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Cognitive functioning of college freshmen at the University of Southern Mindanao: a match between CSMS science reasoning tasks, NCEE, achievement in class, and teachers' perception of factors related to achievement.

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COGNITIVE FUNCTIONING OF COLLEGE FRESHMEN
AT THE UNIVERSITY OF SOUTHERN MINDANAO: A MATCH BETWEEN
CSMS SCIENCE REASONING TASKS, NCEE, ACHIEVEMENT IN
CLASS, AND TEACHERS' PERCEPTION OF FACTORS RELATED
TO ACHIEVEMENT

A Dissertation Presented
By
KALINGGALAN B. ABDULSANI

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

DOCTOR OF EDUCATION

September, 1985

School of Education
COGNITIVE FUNCTIONING OF COLLEGE FRESHMEN
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In dedication to my loving wife, Patricia, and my three lovely daughters, Juheina, Aneyza Tarhata, and Maribel, for their love, patience, and encouragement.
"From birth to the end of adolescence, education is one whole, and is one of two fundamental, necessary factors for intellectual and moral formation, so much so that the school carries a great responsibility regarding the final success or failure of the individual in pursuit of his own potential and adaptation to social living."

Jean Piaget
This research study has been a rewarding experience for me, and I would like to thank several persons and agencies who were instrumental in making all that I have achieved possible.

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ABSTRACT

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September, 1985

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The purpose of this study was to assess the cognitive functioning of college freshmen at the University of Southern Mindanao and to match the level at which they were assessed with their scores on the NCEE and their achievement in class. The teachers' perception of the factors that contribute to the poor performance of some students in class and whether sex was associated with cognitive development were also determined.

Two Piagetian tasks and a questionnaire were administered to 148 students and 30 teachers respectively. The students were college freshmen enrolled
at the University of Southern Mindanao, during the school year 1984-1985. They were composed of two groups. The first group consisted of 100 college freshmen that were randomly selected from the total college freshmen population including those enrolled in the BS' Biology and BS' Chemistry curricula. The second group consisted of the 50 college freshmen enrolled in the BS' Biology and BS' Chemistry curricula. The teachers were the faculty members of the BS' Biology and BS' Chemistry together with all college freshmen English and Math instructors at the same university and during the same school year.

It was concluded that, based on the two Piagetian tasks, a substantial number of college freshmen at the University of Southern Mindanao were not reasoning at the formal level of cognitive development. Significant differences at .05 level were found for the random sample of the total freshmen population, but not for the BS' Biology and BS' Chemistry population, between cognitive levels and the following variables: NCEE scores and achievement in Science and Math courses. There were no significant differences between cognitive levels and achievement in English for either group.

The NCEE scores and achievement in Science and Math were found to be correlated at the .05 level for the random sample of the total college freshmen population but not for
the BS'Biology and BS'Chemistry freshmen. There were no
correlations between NCEE scores and achievement in English
for either group.

It was also found that the teachers' perception of
why some students do poorly in class does not place primary
responsibility for the problem on the low level of
cognitive development of the students.
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CHAPTER I

INTRODUCTION

Background of the Study

During the Spanish times, higher education in the Philippines was in the hands of the religious orders. When the Americans occupied the Philippines at the turn of the century, they set up a public school system, teacher training schools, and later on the first state university. At the same time, they allowed private entrepreneurs to operate colleges and universities for profit. Before the Second World War, there were 398 private schools and colleges in various regions of the country. By 1969-1970, the number had grown to 595; and by 1980-1981, there were 775 private colleges and universities as well as another 309 government-operated tertiary-level institutions.

Goals

Colleges and universities in the Philippines, both private and public, assume much the same sort of responsibilities as many of their counterparts in other developing countries. These institutions are called upon to help proper development efforts as the nation struggles to modernize itself. Higher education is supposed to serve
as an agent of change and as a source of change agents, to help define the future and provide guideline for future action, and to define, study and provide answers to present and future concerns. It is called upon to do all these and at the same time to maintain itself as a bastion for intellectual inquiry, scholarship and academic freedom. More realistically, the university is expected to perform a myriad of developmental tasks and at the same time to make itself financially and organizationally viable.

The goal of tertiary education in the Philippines as stated in the Five-Year Philippine Development Plan, 1983-1987, stated that "tertiary education will continue to be rationalized and integrated to meet the need for future democratized access to the system while maintaining acceptable standards of quality." The twin objectives of access and quality are to be pursued by providing financial assistance and by establishing a national accreditation system, and by adapting policies of progressive deregulation, and an incentive system. A science education plan, for example, will be formulated to more systematically provide for training of manpower in the sciences.

