Cognitive Styles and Technology-Based Education

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This article discusses the elements and implications of cognitive style and a study of students in postsecondary industrial technology and vocational education programs that relates several areas where cognitive styles may influence instructional design. Technology education, industrial technology, industrial arts, and vocational education programs are some of the mechanisms by which secondary students gain an interest in pursuing a technology-oriented career. To some extent, each of these programs acts as a feeder for two- and four-year college programs. The selection of a career path often determines the type of college a student will enter. For example, a student interested in becoming an electronics technician may enter a two-year technical program while a student interested in designing electronic systems may enter a four-year program, such as engineering.

About Cognitive Styles

Witkin, Moore, Goodenough, and Cox (1977a), in their review of research concerning the cognitive style construct of field dependence/independence, indicated that educational-vocational choice has been consistently related to cognitive styles in the published research. They noted that field independent persons prefer careers without many interpersonal responsibilities while field dependent persons prefer careers with many interpersonal contacts. They also indicated that within broad-gauge career clusters, such as business or education, differences in cognitive styles are based on specific vocational choices, such as social studies teachers and industrial arts teachers. Little has been reported on the differences in cognitive styles between two- and four-year college students or on the cognitive styles of students who pursue different technical specializations.

During the instructional design process, cognitive style differences may not be considered when selecting instructional strategies (Rush & Moore, 1991). With the current emphasis on "learning to learn," it seems appropriate to assess the cognitive styles of students and allow students to take control of their learning processes.

Cognitive styles can be described as the manner in which information is acquired and processed. Cognitive style measures identify how the brain perceives and processes information, not the content of the information (Messick, 1979). Cognitive style constructs include spatial visualization, sequential or parallel processing, field dependence/independence, and hemispherical lateralization (left versus right brain) (Keefe, 1979). This study measured the field dependence/independence and hemispherical lateralization constructs.

When discussing differences in cognitive styles, it is important to remember that cognitive styles do not indicate differences in learning ability or memory. Cognitive styles indicate the preferences an individual has for perceiving and processing information. Exploiting the learner's preferred mode of processing information may lead to gains in learning and remembering (Witkin et al., 1977a).

Field Dependence/Independence

Persons who tend to adhere to an existing, externally imposed framework when presented with information are classified as field dependent while field independent persons tend to restructure the information into a framework that seems more appropriate (McGee, 1979). The field dependence/independence construct is also associated with certain personality characteristics (Olstad, Juarez, Davenport, & Haury, 1981), which may have important instructional and learning implications. Field dependent individuals are more likely to seek the opinions of others to establish a framework for an experience and, as a result, have a more social orientation than field independent persons. Field dependent persons 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, & Herold, 1972).

Field independent individuals develop their own internal referents and may restructure the information in ways that are not bound by the existing format. They do not require an imposed external structure to organize their experiences. Field independent individuals exhibit more individualistic behaviors, 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., 1977b).

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Educational Implications of Field Dependence/Independence

Witkin et al. (1977a) have elaborated several areas in which the role of field dependence/independence may have an effect on learning. The first area they mentioned is the learning of social material. In most cases, they found that field dependent persons are better at learning material that has a social context. Technology has always been focused on the meeting of human needs. Yet, within the classroom, instructors have concentrated on teaching the machines, tools, materials, and processes without an orientation to a social need. The inclusion of a human factor in the study of technology may help field dependent persons become more interested in technology.

Cooperative learning is a teaching strategy that has gained widespread approval and is supported by a significant body of research. Research should be conducted on the role of field dependence/independence and cooperative learning. In particular, since field dependent persons seek external sources for structuring information, are the group members providing that structure? If field independent persons prefer not to interact with others, are they less likely to gain from the cooperative learning experience?

