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Student Cognitive Styles in Postsecondary Technology Programs

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Much of the published research on cognitive styles focuses on the differences in cognitive styles of students pursuing different majors in either a four year institution or a two year institution. For example, Witkin, et al. (1977) conducted a ten year longitudinal study in four year institutions which sought to determine if field dependence/independence was related to a student's (1) initial major choice (science, education, and other) and final degree major and (2) achievement in various major courses. The study determined that the selection of a major was influenced by cognitive styles and that students who initially selected majors that required a particular cognitive style which was different than their own were more likely to change to a major which complemented their cognitive style. The study also found a tendency for students to receive higher grades in fields that were compatible with their cognitive style.

Frank (1986) found that field dependence/independence of female education majors varied depending on the particular area of specialization within an education major (home economics, nursing, science, and special education). His results indicate that within an apparently homogeneous group characterized by a college major such as education, differences in cognitive styles may exist.

No research was found which assessed the cognitive styles of students pursuing technology majors and their specializations. When attempting to utilize cognitive styles research to improve instruction, educators should not assume that, within the field of technology, student cognitive styles are the same. Neither should they assume that the cognitive styles of students pursuing different technical specializations, such as electronics and mechanics, are different.

Technology teacher preparation programs continue to be arranged around the unit shop model (Clark, 1989). Brown (1993) suggests that technology educators acquire technical knowledge by taking technical courses: (1) exclusively in technology programs designed to prepare educators, (2) derived from

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industry oriented majors, i.e. industrial technology or engineering technology, and (3) which form a core of technical knowledge for both groups and then taking courses unique to education. An additional means for acquiring technical content not mentioned by Brown is to take the technical courses at the community college level and transferring the courses to a four year program. Assessing the cognitive styles of students solely within a four year teacher preparation program while neglecting the community colleges may not be an effective strategy for determining the cognitive styles of technology educators.

Cognitive Styles

Cognitive styles can generally be described as the manner in which information is acquired and processed. Cognitive style measures do not indicate the content of the information but simply how the brain perceives and processes the information. Cognitive styles can be described in a variety of ways, including hemispherical lateralization (left versus right brain), sequential or parallel processing, field dependence/independence, and spatial visualization. This study focused on only two of the cognitive style constructs: field dependence/independence and spatial visualization.

Field dependence represents the tendency to perceive and adhere to an existing, externally imposed framework while field independence represents the tendency to restructure perceived information into a different framework (McGee, 1979). The field dependence/independence construct is also associated with certain personality characteristics (Olstad, Juarez, Davenport, and Haury, 1981) which may have important instructional and learning ramifications. Field dependent individuals are considered to have a more social orientation than field independent persons since they are more likely to make use of externally developed social frameworks. They tend to seek out external referents for processing and structuring their information, are better at learning material with human content, are more readily influenced by the opinions of others, and are affected by the approval or disapproval of authority figures (Castaneda, Ramirez, and Herold, 1972).

Field independent individuals, on the other hand, are more capable of developing their own internal referents and are more capable of restructuring their knowledge, they do not require an imposed external structure to process their experiences. Field independent individuals tend to exhibit more individualistic behaviors since they are not in need of external referents to aide in the processing of information, are better at learning impersonal abstract material, are not easily influenced by others, and are not overly affected by the approval or disapproval of superiors (Frank, 1986; Rollock, 1992; Witkin et al., 1977).

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The construct of spatial abilities was originally investigated in connection with the study of mechanical aptitude in the 1920s. In addition to the many factor analysis studies that have been conducted since the mid 1920s, many predictive studies were conducted to assess the role of spatial abilities in predicting job success (Ghiselli, 1966, 1973; Smith, 1964) and course grades in vocational and technical education (Lichert and Quasha, 1970; Martin, 1951). Occupations which have a strong correlation with spatial visualization included auto mechanics, aircraft construction supervisors and inspectors, plumbers, machine operators, and managerial occupations (Ghiselli, 1973; Lichert and Quasha). Lichert and Quasha also found statistically significant correlation between spatial visualization abilities and grades in several vocational-technical education courses such as drafting, electricity, machine shop, and printing. Eisenberg and McGinty (1977) suggest that students with different spatial abilities enter different professions.