**Quality**

Recognizing the rampant commercialization of higher
education, the Ministry of Education, Culture, and Sports (MECS) started to apply some controls in the 1970s. A National College Entrance Examination (NCEE) was instituted to determine who should go on to college and who should enroll in technical and vocational courses. Originally the cut-off scores were at the 25th but are now at the 40th percentile. This means that only the upper 60 percent of the examinees, who normally are newly graduated high school students, can enroll in four year degree courses.

How does the NCEE affect higher education as it tries to fulfill the mandate? Data from the National Educational Testing Center showed that family background (especially parent's occupation and education), educational background (such as size of graduating class), career choice, and other factors were significantly related to performance in the NCEE. The national capital of Metro Manila had the highest mean score in the various sub-tests and the highest General Scholastic Average (GSA) in the 1981 NCEE among all the regions (National Educational Testing Center Reports, 1981).

The NCEE has served to prevent very low achievers, as measured by that examination, from enrolling in degree courses. This barrier to enrollment seems based on the assumptions that low achievers could not succeed in a college curriculum, or that the college or university has
no obligation to examine what they do to see if success might not possibly be provided, or that by low achievers' enrollment standards might be lowered or eroded. The NCEE could also function as a standard that would pressure high schools to improve the quality of their education. This later function might also be based on the assumption that high scores on the NCEE represent what high schools should be striving to accomplish.

The fact that those who do not win a place in college are forced to enroll in technical or vocational courses is rationalized by Zwaenepoel and Mendoza thus:

What is to be realized is that the goals of equality and quality could actually be unified into one and the same goal without creating all the conditions usually encountered. This could be achieved by encouraging the development of a technologically flexible and non-standardized educational system which gives more attention to individual characteristics and needs in the formulation of appropriate educational services... (Zwaenepoel and Mendoza, 1979).

A research report on equalization of educational opportunities for private higher education recommended certain measures to be taken within the system of higher education (Private Higher Education Project Reports, 1978). With reference to admission requirements, a regional cut-off in the NCEE was recommended to correct the Manila bias. Another measure is an NCEE correction factor based on socioeconomic variables. Still another suggestion was
to adopt a quota system of enrollment in the different regions that considered the distribution of the population by income groups. A system of socialized fees according to income, and programs for scholarships and loans has also been proposed. A scholarship and loan program is already operational nationwide.

The state-supported colleges and universities (University of Southern Mindanao is one of them) which are attended by 15 percent of the tertiary level student population charge relatively low tuition fees. These schools tend to limit enrollment, and except for a few, offer only a limited set of courses, the most common of which is agriculture. But the government provides a large subsidy to public institutions of higher learning and the students pay only a fraction of the cost of education. In contrast, private colleges and universities subsist almost entirely on tuition fees, and therefore they have to charge higher fees.

Admission to both private and public colleges and universities is generally determined by the student's record in secondary school and passing the National College Entrance Examination (NCEE).

Admission to the University of Southern Mindanao is granted to a student who has a satisfactory secondary school record, and has passed the NCEE. However, because
admission procedures were not regarded as satisfactory, the university was using its own college admission test to supplement the use of secondary school records and the National College Entrance Examination (NCEE) as bases for student's admission. However, due to financial constraints on the part of the college applicants as well as the university, the University of Southern Mindanao College Entrance Test (USMCET) was indefinitely suspended. It can be anticipated, however, that new moves will be initiated in the future to supplement the data utilized in admission decisions. When that occurs it would be hoped not only would the university be better prepared to help the students admitted to succeed, but also that the new data would enable the university to make better admission decisions.

Statement of the Problem

The developmental theory of Jean Piaget views intelligence as a form of adaptation. The child, from birth, progresses through cognitive developmental stages interacting with his/her environment (Killian, 1979). Piaget and his chief collaborator, Inhelder (1958), believe that they can distinguish three main periods in which cognitive development is qualitatively different, with
sub-stages in each. The first of these is the period of sensori-motor intelligence which extends from birth until the appearance of language, approximately during the first eighteen months of life. The second period (Period II) extends from this time until about eleven or twelve years and consists of preparation for, and realization of, concrete operations of classes, relations and numbers.

The third period, that of formal operations, begins at about twelve years and achieves its full development roughly three years later. The second period (Period II) may be subdivided. Period IIA extends from about eighteen months to about seven years, and is a pre-operational period. It is again subdivided into two stages; the first extending until about four years is the pre-conceptual stage; the second is the intuitive stage. Period IIB extends roughly from seven years to adolescence and is the period of concrete operations.

