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AUTHOR	Zhang, Zhicheng; RiCharde, R. Stephen	
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ABSTRACT

A study was conducted to examine the validity of the Learning-Thinking Style Inventory (LTSI) and to investigate the learning and thinking styles of college students in relation to their major and academic performance. Generated out of the framework of personality model and information processing theory, the 49-item LTSI embraces a broad spectrum of learning-thinking styles including perceptual modality preference, distractibility, metacognition, and analytic-global tendency. The construct validity of the instrument was supported by the congruence between the four subscales and the four-factor structure generated and verified by confirmatory factor analysis using the LISREL computer program. A 3x3 multivariate analysis of variance conducted on the data from 243 college students revealed significant main effects for major and academic performance on students' learning and thinking styles. Further analyses showed that liberal arts students and engineering students differed in their perceptual modalities. Students with higher cumulative grade point averages demonstrated a higher degree of metacognition and lower degree of distractibility in comparison with their peers. Implications for higher education are discussed. (Contains 7 tables and 30 references.) (Author/SLD)

Learning-Thinking Style Inventory: LISREL and Multivariate Analyses

Zhicheng Zhang

R. Stephen RiCharde

Virginia Military Institute

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the American Educational Research Association
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Abstract

The study has two purposes: examine the validity of the Learning-Thinking Style Inventory (LTSI) and investigate college students' learning and thinking styles in relation to their major and academic performance. Generated out of the framework of personality model and information processing theory model, the 49-item LTSI embraces a broad spectrum of learning-thinking styles including perceptual modality preference, distractibility, metacognition, and analytic-global tendency. The construct validity of the instrument was supported by the congruence between the 4 subscales and the 4-factor structure generated and verified by confirmatory factor analysis using LISREL. A 3x3 MANOVA conducted on the data from 243 college students revealed significant main effects for major ($p < .05$) and academic performance ($p < .01$) on students' learning and thinking styles. Further analyses showed that liberal arts students and engineering students differed in their preferred perceptual modalities; students with higher cumulative GPA demonstrated a higher degree of metacognition and lower degree of distractibility in comparison with their peers. Implication for higher education is discussed.

Learning-Thinking Style Inventory: LISREL and Multivariate Analyses

Introduction

learning styles have been defined as information-processing habits which represent the learner's typical modes of perceiving, thinking, remembering, and problem solving (Messick, 1970). As cognitive, affective, and physiological traits, learning styles serve as relatively stable indictors of how learners perceive, interact with, and respond to the learning environment (Keefe, 1982).

The concept of learning style has been used interchangeably with cognitive style, perceptual style, and learning modalities, and it has unique characteristics that sets it apart from ability, achievement, performance or productivity. Ehrhardt (1983) summarized these characteristics as the following:

1. Cognitive style is a preference for learning. Individual learning styles are identifiable.
2. Cognitive style is value free.
3. Cognitive style is stable throughout life.

Learning styles have captured much attention from researchers in the past few years. A number of stylistic models have been proposed and different instruments have been used to investigate learning styles either from a theoretical perspective (e.g., Ehrhardt, 1983; Kirby, Moore, & Schofield, 1988; Widiger, Knudson, & Rorer, 1980; Wtkin, 1976) or in relation to college major (e.g., Murrell & Claxton,1987), achievement (e.g., Blagg, 1985; Dunn, Beaudry, & Klavas, 1989; Smith & Holliday, 1986) or instructional styles (e.g., Doyle & Rutherford, 1984).

The present study seeks to expand research on learning styles by introducing a more comprehensive measure that utilizes objective techniques. The factorial validity of the instrument was examined using LISREL. The instrument was then used in a MANOVA design to investigate college students' learning styles in relation to their major and academic performance.

Literature Review

Research on learning styles has centered around a few dominant models. Among the most popular are the personality model, the information-processing model, and the social-interaction model.

Field dependence-independence, first advanced by Witkin (1976), is a popular measurement approach to learning style within the framework of the personality model. Measures of field dependence-independence such as the Group Embedded Figures Test (GEFT) focus on two principal styles: the articulative and the global. The articulative style, also called analytic style, involves the separation of figure from ground. Field-independent people perceive embedded objects without being influenced by the surrounding field. Field-dependent people are heavily influenced by the surrounding field. A low score on the test is interpreted as being due to the possession of a global style.

