To the Graduate Council:

I am submitting herewith a dissertation written by Martha Ruth Bryan entitled "Interrelationships Between Learning Styles, Formal Operations, Achievement in Specified Content Areas, Age, and Level of Education." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Educational Psychology.

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INTERRELATIONSHIPS BETWEEN LEARNING STYLES, FORMAL OPERATIONS, ACHIEVEMENT IN SPECIFIED CONTENT AREAS, AGE, AND LEVEL OF EDUCATION

A Dissertation

Presented for the

Doctor of Education

Degree

The University of Tennessee, Knoxville

Martha Ruth Bryan

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DEDICATION

This dissertation is dedicated to my parents, Andrew Jackson Bryan (1898-) and Blanch Winebarger Bryan (1904-1983). Although their combined formal education was less than eight years, they taught me the necessary skills to find fulfillment in life and instilled in me a zeal for learning. With a family of eleven children, twenty-six grandchildren, and twelve great grandchildren, they recognized individual differences and promoted acceptance, growth, and independence for each of us.

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ABSTRACT

The primary purpose of this study was to determine the correlations between learning style, level of formal operations, ACT scores, and grade point averages in specified content areas of undergraduate college students. A secondary objective was to explore the association between age and level of education, learning style and formal operations. These relationships were investigated in a study with 78 sophomore, junior, and senior students at The University of Tennessee, Knoxville, during October 1984. Data were collected using the Schmeck, Ramanaiah, Ribich Inventory of Learning Processes, the Burney Logical Reasoning Test, and from students' academic records.

The results showed significant correlations ($p < .0001$) between the dimensions of learning style (deep processing, elaborative processing, shallow processing, methodical study) in both the humanities/social sciences and mathematics/natural sciences content areas. In addition, significant positive correlations ($p < .05$) were found between level of formal operations and natural science, mathematics, and social studies ACT scores and grade point averages in both humanities/social sciences and mathematics/natural sciences courses. Similarly, the deep processing learning style dimension was significantly positively correlated ($p < .05$) with ACT scores in all areas and with grade point averages in all content areas. However, negligible or significant negative correlations were found between the learning style dimensions of shallow processing, methodical study,

elaborative processing and formal operations, grade point averages and ACT scores in all areas. Age was only found to be significantly positively correlated with methodical study and level of education with shallow processing.

Thus, it was concluded from this study that: (1) a high level of propositional logic and reasoning as well as syllogistic and analogical reasoning, and (2) the ability to analyze and synthesize information are related to a high level of achievement in college. This relationship is more significant in mathematics/natural sciences than in humanities/social sciences courses. On the other hand, verbatim memorization, organized study habits, and the ability to personalize information are minimally related to achievement.

Further research was recommended to: (1) explore the effect of educational experiences in developing deep processing and formal operations and, (2) further clarify the relationship of age and level of education to learning styles and formal operations, and elaborative processing to the achievement variables.

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CHAPTER I

INTRODUCTION

Through decades of educational and psychological research, the predominant belief was that intelligence and behavioral variables were the primary factors which influenced learning. Over the past 20 years, however, research in cognitive psychology has identified other learner characteristics found to be significant in academic achievement. Out of this research has emerged an emphasis on individual differences in learning, cognitive structure, stages of cognitive development, and strategies employed in information processing.

More specifically, recent research has indicated that learning style, independently of intelligence, is related to achievement (Dunn & Dunn, 1978, 1979; Entwistle, 1981; Hill, 1981; Kolb, 1984; Pask, 1976a; Schmeck, 1982, 1983). Similarly, research has suggested that formal operations thinking patterns are correlated with academic performance, especially in natural sciences and mathematics courses (e.g., Biggs & Collis, 1982; Burney, 1974; Bybee & Sund, 1982; Commons, Miller, & Kuhn, 1982; and Sund, 1976). Additionally, Perry (1970) showed through his studies at Harvard and Radcliffe that college students' styles of reasoning change during their college years. Schmeck also speculated that learning style likely changes as one continues in college or with increased chronological age. Studies (e.g., Sund, 1976) have further indicated that higher percentages of upper-class students score high on formal operations tasks. Furthermore, Schmeck (1983, p. 242) stated that: "It is likely that future research will uncover relationships between the stages of cognitive development described by Jean Piaget (1963) and learning style." Along with Kolb (1984), Schmeck also suggested that both the development of learning style and formal operations may be found to vary from one content area to another.

Although substantial research has been conducted which shows correlations between learning style and achievement as well as formal operations and achievement, only in rare instances have specific content areas (i.e., mathematics, science, English, social sciences) been variables in the research. For these studies (which will be discussed in the literature review on subsequent pages), a variety of learning styles and formal operations instruments were used which measured only one specific aspect of the variables. Research on these variables among college students in the United States has been very limited as studies by Biggs, Marton, Entwistle, Pask, and others were conducted in Australia, Sweden, and England. Schmeck (1982, 1983) has conducted considerable research on the learning styles of college students in the United States, basing some of his theoretical background on Biggs (1972, Biggs & Collis, 1982), Entwistle (1979, 1981), Marton (1976), and Pask (1976a). Similarly, Burney (1974) developed an instrument to measure levels of formal operations (based on Piagetian model) which has been used in research by Popejoy and Schweers (In Bybee & Sund, 1982). However, no study has examined the relationship between Schmeck's dimensions of learning style, Burney's levels of formal reasoning, and American College Testing entrance examination scores and grade point averages of college students in specific content areas (i.e., natural sciences/mathematics and social sciences/humanities). Minimal attention has been given to the developmental changes in learning styles and formal operations occurring in college students.

Schmeck defined learning strategy as the pattern of information-processing activities a person engages in when confronted with a learning task and style as a predisposition to favor a particular strategy used with cross-situational consistency in learning situations. The researcher included four scales on the Inventory of Learning Processes: deep processing (formerly labelled as synthesis-analysis), elaborative processing, shallow processing (replaces fact retention), and methodical study. Deep processing assesses the extent to which students critically evaluate, conceptually organize, and compare and contrast information whereas elaborative processing measures the degree to which students translate new information into their own terminology, apply it to their own lives, generate concrete examples from their own experiences, and use visual imagery to encode new information. Shallow processing (replaces fact retention with revised items) refers to the students' preference for simply memorizing information for recall. The methodical study scale assesses the students' employment of systematic study techniques, regular review, and the integration of relevant study material. (A listing of the operational definitions of these terms is included in Appendix B.)

Burney based his model on the Piagetian formal operational tasks which consist of hypothetical deductive thinking, ratios and proportions, inductive reasoning, reflective abstraction, systematic isolation and control of variables, and combinatorial logic. Based on the score on the Burney Logical Reasoning Test (which measures propositional logic, hypothetico-deductive reasoning, and combinatorial logic), the student is classified as preformal, transitional, or formal. (The scales are defined more specifically in the operational definitions of terms listing in Appendix B.)

The Problem

The purpose of this study was to examine the relationships between the learning style, level of formal operations, ACT scores, and grade point averages in specified content areas of undergraduate college students. More specifically, the dimensions of learning style (i.e., deep processing, elaborative processing, shallow processing, and methodical study) and formal operations (preformal, transitional, formal) were compared with ACT scores in English, social studies, mathematics, and natural science and grade point averages in the humanities/social sciences area and the mathematics/natural sciences area. In addition, the study examined the relationship of age and level of education to the development of learning style and formal thought.

Generated by the statement of the problem and Schmeck's speculation, the following hypotheses were explored in this study:

1. What are the correlations between the learning style (i.e., deep processing, elaborative processing, shallow processing, methodical study) employed when studying for mathematics/ natural science courses and those used when studying for humanities/social sciences courses?
2. What are the correlations between level of formal operations, natural science and mathematics ACT scores, grade point average in natural sciences and mathematics courses, and the learning style employed in the courses?
3. What are the correlations between level of formal operations, English and social studies ACT scores, grade point average in social sciences and humanities courses, and the learning style employed in the courses?
4. How are chronological age and level of education associated with learning style and level of formal operations?

Vu (1977) found that when individuals reached formal operational thought in one content area, they may not have attained it in others. Assuming a relationship, Schmeck (1983, p. 242) further stated: "Thus, some adults may be incapable of using a deep processing learning strategy, and those that can use it in one content area might be incapable of using it in some other area." Schmeck recommended further research to substantiate the relationship between learning style and stages of cognitive development as well as correlations between these variables and performance in specified content areas.

In a previous article, Schmeck (1982, 1983) suggested that it was improbable that an individual could process deeply before attaining the formal operations stage. Since both scales require a high degree of abstract reasoning, the individual with a high degree of consistency in processing deeply would also likely engage in formal reasoning with a high degree of consistency, thus be classified as formal on Burney's scale. In addition, it was suggested that since elaborative processing utilizes concrete examples, this scale would have a higher correlation with lower levels of formal thought (transitional on the Burney scale).

Unlike deep or elaborative processing, methodical study was predicted to correlate with preformal operations. Schmeck (1982) speculated that students who scored high on methodical study were strongly motivated but lacked the skills necessary for deep processing. Their main strategy was to follow instructions closely and rehearse information numerous times before an examination. In an unpublished study by Hudson, referred to by Schmeck (1983), findings indicated that seventh graders who earned the highest scores on methodical study had not yet attained the formal operations stage of cognitive development.

Significance of the Study

The need for further research on learning styles and formal operations has been well substantiated in the current literature. (Additional rationale is presented in the literature review on subsequent pages.) As much of the research has been general and inconclusive raising questions about relationships among and effects of the above-described learner characteristics on performance in particular subject areas, this present study was needed in order to increase educators' understanding of them. If instructors are knowledgeable of the various learning styles and levels of formal operations of their students, they can better plan instructional techniques which will facilitate learning for individual students. Understanding the significance of chronological age and level of education in the development of these skills also has implication for educators. In order to maximize the learning potential of students, instructors must have the necessary knowledge to provide learning opportunities whereby students will develop learning strategies and reasoning abilities at the appropriate stages.

Limitations of the Study

Although the instruments used in this study to measure learning style and formal operations had significant test-retest and internal consistency reliability and some research studies had validated them, no norms have been established with the Inventory of Learning Processes or the Burney Logical Reasoning Test. Therefore, in evaluating the data, consideration must be given to the experimental nature of the instruments. Also, since self-report and paper-pencil inventories have not been found to be as accurate in gathering data as actual observations of behavior and measurements of performance on tasks, these limitations must be considered. Both the lack of normative data on instruments and the nature of inventories have been found to be shortcomings in learning styles research (Cherry, 1981; Keefe, 1979, 1982; Schaiper, 1983).

Another limitation of the study was that the participants' gender-linked differences, as related to learning style and level of formal operations, were not an initial concern to be investigated. Since gender was not controlled, an uneven distribution of males (17) and females (61) participated in the study. It should be noted, however, that Schmeck et al. (1977), in a study with 434 undergraduates (232 males, 202 females), found no significant gender-linked differences on any of the scales of the Inventory of Learning Processes.

The sample for this study was sufficient to yield significant results except for nominal subjects in the preformal category of the Logical Reasoning Test. However, larger sample sizes would increase the statistical power, and thus stronger conclusions could be drawn from the data.

Review of Literature

Learning Styles

Whereas in the past, learning theorists (e.g., Bandura, Guthrie, Guilford, Skinner, and Thorndike) emphasized the content of cognition, behavioral variables, the learning environment, and the product of learning, more current cognitive/developmental theorists have focused on the process of learning. The developmental stages of the learning process as well as the process of cognition were elaborated on by Piaget (1963; Inhelder & Piaget, 1958, 1964), Bruner (1956, 1966, 1975), and Ausubel (1968, 1975, 1983). Moreover, individual differences in the process of cognition have been the focus of contemporary cognitive style theorists (Gardner, 1960; Kagan, 1966; Kogan, 1976; Messick, 1963, 1976a, 1976b; Witkin, 1971, 1976). More recently, learning style practitioners (Barbe & Swassing, 1979; Dunn & Dunn, 1979, 1981; Gregorc, 1979, 1982; Hill, 1981; Kolb, 1981, 1984; Schmeck, 1977, 1978, 1979, 1982, 1983) have expanded the theoretical base to include individual differences in perceptual, cognitive, affective, and physiological processes of learning in their applied learning styles models.

Some of the learning style theorists and practitioners (e.g., Dunn & Dunn, 1979, 1981; Goldman, 1973; Gregorc, 1982; Hill, 1981; Kagan, 1966; Witkin, 1976) have advocated matching teaching style to learning style in order to improve learning. For example, Dunn et al. (1981) cited two studies (Martin, 1977; Trautman, 1979) which demonstrated that matching instruction to individuals' styles produced significant academic gains. In addition, Anderson and Bruce (1982) reported that in a study with high school students in California, subjects' learning styles as measured by the Group Embedded Figures Test and Rotter's Locus of Control were correlated with their educational attainment. Furthermore, a number of studies utilizing Hill's Cognitive Style Mapping Program (Hinton, 1980; Kusler, 1979; Warner, 1982) have indicated that dimensions of cognitive style are related to achievement.