A second area of concern identified by Witkin et al. (1977a) is the use of reinforcement and instructor approval in the classroom. Since field dependent persons seek outside referents to provide structure to their experiences, praise and reinforcement may be effective strategies for improving their achievement. Pucel (1989), in his performance-based instructional design model, included the identification and selection of the types of feedback an instructor should incorporate into the instructional experience. This step, the selection of the feedback procedures, may be more important to field dependent students than field independent students. Field independent students may find self-determined feedback sufficient while the field dependent student requires affirmation from the instructor.

Another important area in the role of field dependence/independence and learning may be in teaching problem-solving skills. One of the first steps in solving problems is to identify and structure the problem (Beatrice, 1995; Fogler & LeBlanc, 1995). Field independent persons may be more capable of restructuring the problem (approaching the problem from a different perspective) since they are not generally bound by the existing structure of the problem. Field independent persons may also be more adept at disembedding the relevant information and ignoring nonessential information. Restructuring and disembedding are both related to the cognitive style of field dependence/independence. When teaching problem solving, instructors should be aware that the performance they are evaluating may depend on the cognitive style of the student. Strategies for disembedding and restructuring information should be included in the problem-solving instruction.

Hemispherical Lateralization

Hemispherical lateralization refers to a learner's natural preference for right or left brain information processing. In most cases, both sides of the brain are involved in a learning activity, but one side usually dominates or is responsible for final decision making (Miller, 1986). Left hemisphere functions include the control of the right side of the body, written and spoken language, numerical operations, deductive logic, sequential processing, and analytical and rational analysis. The right hemisphere functions include the control of the left side of the body, visual/spatial skills, parallel processing, perceptual thinking, intuitive decision making, inductive logic, and gestalt or the viewing of the whole situation (Miller, 1986; Torrance, Taggart, & Taggart, 1984).

Educational Implications of Hemispherical Lateralization

The construct of cerebral hemisphericity has been criticized by neuroscientists because of its use of broadly defined terms, such as rational thinking, intuitive, creative, and analytical. These thought processes are considered difficult to localize to a particular cerebral hemisphere. There is general agreement that a person does not think with only one side of the brain (Hellige, 1993). Hellige stated that the construct of hemisphericity is difficult to support since many cognitive operations cannot be localized to a single part of the brain. In most tasks, cognitive processing occurs in both hemispheres and, as a result, a preference for processing information on only one side of the brain is not supported. Thus, descriptions of students as right or left brain should be interpreted with a great deal of caution.

Cognitive Styles, Ethnic Origin, and Learning

The discussion of the role of ethnicity and culture on learning is prone to misinterpretation because of the different frameworks from which the interpretations are analyzed (Bacon & Carter, 1991). Cole and Bruner (1971) suggested two frameworks from which ethnic and cultural differences in intellectual achievement can be analyzed. The first framework utilizes a deficit interpretation. The deficit interpretation arises when one assumes that a particular culture or viewpoint is the correct position and differences between the "correct" position and the divergent position must be reduced or eliminated. For example, if one assumes the Western model of learning and tries to modify an ethnically or culturally different model of learning to conform to the Western model, one has utilized a deficit interpretation of cultural differences.

The second framework is referred to as the difference interpretation and recognizes that differences between cultures exist and that efficient learning can occur within all cultures. The difference interpretation recognizes that there are different but equally valid interpretations of the world.

These misunderstandings can also occur when discussing occupations or career choices and cognitive styles. In numerous presentations the author has made concerning this subject, the concept is always mentioned that maybe there is, or ought to be, an academic or occupationally specific cognitive style. It is suggested that students who do not have the "required" cognitive style should select another major or career. This reaction is an example of a deficit interpretation of differences in cognitive styles. The difference interpretation understands the differences in students' cognitive styles and attempts to maximize their learning by understanding the differences. The ultimate objective is to enhance the learning of all students through their individual differences, not to pre-select students out of particular occupations.