Spatial visualization is the ability to mentally rotate or manipulate a visual image (McGee, 1979). It involves the ability to recognize relevant visio-spatial information, retain the information, cognitively manipulate the information, and predict the final position of the visual image.

Purpose

The purpose of this study was to describe the field dependence/independence and spatial visualization skills of postsecondary students enrolled in technology programs, which provide opportunities for technology educators to acquire technical knowledge, specifically, an industrial technology program at the four year level and a vocational education program at the two year level. The study sought to determine: (1) if there were significant differences in cognitive styles of students with different ethnic origins, (2) if there were significant differences in the cognitive styles of four year industrial technology and two year vocational education students, (3) if there were significant differences in the cognitive styles of students specializing in a mechanical or an electrical field of study, (4) if there was a significant relationship between academic achievement and cognitive style, and (5) if students who had completed a significant number of their major courses had significantly different cognitive styles than did novice students in the major.

Methodology

Design and Instrumentation

A causal-comparative study with two response (dependent) variables and five research (independent) variables was established to compare the cognitive styles of students in different technology majors and specializations. The two response variables consisted of the field dependent/independent score provided

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by the Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin, and Karp, 1971) and the spatial visualization score Part VI, Spatial-Visualization (S-V), of the Guilford-Zimmerman Aptitude Survey (Guilford and Zimmerman, 1981).

The Group Embedded Figures Test is an 18 item instrument which requires the subject to identify a simple geometric shape in a complex figure. The instrument is visually oriented and requires reading for the instructions only. Subjects who correctly identify most of the simple figures are considered field independent while subjects who cannot identify the simple figure in the complex figure are considered field dependent.

The Spatial Visualization instrument is a 40 item test which requires the subject to mentally rotate a figure in a specified direction, magnitude, and sequence and determine its final resting position. This instrument is also visually oriented and requires reading only for the instructions. Students who correctly identify the final position of the object have higher spatial visualization skills than those who cannot.

Data Collection

The cognitive style instruments were administered to 95 industrial technology and vocational education students attending a central California university and the two community colleges which provided the largest number of transfer students to the university. At each of the instrument administration sessions, exact procedures were followed. Subjects were read, verbatim, the instructions provided by each of the instrument administration manuals. Practice problems provided in the administration manuals ensured comprehension of the directions. The subjects first completed the Group Embedded Figures Test and then the Spatial-Visualization test.

Data Analysis

The individual scores for the Group Embedded Figures Test and the Spa--tial Visualization test were used as the two dependent variables in a multivari--ate analysis of variance (MANOVA). A MANOVA was utilized since the cognitive style constructs of field dependence/independence and spatial visualization, even though they are highly correlated, may measure different constructs and that the joint analysis of the scores, rather than a series of one way analyses of variance, may provide additional insights into the cognitive style construct (Barker and Barker, 1984). A MANOVA essentially develops a synthetic variable (or vector) from the dependent variables. Thus, a single score or vector is used to represent the scores of multiple dependent variables. The means of the synthetic scores (sometimes referred to as centroids) are then analyzed for significant differences. In addition, the joint analysis of the cog

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nitive style scores may tend to stabilize the variances and could reveal significant differences between the groups when neither of the individual scores detect any differences (Barker and Barker).

The Group Embedded Figures Test and Spatial Visualization scores were jointly analyzed for a multivariate normal distribution and homogeneity of variance-covariance matrices. No violations of assumptions were detected. Significant multivariate differences ($p \leq .05$) were followed up with an analysis of variance utilizing Student-Neuman-Keuls (SNK) post hoc comparisons to determine which groups were significantly different. Effect size (η^2) was also calculated to indicate the relative strength of any significant group differences.

The low number of African American and American Indian (two) and female (two) students required a decision as to whether they should be combined into a single group for statistical purposes. Since a hypothesis of this study was to determine if ethnic origin mediates cognitive styles, it was decided that the consolidation of ethnic groups and male and female groups was not justifiable from a philosophical perspective (Ogbu, 1987). As a result, the ethnic groups of Asian, Hispanic, and White and males were the only groups utilized in the analyses. The other ethnic groups and female students were deleted from the sample.