Field dependents and field independents differ not only in their perceptual ability in academic settings but also in social interaction. Field-dependent people predominantly use external cues for the structure of information and they demonstrate better social skills than field-independent people. Field-independent people use internal cues when making judgments on perceptual tasks. In academic settings, field-dependent students favor areas that involve extensive interpersonal relations such as the social sciences, humanities, counseling, teaching, and sales. Field-independent students prefer areas of study that require analytic skills such as mathematics, engineering, and science (Witkin, 1976).

The research on the field dependence-independence dichotomy was extended by Widiger, Knudson, and Rorer (1980) when they claimed that the GEFT was convergent with ability measures and not with stylistic ones, thus concluding that the GEFT was a measure of ability rather than cognitive style. Their study also emphasized the link between the field dependence-independence distinction and the analytic-global distinction. The Stimuli Grouping Test (SGT) used in their study uses similar stimuli to generate two scores one on analytic tendency and the other on global tendency. The analytic style focuses on details whereas the synthetic or the global style involves the tendency to create wholes out of stimuli through the integration of parts. An individual's learning style, either analytic or global, regulates his/her way of perceiving and processing information.

A major component of the information-processing model is Kolb's (1984) experiential learning cycle. Kolb describes learning as a four-step process through which the learner progresses from concrete experience to reflective observations, abstract conceptualization, and active experimentation. Based on the way experience is grasped and transformed, people can be classified into four categories: (1) divergers who grasp the experience through concrete experience and transform it through reflective observation, (2) assimilators who grasp the experience through abstract conceptualization and transform it through reflective observation, (3) convergers who grasp the experience through abstract conceptualization and transform it through active experimentation, and (4) accommodators who grasp the experience through concrete experience and transform it through active experimentation.

Kolb (1981a) developed the Learning Style Inventory (LSI) based on his experiential learning model. Research using Kolb's LSI suggests that learning styles interact with college majors (Kolb, 1981b) and that college students move from a reliance upon concrete experience to greater use of abstract conceptualization as they progress through college (Mentkowski & Strait, 1983).

Metacognition is another component in the information-processing model. Metacognition refers to the ability to monitor, evaluate, and reflect upon one's own behavior. Effective learning requires metacognitive knowledge about people, tasks, and strategies. In solving a problem, metacognition is used in planning and applying strategies, monitoring progress, and evaluating results. Thus, metacognition is often interwoven with other cognitive activities such as problem solving and task analysis. Due to the complex nature of metacognition, the objective assessment of metacognition is scarce in literature on learning styles.

Assessment of perceptual-modality preference constitutes another focus in information-processing research. Research indicates that people show preference for different modalities when perceiving stimuli (Ormrod, 1995). The commonly identified perceptual modalities are verbal, visual, auditory, and kinesthetic. In one study on the strength of perceptual modalities, subjects were asked to replicate the sequences of fixed shapes following visual, auditory, and tactile presentation. Relative strengths in each modality were expressed as percentages of the total number of correctly identified sequences. The researchers concluded that these recognition abilities varied with age. As children grow older, they also experience a decrease in distractibility (Ormrod, 1995). The research on perceptual modality has both theoretical and practical implications for teaching and learning.

The social-interaction model focuses on external factors such as instructional style of the teacher and classroom environment. The Learning Style Inventory (LSI) (Dunn, Dunn, & Price, 178), for example, provides a profile of environmental preferences (sound, light, temperature), sociological preferences (self-, peer-, or authority-oriented), and physical needs (time of day, intake, mobility, perceptual modality). Smith & Holliday's (1986) study using Dunn, Dunn, and Price's LSI suggests that high achievers in elementary school were independent and responsible students who benefit from self-directed tasks whereas low achievers benefit from more structured school schedules. The Grasha-Riechmann Learning Styles Inventory (GRLSI) (1996) is another instrument in the social-interaction model. The GRLSI measures college students' instructional preference.

Can cognitive and learning styles be used as predictors of academic success? Research has produced inconsistent results. Blagg's (1985) study with 51 graduate students in a health program concluded that there were no significant relationships between academic success and the cognitive-style variables. Kirby, Moore, and Schofield's study (1988) did suggest, however, that verbal learning style is correlated with verbal ability and the visual learning style is correlated with spatial visualization.

