AN ABSTRACT OF THE THESIS OF

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Title: Relationship Between the Arlin Test of Formal Reasoning and the Watson-Glaser Critical Thinking Appraisal

Abstract approved:

This study examined the relationship between the Arlin Test of Formal Reasoning (ATFR) and the Watson-Glaser Critical Thinking Appraisal (WGCTA). This study identified the percentage of students at each of the five levels of reasoning according to the ATFR. The students' WGCTA scores were then compared to a normative mean and the percentages of students scoring below, the same as, and above the mean were computed.

The data were obtained from 97 college students (69 women and 28 men) enrolled in introductory psychology courses at a medium-sized midwestern university. The student mean age was 20.20 years with a range of 18 to 41 years. Within a three day time period, both the ATFR and the WGCTA were administered to each student.

Results obtained indicated a significant correlation between the ATFR and the WGCTA. Also, ATFR indicated 42% of the students scored at the formal reasoning level, 36% scored at the concrete operational level and 21% scored at the transitional level. When the total WGCTA scores were compared to a normative mean, 66% of the students fell below the mean, 4% were the same, and 30% were above the mean.

It was concluded that colleges need to accommodate students at various cognitive levels. When critical thinking and formal reasoning skills were measured, students' abilities seemed to be consistent. For example, students with high formal reasoning skills also had high critical thinking skills. Students with low formal reasoning skills had low critical thinking skills. Perhaps, the cognitive skills of students are developed at the same rate, and their abilities in all the cognitive areas are similar.

The Relationship Between the Arlin Test of Formal Reasoning and the Watson-Glaser Critical Thinking Appraisal

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CHAPTER 1

INTRODUCTION

Many diverse problems deserving immediate attention exist in our education system. For example, recent attention has been given to the expectations that teachers and society hold for students once their education is completed. While most people agree the three "R's" (reading, writing, and arithmetic) are important, an increasing number of critics question whether this information is sufficient for survival in today's high paced, technological society. Education is the corner stone of society and must be utilized by students for maximum benefit. Therefore, research is necessary to evaluate the effectiveness of our education system and the quality of students entering into the system. Costa (1989) suggested success in today's society requires learning and utilizing thinking skills. He argued that the educational process should create students with problem-solving abilities and reasoning skills that can be generalized to a wide range of real life situations.

With technology increasing and industrialization continuing, universities have little choice about upgrading the educational process. Because of societal complexity, an increased ability to choose among correct solutions is needed (Gadzella, Hartsoe, & Harper, 1989). Adding to the quality of the system are teaching methods that will provide a framework for increasing and developing students' cognitive skills. In order to ensure that students are prepared for higher education, instructional methods must be matched to the thinking skills and abilities of students.

Currently, many teachers have relaxed their academic standards to get good behavior from their students (Claus, 1989). Hence, many students despise and resist any activity involving higher intellectual functioning. Claus feels many teachers are willing to sacrifice these intellectual activities to avoid discipline problems. Obviously, such an approach lessens chances for the development of cognitive skills. While discipline problems have become an increasing concern at all educational levels, educational systems need to be redefined and reformulated in order to facilitate, not hinder, cognitive skill development. Because research has shown cognitive skills may be lacking in college students, it is clear this problem is cumulative and not limited to grade school or high school. The lack of critical thinking and abstract reasoning skills on the part of college students is important knowledge for college educators who must decide at what cognitive level they will teach their courses.

What can public education do to meet this challenge? Assessing a student's ability in the beginning of the course would help protect against inaccurate assumptions about students' cognitive abilities. Many educators assume college students have high cognitive skills such as critical thinking and abstract reasoning. Unfortunately, courses geared toward critical thinking and abstract reasoning may not be effective if the majority of the students do not possess the requisite skills. In fact, courses may need to be taught in such a manner as to develop the lacking skills. It is arguable, then, that the development of thinking skills should become the central focus of grade-school and secondary education (Helmstadter, 1985). The main objectives should become the identification of the actual cognitive level of the students and tailoring courses suitable for that level.

Colleges and universities will need to reevaluate their standards and the expectations for beginning students. If entering students are evaluated to ascertain their skill levels, then deficient skills can be nurtured during their collegiate careers.

Assessing a student's level of cognitive functioning can be done by choosing a few concepts that demonstrate one's cognitive abilities. For example, critical thinking and formal reasoning are positively related to academic achievement in mathematics, science, and general intelligence (Bitner, 1991). These correlations suggest critical thinking and formal reasoning are good indicators of cognitive functioning and will be assessed in this study.