Moreover, Cherry (1981), in a study on perceptual learning styles of adult learners, concluded that there was a relationship between learning style and achievement.

Other learning style theorists and practitioners (e.g., Blackman & Goldstein, 1982; Cross, 1976; Messick, 1976b; Letteri, 1982; Kolb, 1981; Kirby & Das, 1977; and Schmeck, 1981) have emphasized that a multi-approach teaching style which encourages using flexible learning strategies enhances learning. For example, Blackman and Goldstein (1982) stated that the literature suggested that placing students into a learning environment appropriate to cognitive styles improved learning. Also, Cross (1976) advocated the use of challenge matching, a combination of teaching to the style and teaching to develop new cognitive strategies. Additionally, Messick (1976b) described a number of possible matches concluding that the content, process, or affective goal determined the type of match. Cornett (1983) included in her article, a section on how to flex one's teaching style in order to improve students' learning. Moreover, Letteri (1982) has conducted research in which cognitive styles are assessed and a conscious effort made to teach strategies to students who are perceived as lacking them. In the experiment, students made significant gains in their academic performance. Kolb (1981) asserted that educators should not deny students the opportunity to develop themselves fully by only exposing them to educational environments which match their styles. Furthermore, Kirby and Das (1977) studied the simultaneous versus successive conceptualization of processing and found that the highest achievement was obtained by students high in both types of ability. Finally, Schmeck (1981) suggested that styles should roughly match instructional techniques to the students' style while simultaneously providing experience in strategies apart from the style. According to Schmeck, promoting flexibility in this manner may be a greater service than always structuring the context to match the students' preferred style.

More specifically, various dimensions of learning style have in some instances been related to achievement in certain courses. For example, Briars (1983) suggested, based on limited research, that there was a relationship between mathematical processing skills and achievement. Too, Voss, Tyler, and Yengo (1983) indicated that the problem solving strategies within the information processing model which are employed by political scientists differed significantly from those used by chemists. Political scientists spent more time with problem representation whereas chemists moved quickly into the solution. Additionally, Hinton (1980) found the quantitative visual and other scales on Hill's Cognitive Style Mapping Inventory were correlated with achievement in mathematics courses.

Researchers who have not directly supported the position that achievement is improved with flexible teaching, nonetheless, have asserted that learning style can be changed. One of the early cognitive style researchers, Witkin (1976), did longitudinal studies which indicated that field independence and dependence were relatively stable characteristics. However, Chickering (1976) cited more contemporary research which supported that these dimensions as well as other aspects of cognitive style (e.g., reflectiveness/impulsivity) change even during the college years. Cross (1976) defined cognitive style as a habitual way of responding to the environment without conscious choice which may be relatively stable. However, she recognized cognitive strategy as a deliberate choice, a characteristic which can be taught. Reissman (1976) stated that cognitive style is not immutable; it can be augmented. Similarly, Hill (1981) stated that style can be modified; in fact he discussed the means of assessing an augmented cognitive style map. Furthermore, Blackman and Goldstein (1982) stated that the literature suggested that cognitive style can be successfully modified with the presumption that modification leads to improved academic performance.

Questions have been raised in the literature as to whether the modifications in learning style occur as a deliberate effort or if part of the change results from maturation. The research cited in the previous paragraph definitely supported the position that conscious strategies can effect change. However, other research has specifically supported the notion that change in style is developmental. Kirby (1979) indicated that "process" changes occur within the cognitive "structure" throughout one's life span. Perry (1970), in his studies with students at Harvard and Radcliffe, found that learning style development occurs during the 4 years of college. Perry described students as progressing from dualistic thinking (right and wrong) to contextual relativistic reasoning (analysis and synthesis of knowledge).

Furthermore, Cherry (1981) stated the findings of his and other research suggested that the relative strengths of the various perceptual styles are influenced by increasing age, maturity, and achievement. Moreover, Schmeck (1983) suggested that although research is inconclusive in this area, there appears to be evidence that style is developmental. For example, deep processing would not likely occur until the individual has developed higher order metacognitive processes in late adolescence.

Dr. Ronald R. Schmeck of Southern Illinois University has focused his learning styles model on individual differences in the processing of information. Schmeck based his theoretical framework on the works of Craik and Lockhart (1972), Craik and Tulving (1975), Tallmadge and Shearer (1969, 1971), Perry (1970), Biggs (1972, 1980), Biggs and Collis (1982), Entwistle (1975, 1981, 1983), Marton and Saljo (1976), and Pask (1976). Schmeck, Ribich, and Ramanaiah (1977) developed the Inventory of Learning Processes which consists of four scales: deep processing, elaborative processing, fact retention, and methodical study. Deep processing employs synthesizing and analyzing as opposed to superficial information processing. Elaborative processing concerns the use of summarizing, relating, and applying information as opposed to verbatim information processing. Shallow processing (called fact retention) in earlier research measures an individual's preference for memorizing verbatim as opposed to deep or elaborative processing. Methodical study refers to repetitive, drill-and-practice habits of processing information.

Craik and Lockhart (1972) and Craik and Tulving (1975) have extensively researched the information processing model on which some dimensions, i.e., deep and elaborative processing (spread of processing) of Schmeck's learning style model are based. In introducing the concept of levels of processing, Craik and Lockhart (1972) described verbal information processing activities as varying on a continuum from shallow (in which all attention was focused on the verbatim stimulus display) to deep (in which meanings and conceptual associations were processed). Both teams of researchers (Craik & Lockhart, 1972; Craik & Tulving, 1975) found that laboratory subjects' performance on memory tasks was superior when they were instructed to process information deeply. Since the concept of levels of processing has been based partially on the assumption that memory is the result of traces left behind by the processing of information, the more information is processed, the more enduring will the memory traces be. Thus, in the school setting, deep processors are more preoccupied with organizing information into conceptual chunks, comparing and contrasting concepts, recoding information verbally and diagrammatically than with repeating information.

Tallmadge and Shearer (1969, 1971) have been credited by Schmeck (1983) as having clarified the concept of learning style to fit his model. The authors stated: "A learning style may be operationally defined as an attribute of an individual which interacts with instructional circumstances in such a way as to produce different learning achievements as a function of these circumstances" (Tallmadge

& Shearer, 1969, p. 222). This concept was differentiated from the definition of Goldstein and Blackman (1978) which characterized cognitive style as primarily personality and attitudinal attributes. In their research, Tallmadge and Shearer (1969, 1971) found that there was a significant correlation between the style of instruction (inductive or deductive) and the achievement in certain subject areas.

Additionally, key researchers from outside the United States substantially influenced the development of Schmeck's theoretical background, his inventory, and his research. Among those are Biggs and his colleagues (1972, 1982) of the University of New Castle, New South Wales, Australia. Initially, they studied the Piagetian stages of cognitive development in college students and later decided that levels of cognitive processing might be more relevant to college instruction (Schmeck, 1983). They discovered the levels of processing concept to be useful in accounting for individual differences in performance in practical settings (i.e., the college classroom). Biggs developed a learning strategies measure consisting of open-ended questions (the Structure of Observed Learning Outcome). Subsequently, he developed the Study Processes Questionnaire which includes higher order factors of utilizing (similar to shallow processing) and internalizing (similar to deep processing). These two scales accounted for the largest variance of the inventory.

Entwistle and his colleagues (1975, 1979, 1981, 1983) of the University of Lancaster, England established a research center with the objective of identifying college student characteristics (personality and motivation) which would predict academic performance. They developed and refined a number of inventories for assessing aspects of study behavior. Based on their findings, Entwistle and Hounsel (1975, p. 192) stated that: "Students who are matched to materials which fit their preferred style of learning learn much more effectively than those that are mismatched." Additionally, Entwistle et al. (1983) reported that the higher order factors of meaning (comparable to deep processing) have a stronger correlation with high achievement and that meaning and reproducing (shallow processing/fact retention) marked the sharpest differentiations on his scale.

At the University of Gothenburg, Sweden, Marton and his colleagues (1976) researched students' varying approaches to reading academic articles. They identified two basic types of learning outcomes, i.e., the conclusion-oriented and the description-oriented. The conclusion-oriented (or shallow processors) devoted their energy toward rote learning of important pieces of information. On the other hand, the description-oriented (deep processors) developed a more thorough understanding of the main argument. Thus, the work of Marton and his colleagues (1976) has suggested that the concept of levels of processing might be used as a dimension of individual differences, not merely as a way of classifying information processing activities. Depending on what the instructor might test, whether the student utilized deep or surface processing could affect performance. Svensson (1977) found a significant correlation between a deep approach to study and high academic performance and a surface approach to study and a low level of academic performance.

Pask and his associates in London (1976) have conducted extensive research on learning styles. Through their experimental approach of requiring subjects to understand and not merely memorize material, they have identified holistic and serialist strategies. Associated with the holistic strategy is the comprehension learning style, and affiliated with the serialist strategy is the operation learning style. A combination of the styles is known as a versatile style, i.e., the employment of analogy to get an overall picture and the examination of details to test its application. Pask found that when styles were matched to different instructional strategies, learning was facilitated. Furthermore, Entwistle et al. (1983) reported that comprehension learning was more strongly correlated with self-rated academic performance in arts subjects while operation learning was more effective in science. Versatility was most closely related to overall achievement in science courses.

According to Schmeck (1983), the models of Entwistle, Biggs, Pask, and Marton have a number of similarities. The student seeking meaning (Entwistle) would likely adopt a deep-level approach (Marton's concept) or a holistic strategy (Pask's concept). However, the individual with a meaning orientation who uses only the holistic strategy has a tendency to achieve limited understanding because of the inclination toward globe-trotting (Pask). The student who has a reproduction orientation is prone to use a surface-level approach

(Marton) which leads to memorization or a serialist strategy (Pask) which limits the scope of understanding. The achieving orientation motivates the individual to use any strategy which earns high grades.

Schmeck has agreed with Biggs, Entwistle, Marton, Pask and their colleagues that both consistency and variability can be seen in students' approaches to learning. All of the models have suggested that some individuals are more consistent in their strategy use while others are more adaptable to the demands of the immediate situation. In addition, Schmeck has viewed all of the models as based on Craik and Lockhart's levels of processing concept.

Schmeck and his colleagues have conducted substantial research with the Inventory of Learning Processes. One study conducted by Schmeck and Grove (1979) compared the learning styles of 790 high and low college achievers. The researchers used grade point average and scores on the American College Testing (ACT) entrance examination as measures of academic achievement, and the ILP as a measure of learning style. The findings indicated that college achievement was significantly correlated with synthesis-analysis (deep processing), elaborative processing, and fact retention (shallow processing) but not with methodical study. Hence, the author concluded that the high achieving students were processing deeply, encoding elaboratively, and retaining specific details.

In the same study it was indicated that methodical study was not positively correlated with grade point average. In fact, students with high grade point averages and ACT scores had lower scores on methodical study. Thus the authors concluded that students who score high on methodical study may lack the necessary skills to engage in deep and elaborative processing. In another study, Schmeck and Ribich (1978) found a significant negative correlation between critical thinking ability and methodical study. In agreement with the previous conclusion, the researchers stated that students with lower scores on critical thinking ability who are motivated to achieve tend to emphasize traditional, repetitive "study."

Additional research has established relationships between deep and elaborative processing and other variables. For example, in a study by Schmeck, Ribich, and Ramanaiah (1977), results on a spontaneous, unannounced test were significantly correlated with the students' scores on the deep processing scale. Deep processors scored higher overall and earned especially higher scores on test questions which demanded greater thinking ability. Schmeck (1983) found also that the students who scored high on deep processing had high semantic memory recall and were more attuned to meanings than superficial, shallow aspects of materials. Furthermore, Ribich (1977) discovered that, unrelated to intelligence, individuals who earned high scores on deep processing were better at structuring information than those who were low on deep processing. Schmeck (1983) indicated that those individuals who scored high on deep processing had greater reading comprehension skills, and they attended more to ideas and the interrelationships among ideas and less to the precise wording of passages. In addition, Schmeck and Ribich (1978) found a significant positive correlation between deep processing and critical thinking ability.

In another study (Schmeck & Phillips, 1982), statistically significant positive correlations were found between the scales on the Inventory of Learning Processes and scores on the Iowa Silent Reading Test and Biggs SOLO Taxonomy. Deep processing was positively correlated with reading comprehension and performance-based deep processing activities as assessed by the SOLO Taxonomy.