One problem with the current literature is that most studies were limited to one aspect of learning style. A comprehensive measure of learning styles is not readily available. Moreover, thinking and problem-solving approaches, two important components in Messick's (1970) definition of learning styles, were absent from most measures of learning styles. The current literature does not provide an abundance of objective measures of metacognition and problem-solving strategies. The present study strives to overcome these limitations by using the Learning-Thinking Style Inventory (LTSI) which embraces a broad spectrum of learning-thinking styles within the framework of personality and the information-processing models.

Methodology

Sample

Data were collected from 243 first class men (seniors) at Virginia Military Institute (VMI) in April 1996. Since VMI is an all-male college, the sample was made up of only male students. Sixty-two percent of the cadets came from Virginia; 31% had out-of-state residence status; and the remaining cadets did not reveal their residence status. Approximately 82% of the participants were white; 5% were black; 3% were Asian; less than 1% were Hispanic; and 2% were non-resident alien. Thirty percent of the cadets majored in engineering (civil, mechanical, and electrical); 16.8% had a science major (biology, chemistry, computer science, math, and physics); and 48.6% majored in liberal arts (history, English, international studies, and economics). The average age of participants was 22. In addition, data from 291 freshmen in the class of 2000 were used to calculate test-retest reliability for the LTSI.

Instrumentation

The LTSI (RiCharde, 1992) is a 49-item instrument designed to investigate learning and thinking styles in academic settings. Since its first appearance in 1991, the instrument has gone through different phases of change. The current version of the instrument consists of four subscales: (1) perceptual modality preference (auditory, visual, kinesthetic, and reading), (2) distractibility, (3) metacognition (logical reasoning, logic metacognition, problem-solving approach), and (4) analytic-global tendency. Subscale II contains bipolar statements, thus results in dichotomous data. Subscales I, III, and IV contain multiple-choice items, generating continuous data. Subscale III consists of seven sets of multiple-choice items with three items in each set. The first item involves logic reasoning; the second item requires the respondent to estimate his probability of selecting the correct answer for the first item; the third item concerns the strategy the respondent uses in solving the problem presented in the first item. The focus of this section is on assessing metacognition as reflected in the evaluation of one's cognitive behavior and problem-solving strategies.

The inclusion of metacognition signifies a major contribution that the LTSI may make to the learning-style literature. What makes it unique is the objective measurement technique used in section III where respondents need to demonstrate rather than report their metacognitive skills. This objective assessment method avoids the pollution of data due to social desirability commonly associated with self-report inventories. Another strength of the LTSI exists in its ability to measure a broad spectrum of learning styles. By utilizing multi-subscales (four subscales) and multi-response formats (bipolar and multiple-choice items), the LTSI provides a broad measure of learning and thinking styles within a reasonable number of items.

The statistical analysis of the data from 243 male college seniors generated a Cronbach alpha reliability coefficient of .65, suggesting the instrument possessed a respectable degree of internal consistency. The standard error of measurement was 7.3. The mean, standard deviation, reliability coefficient, and standard error of measurement for each subscale are presented in Table 1. The reliability coefficient for subscale IV was low (Cronbach alpha = .21). This reliability problem occurred mainly due to the fact that, out of the five options offered for each item, more than 80% of the participants chose only the options designated as either analytic or global. Since the analytic and the global options were presented in a random fashion, the internal consistency was affected, resulting in low reliability coefficient. This explains why the test-retest reliability (two-month interval) was also low for subscale IV (.233) but higher for individual variables (.42 for analytic, .45 for global). This information is provided in Table 2.

Insert Tables 1 & 2 About Here

Divergent validity of the LTSI was evidenced in the low correlations among its four subscales (-.05 to .11), suggesting that the subscales measured different constructs and that there was little measurement overlap between the subscales (Williams & Coombs, 1996). Low correlations (-.11 to .23) were also found between the four subscales of the LTSI and the eight subscales of the Myers Briggs Type Indicators (MBTI) (extraversion, introversion, intuition, sensing, thinking, feeling, judging, and perceiving). The negligible correlations between the two instruments provided evidence for the discriminant validity of the LTSI, suggesting the learning styles measured by the LTSI were different from the construct of personality type (Gregory, 1996).

The construct validity of the LTSI was supported by the 4-factor structure that corresponded to the four subscales (Gregory, 1996). The results of factor analysis are discussed in more detail in the next section.