Literature Review

Considerable research has focused on the impact that the collegiate experience has on the development of one's intellectual processes. Educational researchers are concerned about effective instructional techniques that will improve the quality of both instructors and their methods. An important way universities can attract students is to constantly improve the quality of instructors and their methods of instruction (Smith, 1977).

While teachers strive to perfect teaching methods, a major factor seems to have been overlooked -- students. Teaching methods are effective <u>only</u> if they are compatible with the learning styles of students. Many colleges focus on the end result each student is to achieve after his or her education is finished. Before any end results are discussed, the beginning product must be ascertained and the "value added" component considered. Thus, it is important to assess the intellectual skills of freshmen students and implement teaching methods that will facilitate their future development (Soloff & Houtz, 1991).

Understanding the need for assessment of intellectual functioning is straightforward, but the actual assessment is a difficult task. Critical thinking abilities and formal abstract reasoning skills are often measured to assess cognitive processes. Subsequently, each of these topics will be examined in depth.

Critical Thinking

Critical thinking has been studied for years; its roots can be traced back to early intelligence tests (Pierce, Lemke, & Smith, 1988). Many tests have been developed to measure critical thinking, but few agree upon a definition of the concept.

As a specific cognitive process, however, critical thinking has had various definitions. Facione (1986) defined it as the ability of a person to argue well and evaluate the arguments others present. He also feels critical thinkers are more open-minded, objective, and fair when making decisions. Ennis (1985) stated critical thinkers make decisions using reflective and reasonable thinking, while Chaffee (1988) defined critical thinking as a person's effort to make sense out of the world by examining his or her own thinking and the thinking of others to assist in the understanding of different situations. Dressel and Mayhew, (1954) suggested abilities such as defining a problem, selecting pertinent information, recognizing assumptions, and formulating hypotheses, comprise critical thinking.

Depending on which definition is chosen, the instrument used to assess critical thinking will differ. Because the Watson-Glaser Critical Thinking Appraisal (WGCTA) was used for assessment in the present study, Watson and Glaser's (1980) definition of critical thinking will be used:

> a composite of attitudes of inquiry that involve an ability to recognize the existence of problems and an

> acceptance of the general need for evidence in support of what is asserted to be true, knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined, and skills in employing and applying the above attitudes and knowledge (p. 1).

When validating the WGCTA, Watson and Glaser (1980) established acceptable correlations between their test and academic achievement, general intelligence, aptitude tests, and grade point averages. These results suggest the WGCTA measures cognitive functioning at an appropriate level.

No one conclusion can be drawn from the body of critical thinking research because no one dimension has consistent support. While the adaption of an operational definition of critical thinking is important, it is not the only factor the education system needs to address. Facione (1986) suggested researchers also need to identify acceptable entry and exit levels of critical thinking. Once the levels have been identified, then appropriate instructional programs to deliver instruction in critical thinking can be designed and implemented. With interest in this area growing, now is the time to put forth such an effort (Facione, 1986).

The difficulty in producing an operational definition of critical thinking is accompanied by the equally difficult task of identifying individuals with critical thinking skills. How does a critical thinker look, act, or solve problems? While no typical critical thinker has been found, most do share some basic attitudes, strategies, and skills (DeNitto & Strickland, 1987). Critical thinkers more actively process and retain information (Piro & Iorio, 1990). Perhaps, if these attitudes, strategies, and skills were focused on, they could be taught and nurtured in those lacking critical thinking ability. The benefits of critical thinking skills are not in question. But to assess critical thinking skills and help students develop them is necessary. Assessment is the first logical step in this process.

When using critical thinking skills to solve problems in a classroom, all the facts needed are available, but in the real world all the facts may not exist (Kamii, 1991). When facts are missing, critical thinking is more likely to differ as much as each individual differs from the next. Therefore, critical thinking depends on certain assumptions and values held by the critical thinker, in conjunction with the ability to move through levels of abstraction quickly (Kamii, 1991). Academic situations still influence critical thinking skills, but these skills are not influenced by any specific academic aspect (Bitner, 1991). However, Albrecht (1985) states not much is currently known about thinking processes and how they are learned, if they can be developed, or how to develop them. These questions must also be answered with future research to assess how one becomes a critical thinker.