Findings

Table 1 provides the means and standard deviations for the two cognitive style instruments grouped according to the research question under investigation. The GEFT and S-V had a maximum possible score of 18 and 40 respectively.

The cognitive style scores were first analyzed jointly with a multivariate analysis of variance. The results of the multivariate analyses of variance are provided in Table 2. The joint analysis of the cognitive style scores revealed significant differences between the groups based on ethnic origin, four or two year educational major, GPA, and novice/advanced standing. There were no significant differences in cognitive styles of students studying different technical fields and no interaction of educational origin and specialization.

The one-way analysis of variance of cognitive style scores (Table 3) based on ethnic origin revealed that the Asian and Hispanic groups had significantly different cognitive style scores than the White group (Table 1). The Asian and Hispanic groups were not significantly different from each other.

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Table 1
Cognitive Style Score Means and Standard Deviations by Hypothesis

		GEFT		S-V	
Variable	*n*	*M*	*SD*	*M*	*SD*
Entire Sample	87	10.15	5.81	13.01	9.62
1. Ethnic Origin					
Asian	15	6.93_a	5.16	6.03_a	7.55
Hispanic	24	8.13_a	5.21	8.21_a	6.75
White	48	12.17_b	5.56	17.59_b	9.01
2. Major					
Voc. Educ.	56	8.29	5.52	10.17	8.61
Indust. Tech.	31	13.52	4.76	18.14	9.33
3. Specialization					
Mechanical	49	9.51	5.41	11.37	8.73
Electrical	38	10.97	6.26	15.13	10.39
4. Major GPA	72	10.72	5.75	13.44	9.53
Below 2.0	23	7.83_a	5.47	8.09_a	7.62
2.0 to 3.0	24	10.58	5.07	14.30_b	9.67
Above 3.0	25	13.52_b	5.43	17.55_b	8.95
5. Novice/ Advanced	73	10.74	5.71	13.56	9.52
Below 31 units	43	10.19	5.82	11.25	8.53
Above 31 units	30	11.53	5.56	16.88	10.01

Note: Means with different subscripts in a column differ significantly at $p < 0.05$ by the Student-Neuman-Keuls test.

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Table 2
Multivariate Analysis of Variance for Cognitive Style Scores by Hypothesis

Effect	Multivariate Tests of Significance			
	T^2	Approximate *F*	Hyp. *df*	Error *df*
Ethnic Origin	0.41	8.33***	4	164
Major (M)	0.23	9.53***	2	82
Specialization (S)	0.02	0.70	2	82
M X S	0.00	0.01	2	82
Major GPA	0.26	4.32**	4	134
Novice/Advanced	0.11	3.81*	2	70

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Table 3
Analysis of Variance of Cognitive Style Scores and Ethnic Origin

Source	*df*	*SS*	*MS*	*F*	Effect Size
GEFT					
Ethnic Origin	2	448.83	224.42	7.69***	0.155
Error	84	2452.23	29.19		
Total	86	2901.06			
S-V					
Ethnic Origin	2	2076.14	1038.07	14.72***	0.244
Error	91	6425.29	70.61		
Total	93	8501.43			

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

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The one-way analysis of variance based on major GPA (Table 4) indicated that the GEFT only detected differences between the "below 2.0" and "above 3.0" group, while the S-V instrument detected significant differences between the "below 2.0" group and the "2.0 to 3.0" and "above 3.0" groups (Table 1). The "2.0 to 3.0" and "above 3.0" groups were not significantly different from each other.

Table 4
Analysis of Variance of Cognitive Style Scores and Major Grade-Point-Average

Source	*df*	*SS*	*MS*	*F*	Effect Size
GEFT					
GPA	2	389.07	194.53	6.86**	0.166
Error	69	1957.38	28.37		
Total	71	2346.44			
S-V					
GPA	2	1182.81	591.40	7.63***	0.169
Error	75	5814.40	77.53		
Total	77	6997.21			

$^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$.

The analysis of variance of the cognitive styles scores and the novice or advanced classification (Table 5) revealed that there was a significant difference between the groups for the Spatial Visualization instrument and not on the Group Embedded Figures Test.