Data Analyses

Preliminary Analysis. In order to examine the construct validity of the LTSI, factor analyses were performed on item parcels. Item parcels were recommended by Gorsuch (1983) for range restricted data (e.g., dichotomous data or continuous data where a large number of individuals receive the same score despite the use of several points on the scale) to obviate the problem of identifying factors that reflect item distributional properties rather than their content. The method has been used by many in confirmatory parcel analyses (e.g., Bolton & Brookings, 1987; Brookings & Bolton, 1988; Marsh, 1987).

Item parcels were used with both dichotomous and continuous data in the present study to maintain consistency of analysis. Based on the similarity of item content and difference in item means, three to four items and two to three items were used to form an item parcel for the dichotomous and continuous subscales, respectively. The number of item parcels for the four subscales were five, three, ten, and three, respectively.

The distribution of the 21 item parcels were generally symmetrical with all univariate skewnesses less than 1 in absolute value. The distribution was slightly leptokurtic, as indicated by mostly positive univariate kurtoses; however, 71% of the kurtoses were less than 1 and only two were greater than 2 in absolute value. The use of 21 parcels improved the distributional properties over the original 49 items and yielded a more favorable parameter-to-subject ratio. Since most univariate skewnesses and kurtoses did not exceed $\pm$ 1, the method of Maximum Likelihood was used to estimate parameters in the LISREL analyses (Muthen & Kaplan, 1984).

Principal Component and LISREL Analyses. The principal component and LISREL analyses were used to examine the construct validity of the LTSI. Principal component analysis was used to determine the loadings of the 21 parcels on their target factors (four subscales). The factor model was further evaluated and confirmed in the LISREL analysis.

LISREL involves two conceptually distinct models. First, a measurement model that relates observed variables to unmeasured constructs is specified and estimated. Second, a linear structural equation model that relates unobserved (i.e., latent) variables to each other is specified and estimated. Confirmatory factor analysis using LISREL VII (Joreskog & Sorbom, 1995) involves the use of a measurement model. The specification and estimation of the first-order factor model is accomplished by fixing or constraining elements in three matrices that are conceptually similar to those resulting from a common factor analysis. These are: (1) the factor loading matrix (lambda X); (2) the factor variance-covariance matrix (phi) which represents the relations among the factors; and (3) a diagonal matrix of error/uniqueness parameters for each measured variable (theta delta) which is conceptually related to the communality estimates in common factor analysis (Marsh & Hocevar, 1985).

For a multi-subscale instrument, LISREL specifies a target matrix that represents the postulated subscale structure of the instrument. In the present study, the target matrix (lambda X) consisted of 21 rows (parcels) and four columns (factors). LISREL estimated the target loadings for each parcel on its hypothesized factor while fixing non-target loadings at zero. Information concerning overall data to model fit, measurement error, t-values for the estimated parameters, and modification of the factor model was also provided by the LISREL.

Several indices of overall fit are provided by LISREL. The familiar chi-square statistic is a global test of a model's ability to reproduce the sample variance/covariance matrix. A nonsignificant chi-square statistic indicates high congruence between a model and data (Hu & Bentler, 1995). The ratio of chi-square to the degrees of freedom (X^2/df) provides information on the relative efficiency of alternative models in accounting for the data, with values of 2.0 or less interpreted as indicating adequate fit. The adjusted goodness of fit index is another global index of fit that varies between zero and 1, with larger values (around .9) interpreted as being indicative of better fit. The root mean square residual is a measure of average residual variance and covariance. Smaller values (.10 or lower) are reflective of better fit.

3x3 MANOVA. Ten composite scores were calculated from the original data: auditory, visual, reading, kinesthetic (subscale I), distractibility (subscale II), logical reasoning, logic metacognition, problem-solving approach (subscale III), analytic, and global (subscale IV). The ten composite scores were used as dependent variables. The two independent variables were major with three levels (engineering, science, liberal arts) and academic performance represented by cumulative GPA with three levels (top 10%, middle 40%, bottom 50%). The MANOVA design was used to investigate learning styles in relation to major and academic performance.