However, Gadzella et al. (1989) found critical thinking scores improved more for those students of average and high ability than for low ability students. Students were tested with several instruments, including the WGCTA, and were then randomly assigned to small group or individualized instructional approaches. Different instructional approaches produced different results. Small group interaction seemed to benefit high ability students while the individual approach benefitted both those students of high and average ability. No method was best suited to benefit students of low ability. Approaches other than small-group and individualized study may also prove beneficial. For example, Smith (1977) evaluated several groups of college students before and after receiving encouragement and praise from instructor, instructor involvement with students, student participation, and/or peer-to-peer interaction. Students whose critical thinking skills improved the most had peer-to-peer interaction, encouragement, and participated often in class (Smith, 1977). Thus, it appears that active involvement on the part of both the student and instructor are important in critical thinking skills development. Interestingly, a decline in critical thinking appeared in subjects when instructors emphasized memorization and discouraged practicing concepts. Student involvement in the learning process may increase critical thinking skills.

Classroom methods are not entirely responsible for critical thinking. Pascarella (1989) compared high school graduates who attended college for one year with high school graduates who did not attend college. Higher but not significant, scores were found for college students. Moreover, even that slight advantage could not be traced back to the classroom suggesting the academic experiences may not even be responsible for this advantage.

Thus, it is arguable that no one specific area may be responsible for critical thinking abilities. Perhaps the contribution of independent living and social interactions or extracurricular activities are critical factors (Pascarella, 1989). In support of this contention, Pascarella et al. (1993) found significant differences in critical thinking gains for college students who lived on campus compared to students who commuted. The campus students showed greater improvement with the largest gains occurring during the freshmen year. The academic situations may not be solely responsible for the improvement in critical thinking skills throughout college. The actual courses appear to be only a small part in the development of critical thinking. Students assessed in the beginning of their college education could be followed throughout their academic years so the effects of all parts of their college experience on their critical thinking could be examined. The assessment at the beginning of the educational process is necessary for any valuable knowledge to be gained about when and how critical thinking skills develop or improve.

Even though academic success cannot be fully linked to critical thinking skills, it should not be minimized. McCammon, Golden and Wuensch (1988) compared cognitive skills with course grades using several tests including the WGCTA. Critical thinking was one of the best predictors of course grades. Clearly, academic skills appear to be positively related to critical thinking. If critical thinking skills are to be nurtured, it is imperative that teaching methods continue to receive appropriate evaluation. For example, Smith (1977) believes active involvement by the students during the learning process fosters critical thinking skills. Perhaps the involvement of other characteristics, such as socializing, in addition to instructional methods will increase critical thinking skills.

Another relevant aspect of critical thinkers is the ability to use their skills in situations outside of academia. Hudgins, Riesenmy, Ebel, and Edelman (1989) suggest that once critical thinking is self-directed, students learn to use these skills in other situations. However, until the internalization of critical thinking occurs, these skills are not always used outside the academic situation. Perhaps instruction in using critical thinking in a wide range of situations would facilitate this desirable transfer.

Despite such optimistic hopes for the training of critical thinking, McMillan's (1987) review of the literature revealed most studies focused on the influence of instructional methods and few yielded significant differences. Moreover, actual courses for the development of critical thinking skills did not produce significantly higher scores on the WGCTA. Such results question whether the concept of critical thinking has been grasped by the students. Reiterating a point raised earlier, McMillion has emphasized the need for consistent operational definitions of critical thinking, thinking, reasoning, and problem solving. Because such definitions are lacking, most instruments used to measure these characteristics are controversial and contradictory. To add to the confusion, it is still unclear whether critical thinking is an innate ability or a system of learned and teachable skills (Walters, 1986). With one group of studies showing a positive effect of instructional methods on critical thinking and another group showing no improvement, the controversy continues.

Formal Reasoning

As with critical thinking, there exists no consistent, accepted definition of formal reasoning. Given the lack of consistency, one is not surprised to find contradictory results abound in the literature.

On the other hand, if one chooses to view formal reasoning in the same manner as Piaget, then some semblance of organization emerges. The sizeable amount of research on Piaget's theory suggests a large number of professionals have followed this option. Piaget's theory focuses on a developmental capacity; various other levels of thinking must be reached in order to move into the next developmental level. Also, the various levels have some age constraints under which the abilities usually appear. Piaget felt formal operational thought was characterized by the capacity to consider all possible solutions to a problem by thinking in a hypothetical and deductive manner (Bart, 1971). Piaget also felt formal reasoning was the ability to think about the thinking process and being able to apply logical operations to concrete and abstract situations (Furth, 1969).

Developing tests to measure formal reasoning capabilities could be invaluable. Assessing formal reasoning abilities will help teachers recognize the developmental stage of their students when they enter college. Such knowledge might be useful in the preparation of course objectives, lectures, and evaluation instruments. Students could use their skills or learn skills they may be lacking when they enter college.