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Table 5
Analysis of Variance of Cognitive Style Scores and Novice/Advanced Standing

Source	*df*	*SS*	*MS*	*F*	Effect Size
GEFT					
Novice/Advanced	1	32.08	32.08	0.98	
Error	71	2315.98	32.62		
Total	72	2348.05			
S-V					
Novice/Advanced	1	698.07	698.07	8.42**	0.162
Error	77	6382.62	82.89		
Total	78	7080.69			

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Discussion

The similarities in the results of the Group Embedded Figures Test and the Spatial Visualization test may be attributed to an order effect. In all cases, the GEFT was administered first and then followed with the spatial visualization test. The test sequence was established based on the perception that the GEFT was easier to complete than the S-V test. This may not have been true for the field dependent subjects. Replication of this study or studies that assess cognitive styles with multiple instruments should control for order effect.

The results of this study confirm the findings of a number of researchers regarding the differences in cognitive styles of ethnic minorities and white students (Castaneda, Ramirez, and Herold, 1972; Kagan and Zahn, 1975; Ramirez and Price-Williams, 1974). In most cases, these studies found that the ethnic minority students where more field dependent than the white students.

The administration procedures for both instruments includes several practice problems to ensure that the directions are understood. In particular, the GEFT includes seven problems that are administered at the beginning of the test to determine if the subject understood the directions. If these seven items were not completed correctly, the scores from these subjects were eliminated from the sample. The students who completed the seven control problems correctly appeared to have a sufficient level of English proficiency to complete the remaining portions of the test and, as a result, English language deficiencies do not appear to be the source of variation between the ethnic groups.

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The comparisons between groups based on ethnic origin indicated that the Hispanic and Asian groups were significantly more field dependent and had lower spatial visualization skills than the White group. The differences in cognitive styles due to ethnic diversity in the technology classroom introduces a learning factor which has, in all likelihood, been ignored by most faculty. This suggests that as postsecondary institutions experience shifts in ethnic diversity, instructors and students need to be aware of the different cognitive styles of the students. Faculty should recognize that their students' learning processes may have changed and that they need to determine how they can best assist the learning of their new students (Berthelot, 1982; Brodsky, 1991; Sinatra, 1983).

The relationship of cognitive style and major and specialization selection and achievement is an important issue since universities and colleges have undertaken major recruitment efforts seeking to increase minority and female student enrollment and retention in underrepresented programs, such as math, science, and technology. The newly recruited minority and female students may not, though, succeed in the program due to their cognitive styles. In fact, students may have originally preselected themselves out of a particular major or specialization due to past failures in courses that did not match their cognitive style strengths.

Pettigrew and Buell (1988) found that preservice and experienced teachers could not correctly diagnose the learning styles of their students. This suggests that instructors are not aware of differences in the ways in which students process information differently. Teacher educators, existing teachers, and new teachers should be informed of the potential differences in cognitive styles of their students and the ways by which they can facilitate the learning of their students.

The classification scheme used in this study grouped many ethnic subgroups into major categories such as Asian, Hispanic, and White. This was done to conform to the standard ethnic categories provided by the university. In retrospect, this was an error, since there may have been an extreme amount of heterogeneity within each major ethnic group (Knott, 1991; Ogbu, 1987) which could be attributed to factors such as culture. The classifying of Japanese Americans and Hmong immigrants into a single Asian group may not be justifiable with a student population that is possibly more culturally diverse than ethnically diverse.

Differences in student cognitive styles based on a four or two year major were found in this study. The findings of this hypothesis, the cognitive style differences between four and two year programs, were unexpected and introduce an additional variability factor into the technology classroom. Future technology teachers enter teacher education programs by enrollment in either a four year university or transferring from a two college to a four year university.

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The selection of a four or two year institution is based on a variety of factors such as location, cost, high school achievement, and SAT scores. One factor which has not been reported in the literature is the role of cognitive styles in determining enrollment in a four or two year institution. From an instructor's perspective, differences in cognitive style may come from differences due to culture and also differences in the educational origin of the student. Transfer students may have different cognitive styles than the students who began their educational endeavors in a four year institution.

Differences in cognitive styles do not indicate differences in learning ability or memory (Witkin, Moore, Goodenough, and Cox, 1977). Cognitive styles indicate the preferences an individual has for perceiving and processing information, not the ability to learn the material. Thus, students with equal learning abilities but different cognitive styles may experience different levels of success in the same environment. This suggests that the "screening" mechanisms of GPA and, potentially, SAT scores for enrollment in a four year institution may be preventing students with different cognitive styles from entering four year institutions.