Using the General Linear Model (GLM) in SAS, the results of the 3x3 MANOVA were checked in the following way: Overall Multivariate interaction effects between independent variables were examined first. If overall multivariate interaction effects were significant, an examination of multivariate simple effects was conducted; if overall multivariate interaction effects were not significant, overall multivariate main effects were examined separately for the two independent variables. When overall multivariate main effects for an independent variable were significant, univariate main effects were considered for that variable; when overall multivariate main effects for an independent variable were not significant, no further statistical exploration was conducted for that variable (Littell, Freund, & Spector, 1991).

Results

Principal Component and LISREL Analyses

A principal component analysis of the 21 parcels with varimax rotation yielded a 4-factor solution that explained 40.5% of the variance. The four eigenvalues were 3.08, 2.16, 1.77, and 1.50. The 4-factor structure confirmed the initial classification of the four subscales, providing evidence for the construct validity of the LTSI. Table 3 contains the loadings of the parcels on their target factors only.

Insert Table 3 About Here

The overall goodness of fit indices provided by LISREL suggested that the 4-factor is a good representation of the subscale structure of the LTSI. The overall goodness of fit of the model was evidenced in the following indices: (1) X^2/df = 1.34, (2) goodness of fit index (GFI) =.91, (3) adjusted goodness of fit index (AGFI) = .89, and root mean square residual (RMSR) = .06.

The target loadings estimated with the method of Maximum Likelihood are reported in Table 4. The mean target loading from LISREL analysis (.48) was somewhat smaller than that from principal component analysis (.57). The difference may be caused by the fact that the factors in the principal component analysis were uncorrelated due to varimax rotation where the LISREL analysis estimated the interfactor correlations. All t-values for the target loadings were greater than 2, suggesting that these estimated parameters were significantly different from zero (Joreskog & Sorbom, 1995). The coefficient of determination, varying between zero and 1, indicates how well the observed variables jointly serve as measurement instruments for the latent variables. In this case, the total coefficient of determination is .98, suggesting the measurement model is very good.

Insert Table 4 About Here

The interfactor correlations from phi matrix ranged from -.10 to .18, indicating the four subscales were measuring different constructs. This provided evidence for the discriminant validity of the LTSI. Thus, no attempt was made to examine the higher-order factor structure.

3x3 MANOVA

Multivariate analysis of the data using SAS revealed significant multivariate main effects for major (F=1.67, p<.05) and academic performance as reflected in cumulative GPA (F=2.77, p<.001). Table 5 reports the overall multivariate main effects for the two independent variables.

Insert Table 5 About Here

Subsequent examination of the univariate main effects of college major revealed that there were significant univariate main effects on auditory (F=4.7, p<.05) and kinesthetic sensory preference (F=7.02, p<.01). These statistics are reported in Table 6.

Insert Table 6 About Here

Follow-up comparisons between means indicated that on auditory measure liberal arts students scored significantly higher than engineering students (4.36 versus 2.99, t=2.87, p<.01) and science students (4.36 versus 3.23, t=2.15, p<.05). Follow-up comparisons between means also indicated that on kinethetic measure engineering students scored significantly higher than liberal arts students (3.89 versus 2.18, t=3.73, p<.001).

Subsequent examination of the univariate main effects of academic performance as reflected in cummulative GPA yielded significant univariate main effects for auditory (F=7.80, p<.001), distractibility (F=8.44, p<.001), logic reasoning (F=5.27, p<.01), logic metacognition

(F=6.32, p<.01), and problem-solving approach (F=3.05, p<.05). These statistics are reported in Table 7.

Insert Table 7 About Here

Follow-up comparisons between means indicated that on the auditory measure the top 10% of the students scored significantly higher than the middle 40 % of the students (4.93 versus 2.92, t=3.58, p<.001) and the bottom 50% of the students (4.93 versus 2.73, t=3.58, p<.001).

On the distractibility measure, the bottom 50% of the students scored significantly higher than the middle 40% of the students (4.97 versus 4.27, t=2.11, p<.05) and the top 10% of the students (4.97 versus 4.27, t=4.07, p<.001). Also, on the distractibility measure, the middle 40% of the students also scored significantly higher than the top 10% of the students (4.27 versus 3.00, t=2.69, p<.01).