Formal reasoning skills were first measured by Piaget's interview method. This method is regarded as preferable to assessing formal reasoning skills because it provides the most useful framework for this type of research (Ahlawat & Billeh, 1987). Because interviews are subjective, time consuming, extremely cumbersome, and expensive to administer, the development of new tests was necessary (Santmire, 1985). Specifically, Santmire felt a test was needed "which gives consistent results, is valid in relationship to the assessments obtained by the clinical interview, and which is easily administered to groups" (p. 81). This task was not easily accomplished. Many characteristics must be taken into consideration, such as age, gender, and the theoretical basis of the test.

In hopes of developing such a test, many researchers have focused on the evaluation of the formal reasoning skills of adults. Hooper, Hooper, Colbert and McMahan (1986) used the Arlin Test of Formal Reasoning to measure formal reasoning in college students. They found 60% of the subjects were not at Piaget's formal operations stage. McKinnon and Renner (1971) found only 25% of college freshmen were able to think at the formal operational level.

Because of such empirical evidence, researchers have begun to question Piaget's theory and whether its formal reasoning tasks are valid indicators of cognitive functioning (Hooper et al., 1986). In response to such scrutiny of the Piagetian model, several tests that yield a more simplistic measure of formal reasoning have been developed. For example, the Arlin Test of Formal Reasoning (ATFR) is a paper-and-pencil test that allows groups of subjects to be tested at the same time.

With the advent of a variety of tests, other problems soon became apparent. For example, Broughton, (1977) believes formal reasoning skills are generalized to all aspects of cognition but many tests, including the ATFR, have most tasks looking like physics problems. Yet, others argue that an underlying ability is needed to make all solutions to problems possible and if that ability is demonstrated in one area it is likely to appear in all problem solving. Lawson (1982) stated that formal reasoning is related to general achievement not just math and science. Therefore, improved formal reasoning skills will improve achievement in all aspects.

One test may not be sufficiently comprehensive enough to measure formal reasoning skills. Hooper et al. (1986) administered a battery of tests to assess formal reasoning skills. While the majority of their college student subjects had some formal reasoning abilities, these skills were not consistent and depended on aptitude, course of study, and personality. Thus, assessing formal reasoning may not be accomplished by one test, but rather via a complete battery of tests that will provide a complete picture of formal reasoning skills in all relevant areas.

Another problem that has confronted research on formal reasoning has been its focus. The majority of formal reasoning research has concentrated on scientific and technological settings, not everyday situations. Linn, Pulos, & Gans (1981) found the general construct of formal reasoning to emerge in preadolescence and that most formal reasoning strategies learned do not generalize without additional instruction. As noted, assessment must involve all aspects of cognition. Reasoning tasks have been shown to vary from one setting to another, such as home or school (Guberman & Greenfield, 1991). This variability may be caused by the actual goal of the activity (Ward, Nurrenberg, Lucas, & Herron 1981). The goal of formal education is generalized learning ability while the goal of an informal activity, such as a job or chore, may be efficiency in one endeavor. These divergent goals may direct the type of reasoning used in such different situations. When assessing formal reasoning skills, educational systems must avoid concentrating on one specific ability or area. Wertsch (1984) found that, in addition to the specific goal involved, much of the reasoning involved depended upon the assistance provided. Parents provided more structure and tried to prevent error while teachers encouraged independence and the use of trial-and-error strategies.

Not only do situational factors play a role in formal reasoning development but biological factors seem to play a part as well. In support of this contention, neurological differences have been observed between individuals at the concrete and formal reasoning stages. Lawson (1982) believes a certain level of neurological development is needed for formal reasoning. Concrete thinkers showed incomplete lateralization as measured by eye movements. While thinking during a problem, right-to-left eye movement was measured. Those lacking this movement were thought to have incomplete lateralization which, in turn, hindered formal reasoning skills (Lawson, 1982). Because age did not correlate with the difference in lateralization, Lawson (1982) concluded lateralization may be stimulated through physical and social factors. This situation would then increase formal reasoning abilities. No instructional method would improve formal reasoning skills until this neurological development occurred. Assistance might be of some benefit, however, while this neurological development is taking place.

While neurological development is crucial, it does not seem to be <u>the</u> key factor in the establishment of formal reasoning. Lawson (1982) also found the development of formal reasoning was retarded by those subjects having restricted mental capacity, oversensitivity to misleading information, and/or an impulsive cognitive style. He concluded a substantial percentage of adolescents and adults never acquire formal reasoning skills because of such characteristics. Training may be productive for people with these impediments to improve formal reasoning, however lateralization must have already occurred.