ADDITIONAL IMPLICATIONS

Schmeck (1988) suggested that there are two approaches to improving education through the use of learning styles. Learning styles, in most cases, are more comprehensive and incorporate cognitive, physiological, and affective preferences (Keefe & Monk, 1988). The first approach mentioned by Schmeck, which has been the subject of much research, utilizes the instructor's ability to adapt the learning situation to coincide with the learning styles of the students. Some studies have indicated that when students are taught through their preferred learning style their achievement improves (Sinatra, 1983).

The second approach attempts to enhance the learning style of the student to match that of the instructional style being used. This occurs through deliberate efforts to restructure the student's learning style by replacing the existing learning style with another. This restructuring is under the control and direction of the instructor.

Matching of learning styles and instructional styles can also be accomplished by providing the student with a larger repertoire of learning styles. Faced with a different learning situation, students apply the appropriate learning strategy to maximize their learning (Rush & Moore, 1991). The student has learned strategies for learning, or has learned how to learn.

The approaches can be summarized as (a) attempts to change the learning setting, which is instructor controlled, and (b) attempts to change the student, which could be either instructor controlled or learner controlled. In a classroom setting, where diverse learning styles can be found and cannot be controlled, attempts to change the learning environment would require considerable effort on the part of the instructor.

Frank (1986) raised the issue of whether students and teachers should be matched based on the cognitive styles. He stated:

> It is possible that a self-perpetuating situation currently exists in which teachers in a given academic area are representative of a particular cognitive style and thus treat field independent or field dependent students in discriminating ways that may encourage them to choose or avoid certain areas of study. (p. 21)

Matching students and instructors based on cognitive style, while of significant theoretical importance, may be of limited practical importance. Attempts to teach the same material through different instructional styles in a single classroom that address the learning needs of most of the students in the classroom may not be feasible since few instructors have the time to develop and present the same material in different ways. An important exception to the matching of instructional styles and cognitive styles is with at-risk students who need immediate success in their courses as an incentive for continuing their studies (Dunn, 1990).

Augmenting the availability of learning styles to a student appears to be a more realistic choice when one considers the variables in the postsecondary classroom and the individual needs of the student. This concept is particularly true when considering the massive amount of training that would be required to effectively educate existing faculty about the differences in student learning styles.

Providing alternative learning strategies has an additional long-term advantage. From the perspective of student autonomy, providing students with an understanding of their own cognitive styles and the ability to use alternative learning strategies would allow them to maximize their learning in whatever situation they may find themselves. They will have learned how to adapt their learning to the immediate situation. Students will have learned how to learn.

Gains may be made in student achievement and retention if the students are aware of their particular learning style and recognize their natural preferences for perceiving and processing information. With this knowledge, students could adapt their learning strategies to those that are more congruent with the learning situation (Rabianski-Carriuolo, 1989).

THE STUDY SET-UP

The following questions formed the study's framework: Are there significant differences in the cognitive styles of four-year industrial technology students and two-year vocational education students? Are there significant differences in the cognitive styles of students specializing in a mechanical or an electrical field of study? Is there a significant relationship between academic achievement and cognitive style? Is there a significant difference in cognitive styles between advanced students and novice students? Is there a significant difference in the cognitive styles of students with different ethnic origins?

This expost facto study assessed the field dependence/independence and hemispherical lateralization of postsecondary technology students. The scores on the cognitive style instruments were treated as the dependent variables with the five research questions serving as the independent variables. The two dependent variables consisted of the field dependent/independent score provided by the Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin, & Karp, 1971) and the hemispherical lateralization score from the Human Information Processing Survey (HIPS) (Torrance et al., 1984).

The GEFT is an 18-item paper and pencil instrument that requires the subject to identify a simple geometric shape in a complex geometric shape. The instrument is visually oriented and requires little reading. Subjects who 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 HIPS is a 40-item forced choice, paper and pencil test that assesses which side of the brain the respondent tends to utilize. The test items require the student to select which statement most closely describes the student. The choices reflect a left, right, or integrated hemispherical dominance. The scoring procedures classify the individual as being left dominant, right dominant, integrated, or mixed. A left dominant person is generally considered rational; a right dominant person is considered intuitive; an integrated person who utilizes both hemispheres, left and right, to solve problems is considered both rational and intuitive; and a mixed learner who is capable of utilizing either hemisphere to solve problems is considered either rational or intuitive (Taggart, Kroeck, & Escoffier, 1991).