Scmeck (1983) described elaborative processing as another means whereby the learner can form more intricate and enduring memory traces (Schmeck, 1983). He indicated that as students elaboratively process, they recall concrete examples or associations from their own experience. Schmeck and Ribich (1978) found that individuals scoring high on elaborative processing had greater mental imagery ability than those who scored low. Schmeck, Ribich, and Ramanaiah (1977) indicated that students who scored high on elaborative processing were significantly better at learning long lists of concrete words for a free-recall memory test.

Schmeck (1982) described that, in combination, the deep processing and elaborative processing scales measured a degree of reasoning ability. Both processes were believed to enhance the probability of recall of information. However, some differences were noted in that deep processors categorized and compared and contrasted categories of information in order to improve recall whereas elaborative processors translated ideas into a personalized framework to facilitate recall (Schmeck, 1982).

Formal Operations

In an effort to further understand levels of reasoning ability, other researchers have continued to explore the Piagetian stages of cognitive development as related to secondary and college learners. Known by Piaget as the summit of cognitive development, formal operations was described as including hypothetical deductive thinking, ratios and proportions, inductive reasoning, reflective abstraction, systematic isolation and control of variables, and combinatorial logic. Among the contemporary researchers on the Piagetian model have been Sund, Popejoy, Schweers, and Burney at the University of Northern Colorado (Sund, 1976; Bybee & Sund, 1982; Burney, 1974), Commons, Miller, and Kuhn (1982) at Harvard University, and Lawson (1981, 1982) of Arizona State University. Numerous research findings have substantiated that not all adults reach the formal operations stage of learning (Ennis, 1975; Keating, 1979; Kuhn, 1979; Mills & Funnel, 1983; Sund, 1976; Bybee & Sund, 1982). Kuhn (1975) reported that empirical studies showed that approximately 50% of the adult population reached formal operations. Some authors have specifically indicated that a percentage of college students do not attain formal operational thought. Furthermore, Lawson and Snitgen (1982, p. 233) reported that:

> The failure of many college students to demonstrate the use of advanced or "formal" reasoning strategies such as the control of variables and probabilistic correlational, proportional, and combinatorial reasoning is well documented in the literature (e.g., Towler & Wheatley, 1971; Cohen, Hillman, & Ange, 1978; Kolodiy, 1976; Lawson, Norland, & DeVit, 1975; Piaget, 1972; and Chiapettam, 1976).

Burney (1974) developed the Logical Reasoning Test, a paper-pencil inventory, to measure formal operations. The instrument assesses the use of propositional logic, propositional reasoning, syllogistic reasoning, and analogical reasoning. The score on the instrument classifies the individual as preformal, transitional, or formal. Believing it to be a reliable measure of formal operations, Popejoy and Schweers (In Sund & Bybee, 1982) have used the instrument in research with secondary and college students. Their research suggested that in planning appropriate instructional techniques, it is important to know to what extent students have developed formal operational thought. The researchers further indicated that some content requires a mature level of formal reasoning whereas other content may be better learned with concrete thought.

In a study conducted by Lawson (1982), concrete operational seventh graders and college students were compared to determine their level of responsiveness to science instruction. Although the results indicated that the scores on the Lawson formal reasoning test were not statistically significant, the mean gain in knowledge (based on pre- and posttests in the course) with the same instruction was significantly higher for the college students. Thus the authors concluded that (probably due to increased age and maturation) concrete operational college students were better able to develop use of the formal reasoning patterns than the concrete operational seventh graders. The authors also suggested that instruction in formal reasoning strategies can be effective with persons over 18 years of age. Lawson and

Snitzen (1982) demonstrated in another study with 72 college biology students that inquiry-based instruction which included specific instruction in a variety of components of formal reasoning produced measureable advances. Kuhn (1975) further indicated that, although research showing how and when formal operations develops is inconclusive, research does show that when adults are given formal operations tasks to perform, they develop formal operations thought rapidly.

A number of studies have been conducted (e.g., Pascual-Leone, 1969; Adi & Pulos, 1980; Numnedal & Collea, 1981; Skymansky & Yore, 1980; and Neimark, 1979) which showed a high correlation between the cognitive style of field independence and level of formal operations. Some of this research (e.g., Mcleod, Carpentar, & Skvarius as cited by Adi & Pulos, 1980; Skymansky & Yore, 1980) further suggested a significant correlation between field independence and performance in mathematics and science courses. Although no studies have reported a relationship between field independence and Schmeck's deep and elaborative processing, an association may be inferred. Field independents have been found to demonstrate greater skill in problem-solving strategies (Witkin et al., 1977), analytical intelligence (Witkin & Moore, 1974), self-identity, and internal locus of control (Cross, 1976). Likewise, Schmeck (1982) reported that deep processing was related to self-efficacy, critical thinking ability, and analytical reasoning. One similarity may be recognized between elaborative processing and field independence. Elaborative processors have greater mental imagery, and the measures of field independence require visual perception skill.

The relationship between field independence and deep processing appears probable, and a somewhat less logical association can be made with some aspects of elaborative processing.

In a study with 64 college freshmen, Commons, Miller, and Kuhn (1982) found that more students categorized as formal operational took significantly more science/mathematics courses and received significantly higher grades in them. The primary question investigated was whether college students who do not exhibit reasoning at a formal operational level show inferior performance compared to those reasoning at that level. The authors employed the isolation of variables dimension of formal operational thought, which they believed to be the strategy having greatest face validity with respect to a role in the performance of college-level course work.

The categories based on course work were: (1) natural sciences and mathematics, and (2) liberal arts and social sciences. Among the subjects categorized as concrete operational, 16 of 32 completed no courses in science or mathematics; the remaining 16 completed one course. Among those classified as formal operational, 5 completed no courses, 8 completed one course, and 19 completed two or more courses in the science/mathematics category. The mean grade point average in science/mathematics courses of the students classified as concrete was 1.62 whereas for those categorized as formal, it was 2.40. In the liberal arts/social sciences, the mean GPA of "concretes" was 2.08 and of "formals" was 2.18.

Since the only significant difference between subjects designated as concrete and formal was in the science/mathematics area, the authors conducted a second study to explore more specifically the performance of students enrolled in science and mathematics courses. The subjects consisted of 182 college students enrolled in mathematics or science courses in three colleges or universities in the northeast. As in the previous study, the subjects were matched on college entrance examination scores. Of the 182 students, only one scored at level 0 (completely concrete operational) and none at level 1 (predominantly concrete operational but with some emergent formal reasoning). The remainder were transitional or fully formal.

In summary, research findings have shown that college students have various styles of processing information and levels of formal operational ability. Although not substantiated by research, there is indication that a relationship exists between these two variables. Both learning style and formal operations have been found to be correlated with overall achievement. Additionally, researchers have suggested that subjects show variability in their use of learning style and level of formal operations in different content areas. The type of learning style and level of formal operations chosen might be correlated with achievement in these areas. Finally, research has also suggested that age and level of education may be related to the development of learning style and formal operations.

CHAPTER II

METHOD

Subjects

The subjects for this study were 78 undergraduate students from educational psychology and human services courses at The University of Tennessee, Knoxville. Classified on the basis of the number of quarter hours of coursework completed, the subjects consisted of 17 sophomores, 28 juniors, and 33 seniors. (Refer to the operational definition of terms listing in Appendix B for these classifications.) Subjects ranged in age from 18 to 46 with a mean of 22.6. Sixty-one females and 17 males participated in the study. In order to participate in the study, subjects had had at least two college-level courses in each of the content areas dealt with in the study, i.e., mathematics/-natural sciences and humanities/social sciences.

Procedures

During October 1984, potential participants were approached in educational psychology and human services classes and were given the following information by the researcher:

> I am doing research on learning styles and other learner characteristics. Participation in the study will include taking two inventories, one which will require 30-40 minutes and the other which will take approximately 20-30 minutes. If you would like feedback on the inventories, I would gladly arrange a time to discuss your results with you individually. For the study, you will also be requested to supply your name, age, social security number, level of education, and number of courses in subject areas and to

grant permission to review your academic records for ACT scores and grade information. All data are for research purposes and will be held in strictest confidence. In accordance with university policy, you will be requested to sign an informed consent statement which includes the above information.

Arrangements were made with subjects who completed informed consent forms to complete the two inventories. For completion of the Logical Reasoning Test (LRT), group sessions were scheduled at six different time intervals and individual appointments for the students who could not meet any of those times. At the time of the announcement of the research project, participants were given the Inventory of Learning Processes (ILP) to complete and return at the time scheduled for the LRT. Instructions were given for the subjects to respond to each item on the ILP twice, first as the item pertained to their preparation for examinations or assignments in humanities/social sciences courses and secondly as to the item's usefulness in preparation for examinations or assignments in mathematics/natural sciences courses.

American College Testing (ACT) scores in English, mathematics, social studies, and natural science and grades in the specified content areas were collected from the subjects' academic records. Grade point averages were computed for courses classified in humanities/social sciences which included: English, (composition and literature), sociology, psychology, history, languages, economics, and political science. Additionally, grade point averages were computed for courses in the mathematics/natural sciences which included mathematics, physics, chemistry, biology, geology, and astronomy. When the inventories were scored and data compiled, a letter was sent to each participant in which the researcher expressed appreciation for the individual's participation in the study and offered to interpret the results of the data.

Instrumentation

The inventories used in this experiment were the Schmeck, Ramanaiah, Ribich Inventory of Learning Processes and the Burney Logical Reasoning Test. Additionally, scores from the ACT college entrance examination were collected from students' academic records. Following are descriptions of the instruments:

Schmeck, Ramanaiah, Ribich Inventory of Learning Processes

Schmeck, Ramanaiah, and Ribich developed their inventory by factor analyzing the responses of 503 students to 121 statements (selected by a panel of experts as) pertaining to behaviors in which college students engage while preparing for course examinations. The inventory assesses various dimensions of learning behavior and conceptual characteristics of college students. In this study, subjects were requested to respond to each item in terms of its usefulness in preparing for, or performing on, examinations in mathematics or mathematics-based science courses and in verbally-based humanities/social sciences courses.

The Inventory of Learning Processes, a paper-pencil inventory with 65 true/false items has four scales: deep processing, elaborative processing, shallow processing, and methodical study. Deep processing (18 items) assesses the extent to which individuals critically evaluate, analyze, and conceptually organize information. Elaborative processing (14 items) concerns the use of summarizing, visualizing, relating, and applying information. Shallow processing (10 items) measures an individual's preference for facts and details, rote learning, and, in general, a good memory. Methodical study (23 items) refers to the employment of systematic study techniques, regular review, and integration of relevant study material.

Reliability information on the ILP is as follows: deep processing (18 items) internal consistency = .94 test-retest = .88; elaborative processing (14 items) internal consistency = .89 test-retest = .80; shallow processing (10 items) internal consistency = .97 test-retest = .79; methodical study (23 items) internal consistency = .74 test-retest = .83. Construct validity studies have been conducted comparing the ILP with the Watson-Glaser Critical Thinking Appraisal, Form Ym, the Cognitive Preference Test, Betts Questionnaire Upon Mental Imagery, Imagery Rating Scale, Manifest Anxiety Scale, Scale of Academic Curiosity, Achievement-via-Independence and Achievement-via-Conformance, and scales of the California Psychological Inventory. Additionally, a study examining the discriminant validity of the inventory was conducted in which correlations were made with the

Nelson-Denny Reading Test. The deep processing scale was significantly correlated with vocabulary and comprehension (r_s = .27, .37) and was not related to reading rate (r = .07).

Schmeck et al. (1977) conducted two validity studies on the ILP while developing it. In one study, subjects watched a videotape of a psychology lecture while reportedly trying to judge its complexity. Afterward, they were administered an unannounced test. The results indicated significant positive correlations between performance on the test and both deep and elaborative processing. These results were consistent with Craik and Lockhart's (1972) and Craik and Tulving's (1975) laboratory findings that deep and elaborative processors retain more information even when not instructed to learn it. Thus, Schmeck et al. (1977) concluded that the results suggest a predisposition to favor a particular learning style.

The second validation study by Schmeck et al. (1977) was a traditional memory study composed of 15 concrete and 15 abstract nouns. Half the subjects were instructed to study the list and the other half were given a disguising task which presumably led them to read the list but not actively study it. Then all subjects were given recall and recognition tests of memory. Correlations between the scales of the ILP and performance on the memory tests occurred only on the recall test and with concrete material. The researchers concluded that since recall tests are particularly sensitive to retrieval processes and recognition tests merely reflect what is in storage, the data indicated that retrieval processes are assessed by the inventory. Furthermore, they found significant relationships between memory for the word list and both deep and elaborative processing when students were not instructed to learn. Methodical study was correlated when students were directed to learn in which case the researchers believed the instructions intensified study behavior (i.e., repetitive rehearsal).

Burney Logical Reasoning Test

The Logical Reasoning Test consists of 21 multiple choice items. Of the 21 questions, 7 assess the use of propositional logic, 5 assess propositional reasoning, 3 assess syllogistic reasoning, and 6 assess analogical reasoning.