Because many college students do not possess formal reasoning skills, instructional methods can take one of two courses. Concepts can be taught concretely and formal reasoning ignored or students who are in need of assistance can be taught to think at the formal reasoning stage (DeCarcer, Gabel, & Staver, 1978). Piaget theorized that not only is a certain level of physical maturity needed but experience in logical thinking is also required (DeCarcer et al., 1978). The problem is finding a productive method to teach these much needed skills. The first step toward this goal is to ascertain the actual thinking level of the students. Assessing formal reasoning ability would allow the educational system to recognize students with the most immediate problems and needs. Once this level is determined, those students needing instruction in formal reasoning can be assisted. Then these needs can be addressed throughout their educational experience.

The existing research on instructional methods has focused on the trainability of formal reasoning skills. Such an approach suggests these skills may not be developmental in nature. However, the empirical evidence on the trainability of formal reasoning is inconclusive (Van de Vijver, Daal & Zonneveld, 1986). Some studies reported improvement in formal reasoning skills after training (e.g., Holyoak, Junn & Billman 1984; Siegler, 1976). Lawson (1985) found older students to be more responsive to formal reasoning training, but the reasons for this increased responsivity were unclear. Of students not functioning at the formal operations level, 15% reached the formal operations level after taking student oriented courses with considerable student involvement (Norris, 1990). Other studies have reported less impressive data finding no improvement after training sessions (e.g., Bredderman, 1982; Linn, 1982). Those studies finding improvement are somewhat controversial. Most of the training effects did not last for a substantial amount of time and were not shown to have carry over effects to other tasks outside of the test specific tasks. Trainable or not, formal reasoning skills must be assessed so the instructional methods can match the student's level of thinking.

Evaluating the overall cognitive level of college students would prove beneficial to all individuals involved in the educational system. If everyone in the system could work together to build on the skills that already exist in college students, the educational process would be much more productive.

The main objective of this study was to assess the relationship between the WGCTA and the ATFR. It was hypothesized the two tests would correlate positively. Thus, subjects with high formal reasoning skills also will have high critical thinking skills, and subjects with low formal reasoning skills will have low critical thinking skills.

The study also assessed the cognitive level of freshmen college students. First, the Watson-Glaser Critical Thinking Appraisal (WGCTA) was administered to assess the level of critical thinking of freshmen college students. Second, the Arlin Test of Formal Reasoning (ATFR) was administered to determine the proportion of freshmen college students functioning at the concrete and formal operations stage. It was hypothesized that a significant number of subjects would score below the formal operations stage and those subjects functioning at the concrete stage would have significantly lower critical thinking scores when compared to subjects functioning at the formal operations stage.

CHAPTER 2

METHOD

Subjects

Ninety-seven subjects (69 women, 28 men) from a medium-sized midwestern university were administered the Arlin Test of Formal Reasoning (ATFR) and the Watson-Glasser Critical Thinking Appraisal. Subjects ranged in age from 18 to 41 years (M = 20.20). All subjects were freshmen and were enrolled in six sessions of an introductory psychology course. The subjects volunteered to participate in the study, and extra credit was given to those subjects completing both tests.

Instruments

The Watson-Glaser Critical Thinking Appraisal (WGCTA) consists of 80 multiple-choice items divided into 5 subtests of 16 items each. The subtests were designed to measure different aspects of critical thinking (Pascarella, 1989). The subtests are inference (discriminating inferences and their degrees of truth or falsity), recognition of assumptions (recognizing unstated assumptions from given statements), deduction (deciding if conclusions follow the information provided), interpretation (deciding if conclusions are correct about the data by weighing evidence given), and evaluation of arguments (determining which arguments are strong or weak, as well as relevant or irrelevant) (Pascarella, 1989). Two forms, A and B, each have an equal number of items in each subtest to facilitate comparison of scores across tests. Form A of the WGCTA was used in this study.

Reliability was assessed by estimates of internal consistency, stability of scores over time and correlation between scores on alternate forms (Watson & Glaser, 1980). Split-half reliability ranged from .69 to .85 for Form A and .70 to .82 for Form B. The coefficient for stability over a three-month period was .73. Alternate form reliability was .75 for 228 twelfth graders. The five subtests had test-retest reliabilities ranging from .45 to .69. The subtests were weighted equally in computing the total score. Berger's (1985) review of the WGCTA discouraged the use of the subtests to evaluate an individuals achievement on a particular skill because the subtests were based on a small number of items and lacked sufficient reliability. However, Berger stated the subtests may be useful when analyzing critical thinking abilities of a class or large group to determine what types of instruction are needed most.