The cognitive style instruments were administered to 101 vocational education and industrial technology students attending a four-year university and two community colleges. The industrial technology students were enrolled in a single four-year university. Two community colleges that provided the largest number of transfer students to the university were selected. One community college provided the mechanical specialization while the second community college provided the electrical specialization. All participants volunteered for the study.

At each of the instrument administration sessions, exact procedures were followed. The investigator 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 GEFT and then the HIPS.

Handling the Data

An analysis of variance (ANOVA) was conducted to determine if there were any significant differences between the groups based on each of the research questions. Major, specialization, and ethnic origin were analyzed with a 2 X 2 X 3 research design. Major grade point average (GPA) and novice or advanced standing were not included in the factorial analysis since several of the groups had cells with no subjects, which would suppress higher order interaction effects. These variables were subjected to a one-way ANOVA. Significant differences ($\alpha \leq .05$) 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 HIPS classifies subjects as either left, right, integrated, or mixed hemisphere dominant. Since this dependent variable is categorical in nature, a chi-square analysis was conducted for each of the research questions.

Seven of the subjects completed the GEFT instrument incorrectly and were not included in the analyses. Since only two African American, two American Indian, and two female students participated in the study, a decision as to whether they should be combined into a single group for statistical purposes was required. 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 (Ogbu, 1987). As a result, the ethnic groups of Asian, Hispanic, and White and males were the only groups utilized in the analyses. One respondent provided incomplete demographic information and was not included in the analysis. The final sample size was 87 students.

First semester students were not included in the analyses for the major GPA and the novice/advanced classification schemes since a major grade point average had not been established.

Table 1 provides a summary of the means and standard deviations for the GEFT scores grouped according to the research question under investigation.

The 2 X 2 X 3 factorial analysis (Table 2) indicated that there were significant main effects for the major and ethnic origin variables and a significant interaction between specialization and ethnic origin. The effect size was relatively small for all significant comparisons.

Figure 1 depicts the interaction of the specializations and ethnic origin with the major separated for clarity purposes. It appears that the interaction effects are due to the low GEFT scores of the Asian students in the electrical specialization. The Asian GEFT low scores were found in both the vocational education and the industrial technology majors.

Table 1

GEFT Means and Standard Deviations

Variable		GEFT Score	
	n	*M*	*SD*
Entire Sample	87	10.15	5.81
Ethnic Origin			
Asian	15	6.93_a	5.16
Hispanic	24	8.13_a	5.21
White	48	12.17_b	5.56
Major			
Vocational Education	56	8.29_a	5.52
Industrial Technology	31	13.52_b	4.76
Specialization			
Mechanical	49	9.51	5.41
Electrical	38	10.97	6.26
Major GPA			
Below 2.0	9	6.44_a	5.34
2.0 to 2.9	24	9.83	5.37
Above 2.9	39	12.26_b	5.57
Novice/Advanced			
Below 30 units	43	10.19	5.82
Above 31 units	30	11.53	5.56

Note: Means with different subscripts differ significantly at $p \leq .05$ by the Student-Neuman-Keuls test.

The SNK post hoc analysis results of the ethnic origin and GEFT scores are provided in Table 3. The analysis revealed that the Asian and the Hispanic groups were not significantly different from each other. The Asian and Hispanic groups were significantly different, though, from the White group (Table 1).

The one-way ANOVA based on major GPA (Table 4) indicated that the GEFT only detected differences between the "below 2.0" and "above 2.9" groups. The "2.0 to 2.9" and "above 2.9" groups were not significantly different from each other (Table 1).