Burney stated that initially 42 items were constructed based on a review of the literature concerning formal thought and the construction of paper-and-pencil Piagetian instruments. This pool of items contained syllogisms, verbal analogies, questions involving combinatorial and probabilistic reasoning, and questions similar to Piagetian tasks. The items were administered to 50 ninth, eleventh, and thirteenth graders. A set of 5 Piagetian tasks (developed and used by Piaget and Inhelder) was then administered to this sample. The biserial $\underline{r}$ correlation coefficient was computed for each paper-and-pencil item using scores on the task instrument as an outside criterion to render a value of item validity for each paper-and-pencil item. Using information obtained from this analysis of the 42 items, 24 with highest biserial ratings were selected for the objective instrument. Following the study, the three with lowest biserial ratings were eliminated.

Once the final form of the objective instrument was determined, it was administered to 78 ninth, eleventh, and thirteenth graders. The Piagetian task instrument was also administered to this sample. Again, biserial r correlation coefficients were calculated for each item on the objective instrument. Two biserial r values were reported for each item. One was calculated using the criterion scores (item validity) and the other was calculated using the total scores on the paper-and-pencil inventory (internal consistency). Item validity scores ranged from .322 to .878, and internal consistency scores ranged from .171 to .966.

In order to determine concurrent validity, the Pearson product-moment correlation coefficient was computed comparing scores on the objective test with scores on the task instrument. A Pearson r correlation coefficient of .853 was obtained (.565 for college freshmen). Using the Kuder-Richardson formula #20, a reliability coefficient of .825 was obtained (.528 for college freshmen). When students were classified in three categories (formal, transitional, and concrete or below) there was an 84.6% agreement in classification.

Burney assigned subjects to three classifications depending on performance on the Piagetian Task Instrument (Ball & Sayre, 1972) and the Test of Logical Reasoning. Examination of items on the inventory in comparison with Piagetian tasks led to the following categories based on the subject's score: formal operational if they answered 17-21 items correctly, transitional if they answered 0-10 items correctly. In Burney's population, the mean score was 16.62 with a range of 5-23. Among the college freshmen, the range was 14-23 with a mean of 19.44. A second revision of the instrument, which eliminated 3 items, recategorized the items as follow: formal operational--14-21 correct items, transitional--8-13 correct items, and concrete operational--0-7 correct items.

Conclusions from Burney's study indicated that the Logical Reasoning Test could be used in its present form to measure formal thought to a "fairly high degree of confidence" (p. 60). He indicated that the validity and reliability coefficients of the test when used with college freshmen were probably much better than would appear when compared with those of the other two age groups. This conclusion was supported by Downie (1967) who explained that a major determinant for the magnitude of a correlation coefficient was the range of talent in the sample. A moderate coefficient may be as meaningful when obtained from a homogeneous group as a high one from a group with a wide range of scores. The college group with a large percentage (.78) of formal operational was more homogeneous than the ninth and eleventh grades. A recommendation made by Burney was that: "college students should be studied further to determine if this population presents any unique problems concerning the use of this type of instrument" (p. 62).

Popejoy and Schweers (In Bybee & Sund, 1982) who have utilized the Burney Test reported that they believed it to be a reliable, though somewhat conservative, measure of formal reasoning. Popejoy has also revised the categorization of the instrument to consist of preformal 0-9, transitional 10-14, and formal 15-21.

American College Testing Program

The American College Testing Program (1973, 1978) includes four academic tests which measure abilities in the subject areas traditionally identified with college and high school programs: English, mathematics, social studies, and natural science. The English test measures students' understanding and use of the basic elements of correct and effective writing. The mathematics test assesses mathematical reasoning and problem-solving ability. The social studies test measures the critical reasoning and problem-solving skills required in the social sciences, and the natural science test assesses the critical thinking and problem-solving skills required in the natural sciences.

ACT test scores are reported on a standard scale that ranges from 1 to 36. On this scale, a student's true score is usually within two score points on either side of the reported score for each of the four tests.

Since its beginning, the ACT Program (1978) has continually collected information about the quality of its test battery. Reliability of the tests has been examined by three methods: internal consistency, parallel forms, and test-retest. Internal consistency has yielded median reliabilities ranging from .84 for a single test to .95 for the composite score. Results of parallel forms of the four tests have ranged from .78 to .87. Long-term test-retest coefficients over a 2 year period have ranged from .67 to .84.

Validity of the tests has also been established. Reviewers have evaluated the content by thoroughly examining the items of the battery, rationale for their development, and the intellectual processes required to respond to the items. Predictive validity studies have repeatedly shown that the tests in combination with high school grades have been useful in predicting academic success. Median predictive validity of individual tests ranges from .37 to .50.

ACT score norms are reported in percentile ranks, a method of indicating the rank of a score relative to the scores of a group of people. Normative data are collected each year from thousands of subjects. Normative data from subgroups on the basis of age, sex, family income, racial-ethnic background, region, and planned educational major are available.

CHAPTER III

RESULTS

In this correlational study, the independent variables were learning style and level of formal operations. The dependent variable was achievement in specified content areas as determined by the ACT scores and grade point averages in those content areas. In addition, sociodemographic variables (age and level of education) were correlated with learning style and level of formal operations to determine the relationship of the former on the development of the latter. Also, the intercorrelations between the dimensions of learning style and levels of formal operations were determined.

The data were collected and analyzed to determine the relationships between all the variables. The means, standard deviations, variances, and range of scores were computed for all variables. (Refer to Appendix E for these data.) The Pearson Product Moment $\underline{r}$ was used with the two variable comparisons of interval data, i.e., mathematics/natural sciences learning styles dimensions with humanities/social sciences learning styles dimensions; mathematics/natural sciences learning styles dimensions with mathematics and natural science ACT scores, grade point averages in mathematics/natural sciences courses, and formal operations scores; humanities/social sciences learning style dimensions with English and social studies ACT scores, grade point averages in humanities/social sciences courses, and formal operations levels; and chronological age with learning styles scores and formal operations scores. The level of probability of each correlation coefficient exceeding the absolute value of /r/, i.e., being higher with a comparable population of a similar number of subjects (or the probability of a Type I error) was provided. The .05 level was used to determine which correlations were significant. Also, the contingency coefficient (a descriptive statistic, analogous to a correlation coefficient) was used with the multiple category coefficients, i.e., learning styles dimensions and levels of formal operations with levels of education. The level of significance for each contingency coefficient was provided.

The findings of the study are presented for each of the hypotheses in the study. The first hypothesis determined the correlations between the learning style (i.e., deep processing, elaborative processing, shallow processing, methodical study) employed when studying for mathematics/natural sciences courses and those used when studying for humanities/social sciences courses. As shown in the highlighted section of Table 1, significant correlations were found between the dimensions of learning style in each of the content areas. For example, elaborative processing for mathematics/natural sciences courses and for humanities/social sciences were significantly correlated ($r = .71$, $p < .001$). In addition, shallow processing for mathematics/natural sciences and for humanities/social sciences were significantly correlated ($r = .54$, $p < .001$). Similarly, deep processing for mathematics/natural sciences was significantly correlated with deep processing for humanities/social sciences ($r = .71$, $p < .001$). The

Table 1

Correlations Between Humanities/Social Sciences and Mathematics/Natural Sciences Learning Styles

	Elaborative proc. math./nat. sci.	Shallow proc. math./nat. sci.	Deep proc. math./nat. sci.	Methodical study math./nat. sci.	Elaborative proc. hum./soc. sci.	Shallow proc. hum./soc. sci.	Deep proc. hum./soc. sci.	Methodical study hum./soc. sci.
Elaborative processing math./nat. sci.	1.00 0.0000	-0.32 0.0045	0.55 0.0001	0.55 0.0001	0.71* 0.0001	-0.29 0.0079	0.42 0.0002	0.44 0.0001
Shallow processing math./nat. sci.	-0.32 0.0045	1.00 0.0000	-0.22 0.0597	-0.08 0.4571	-0.14 0.2377	0.54* 0.0001	-0.12 0.3523	-0.04 0.7007
Deep processing math./nat. sci	0.55 0.0001	-0.22 0.0597	1.00 0.0000	0.28 0.0128	0.43 0.0001	-0.21 0.0720	0.71* 0.0001	0.12 0.3223
Methodical study math./nat. sci.	0.55 0.0001	-0.08 0.4571	0.28 0.0128	1.00 0.0000	0.38 0.0006	-0.09 0.4068	0.32 0.0049	0.73* 0.0001
Elaborative processing hum./soc. sci.	0.71 0.0001	-0.12 0.2877	0.42 0.001	0.38 0.006	1.00 0.0000	-0.26 0.0237	0.51 0.0001	0.47 0.0001
Shallow processing hum./soc. sci.	-0.29 0.0079	0.54 0.0001	-0.21 0.0720	-0.09 0.4068	-0.26 0.0237	1.00 0.0000	-0.32 0.0055	-0.08 0.4449
Deep processing hum./soc. sci.	0.42 0.0002	-0.11 0.3523	0.71 0.0001	0.32 0.0049	0.61 0.0001	-0.32 0.0055	1.00 0.0000	0.27 0.0140
Methodical study hum./soc. sci.	0.44 0.0001	-0.04 0.7007	0.12 0.3223	0.73 0.001	0.47 0.0001	-0.08 0.4449	0.27 0.0140	1.00 0.0000

*p < .05

deep processing scales for methodical study in mathematics/natural sciences and humanities/social sciences were also significantly correlated ($r = .73$, $p < .001$).

The second hypothesis investigated the correlations between level of formal operations, natural science and mathematics ACT scores, grade point average in mathematics and natural sciences courses, and the learning style employed in the courses. The highlighted sections of Table 2 depict these correlations. As shown in Table 2, the findings indicated the most significant positive correlations among the level of formal operations and mathematics ACT scores ($r = .38$, $p < .0005$), natural science ACT scores ($r = .27$, $p < .0167$) and grade point average in mathematics/natural sciences courses ($r = .44$, $p < .0001$). In addition, the level of formal operations and deep processing in mathematics/natural sciences courses were significantly correlated ($r = .24$, $p < .036$). Also, the level of formal reasoning was negatively correlated with methodical study in mathematics/natural sciences courses ($r = -.21$, $p < .0599$). A low negative correlation was shown between level of formal reasoning and elaborative processing ($r = -.12$, $p < .31$). Similarly, grade point averages in natural sciences/mathematics courses were negatively correlated ($r = -.20$, $p < .08$) with shallow processing whereas grade point averages in mathematics/natural sciences courses were significantly positively correlated with deep processing ($r = .24$, $p < .03$). The correlations between grade point average in mathematics/natural sciences courses and elaborative processing ($r = .07$, $p < .53$) and methodical study ($r = .06$, $p < .64$) were negligible.

Table 2

Intercorrelations Between Formal Operations, G.P.A. in Mathematics/Natural Sciences Courses, Mathematics and Natural Science ACT Scores, and Learning Style

	Elaborative proc. math./nat. sci.	Shallow proc. math./nat. sci.	Deep proc. math./nat. sci.	Methodical study matn./nat. sci.	Math. ACT score	Natural science ACT score	G.P.A. math./nat. sci.	LRT Formal reasoning
Elaborative processing math./sci.	1.00 0.0000	-0.32 0.0045	0.55 0.0001	0.55 0.0001	0.09 0.4384	0.14 0.2318	0.07 0.5341	-0.12 0.3116
Shallow processing math./sci.	-0.32 0.0045	1.00 0.0000	-0.22 0.0597	-0.08 0.4571	-0.19 0.0855	-0.04 0.7175	-0.19 0.0845	-0.01 0.9182
Deep processing math./sci.	0.55 0.0045	-0.22 0.0597	1.00 0.0000	0.28 0.0128	0.20 0.0810	0.32* 0.0045	0.24* 0.0346	0.24* 0.0369
Methodical study math./sci.	0.56 0.0001	-0.08 0.4571	0.28 0.0128	1.00 0.0000	-0.04 0.74	-0.47 0.68	0.54 0.64	-0.22* 0.0599
Math. ACT score	0.10 0.4384	-0.19 0.0855	0.19 0.0810	-0.04 0.7388	1.00 0.0000	0.46 0.0001	0.56 0.0001	0.39 0.0005
Natural science ACT score	0.14 0.2318	-0.04 0.7175	0.32 0.0045	-0.05 0.6847	0.46 0.0001	1.00 0.0000	0.37 0.0008	0.27 0.0167
G.P.A. math./ natural sciences	0.07 0.5341	-0.20 0.0845	0.24 0.0346	0.05 0.6393	0.56 0.0001	0.37 0.0008	1.00 0.0000	0.44 0.0001
LRT (Formal reasoning)	-0.12 0.3116	-0.01 0.9182	0.24 0.0369	-0.22 0.0599	0.38* 0.0005	0.27* 0.0167	0.44* 0.0001	1.00 0.0000

*p < .05

As shown in Table 2, a significant positive correlation was shown between natural science ACT scores and deep processing ($r = .31$, $p < .0045$) and a noted correlation between mathematics ACT scores and deep processing ($r = .20$, $p < .08$). Negative correlations were shown between mathematics ACT scores and shallow processing ($r = -.20$, $p < .09$) and methodical study ($r = -.04$, $p < .74$). The negative correlations between natural science ACT scores and shallow processing ($r = -.04$, $p < .71$) and methodical study ($r = -.04$, $p < .68$) were negligible. On the elaborative processing scale, negligible positive correlations were indicated with mathematics ACT scores ($r = .09$, $p < .44$) and natural science ACT scores ($r = .14$, $p < .23$).