Samples for the validity studies included students (9th grade through college), nursing and medical students, police officers, and sales representatives (Watson & Glaser, 1980). Content and construct validity were established through instructional programs (Bitner, 1991). Content validity was determined by specific objectives of a critical thinking program and how well the WGCTA measured them. Construct validity was based on increases in WGCTA scores after experiencing several different instructional strategies. Also, correlations of the WGCTA with intelligence tests ranged from .30 to .75 while correlations with achievement tests were .20 to .65 (Woehlke, 1985).

McMillan (1987) reviewed the critical thinking literature and found the WGCTA to be the instrument of choice. It was used in 16 of the 27 studies he reviewed. McMillan suggested that the WGCTA measures critical thinking as a broad and general concept. Because of this, the WGCTA is not likely to be influenced by a specific academic experience (a single course or teaching method), but it is more likely to be sensitive to a broad educational experience (high school or college education) (Pascarella, 1989). Because this study sought to assess critical thinking skills from the general college experience, the WGCTA was the selected instrument.

The Arlin Test of Formal Reasoning (ATFR) was also used in the current study. The ATFR estimates a level of reasoning based on the written Piagetian interview items (Strahan & O'Sullivan, 1988). Five cognitive levels may be assessed: concrete, high concrete, transitional formal, low formal, and high formal. Two scores are derived from the ATFR. One is based on the total number of items that the formal operational response was chosen. This total determines the overall cognitive level (Santmire, 1985). Then the total score is divided into five levels that are based on the descriptions developed by Piaget.

Arlin (1982) indicated high construct validity with interview assessments and test-retest reliabilities ranging from .76 to .89. Santmire (1985) found low internal consistency, especially for the subscales. Some of the coefficients were low enough to question the usefulness of the subscales as indicators of a particular skill.

The concept of formal operational reasoning is probably robust enough that the total score of the ATFR is reasonably correlated with level of formal operational functioning (Santmire, 1985). However, Santmire was critical about the calculation of the total score because items were only correct if the formal operational alternative were chosen. Therefore, a score of 0-4 will be scored as concrete functioning without distinguishing the level of functioning of the actual answer chosen. Hence, while some indications of formal reasoning may be present but this would not be indicated. Further, Santmire noted an individual who guesses would score an eight or high concrete level as opposed to an individual doing his/her best who may only score four and be classified at the concrete level.

Santmire (1985) stated that despite the shortcomings of the ATFR, it is a start in obtaining a standardization assessment of formal operations which can generalize across situations. For this reason, the current study used the ATFR scores only as a generalization for the sample tested.

Procedure

When subjects volunteered to participate, they signed up for an accommodating time slot. Each time slot consisted of two sessions with one day separating each session. Consent forms were signed by each subject. These forms explained the purpose of the study and the subjects' right to withdraw from the study at any time. Subjects were instructed to use only the last four digits of their social security number on all other forms used in the study. The consent forms were collected separately to insure confidentiality.

One half of the subjects took the WGCTA while the other half took the ATFR the first session. During the second session, the subjects took the remaining test. Both tests were administered according to their respective test manuals. Neither was timed nor was the completion time noted. Five groups of subjects were tested. Both sessions for each group were monitored by the same administrators. Group size ranged from 12 to 25 students. The tests were scored by hand with the aid of stencils provided by the test manufacturer.

Statistical Procedure

The relationship between the ATFR and WGCTA was determined by computing a Pearson product-moment correlation coefficient. A coefficient was computed to determine the overall relationship between both tests. Also, a t-test examined the relationship between formal reasoning and critical thinking. The WGCTA scores of subjects functioning at the formal operational level and subjects functioning at the concrete operational level according to the ATFR (both high and low levels were used) were compared to find if their WGCTA scores differed significantly.

The statistical procedure used to determine the number of students functioning at each of the five levels of reasoning was to convert the number of individual ATFR scores at each level into percentages. Also, the percentage of students scoring above, the same as, and below the mean of the WGCTA was computed.

CHAPTER 3

RESULTS

The total score on the ATFR was used in determining the level of formal reasoning skills. The number of students functioning at each of the ATFR's five levels of reasoning was determined by converting the number of individual ATFR scores at each level into percentages. The results are shown in Table 1.

As shown in Table 1, 43% of the students scored in the formal reasoning range, with only 6% reaching the highest Formal Reasoning level. Those students at the Transitional level (21%) were not included with either Formal or Concrete Operational students. While 55% of the students have not reached the Formal Reasoning level, the Low Formal Reasoning level had the highest percentage of students (37%).

The total score on the WGCTA was used to determine critical thinking skills. These scores were compared to the normative mean for college freshmen ($\underline{M}$ = 53.8) at a four year college reported in the WGCTA manual. Table 2 shows the percentage of scores above, the same as (scores of 53), and below the mean. The majority of students (66%) have lower critical thinking skills when compared to the normative mean of college students.