The ANOVA of the GEFT scores and the novice or advanced classification (Table 5) revealed that there was no significant difference between the groups based on the GEFT scores.

The cross classification of the research questions and the HIPS results are summarized in Table 6. The chi-square analysis revealed significant differences in the observed and expected frequencies for the major and specialization variables. The cross classification tables (Tables 7 and 8) provide the observed and expected cell frequencies. For the major research variable, it appears that there were fewer right hemisphere dominant vocational education students than expected ($f = 5$, $f_e = 10$) and more mixed hemisphere students ($f = 34$, $f_e = 29$). The opposite is true for the industrial technology students. There were more right hemisphere students than expected ($f = 11$, $f_e = 6$) and fewer mixed students ($f = 11$, $f_e = 16$). For the specialization variable, it appears that there were fewer integrated mechanical students ($f = 2$, $f_e = 6$) and fewer mixed mechanical students than expected ($f = 28$, $f_e = 25$). There were also more integrated electrical students than expected ($f = 9$, $f_e = 5$).

Differences in student cognitive styles based on a two- or four-year major were found in this study. In particular, the study found that the two-year vocational education majors were more field dependent and had different hemispherical dominance than the four-year industrial technology group. The findings of this hypothesis, the cognitive style differences between two- and four-year technology-based programs, introduce an additional variability factor into the university technology classroom. The results of this study indicate that cognitive style differences in the classroom may come from 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.

Table 2

Analysis of Variance of GEFT Scores

Source	*df*	*SS*	*MS*	*F*	Effect Size
Major (M)	1	194.23	194.23	5.80 ***	0.067
Specialization (S)	1	3.44	3.44	0.15	0.001
Ethnic Origin (E)	2	263.74	131.87	5.71**	0.091
MXS	1	12.87	12.87	0.56	0.004
MXE	2	20.12	10.06	0.44	0.007
SXE	2	162.14	81.07	3.51*	0.056
MXSXE	2	21.59	10.79	0.47	0.007
Residual	75	1732.49	23.10		
Total	86	2901.06	33.73		

*$p < .05$; **$p < .01$; ***$p < .001$

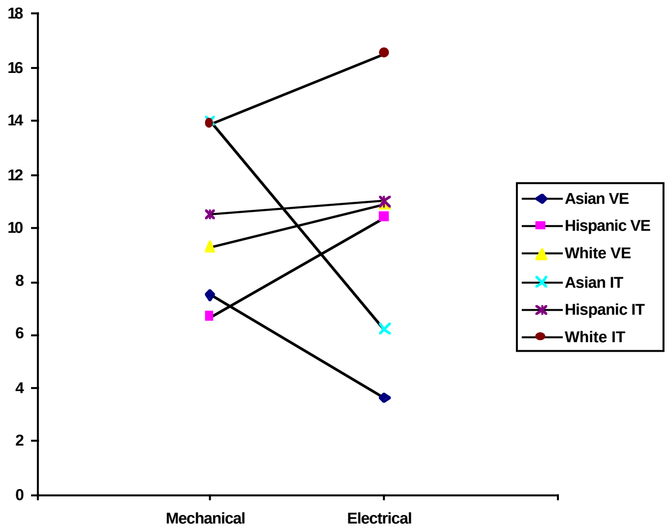

Figure 1. **Interaction Effects of Specialization and Ethnic Origin**

Table 3

Analysis of Variance of GEFT Scores and Ethnic Origin

Source	*df*	*SS*	*MS*	*F*	Effect Size
Ethnic Origin	2	448.83	224.42	7.69***	0.155
Error	84	2452.23	29.19		
Total	86	2901.06			

*$p < .05$; **$p < .01$; ***$p < .001$

Table 4

Analysis of Variance of GEFT Scores and Major Grade Point Average

Source	*df*	*SS*	*MS*	*F*	Effect Size
GPA	2	389.07	194.53	6.86**	0.166
Error	69	1957.38	28.37		
Total	71	2346.44			