The third hypothesis explored the correlations between level of formal operations, grade point average in social sciences/humanities courses, English and social studies ACT scores, and the learning style employed in the courses. Refer to the highlighted section of Table 3 for a complete analysis of the results. As depicted in Table 3, the most significant positive correlations were shown between formal operations and English ACT scores ($r = .30$, $p < .0082$), social science ACT scores ($r = .29$, $p < .0107$), and grade point average in humanities/social sciences courses ($r = .31$, $p < .0062$). The levels of formal operations also showed a significant negative correlation with methodical study ($r = -.40$, $p < .0003$) and a low negative correlation with elaborative processing ($r = -.12$, $p < .30$). Deep processing was slightly positively correlated ($r = .14$, $p < .21$) with formal operations while shallow processing showed a negligible correlation ($r = .03$, $p < .82$). A significant positive correlation was shown between social

Table 3

Intercorrelations Between Formal Operations, G.P.A. in Social Sciences/Humanities Courses, English and Social Sciences ACT Scores, and Learning Style

	Elaborative proc. hum./soc. sci.	Shallow proc. hum./soc. sci.	Deep proc. hum./soc. sci.	Methodical study hum./soc. sci.	English ACT score	Soc. studies ACT score	G.P.A. hum./soc. sci.	LRT (Formal operations)
Elaborative processing hum./soc. sci.	1.00 0.0000	-0.25 0.0237	0.51 0.0001	0.47 0.0001	0.02 0.8367	0.12 0.2848	-0.04 0.7043	-0.12 0.3045
Shallow processing hum./soc. sci.	-0.26 0.0237	1.00 0.0000	-0.31 0.0055	-0.08 0.4449	-0.09 0.4306	-0.31* 0.0053	0.11 0.3532	0.03 0.8180
Deep processing hum./soc. sci.	0.51 0.0001	-0.31 0.0055	1.00 0.0000	0.28 0.0140	0.17 0.1393	0.37* 0.0009	0.10 0.38	0.14 0.21
Methodical study hum./soc. sci.	0.47 0.0001	-0.08 0.4449	0.27 0.0140	1.00 0.0000	-0.02 0.8459	0.05 0.6910	-0.06 0.6306	-0.40* 0.0003
English ACT score	0.02 0.8367	-0.09 0.4306	0.17 0.1393	-0.02 0.8459	1.00 0.0000	0.66 0.0001	0.42 0.0001	0.29 0.0082
Social studies ACT score	0.12 0.2848	-0.31 0.0053	0.37 0.0009	0.04 0.6910	0.66 0.0001	1.00 0.0000	0.38 0.0005	0.28 0.0107
G.P.A. hum./soc. sci.	-0.04 0.7043	0.11 0.3532	0.10 0.3841	-0.05 0.6306	0.42 0.0001	0.38 0.0005	1.00 0.0000	0.31 0.0062
LRT (Formal reasoning)	-0.12 0.3045	0.03 0.8190	0.14 0.2121	-0.40 0.0003	0.30* 0.0082	0.29* 0.0107	0.31* 0.0062	1.00 0.0000

*p < .05

science ACT scores and deep processing ($r = .37$, $p < .0009$) whereas a significant negative correlation was indicated with shallow processing ($r = -.31$, $p < .0053$). All other relationships, i.e., English ACT score with elaborative processing ($r = .02$, $p < .84$), shallow processing ($r = -.09$, $p < .43$), deep processing ($r = .17$, $p < .14$), and methodical study ($r = .02$, $p < .85$) were negligible. In addition, social studies ACT scores showed no significant correlation with elaborative processing ($r = .12$, $p < .28$) and methodical study ($r = .05$, $p < .69$). Moreover, GPA in humanities/social sciences courses showed negligible relationships with elaborative processing ($r = -.04$, $p < .70$), shallow processing ($r = .11$, $p < .35$), deep processing ($r = .10$, $p < .38$), and methodical study ($r = -.06$, $p < .63$).

The following results were found in response to hypothesis four, which explored the associations between chronological age and level of education and between learning style and level of formal operations. As shown in Tables 4 and 5, with this population, age was found to be significantly negatively correlated with shallow processing (for mathematics/ natural sciences $r = -.26$, $p < .02$; for humanities/social sciences $r = -.33$, $p < .0029$). Also, age was positively correlated with methodical study (for mathematics/natural sciences $r = .30$, $p < .0077$; for humanities/ social sciences $r = .30$, $p < .0067$). A negative correlation was found between age and formal operations ($r = -.21$, $p < .07$). Age showed no meaningful correlations with the other variables in the study, i.e., elaborative processing (mathematics/natural sciences, $r = .17$, $p < .13$; humanities/social science, $r = .18$,

Table 4

Correlations Between Age and Mathematics/Natural Sciences Learning Styles, ACT Scores, G.P.A.'s, and Formal Operations

	Elaborative proc. math./nat. sci.	Shallow proc. math./nat. sci.	Deep proc. math./nat. sci.	Methodical study math./nat. sci.	Mathematics ACT scores	Natural science ACT scores	G.P.A. math./nat. sci.	Logical reasoning test	Age
Age	0.17221	-0.25802	-0.04174	0.29953	0.03297	0.12100	-0.09496	-0.20504	1.00000
	0.1316	0.0226*	0.7167	0.0077*	0.7745	0.2913	0.4082	0.0717	0.0000

*p < .05

Table 5

Correlations Between Age and Humanities/Social Sciences Learning Styles, ACT Scores, G.P.A.'s, and Formal Operations

	Elaborative proc. hum./soc. sci.	Shallow proc. hum./soc. sci.	Deep proc. hum./soc. sci.	Methodical study hum./soc. sci.	English ACT scores	Social studies ACT scores	G.P.A. hum./soc. sci.	Logical reasoning test	Age
Age	0.18000	-0.33300	-0.01651	0.30475	0.08039	0.19428	-0.13043	-0.20504	1.00000
	0.1148	0.0029*	0.8859	0.0067*	0.4842	0.0883	0.2551	0.0717	0.0000

*p < .05

$p < .11$), deep processing (mathematics/natural sciences, $r = -.04$, $p < .72$; humanities/ social sciences, $r = -.02$, $p < .89$), ACT scores (mathematics, $r = .03$, $p < .77$; natural science, $r = .12$, $p < .29$; social studies, $r = .19$, $p < .09$; English, $r = .08$, $p < .48$), GPA (mathematics/natural sciences, $r = -.09$, $p < .41$; humanities/social sciences, $r = -.13$, $p < .26$).

A contingency coefficient was used to determine the correlation between level of education (i.e., sophomore, junior, senior) and all other variables in the study. As shown in Table 6, the only learning style dimension found to be significantly associated with level of education was shallow processing in humanities/social sciences courses (contingency coefficient = .63; $p < .02$). As depicted in Table 7, level of education was not significantly related to level of formal operations (contingency coefficient = .30, $p < .27$).

Table 6

Chi-Square Analysis and Contingency Coefficients of Level of Education (Sophomore, Junior, Senior) and Learning Style

Level of education and learning style dimension	χ^2	df	Level of significance	Contingency coefficient
Elaborative processing math./natural sciences	46.43	38	.16	.61
Elaborative processing hum./social sciences	32.38	30	.35	.54
Shallow processing math./natural sciences	20.22	24	.68	.45
Shallow processing hum./social sciences	54.07	34	.02*	.63
Deep processing math./natural sciences	24.55	32	.82	.49
Deep processing hum./social sciences	36.22	34	.37	.56
Methodical study math./natural sciences	37.33	32	.24	.57
Methodical study hum./social sciences	25.46	34	.85	.50

*$p < .05$

Table 7

Chi-Square Analysis and Contingency Coefficients of Level of Education and Level of Formal Operations

	Preformal	Transitional	Formal	Raw total
Sophomore	0	6	8	14
	0.0	42.9	57.1	17.9
	0.0	23.1	17.0	
	0.0	7.7	10.3	
Junior	0	10	20	31
	0.0	32.3	64.5	39.7
	0.0	38.5	42.6	
	0.0	12.8	25.6	
Senior	4	10	19	33
	12.1	30.3	57.6	42.3
	100.0	38.5	40.4	
	5.1	12.8	24.4	
Column total	4	26	47	78
	5.1	33.3	60.3	100.0

$\chi^2 = 7.60852$ with 6 degrees of freedom.

Significance = 0.2682

Contingency coefficient = 0.29812

CHAPTER IV

DISCUSSION

The primary focus of this study was to determine what relationships existed among learning style, formal operations, ACT scores, and grade point averages in specified content areas of undergraduate college students. A secondary objective was to explore the relationship of age and level of education to the development of learning styles and formal operations.

In response to hypothesis 1, the results of the study indicate that there were significant correlations between the learning styles employed when studying for both mathematics/natural sciences and humanities/social sciences courses. The correlations were actually higher than anticipated based on some researchers' speculation of learning style differences in particular subject areas (e.g., Kolb, 1984; Schmeck, 1983). A number of explanations of the findings and recommendations for research to further clarify similarities and differences in learning styles in specific subject areas may be offered. First, it should be noted that the sample in this study showed a mean number of 54.33 hours of coursework in the humanities/social sciences area and a 30.05 mean number of hours in the mathematics/ natural sciences area (refer to Tables E-1 and E-2 in Appendix E). Also, the categories of humanities/social sciences and mathematics/natural sciences were perhaps too broad to clearly differentiate styles. Research utilizing more narrowly defined categories (e.g., physics and sociology) with a sample who had completed equal number of hours of coursework in each area might show different results. An examination of specific Inventory of Learning Processes answer sheets of subjects who had a more equal balance of coursework in each of the content areas showed a lower correlation between the scales. Additionally, although the ILP showed some differentiations, along with most learning styles instruments, it was designed to assess styles generalizable to both content areas. Thus, the revision or development of an instrument designed to more clearly delineate differences could add to the research in this area.

For the purposes of discussion, hypotheses 2 and 3 were combined. Hypothesis 2 dealt with the correlations between formal operations, mathematics and natural science ACT scores, grade point average in mathematics and natural sciences courses, and the learning style employed in the courses. Hypothesis 3 dealt with the correlations between formal operations, English and social studies ACT scores, grade point average in social sciences and humanities courses, and learning style employed in the courses. Consistent with Schmeck's speculation (1982, 1983), significant positive correlations were found between formal reasoning and deep processing in mathematics/natural sciences courses ($r = .24$, $p < .0369$). However, the positive correlation between formal operations and deep processing in humanities/social sciences were appreciably lower ($r = .14$, $p < .21$). In addition, the correlations between level of formal reasoning and mathematics ACT scores ($r = .38$, $p < .0005$) were higher than the correlations between formal reasoning and English ACT scores ($r = .30$, $p < .0082$). Moreover, the relationship between level of formal reasoning and grade point average in mathematics/natural sciences courses ($r = .44$, $p < .0001$) was considerably higher than with grade point average in English/social sciences courses ($r = .31$, $p < .0062$). (Compare Tables 2 and 3, pp. 40 and 42 for these data.) Thus, these results lend some support to Vu's (1977) finding that individuals attain formal operational thought in certain subject areas at different rates. Furthermore, the findings appear to support Commons, Miller, and Kuhn's (1982) study which indicated formal operations to be more positively correlated with mathematics/science than with liberal arts/social science courses.

In addition, significant positive correlations were found between deep processing, grade point average in mathematics/natural sciences and mathematics, natural science, and social studies ACT scores. These results support Schmeck and Grove's (1979) general finding that deep processing is correlated with achievement. Likewise, the negative correlations between methodical study and mathematics/natural science ACT scores as well as low or negligible correlations with grade point average in all areas, and English and social studies ACT scores lends further support that methodical study is not positively correlated with achievement. Thus, the results suggest that synthesizing and analyzing information are conducive to effective performance in college courses whereas organized study habits are not sufficient to produce high levels of achievement.