On the logical reasoning measure, the top 10% of the students scored significantly higher than the middle 40% of the students (5.25 versus 4.50, t=2.05, p<.05) and the bottom 50% of the students (5.25 versus 4.05, t=3.20, p<.01). On the logic metacognition measure, the top 10% of the students scored significantly higher than the middle 40% of the students (13.77 versus 11.34, t=3.56, p<.001) and the bottom 50% of the students (13.77 versus 10.39, t=2.64, p<.01). On problem-solving approach measure, the top 10% of the students scored significantly higher than the middle 40% of the students (10.00 versus 8.63, t=2.44, p<.05) and the bottom 50% of the students (10.00 versus 8.79, t=2.09, p<.05).

Discussion and Conclusion

LISREL comfirmatory factor analyses showed that the 4-factor model identified in the principal component analysis was a valid measurement model to account for the variance and covariance of the sample on the LTSI. The congruence between the 4-factor model and the initial subscale structure of the LTSI provided evidence for the construct validity of the instrument. The low interfactor correlations lent support to the divergent validity of the instrument, suggesting that perceptual modalities, distractibility, metacognition, and analytic-global tendency were different constructs that constituted the LTSI.

The overall reliability coeffient of .65 was a respectable index of internal consistency for the LTSI with its multi-subscale and multi-response formats. The validity and relialibity of the LTSI lay the foundation on which the following statistical inferences from multivariate analyses were built.

Research findings suggested a relationship between choice of major and leaning and thinking styles. Liberal arts students preferred to rely on auditory modality more than students majoring in engineering and sciences. Engineering students, on the other hand, used kinethetic modality more often than liberal arts students. The finding seemed to reflect the characterisitcs of academic traning in different areas. While attending lectures remains the main source of formal schooling regardless of fields of study, engineering students do have more hands-on experiences in labs than liberal-arts students. Does academic training foster specific modality preferences or does preferred perceptual modality lead to different major and career choices? Future research is required to answer this question. Since the present study used the data from our graduating seniors, the effects of four-year college traning should certainly be considered.

Academic performance was also found to have an effect on learning and thinking styles. The academic performance in the present study was operationalized by the cumulative GPA. The top 10% of the students indicated clear preference for auditory modality than the middle 40% and bottom 50%. This supported the the assumption that students with higher academic achievement benefited more than their peers from classroom instruction. Students with higher academic achievement (top 10% versus middle 40% and bottom 50%, middle 40% versus bottom 50%) were also less distractable in learning. They demonstrated better self-control and stayed focused on tasks once they started processing information.

The top 10% of the students also demonstrated superior performance compared to their peers (than middle 40% and bottom 50%) on all metacognitive measures. The students with higher cummulative GPA not only demonstrated a higher degree of logical reasoning, they also utilized problem-solving strategies more systematically and provided a more accurate estimation of their performance on logical-reasoning items. The relationship between academic performance and metacogniton reflects the role of metacognition in the cognitive growth of college students.

Learning styles seem to be related to maturation and intellectual growth. One indication of this growth is the decrease in distractibility found in the top 10% of the students in this study. Internal locus of control and increase in intentional attention span work together to lower distractibility. Is it just a question of learning habit or does motivation come into play? We can pose this question for future research.

Another important characteristic of cognitive development is metacognition. Top students unvariably demonstrated a higher degree of metacognitive ability in the form of using problem-solving strategy and self-evaluation. It seems reasonable to conclude that metacognition is not just a style characteritic of many successful students; it is a prerequisite for academic success and it should be the goal of higher education if we want our students to function as competent individuals in the society.

The LTSI is one of the few instruments that embraces a broad spectrum of learning and thinking styles. The inclusion of metacognition and the use of objective measurement techniques in the LTSI signify the unique contribution the present study may make to the literature on learning and thinking styles.

Students from different fields of study have different preferences for perceptual modality. The immediate implication of this finding is that teachers armed with the knowledge of students' learning styles can better design their instructional environment in order to maximize students' metacognitive growth. Does academic training foster specific modality preferences or does preferred perceptual modality lead to different major and career choices? Future research is required to answer this question.

The relationship between learning-thinking styles and academic achievement revealed in the present study captures some crucial characteristics of "the successful student" in a college setting. The information may be used by educators and policy makers to redefine the criteria for the products of higher education.