*$p < .05$; **$p < .01$; ***$p < .001$

Table 5

Analysis of Variance of GEFT Scores and Novice/Advanced Standing

Source	*df*	*SS*	*MS*	*F*	Effect Size
Novice/Advanced	1	32.08	32.08	0.98	--
Error	71	2315.98	32.62		
Total	72	2348.05			

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 6

Summary of Human Information Processing Survey Results

Variable	*df*	X^2
Ethnic Origin	6	6.32
Major	3	10.57**
Specialization	3	8.20*
Major GPA	9	7.61
Novice/Advanced	6	6.22

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 7

Cross Classification by Major and Hemisphericity (Expected Frequencies)

	Hemisphere				
Major	**Left**	**Integ.**	**Right**	**Mixed**	**Total**
Vocational Education	9	8	5	34	56
	(10)	(7)	(10)	(29)	
Industrial Technology	6	3	11	11	31
	(5)	(4)	(6)	(16)	
Total	15	11	16	45	87

Note: $X^2 = 10.57$; $p = .014$.

Table 8

Cross Classification by Specialization and Hemisphericity (Expected Frequencies)

	Hemisphere				
Specialization	**Left**	**Integ.**	**Right**	**Mixed**	**Total**
Mechanical	8	2	11	28	49
	(8)	(6)	(9)	(25)	
Electrical	7	9	5	17	38
	(7)	(5)	(7)	(20)	
Total	15	11	16	45	87

Note: $X^2 - 2.80$; $p = .042$.

A review of the research involving field dependence/independence of postsecondary students revealed that existing studies were conducted in either a two-year or a four-year college. None of the studies attempted to compare the cognitive styles of students studying a common specialization between two- and four-year programs. Students who start their postsecondary education in the two-year technical 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 (Witkin et al., 1977b).

The results of the comparisons of cognitive styles and specialization indicated that there were no significant differences in field dependence/independence but that there were significant differences based on the hemispherical dominance of the students pursuing mechanical and electrical specializations. Due to the number and diversity of constructs included under the term *cognitive styles*, it is possible to find significant differences on one cognitive style measure and not on another. These results indicate the importance of not defining cognitive styles by one construct or measure.

The significant relationship of cognitive styles and academic achievement in a major confirms Witkin et al.'s (1977a) study and is interesting when one considers the importance of grades and continued enrollment in postsecondary programs. Further studies should be conducted to see if students with different cognitive styles do, in fact, achieve higher grades when taught by an instructor with a similar cognitive style.

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, & Herold, 1972; Kagan & Zahn, 1975; Ramirez & Price-Williams, 1974). The comparisons between groups based on ethnic origin indicated that the Hispanic and Asian groups were significantly more field dependent than the White group.

The classification scheme used in this study grouped many ethnic subgroups into major categories such as Asian, Hispanic, and White. In retrospect, this was an error, since there may be an extreme amount of heterogeneity within each major ethnic group (Knott, 1991; Ogbu, 1987) that could be attributed to culture and not ethnic origin. Differences found in this study between ethnic groups may be attributed to culture and not ethnicity.

Learning differences due to cultural diversity in the technology classroom introduces an additional learning factor that has, in all likelihood, been ignored by most faculty. Pettigrew and Buell (1988) found that preservice and experienced teachers could not correctly diagnose the learning styles of their students. Instructors may not be aware of the differences in the ways in which students process information. 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. As institutions experience shifts in cultural diversity, instructors need to be aware of the different cognitive styles and how they might impact learning. Difficulties in specific courses may be related to the difference between student cognitive styles and the instructional strategies used in the class. Faculty should recognize that they can no longer generalize about the learning processes and that they need to determine how they can best assist the learning of all students (Berthelot, 1982; Brodsky, 1991; Sinatra, 1983).