The low negative correlations between shallow processing and grade point average and ACT scores in all areas were as expected. It should be pointed out, however, that shallow processing is a revised scale on the ILP which duplicates only some of the original fact retention items. Schmeck (1982, 1983) reported fact retention to be related to achievement. However, shallow processing was not found to be correlated with achievement and was significantly negatively correlated with deep processing in both natural sciences/mathematics and humanities/social sciences (refer to Tables 2 and 3, pp. 40, 42). Thus, the data indicated that verbatim memorization does not appear to be adequate to produce a high level of achievement in college courses.

The findings discussed in these paragraphs are consistent with results of Entwistle and Ramsden (1983) that higher order factors of meaning (deep processing) were more highly correlated with achievement whereas reproducing (shallow processing) was not correlated. In addition, the results support Svensson's (1977) finding that a deep approach to study was significantly correlated with high academic performance while a surface approach was correlated with low performance.

The fact that elaborative processing was found to have negligible correlations with grade point averages and ACT scores in all areas was not expected. Although elaborative processing was predicted to correlate with lower levels of formal reasoning, the low negative correlations were not anticipated. However, in both humanities/natural sciences and mathematics/natural sciences, elaborative processing showed significant positive correlations with deep processing (refer to Tables 2 and 3, pp. 40 and 42). An extrapolation from this finding is that either instructors are failing to make information relevant or that students are not integrating it into a personalized framework. Therefore, it is recommended that further research be conducted with elaborative processing and specific subjects, e.g., English literature, to further probe Schmeck and Grove's (1979) finding that elaborative processing is related to achievement, at least in some content areas. Prior research has indicated elaborative processing to be positively correlated with verbal learning, subjective organization, and imagery ability (Schmeck & Ribich, 1978; Schmeck et al., 1977).

Hypothesis 4 investigated the following associations: chronological age and level of education, learning style and level of formal operations. Based on Perry (1970) and Schmeck (1982, 1983), it was expected that both deep and elaborative processing would show significant positive correlations with age and level of education. The results, however, showed that only age was positively correlated with methodical study, suggesting that more organized study habits, not levels of processing information, develop with increasing age. The negative correlation with shallow processing (interpreting the scale as verbatim memorization, opposite of deep processing) was as expected. Also, based on Sund (1976), Bybee and Sund (1982), and Commons, Miller, and Kuhn (1982), the negative correlation between age and formal operations was not anticipated. Furthermore, the indication that level of education was not related to level of formal operations was not expected.

Perhaps the fact that the age range of the subjects in the study was 18-46 with a mean of 22.7 influenced the results. A number of the subjects were in the "older than average" population returning to college following interruption in educational experiences. Since a number of the subjects could be classified as nontraditional, perhaps future research should control the age variable, choosing only subjects who are the "typical" aged 19-21 college sophomores, juniors, and seniors. It is further suggested that cross-sectional studies comparing freshmen with seniors might show a clearer picture of the growth in both learning style dimensions and formal operations. In addition, longitudinal studies following the same group of subjects over the four year span would show a more lucid pattern of changes.

Although inconclusive, these findings tend toward supporting those researchers (e.g., Cross, 1976; Messick, 1976; Witkin, 1976) who contended that learning style is a more stable, inherent or early developed characteristic than one continuing to develop with college-level educational experience as suggested by Perry (1970). The results also appear to favor the Piagetian formal operations model indicating that age (beyond 18) and college classification are not necessarily associated with level of formal operations. Nonetheless, in agreement with Bybee and Sund (1982) and Commons, Miller, and Kuhn (1982), not all college students were found to have attained mature formal operational thought. Also, in accordance with Schmeck (1982, 1983), not all college students have developed deep processing skills. Furthermore, in support of Kolb (1984), Kuhn (1979), Lawson and Snitzen (1982), Schmeck (1983), and Vu (1977), both skills may have been developed at variable rates in different content areas.

Since a major conclusion of this study was that formal operational thought and deep processing are significantly correlated with achievement, it is suggested that further research be conducted to determine whether instructional techniques have an effect on the development of these learning styles. This more specific research would further substantiate the position of Blackman and Goldstein (1982), Bybee and Sund (1982), Chickering (1976), Hill (1981), Kuhn (1979), and Reissman (1976) who believe that learning style and formal operational thought can be modified by instructional strategies. Furthermore, it is recommended that researchers investigate at what stage students are capable of being taught formal reasoning and deep processing and how these skills may be most effectively taught. This research would build on the position of the multi-approach teaching style advocated by Blackman and Goldstein, 1982; Cornett, 1982; Cross, 1976; Messick, 1976b; Letteri, 1982; Kolb, 1981; Kirby and Das, 1977; and Schmeck, 1981.

Other implications of the study suggest that teaching verbatim memorization, organized study habits, and a transitional level of formal thought is less than adequate to prepare students for a high level of achievement in college courses. Hence, in order to improve learning, college instructors must provide opportunities for the development of deep processing and mature formal operational strategies. Schmeck (1982) suggested that college teaching should encourage the use of deep processing strategies, and Kuhn (1975) as well as Lawson and Snitzen (1982) indicated that college instruction could affect the development of formal operation thought.

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APPENDICES

APPENDIX A

INFORMED CONSENT STATEMENT

INFORMED CONSENT STATEMENT

I understand that the purpose of this study is to develop a more comprehensive picture of characteristics which affect learning. I have been informed that I will complete an inventory dealing with learning styles (20-30 minutes) and one pertaining to reasoning (30-40 minutes) and that I will report my age and level of education on the answer sheet which will be used for research purposes only. I have also been informed that I am granting permission to the researcher to review my academic records for college grades and American College Testing scores. I understand that listing my name and social security number will be necessary solely for the purpose of obtaining this information and that my identity and the information will be held in strictest confidence. Once the data are collected, my identity will not be included in the data analysis or results.

Furthermore, I understand that I can withdraw from participation at any point without penalty. If I have further questions regarding my participation in the study, I will have the option of contacting the experimenter at the address and telephone number listed below.

Martha R. Bryan
108 Claxton Education Building
University of Tennessee
Knoxville, TN 37996

974-6087

Name____________________

Date____________________

APPENDIX B

OPERATIONAL DEFINITION OF TERMS

Operational Definition Of Terms

Learning style--A predisposition to favor a particular learning strategy and utilize that strategy with cross-situational consistency as measured by the Inventory of Learning Processes.

Learning strategy--The pattern of information-processing activities a person engages in when confronted by a learning task as defined by Schmeck (1972, 1973).

Deep processing--The scale on the Inventory of Learning Processes which assesses the extent to which students will critically evaluate, conceptually organize, and compare and contrast the information being studied (formerly labeled synthesis-analysis in Schmeck's research).

Elaborative processing--The scale on the Inventory of Learning Processes which measures the extent to which students will translate new information into their own terminology, apply it to their own lives, generate concrete examples from their own experience, and use visual imagery to encode new information.

Shallow processing (replaces fact retention with revised items)--The scale on the Inventory of Learning Processes which refers to the students' preference for simply memorizing information for recall.

Methodical study--The scale on the Inventory of Learning Processes which assesses the students' employment of systematic study techniques, regular review, and the integration of relevant study material.

Piagetian formal operational period--Known by Piaget as the summit of cognitive development, formal operations involve hypothetical deductive thinking, ratios and proportions, inductive reasoning, reflective abstraction, systematic isolation and control of variables, and combinatorial logic.

Preformal operations--On the Burney Logical Reasoning Test, a score of 0-9 is indicative of preformal reasoning (based on the Piagetian model). In this stage, the learner demonstrates formal thought on less than 35% of the responses, a very low degree of consistency.

Transitional operations--On the Burney Logical Reasoning Test, a score of 10-14 is indicative of early formal thought (based on the Piagetian model). In this stage, the learner demonstrates formal thought on approximately 40 to 60% of the responses, a moderate degree of consistency.

Formal operations--On the Burney Logical Reasoning Test, a score of 15-21 is indicative of mature formal thought (based on the Piagetian model). In this stage, the learner demonstrates formal thought on approximately 65 to 100% of the responses, a very high degree of consistency.

Sophomore--An undergraduate student who has passed between 45 and 90 quarter hours of coursework.

Junior--An undergraduate student who has passed between 90 and 135 quarter hours of coursework.

Senior--An undergraduate student who has completed more than 135 quarter hours of coursework.

APPENDIX C

INVENTORY OF LEARNING PROCESSES

Inventory of Learning Processes
Schmeck, Ramamaiah, Ribich

Instructions:

This questionnaire asks you to describe the way you study and learn. There are many different ways to study and learn, any of which may be effective for a particular individual. Since this is the case, there are no "right" or "wrong" answers to these questions. We are simply trying to find out the ways in which people learn best. If we are successful in this we may be able to help instructors design their courses with student needs and competencies in mind. This instrument could also help counselors advise students as to what courses to take and how to study for them.

Answer TRUE or FALSE to each statement on the questionnaire. Please read the specific instructions for marking your answer sheet. Note that there are two responses to each statement, one for mathematics-based courses and one for verbal-based courses. Be sure that in marking your answer sheet you make the response for each item in the two spaces designated by the same number. For example, for item 1, you mark T or F for science courses in column 1 (no.1) on the answer sheet, and for humanities/social sciences courses, you mark T or F in column 3 (no. 1).

Please list the information requested at the bottom of the answer sheet, including your name and social security number. Otherwise, please do not write in the test booklet.

Thank you very much for participating in this research study!

The Inventory of Learning Processes is used with permission of Dr. Ronald R. Schmeck, Professor of Psychology, Southern Illinois University, Carbondale.

1. When studying for an exam, I prepare a list of probable questions and answers.
2. I have trouble making inferences.
3. I find that I concentrate on memorizing a lot of what we have to learn.
4. I increase my vocabulary by building lists of new terms.
5. I am very good at learning formulas, names and dates.
6. New concepts rarely make me think of many other similar concepts.
7. Even when I feel that I've learned the material, I continue to study it.
8. I have trouble organizing the information that I remember.
9. Even when I know I have carefully learned the material, I have trouble remembering it for an exam.
10. I usually don't have time to think about the implications of what I read.
11. I make simple charts and diagrams to help me remember material.
12. I rarely write an outline of the material I read.
13. I do not try to convert facts into "rules of thumb."
14. I do well on tests requiring definitions.
15. Professors seem to delight in making the simple truth unnecessarily complicated.
16. I usually refer to several sources in order to understand a concept.
17. I try to resolve conflicts between the information obtained from different sources.
18. I learn new words or ideas by visualizing a situation in which they occur.
19. I spend less time studying than most of my friends.
20. I learn new concepts by expressing them in my own words.
21. I often memorize material that I don't understand.
22. For exams, I memorize the material as given in the text or class notes.
23. I carefully complete all course assignments.
24. I have difficulty planning work when confronted with a complex task.
25. I "debate" with the material as I study it.

26. I remember new words and ideas by associating them with words and ideas I already know.

27. I review course material periodically during the quarter.

28. I often have difficulty finding the right words for expressing my ideas.

29. Toward the end of a course, I prepare an overview of all material covered.

30. I can easily handle questions requiring comparison of different concepts.

31. I rarely read beyond what is assigned in class.

32. I have difficulty learning how to study for a course.

33. I rarely sit and think about a unit of material which I have just read.

34. I try to relate ideas in one subject to those in others whenever possible.

35. I have a regular place to study.

36. I read critically.

37. I "daydream" about things I've studied.

38. I do poorly on completion items.

39. I rarely use a dictionary.

40. Although I generally remember facts and details, I find it difficult to fit them together into an overall picture.

41. I learn new ideas by relating them to similar ideas.

42. When learning a unit of material, I usually summarize it in my own words.

43. I maintain a daily schedule of study hours.

44. I think fast.

45. While learning new concepts their practical applications don't usually come to my mind.

46. I get good grades on term papers.

47. Puzzles or problems fascinate me, particularly when you have to work through the material to reach a logical conclusion.

48. Getting myself to begin studying is usually difficult.

49. I have difficulty locating particular passages in a textbook when necessary.

50. I can usually formulate a good guess even when I don't know the answer.

51. I have trouble remembering definitions.

52. I would rather read a summary of an article than the original article.

53. While studying, I attempt to find answers to questions I have in mind.

54. I can usually state the underlying message of films and readings.

55. I do not usually work through practice exercises and sample problems.

56. I find it difficult to handle questions requiring critical evaluation.

57. When I rehearse something, I usually just repeat it over and over to myself.

58. I have regular weekly review periods.

59. I do well on exams requiring much factual information.

60. Most of my instructors lecture too fast.

61. I rarely look for reasons behind the facts.

62. I cram for exams.

63. I find that I remember things best if I concentrate on the order in which the lecturer presented them.

64. When I study something, I devise a system for recalling it later.

65. I have trouble seeing the difference between apparently similar ideas.

66. I suppose that I'm more interested in the college degree that I'll get than I am in the courses that I'm taking.

67. I like to be told precisely what the professor wants from me.

68. I choose courses more from the way they fit in with my career plans than from my own interests.

69. I do well on essay tests.

70. I always make a special effort to get all the details.

71. I am rarely able to design procedures for solving problems.

72. I prepare a set of notes integrating the information from all sources in a course.

Inventory of Learning Processes
Answer Sheet

Please respond to each item in terms of its usefulness for you in preparing for an assignment or examination in natural sciences or mathematics courses, e.g., geometry, physics, calculus, chemistry. Circle T for true and F for false as the item applies to you.