The results of the comparisons of cognitive styles and specialization indicated that there were no significant differences in cognitive styles between students pursuing mechanical and electrical specializations.

The significant relationship of cognitive styles and academic achievement is interesting when one considers the importance of grades and continued enrollment in postsecondary programs. A review of the research involving field dependence/independence and spatial abilities of postsecondary students reveals that existing studies were conducted in either a two year or a four year college. None of the studies attempted to compare the spatial abilities of students studying identical specializations in four and two year programs. This is an interesting omission considering that a function of the two year college is to provide a path by which students can transfer to a four year college.

Students who start their postsecondary education in the two year programs and intend to transfer to a four year college may have a difficult transition due to the incongruities between their cognitive styles and the cognitive styles required to succeed in their new major. The findings that major grades and continued enrollment in a major are related to cognitive styles supports this concept.

Students who start a two year program and achieve success in the program, based on their existing cognitive style, will probably continue in the major. At the completion of the two year program the students may elect to continue their studies by transferring to a four year college. Once there, the students may find that they can no longer maintain the same level of academic performance and

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may drop-out of the four year program or change their majors to coincide with a more cognitively appropriate academic demand (Witkin et al., 1977).

Possible explanations for the differences in the spatial visualization skills of students based on the number of major units completed include attrition and a training effect. Attrition may occur when students with cognitive styles different than the cognitive style required in the major drop-out or change majors (Witkin et al., 1977). As a result, the student populations in a particular major become more homogeneous, reflecting a distinct cognitive style within the major or specialization.

A training effect may occur as students complete more of their major courses. Students who initially had cognitive styles different than the major requires may have adapted or trained themselves to process information more effectively. If this is true, it lends credence to the concept that students who are aware of their learning styles and how they can adapt their learning styles to the learning situation can achieve higher grades (Cook, 1989; Halpin and Peterson, 1986).

Holtzman, Goldsmith, and Barrera (1979) suggest that cognitive styles may become more important as the level of instruction increases. They suggest this as a possible explanation for the low enrollment of ethnic minorities in advanced level or graduate classes. Since this was not a longitudinal study, little can be ascertained about the source of the differences in cognitive styles between novice and advanced students. Both theories are plausible, although the attrition theory is supported by Witkin et al. (1977).

With the establishment of the relationships between cognitive styles, ethnic origin, grade-point averages, novice/advanced standing, and educational origin, students with diverse cultural and educational origins may hit a "cognitive style glass ceiling." Efforts to increase the ethnic diversity in many academic and occupational arenas will be limited since a four year degree is an essential entry-level requirement.

A consideration of the secondary student and the selection of a major or specialization is also germane to this issue. A current and popular emphasis in technical education at the secondary level is Tech Prep. Tech Prep is an innovative program designed to encourage secondary students who are not following a four year college preparation path to consider a technical career. This is accomplished by allowing selected two year college credit for technical courses taken at the secondary level.

Could it be that the two academic paths, college prep and Tech Prep, are determined by the cognitive styles of the students? Evidence to support this idea is the correlation between field dependence/independence and SAT scores (Witkin et al., 1977). Since SAT scores are a fundamental selection criteria by which students enter into a four year institution, secondary students with differ

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ent cognitive styles may be prevented from directly entering into a four year program. If this is true, cognitively diverse students may be prevented from obtaining a four year degree since they could not immediately enroll in a four year college because of their SAT scores and neither could they utilize the stepping stone of a two year college program to transfer to and complete a four year program. Attempts to eliminate the overt selection bias of ethnic origin in enrollment in postsecondary technology related four year programs may have been thwarted by a covert selection bias of cognitive styles.

Efforts to achieve diversity in education, and eventually the workplace, by enticing students into specific areas of technology may be destined to fail since they are not addressing the individual learning needs of the student, in fact, they may not be addressing the very reasons the students had preselected themselves out of the major. If attention to factors, such as cognitive styles, can improve the achievement of all students and the retention of underrepresented students in technology education programs technology educators must address the cognitive style differences of the learner in the instructional design process.

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