The relationship between the ATFR and the WGCTA was determined by calculating a Pearson product moment correlation coefficient for the total score on each

Table 1

The Percentage of Students at Each of the Five Levels of Reasoning on the ATFR.

Level of Reasoning	Percentage
Concrete	4%
High Concrete	32%
Transitional	21%
Low Formal Reasoning	37%
High Formal Reasoning	6%

Table 2

Percentages of WGCTA Score Above, the Same as, and Below the Norm.

	Percentage of Students
Above	30%
Same	4%
Below	66%

instrument. The means and standard deviations of both tests are reported in Table 3. The correlation was .52 (p < .001). The correlation was calculated to determine the degree of similarity between the scores on the ATFR and the scores on the WGCTA.

Further evidence was gathered to show the relationship between formal reasoning and critical thinking skills. Those WGCTA scores of formal operational students (both low and high levels) and concrete operational (both concrete and high concrete levels) levels were divided into two groups. The data were analyzed using a t-test. The results are shown in Table 4. The students WGCTA scores were significantly different ($t = 5.2$, $p < .001$) when separated into groups according to their total scores on the ATFR. The students' WGCTA scores were significantly different for students at the formal and concrete levels of the ATFR. So, students scoring high on the ATFR scored high on the WGCTA. Also, students scoring low on the ATFR scored low on the WGCTA.

Table 3

The Means and Standard Deviations of the ATFR and WGCTA.

	Mean	Standard Deviation	Correlation
ATFR	16.94	5.26	
WGCTA	49.0	9.67	.518*

* $p < .001$

Table 4

t-test Between WGCTA Scores of Students at the Formal and Concrete Levels of the ATFR.

	Formal	Concrete	*t*	DF
N	40	35		
Mean	54.1	43.5	5.2*	73
SD	10.2	6.7		

* $p < .001$

CHAPTER 4

DISCUSSION

According to Piaget's theory of cognitive development, concrete operational reasoning ends at the beginning of adolescence with the development of formal reasoning ability (Piaget, 1972). However, recent research suggests concrete operational reasoning may persist in many adolescents and adults. In fact, most college students appear to lack these much-needed formal reasoning skills. Such deficiencies appear to offer a mandate to colleges to be aware of this deficit and try to find solutions to this problem.

The present results based on scores on the Arlin Test of Formal Reasoning (ATFR) indicated 36% of the students in the sample tested were functioning at the concrete operational level while 42% of the students were functioning at the formal operational level. Clearly, these results do not agree with Piaget's theory of cognitive development. A much higher percentage should have been observed at the formal operational level (Albrecht, 1985). Such results provide concrete evidence to support a need for colleges to provide concrete operational thinkers with instructional methods they are able to comprehend. The first step in this process is to evaluate the cognitive level of all college students and then identify the concrete operational students. Assessment will provide the students and the instructors with information that will make their educational and teaching activities more advantageous.

It is noteworthy that ATFR scores placed 21% of the students in the present sample in the transitional category. This result indicates these students have developed their concrete operational skills but do not exhibit all of the needed formal operational skills. Identification of such transitional students may increase their chances of developing formal operational reasoning more rapidly. If certain formal operational tasks can be done successfully, perhaps the lacking skills can be developed because the students seem to possess the basic fundamentals of formal reasoning. Students in the transitional stage may benefit from classes fostering development of the formal reasoning skills they have begun to develop. Students must use formal reasoning abilities if these skills are to ever be strengthened.

Formal reasoning skills are not the only skills lacking in college students. The present study also indicates that critical thinking skills are also lacking. Sixty-six percent of the students tested on the Watson-Glaser Critical Thinking Appraisal (WGCTA) scored below the normative mean for college students. Thus, a majority of students in this study may be lacking crucial critical thinking skills. Despite the diversity of critical thinking abilities, all students in the present study reflected some critical thinking abilities. These results suggest college courses need to use methods which incorporate critical thinking skills. If the skills, albeit weak, are present but not used, they may be weakened further or possibly lost completely (Smith, 1977). Again, assessment is a key factor in identifying students lacking in critical thinking skills.

Because the majority of students entering college lack high level cognitive skills, colleges must take an aggressive position with regard to assessment of these deficits. Without assessment, students may find themselves in courses for which they do not have the requisite skills needed for success. Possibly, a standard entrance assessment could be administered to inform college students of the skills they will need to develop to be successful in college. This procedure would prevent those students lacking the required skills from attending college until such skills are acquired. Thus, colleges would not have to deal with a large number of students having extremely low cognitive development.