1.	T	F	37.	T	F
2.	T	F	38.	T	F
3.	T	F	39.	T	F
4.	T	F	40.	T	F
5.	T	F	41.	T	F
6.	T	F	42.	T	F
7.	T	F	43.	T	F
8.	T	F	44.	T	F
9.	T	F	45.	T	F
10.	T	F	46.	T	F
11.	T	F	47.	T	F
12.	T	F	48.	T	F
13.	T	F	49.	T	F
14.	T	F	50.	T	F
15.	T	F	51.	T	F
16.	T	F	52.	T	F
17.	T	F	53.	T	F
18.	T	F	54.	T	F
19.	T	F	55.	T	F
20.	T	F	56.	T	F
21.	T	F	57.	T	F
22.	T	F	58.	T	F
23.	T	F	59.	T	F
24.	T	F	60.	T	F
25.	T	F	61.	T	F
26.	T	F	62.	T	F
27.	T	F	63.	T	F
28.	T	F	64.	T	F
29.	T	F	65.	T	F
30.	T	F	66.	T	F
31.	T	F	67.	T	F
32.	T	F	68.	T	F
33.	T	F	69.	T	F
34.	T	F	70.	T	F
35.	T	F	71.	T	F
36.	T	F	72.	T	F

Please respond to each item in terms of its usefulness for you in preparing for an assignment or examination in a social science or humanities course, e.g., history, psychology, literature, sociology. Circle T for true and F for false as the item applies to you.

1.	T	F	37.	T	F
2.	T	F	38.	T	F
3.	T	F	39.	T	F
4.	T	F	40.	T	F
5.	T	F	41.	T	F
6.	T	F	42.	T	F
7.	T	F	43.	T	F
8.	T	F	44.	T	F
9.	T	F	45.	T	F
10.	T	F	46.	T	F
11.	T	F	47.	T	F
12.	T	F	48.	T	F
13.	T	F	49.	T	F
14.	T	F	50.	T	F
15.	T	F	51.	T	F
16.	T	F	52.	T	F
17.	T	F	53.	T	F
18.	T	F	54.	T	F
19.	T	F	55.	T	F
20.	T	F	56.	T	F
21.	T	F	57.	T	F
22.	T	F	58.	T	F
23.	T	F	59.	T	F
24.	T	F	60.	T	F
25.	T	F	61.	T	F
26.	T	F	62.	T	F
27.	T	F	63.	T	F
28.	T	F	64.	T	F
29.	T	F	65.	T	F
30.	T	F	66.	T	F
31.	T	F	67.	T	F
32.	T	F	68.	T	F
33.	T	F	69.	T	F
34.	T	F	70.	T	F
35.	T	F	71.	T	F
36.	T	F	72.	T	F

Number of college courses you have had in mathematics and natural sciences:__________

Number of college courses you have had in humanities and social sciences:__________

College classification: Freshman Sophomore Junior Senior

Age: _____ Name:______________________ Social Security no.__________

APPENDIX D

LOGICAL REASONING TEST

LOGICAL REASONING TEST

by

Gilbert M. Burney

Instructions

1. For most of the questions on this test you will need only to place a cross in the space on the answer sheet like this (X). For a few of the questions, you will be asked to give two or three answers. Instructions for answering these questions will be given when they appear in the test.

2. Several questions refer to diagrams and you should examine these diagrams closely before answering these questions.

3. If you have to change an answer, erase it completely and mark the new choice.

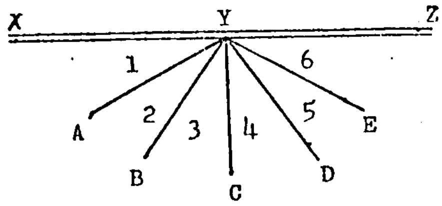
4. Try to answer all questions; if you are not sure of an answer, then choose the one that you think is most apt to be right.

5. Think carefully before you answer each question.

6. Do not make any marks on this test booklet.

Used with permission of Dr. William Popejoy, Advisor for Dr. Burney's dissertation, University of Northern Colorado, Greeley.

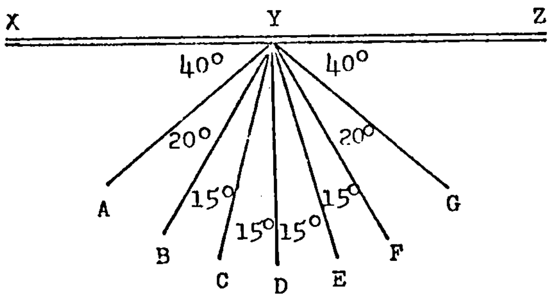
1. In the diagram below, the line XYZ represents a wall and a tennis ball is hit onto the wall so that it always hits at Y. Angle 1 equals angle 6, angle 2 equals angle 5, and angle 3 equals angle 4.



If a ball bounces from Y to B it must have been hit from:

(a) A (b) B (c) C (d) D (e) E

Here is a new diagram similar to the first one. Study it carefully and <u>use it to answer questions 2 and 3</u>.



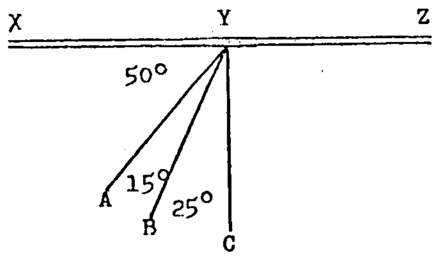
2. If a ball is hit accurately from B to Y on the wall, it will bounce to:

(a) A (b) E (c) C (d) F (e) G

3. If a ball bounces from Y to A it must have been hit from:

(a) A (b) E (c) C (d) F (e) G

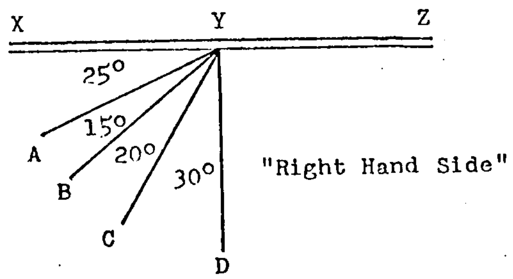
4. In the diagram below, a ball is hit from A to a point Y on the wall.



The angle the new path of the ball makes with CY is:

(a) 50° (b) 75° (c) 65° (d) 40° (e) 25°

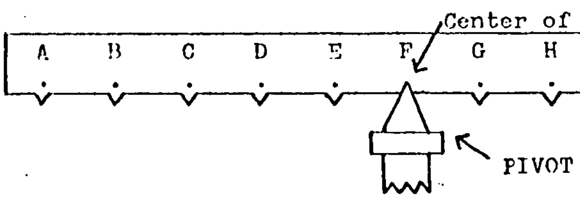
5. A tennis ball is hit from somewhere in the section marked "Right Hand Side" in the diagram below. The ball hits the wall at Y and bounces to C.



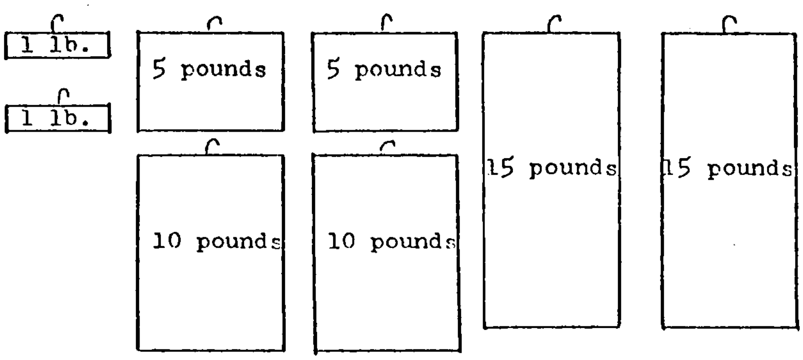
The size of the angle, from YZ, at which the ball must be hit is:

(a) 25° (b) 40° (c) 65° (d) 60° (e) 50°

Suppose you have a balance scale similar to the one in the diagram below. Study the diagram carefully. Questions 6-7 refer to it.



Weights which can be used:



6. A five pound weight is hung at D. To balance the arm again:

   (a) a one pound weight must be hung at A.

   (b) a ten pound weight must be hung at J.

   (c) a five pound weight must be hung at H.

   (d) a ten pound weight must be hung at E.

   (e) a five pound weight must be hung at K.

   (f) is impossible.

7. A five pound weight is hung at E and a ten pound weight at C. To balance the arm again:

   (a) a five pound weight must be hung at G and a ten pound weight at J.

   (b) a ten pound weight must be hung at H and a one pound weight at K.

   (c) a fifteen pound weight must be hung at I and a one pound weight at H.

   (d) a ten pound weight must be hung at I and a five pound weight at G.

   (e) is impossible.

   (f) a five pound weight must be hung at I and a ten pound weight at G.

Questions 8-10 are called syllogisms. Each syllogism consists of two premises and a conclusion. You are to determine whether each argument is valid or not.

Example:

P_1: No one year old babies can walk.

P_2: Paul is a one year old baby.

C: Paul cannot walk.

This is a valid argument.

\- - - - - - - -

8. P_1: Not all R's are T's.

   P_2: All T's are M's.

   C: Some R's may not be M's.

   (a) Valid (b) Invalid

9. P_1: All coal is white.

P_2: All white coal produces red smoke when burning.

C: Therefore when coal burns, the smoke is grey.

(a) Valid (b) Invalid

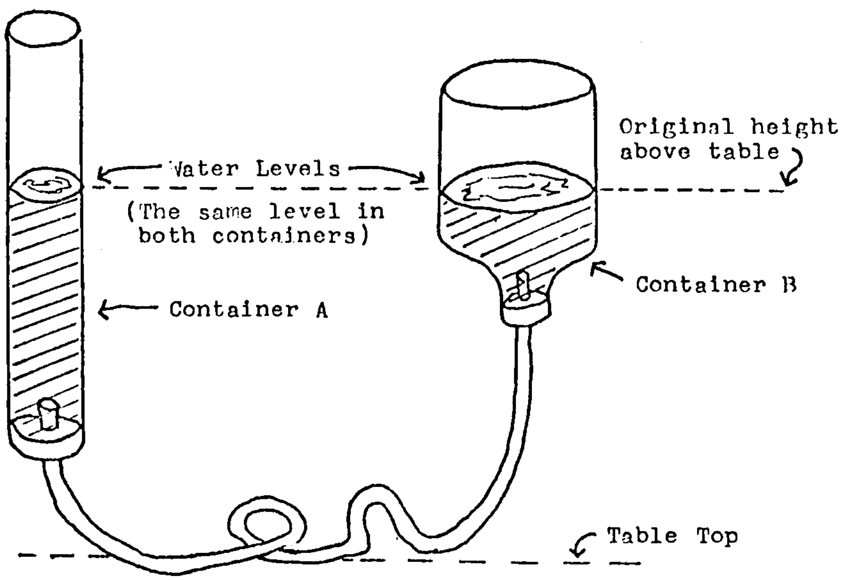
10. P_1: When John gets angry at Mary he hits her.

P_2: John is not angry at Mary.

C: Therefore John will not hit Mary.

(a) Valid (b) Invalid

The diagram below represents two open-top containers with water in them. There is a length of hose connecting them that will allow water to pass from one container to the other. Container B has a larger diameter than container A. Use the diagram to answer questions 11 and 12.



11. The container A and the container B are moved down the same distance. The water levels in the containers will:

(a) stay at the original height above the table.

(b) change so that the level in A is above the original height above the table and the level in B is below.

(c) change so that the level in B is above the original height above the table and the level in A is below.

(d) change so that the levels in A and B are the same distance above the original height above the table.

(e) change so that the levels in A and B are the same distance below the original height above the table.

12. Container A and container B are moved up the same distance. The water levels in the containers will:

(a) stay at the original height above the table.