An analysis of the HIPS results indicated that only 35% of the students could be classified as having either a left or right brain approach to processing information. Almost 65% of the students in this study were classified as having a mixed or integrated approach to information processing. These results suggest that the instrument or the construct may not be an important tool for describing the cognitive styles of students. Discussions with educators about cognitive styles invariably revert to left-brain/right-brain descriptions of students. The results of this study indicate that categorizing students in this way is inappropriate and, quite frankly, wrong.

Although this study concentrated on the differences between various groups based on the research questions, a description of the information processing tactics utilized by students in vocational education and industrial technology programs may be informative. The purpose of Table 9 is to describe the varieties of instructional preferences found in this study.

Ten of the questions on the HIPS can be utilized to develop a "tactics profile" for each student. Based on the responses to the 10 items, a profile of the subject's preferences in information processing is identified. The aggregate tactics profile percentages are presented in Table 9. Each of the tactics has a bipolar construct with an intermediate range identified as an integrated tactic. For tactic two, for example, 50% of the vocational education students sampled preferred structured assignments, 23% preferred integrated assignments, and 27%

Table 9

Descriptive Summary of Student Information Processing Tactics

	Major*			Major*			Major*	
LEFT HEMISPHERE	**VE**	**IT**	**INTEGRATED**	**VE**	**IT**	**RIGHT HEMISPHERE**	**VE**	**IT**
Conforming	32	52	Integrated	52	42	Nonconforming	16	6
Structured assignments	50	58	Integrated	23	16	Open-ended assignment	27	26
Discover systematically	35	42	Integrated	20	10	Discover via exploration	46	48
Recall verbal material	26	16	Integrated	46	26	Recall spatial material	29	58
Look for specific facts	42	42	Integrated	51	39	Look for main ideas	7	19
Sequence ideas	16	13	Integrated	38	45	Show relationships	46	42
Outline	26	36	Integrated	47	23	Summarize	27	42
Draw conclusions	18	29	Integrated	54	39	Produce ideas	29	32
Logical problem solving	41	42	Integrated	46	39	Intuitive problem solving	13	19
Improve something	20	13	Integrated	57	55	Invent something	23	32

*Reported as percentage of vocational education or industrial technology students.

preferred open-ended assignments.

With knowledge such as this, the instructor can provide a variety of instructional experiences. Instructors should also guide students in the process of completing the assignment. For example, 58% of the industrial technology students preferred structured assignments. Assigning an open-ended lab assignment may lead to high anxiety levels and frustration on the part of the majority of students in this class if they are not provided strategies for completing an open-ended assignment. On the other hand, the 26% of students who prefer open-ended assignments may be bored when a highly structured assignment is given. Thus, a variety of assignments accompanied with instructions on how to adapt to a new learning situation may provide for higher achievement in the technology classroom.

In the field of manufacturing, great gains were made in productivity with the implementation of time and motion studies. Time and motion analysis divides each task into a series of motions that consume a certain amount of time. Reducing the number of motions or changing the types of motions allowed for increases in worker efficiency. To some extent, the effects of time and motion improvements on the human worker were ignored. In other words, the source of variability in the production process, the worker, was minimized without consideration of the effects of the minimization techniques on the worker. As a result, the quality of work life decreased and product quality suffered. With the advent of continuous improvement, manufacturers discovered that workers could take a more proactive role in the production process if they were trained and given the responsibility for the process.

Instructional designers had, essentially, adopted the same methods for identifying instructional objectives. Each function or task was broken down into individual components. Teaching the individual components was the focus of instruction. Little attention was paid, in the instructional design process, to the source of variability in learning, the student. Manufacturers learned that ignoring the source of variability on the factory floor affected the quality of the final product. Instructors and instructional designers should learn from this—that ignoring the source of variability in the classroom will have a negative effect on the quality of the final product. If factors such as cognitive styles can positively affect learning, technology educators should not ignore these differences in their students.

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