development of scientific skills.

The proto-theoretical position for the transdisciplinary integration of art education with science education appears to gain support from the data presented. Several assumptions can be generated:

I) Students involved in science activities are also involved in some art activities. Data from the BI and EQA biographical instruments showed significant intercorrelations between reported science involvement and

reported art activities.

2) Students involved in science activities and those identified as scientifically creative perform well in certain art areas. Data from both biographical instruments (BI and EQA) relating to science involvement illustrated significant correlations with instructor rating scores of artistic performance.

3) Certain personality factors affect art and science productivity. Occupational profiles of practicing professionals in the arts and sciences describe certain personality factors related to art and science productivity.

4) Art education activities can positively influence certain personality factors important to the sciences. Art personality factors Self-sufficient-Q2 and Reserved-A were positively related to science personality factor Sober-F. Art factors Expedient-G, Imaginative-M, and Self-sufficient-Q2 were positively related to science factor Reserved-A. Art factors Experimenting-Q1 and Self-sufficient-Q2 were positively related to science factor Expedient-G. Art factor Experimenting-Q1 was positively related to science factor Self-assured-O. Finally, art personality factors Assertive-E, Imaginative-M, and Self-sufficient-Q2 were positively related to science personality factor Bright-B. If one can further assume that certain curriculum activities can be designed to influence the development of certain personality factors appropriate to a given field, then art curricula which can be designed to affect given art personality factors might also affect given science personality factors.

5) Art education activities can negatively influence certain personality factors important to the sciences. Art personality factors Self-sufficient-Q2, Experimenting-Q1, and Expedient-G were negatively related to science personality factor Controlled-Q3. Art factor Self-sufficient-Q2 was negatively related to science factor Self-assured-O, and art factor Tender-minded-I was negatively related to science factor Expedient-G. Again, assuming that curricula can affect personality development, art curricula designed to

influence certain art personality factors could adversely affect certain science personality factors.

5. Significance.

The data are only descriptive and any assumptions identified are only conjectural. Caution is advised with this kind of "post-hoc data-snooping". First, the relationships identified are limited by the measurement instruments used. Also, some relationships may exist due to instrumentation and the method of assessment rather than due to naturally occurring relationships between cognitively-defined variables.

However, advances in science have been made and will continue to be made within the setting of synergistic and sometimes serindipitous activities of theory construction and evaluation. If great advances are to be made in all educational science, a more active interest in and real commitment to theoretical constructs must be demonstrated by educators. This paper has attempted to refocus one area of art and science instruction toward a theoretical setting in the anticipation that more significant and meaningful research will result. Much work remains to be completed for the validation of the assumptions stated. If art education activities can influence the development of certain affective and psychomotor skills required for better sciencing, then science instructional processes could become more efficient through the transdisciplinary integration of science and art.

TABLE 1.—Intercorrelations Between Nine Science-Related and Eighteen Art-Related Variables from PGSA Data.*

Art-Related Variables \ Science-Related Variables	BI Scientific Creativity	EQA Science Activities	16 PF Reserved/Outgoing (A)	16 PF Reserved/Outgoing**	16 PF Dull/Bright (B)	16 PF Dull/Bright**	16 PF Sober/Enthusiastic (F)	16 PF Sober/Enthusiastic**	16 PF Expedient/Conscientious (G)	16 PF Expedient/Conscientious**	16 PF Tough/Tender-minded (I)	16 PF Tough/Tender-minded**	16 PF Self-assured/Apprehensive (O)	16 PF Self-assured/Apprehensive**	16 PF Lax/Controlled (Q3)	16 PF Lax/Controlled**
BI Artistic Talent	61	52			26	23										
EQA Visual Arts		35														
EQA Performing Arts	29	57														
EQA Writing Arts	29	37														
TTCT Flexibility																
TTCT Flexibility**																
TTCT Originality																
TTCT Originality**																
TTCT Elaboration																
TTCT Elaboration**																
TTCT Fluency																
TTCT Fluency**																
pre-Rating		21				24										
post-Rating**	42					38										
16 PF Reserved/Outgoing (A)			—	40			24	26	26							
16 PF Reserved/Outgoing**			40	—				27								
16 PF Dull/Bright (B)	30				--											
16 PF Dull/Bright**						—										
16 PF Humble/Assertive (E)	38	31				27										
16 PF Humble/Assertive**	27															
16 PF Expedient/Conscientious (G)			26						—	40	26				33	
16 PF Expedient/Conscientious**									40	—					23	51
16 PF Tough/Tender-minded (I)									26		—					
16 PF Tough/Tender-minded**												—				
16 PF Practical/Imaginative (M)	46		-35		23											
16 PF Practical/Imaginative**						34										
16 PF Conservative/Experimenting (Q1)	24								-25	-31			-21			
16 PF Conservative/Experimenting**															-23	
16 PF Follower/Self-sufficient (Q2)	25		-22		28		-34	-24		-24			27		-28	
16 PF Follower/Self-sufficient**								-24								

* Decimals have been omitted for ease of reading. All values of r shown are significant at the .01 level of confidence, n=105.

** Data from post-tests.

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