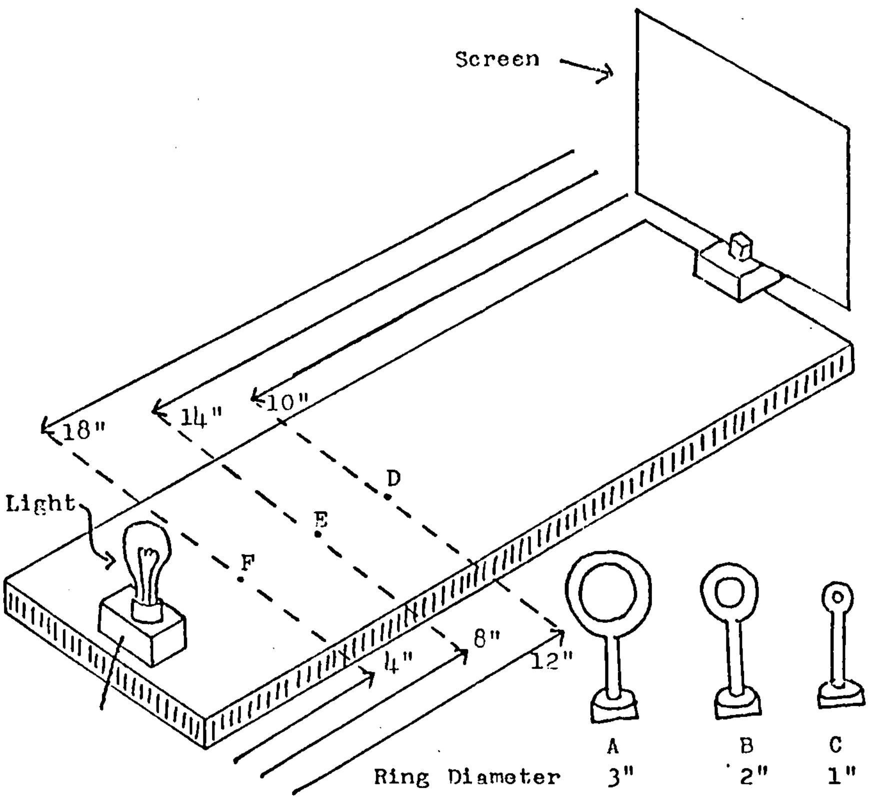
(b) change so that the levels in A and B are the same distance below the original height above the table.

(c) change so that the level in A is above the original height above the table and the level in B is below.

(d) change so that the levels in A and B are the same distance above the original height above the table.

(e) change so that the level in B is above the original height above the table and the level in A is below.

The apparatus pictured below can be used to throw shadows onto a screen. The rings pictured can be placed at points D, E, or F or anywhere along a line through D, E, and F between the light and the screen. The shadows that are referred to in the questions are the circular shadows of the rings only, not the ring stands. The distances of D, E, and F from the screen are indicated above and the distances of D, E, and F from the light are indicated below the apparatus. Study the diagram carefully and use it to answer questions 13-14.



13. The ring A is placed at D and its shadow allowed to fall onto the screen and the size of the shadow is measured. Ring A is removed and ring B is placed at D and the size of its shadow on the screen is measured. The two shadows formed:

(a) will be of equal size.

(b) will be of unequal size, the shadow of A being larger than the shadow of B.

(c) will be of unequal size, the shadow of B being larger than the shadow of A.

(d) will be of unequal size, the shadow of A being smaller than the shadow of B.

14. The ring B is placed at D and its shadow allowed to fall onto the screen and the size of the shadow is measured. Ring B is removed and ring C is placed at D and the size of its shadow on the screen is measured. The two shadows formed:

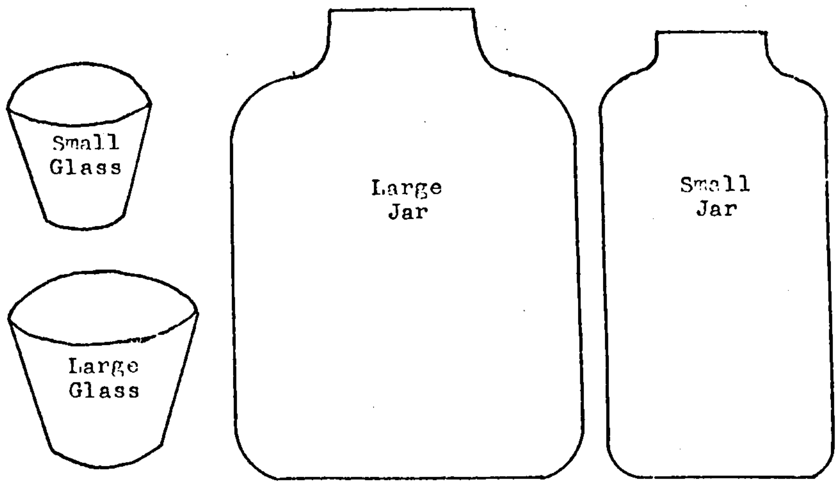
(a) will be of equal size.

(b) will be of unequal size, the shadow of B being larger than the shadow of C.

(c) will be of unequal size, the shadow of C being larger than the shadow of B.

(d) will be of unequal size, the shadow of B being smaller than the shadow of C.

The diagram below represents two glasses, a small one and a large one and two jars, a small one and a large one. Use this diagram for problem 15.



15. If it takes six large glasses of water or nine small glasses of water to fill the small jar and it takes eight large glasses of water to fill the large jar, then how many small glasses of water does it take to fill the large jar?

(a) 10 (b) 15 (c) 11 (d) 16 (e) 12

Questions 16-21 are verbal analogies. Verbal analogies consist of two pairs of words with each pair having the same relationship. In is to out as up is to down is an example of an analogy. The common relationship between in - out and up - down is that they are opposites. Order of the pair of words is also important. Peel is to banana as paint is to house is correct while peel is to banana as house is to paint is incorrect. In the following questions you are to choose two or three words that will best complete each analogy.

Example:

(a) tire			(e) anchor		
(b) motor	is to car	as	(f) deck	is to ship	
(c) highway			(g) captain		
(d) map			(h) ocean		

In this example, the best choices to complete the analogy are highway and ocean resulting in the analogy: Highway is to car as ocean is to ship. In this case "operates on" is the common relationship, a car operates on a highway and a ship operates on the ocean. On the answer sheet the above question would be answered as shown below.

a	b	c	d	e	f	g	h
( )	( )	(X)	( )	( )	( )	( )	(X)

Be careful to mark all required answers for each question on the answer sheet. Some questions require two answers and some require three.

- 16 -

	(a) attempt		(e) problem	
task is to	(b) completion	as	(f) chemical	is to solution
	(c) work		(g) man	
	(d) question		(h) answer	

- 17 -

	(a) switch		(e) engine		(i) boat
light bulb is to	(b) wire	as	(f) canoe	is to	(j) engine
	(c) socket		(g) motor		(k) tractor
	(d) electricity		(h) steam		(l) paddle

- 18 -

(a) walk						(e) roll
(b) toe	is to	body	as	wheel	is to	(f) machine
(c) knee						(g) bicycle
(d) foot						(h) spokes

(a) cow				(e) soldier		(i) bee
(b) horse	is to	flock	as	(f) swarm	is to	(j) pig
(c) sheep				(g) pack		(k) regiment
(d) foot				(h) litter		(l) wolf

- 20 -

(a) brain				(e) spring		(i) bedpost
(b) eye	is to	head	as	(f) blanket	is to	(j) ticking
(c) hat				(g) caster		(k) bed
(d) ear				(h) pillow		(l) summer

- 21 -

(a) music				(e) chair		
(b) house	is to	piano	as	(f) leg	is to	table
(c) bench				(g) eat		
(d) tuner				(h) furniture		

LOGICAL REASONING ANSWER SHEET

Name____________________________________

Date of Birth

_______mo. _______day _______yr.

Year in School________________

Social Security no.____________________

1. a ( ) b ( ) c ( ) d ( ) e ( )

2. a ( ) b ( ) c ( ) d ( ) e ( )

3. a ( ) b ( ) c ( ) d ( ) e ( )

4. a ( ) b ( ) c ( ) d ( ) e ( )

5. a ( ) b ( ) c ( ) d ( ) e ( )

6. a ( ) b ( ) c ( ) d ( ) e ( ) f ( )

7. a ( ) b ( ) c ( ) d ( ) e ( ) f ( )

8. a ( ) b ( )

9. a ( ) b ( )

10. a ( ) b ( )

11. a ( ) b ( ) c ( ) d ( ) e ( )

12. a ( ) b ( ) c ( ) d ( ) e ( )

13. a ( ) b ( ) c ( ) d ( )

14. a ( ) b ( ) c ( ) d ( )

15. a ( ) b ( ) c ( ) d ( ) e ( )

16. a ( ) b ( ) c ( ) d ( ) e ( ) f ( ) g ( ) h ( )

17. a ( ) b ( ) c ( ) d ( ) e ( ) f ( ) g ( ) h ( ) i ( ) j ( ) k ( ) l ( )

18. a ( ) b ( ) c ( ) d ( ) e ( ) f ( ) g ( ) h ( )

19. a ( ) b ( ) c ( ) d ( ) e ( ) f ( ) g ( ) h ( ) i ( ) j ( ) k ( ) l ( )

20. a ( ) b ( ) c ( ) d ( ) e ( ) f ( ) g ( ) h ( ) i ( ) j ( ) k ( ) l ( )

21. a ( ) b ( ) c ( ) d ( ) e ( ) f ( ) g ( ) h ( )

APPENDIX E

TABLES

Table E-1

Means, Standard Deviations, Variances, and Range of Scores of Mathematics/Natural Sciences Learning Styles, ACT Scores, G.P.A.'s, and Formal Operations

Variable	N	Mean	Std. dev.	Variance	Sum	Range
Elaborative processing Math./science	78	0.58	0.23	.05	45.60	0 - 1.00
Shallow processing Math./science	78	0.68	0.14	.02	52.77	0.39 - 1.00
Deep processing Math./science	78	0.54	0.22	.05	41.95	0.10 - 0.95
Methodical study Math./science	78	0.48	0.19	.03	37.19	0.11 - 1.00
Math. A.C.T	78	17.73	6.09	37.03	1383.00	5.00 - 31.00
Natural science A.C.T	78	20.49	5.85	34.23	1598.00	6.00 - 34.00
G.P.A. - Math.	78	2.45	0.74	.55	191.38	0.71 - 3.88
LRT (Formal reasoning)	78	15.09	3.19	10.19	1177.00	7.00 - 21.00
Coursework hours	78	30.05	18.40	338.46	2344.00	8.00 - 85.00

Table E-2

Means, Standard Deviations, Variances, and Range of Scores of Humanities/Social Sciences Learning Styles, ACT Scores, G.P.A.'s, and Formal Operations

Variable	N	Mean	Std. dev.	Variance	Sum	Range
Elaborative processing Humanities/soc. sci.	78	0.67	0.21	.04	52.38	0.08 - 1.00
Shallow processing Humanities/soc. sci.	78	0.61	0.16	.03	47.24	0.16 - 1.00
Deep processing Humanities/soc. sci.	78	0.66	0.21	.04	51.14	0.10 - 1.00
Methodical study Humanities/soc. sci.	78	0.53	0.20	.04	41.00	0.11 - 1.00
English A.C.T	78	19.70	5.16	26.62	1536.80	0.80 - 33.00
Social studies A.C.T.	78	19.50	6.31	39.76	1521.00	1.00 - 33.00
G.P.A. - Humanities/ soc. sci.	78	2.68	0.62	.39	208.73	1.28 - 3.87
Logical Reasoning Test	78	15.09	3.19	10.19	1177.00	7.00 - 21.00
Coursework hours	78	54.33	25.34	642.20	4238.00	7.00 - 99.00

VITA

Martha Ruth Bryan was born in Boone, North Carolina, on July 16, 1947. She received a Bachelor of Science degree cum laude in psychology from Gardner-Webb College, Boiling Springs, North Carolina, in June of 1971. She earned the Master of Arts degree in guidance and counseling from Appalachian State University, Boone, North Carolina, in August of 1972.

Following graduation, she became employed as Director of Student Life for Women, Ferrum College, Ferrum, Virginia. The subsequent year, she was Assistant Director of the Counseling Center and Special Student Services at Ferrum College. In 1974, she moved to Lebanon, Virginia where she was employed as Instructor/Counselor for Special Student Services and later as Assistant Professor/Director of Special Student Services, Southwest Virginia Community College, Richlands, Virginia. From 1974-1977, she completed postgraduate studies at Appalachian State University, Boone, North Carolina and Virginia Polytechnic Institute and State University, Blacksburg, Virginia. In 1980, she moved to Knoxville, Tennessee where she was appointed as Director of Handicapped Student Services at The University of Tennessee, Knoxville, a position she still holds.

In 1982, she was admitted to the University of Tennessee Doctorate of Education degree program and expects to complete requirments for the degree in March 1985. She received an outstanding woman scholar award, and is a member of Phi Kappa Phi and Phi Delta Kappa. She has been active in the American Counseling and Development

Association and the Association on Handicapped Student Services Programs in Postsecondary Education and is also a member of the American Psychological Association and American Educational Research Association.