Table 1

Mean, Standard Deviation, Reliability Coefficient, and Standard Error of Measurement for the LTSI Total and Subscales N=243

Subscale	Mean	SD	Reliability	Measurement Error
Perceptual Modality	23.37	4.9	.59	3.1
Distractibility	14.03	2.2	.54	1.5
Metacognition	64.78	9.3	.70	5.1
Analytic-Global	17.92	3.2	.21	2.8
Total	120.10	11.8	.65	7.0

Table 2

Test-Retest Reliability for the LTSI Measures N=291

LTSI Measures	Reliability (Two-Month Interval)
Auditory	.62 *
Visual	.46 *
Reading	.60 *
Kinesthetic	.63 *
Distractibility	.65 *
Logical Reasoning	.41*
Logic Metacognition	.44 *
Problem-Solving Approach	.33 *
Analytic	.42 *
Global	.45 *

* significant at alpha = .05 (2-tailed)

Table 3

A Principal Component Analysis With Varimax Rotation: Loadings of the Item Parcels on Their Target Factors N=243

Perceptual Modality	Distractibility	Metacognition	Analytic Global
Factor II	Factor III	Factor I	Factor IV
.27	.79	.21	.69
.78	.59	.50	.56
.44	.77	.49	.44
.71		.51	
.78		.71	
		.39	
		.49	
		.57	
		.73	
		.62	

Table 4

Standardized Parameter Estimates for the ITSI Parcels N=243

Parcel	Factor Loadings			
	Perceptual Modality	Distractibility	Metacognition	Analytic Global
PM1	.16 (2.1)	0	0	0
PM2	.69 (9.7)	0	0	0
PM3	.30 (4.1)	0	0	0
PM4	.57 (8.2)	0	0	0
PM5	.74 (10.5)	0	0	0
D1	0	.65 (7.4)	0	0
D2	0	.48 (6.1)	0	0
D3	0	.66 (7.5)	0	0
M1	0	0	.21 (3.0)	0
M2	0	0	.47 (6.8)	0
M3	0	0	.34 (4.8)	0
M4	0	0	.40 (5.7)	0
M5	0	0	.58 (8.7)	0
M6	0	0	.37 (5.3)	0
M7	0	0	.35 (4.9)	0
M8	0	0	.54 (8.0)	0
M9	0	0	.69 (10.7)	0
M10	0	0	.63 (9.5)	0
AG1	0	0	0	.46 (3.0)
AG2	0	0	0	.56 (3.1)
AG3	0	0	0	.20 (2.0)

Given in parenthesis are critical ratios of parameter to standard error of estimation. These ratios can be interpreted as *t* values so that values greater than 2.0 indicate parameters that are significantly different from zero ($p < .05$).

Table 5

A 3x3 MANOVA: Multivariate Main Effects of Major and Academic Performance on the LTSI N=243

	Wilk's Lambda	F Value	p Value
Major	.85	1.67	.0296 *
Academic Performance	.76	2.77	.0001 **

* significant at alpha=.05 ** significant at alpha=.01

Table 6

A 3x3 MANOVA: Univariate Main Effects of Major on the LTSI Measures N=243

LTSI Measures	F Value	p Value
Auditory	4.70	.0100 *
Visual	.46	.6327
Reading	3.01	.0512
Kinesthetic	7.02	.0011 **
Distractibility	.14	.8653
Logical Reasoning	.41	.6645
Logic Metacognition	.38	.6860
Problem-Solving Approach	2.60	.0764
Analytic	1.90	.1522
Global	1.69	.1870

* significant at alpha = .05 ** significant at alpha = .01

Table 7

A 3x3 MANOVA: Univariate Main Effects of Academic Performance on the LTSI Measures N=243

LTSI Measures	F Value	p Value
Auditory	7.8	.0005 **
Visual	2.11	.1232
Reading	1.63	.1990
Kinesthetic	2.14	.1199
Distractibility	8.44	.0003 **
Logical Reasoning	5.27	.0058 **
Logic Metacognition	6.32	.0021 **
Problem-Solving Approach	3.05	.0493 *
Analytic	1.48	.2302
Global	3.01	.0512

* significant at alpha = .05 ** significant at alpha = .01

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Signature: Zhicheng Zhang

Printed Name/Position/Title: Zhicheng Zhang, R. Stephen RiCharde

Organization/Address: Office of Institutional Research, Virginia Military Institute, Lexington, VA 24450

Telephone: (540) 464-7796

FAX: (540) 464-7651

E-Mail Address: ZZ@VMI.edu

Date: March 24, 1997

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