As was noted, not all students are lacking in formal reasoning and critical thinking skills. This result, in and of itself, provides crucial information. Colleges must be aware of students functioning at various levels of cognitive development and act accordingly. One philosophy of teaching is not going to affect all students equally; different abilities will require different instructional methods. Colleges cannot cater only to the needs of those students at one particular level of formal reasoning and critical thinking skills. All students should benefit equally from their education; therefore, classes need to be taught in such a manner to achieve this goal.

To raise awareness about the cognitive development of college students, the present study established a relationship between the ATFR and the WGCTA. It was found students having low formal reasoning skills had low critical thinking skills, while students having high formal reasoning skills had high critical thinking skills. The majority of college students in this sample are lacking in both critical thinking and formal reasoning skills. If a deficit is found in critical thinking or formal reasoning skills, the other ability is also likely to be lacking. These findings imply that one's cognitive development is consistent. If one skill can be developed or strengthened, then it seems reasonable to propose that development may positively affect other skills as well.

The significant relationship between formal reasoning and critical thinking suggests similar skills are used for both processes. The mastery of certain cognitive skills may lead to the development of both formal reasoning and critical thinking. However, the measures (ATFR and WGCTA) used in the present study may have contributed to these findings. Perhaps, the tests are measuring the same cognitive concepts in different ways.

To be knowledgeable about students' cognitive development is not enough. Universities also pride themselves on teaching students how to utilize and increase formal reasoning and critical thinking skills. Thus, further research is needed to establish which instructional styles and techniques foster such cognitive development. Evidence suggests techniques discouraging student involvement or participation do not facilitate cognitive development; they may actually weaken it (Smith, 1977). Yet, the most common teaching tool is the formal lecture. Unfortunately, active intellectual interchange between teacher and student usually does not take place in such situations. Hence, instructors need to be informed of these findings via special training sessions designed to encourage the use of various techniques which will facilitate student participation. Once acquired, these successful techniques should be incorporated into the curriculum to help students develop these essential cognitive skills.

Maturation also must be considered when trying to enhance cognitive skills. The brain continues to develop until approximately 21 years of age. As certain portions of the brain develop so may cognitive skills (Allison, 1992). By the age of 10, formal reasoning has begun to develop, but it is not until 17 years of age when the frontal-temporal region of the brain fully matures. When this maturation occurs, students have the physiological ability to perform all formal reasoning tasks. These observations suggest maturation level also may be a crucial factor related to cognitive development. Again, it appears that Piaget's maturational levels may be incorrect or that the ages paired with each stage may be incorrect. Because maturation is not consistent in all students, various levels of intellectual functioning are to be expected. Maturation theory implies colleges must provide instructional methods applied to all student levels. However, an alternate interpretation must be entertained. If maturation has occurred, the potential for a cognitive ability may exist, but there is no guarantee the skills do. Students who have never used their cognitive abilities will not be able to magically perform the appropriate skills just because a certain maturational level has been achieved.

Clearly, future research is needed to ascertain the reasons students lack cognitive skills, such as critical thinking and formal reasoning. Experimental studies involving direct manipulation of variables are needed to explain the cause-effect relationship of cognitive development. Future research must report how cognitive skills develop along with the current level of cognitive functioning. Studies of this sort would inform instructors and students of actual techniques that have successfully developed and increased students' cognitive skills.

The measurement of cognitive skills can be problematic in itself. The ATFR and the WGCTA were used to assess the students' cognitive development. If other assessment techniques been had been used, different results may have been obtained. Future research must develop an accepted assessment technique to identify the cognitive level of college students. Because of a lack of agreement on the definitions of formal reasoning and critical thinking, instruments measuring either concept will be measuring the concepts as defined by the test author. The various results found may be attributed to different instruments used in the studies. A uniform definition would allow researchers to compare results of various projects.

The present study used only one instrument to evaluate critical thinking and one instrument to evaluate formal reasoning. Research based on a single measurement may not be accurate. A multitude of different skills fall under critical thinking and formal reasoning categories. A set of multiple measures is needed to obtain a comprehensive view of a student's cognitive level. If the overall goal of future research is to identify those students in need of additional skills required for success in college, then a comprehensive assessment will be the most beneficial.

Subjects in the present study were freshmen enrolled in introduction to psychology courses. Future research may benefit from randomly sampling subjects. A larger and more diverse population may provide more stable results. A more extensive study of college students would provide a more accurate view of cognitive development. Thus, future research should be conducted to provide a more accurate representation of college students' cognitive skills. Such information will allow education to benefit all students.

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