In Piaget's theory the final period of intellectual development is that of formal operations, which begins at about age twelve, and continues during the adolescent period. There are several major themes which run through Piaget's account of adolescent thought. One is that the adolescent's system of mental operations has reached a high degree of equilibrium. This means, among other things, that the adolescent's thought is flexible and effective.
He can deal effectively with the complex problems of reasoning. Another major theme is that the adolescent can imagine the many possibilities inherent in a situation. Unlike the concrete operational child, whose thought is tied to the concrete, the adolescent can deal with hypothetical propositions. He can compensate mentally for transformation in reality; this is one of the determinants of equilibrium (Piaget's theory of Intellectual Development, p. 178).

If we were to take Piaget's age level literally, we would assume that students entering college as freshmen have reached the formal stage of cognitive development. College professors of science and mathematics have been making the assumption, either implicitly or explicitly, that students entering college as freshmen have reached the formal level of cognitive development (Killian, 1979). Recently studies of some samples of college freshmen have found that less than 50 percent are reasoning at the formal operational stage. In a study in which two oral tasks were administered to students, Renner and Lawson (1973) reported that forty (40) percent of the 185 students tested reasoned at the formal level. McKinnon and Renner (1971) administered five oral tasks to 131 student subjects and Killian (1979) administered six oral tasks to 106 freshmen student subjects; each reported finding only about twenty
five (25) percent to be reasoning at a formal level of cognitive development. Griffith (1976) administered one oral task to sixty (60) freshmen student subjects and Kolodiy (1975) administered two oral tasks to twenty five (25) freshmen student subjects; each reported finding thirty (30) percent of the freshmen tested reasoning at a formal level.

One goal of effective science teaching is to match instruction and curriculum materials with the developmental level of the learner. Learning difficulties of students in science subjects have often been attributed to an inability to grasp science concepts. A more refined line of thought suggests that students are not yet using reasoning patterns required to comprehend certain science concepts. If college science professors are aware of this reality, then they can do something to remedy the situation. Many concepts in science may be taught in a manner consistent with either formal or concrete thought (Staver and Gabel, 1979).

In the Philippines, the University of Southern Mindanao in particular, it seems there might be a problem of matching college instruction with the developmental level of students. The problem might be considered to be due to a number of factors. First, there is no dependable data available pertaining to the cognitive functioning of
Filipino college freshmen. Their level of cognitive functioning, however, might be implied from studies done in other countries. Second, Filipino institutions do use tests to determine who can go to college and who can not, but there is no evidence that the tests discriminate in terms of the level of the cognitive functioning of students by keeping out those at the pre-formal level. Many entering college students, who are expected to be capable of abstract thought, either operate at the concrete level of cognitive development or do not consistently use formal thinking strategies (Lawson, 1978). This situation presents a serious problem for all institutions of higher education in the Philippines, particularly at the University of Southern Mindanao.

If learning problems of students can be attributed to lack of reasoning ability as identified by the Piagetian concepts, then it appears that identification of students' cognitive stage levels would be helpful to faculty of the University of Southern Mindanao. At this time, it is not known whether the National College Entrance Examination (NCEE) identifies reasoning skills as described by Piaget. A correlation study between these scores would provide an additional diagnostic tool both for admission policies and teaching strategies. This study will provide some evidence of the potential usefulness of both tests in the
identification of students who can go to college and who can not, and in helping students to achieve at a higher level in college.

**Purpose of the Study**

The purpose of this study is to determine the cognitive functioning of Filipino college freshmen at the University of Southern Mindanao by assessing their cognitive development and matching it with their scores on the National College Entrance Examination (NCEE), and their achievement in class (Science, English, and Math subjects). The teacher's perception of the factors that contribute to the performance of some students who do poorly in class will also be determined. More specifically, the main purpose of this study is to investigate the following null hypotheses:

1. A substantial number of college freshmen at the University of Southern Mindanao are not reasoning at the formal level of cognitive development.

2. There is no correlation between their cognitive scores on the CSMS Science Reasoning Tasks and their National College Entrance Examination (NCEE) score.

3. There is no correlation between their cognitive scores on the CSMS Science Reasoning Tasks and their
achievement in class (Science, English and Math subjects) as reflected in grades received.

4. There is no correlation between their NCEE scores and their achievement in class (Science, English and math subjects) as reflected in grades received.

5. The teacher's perception of why some students do poorly in class does not place primary responsibility for the problem on the low level of cognitive development of the students.

6. Differences in cognitive development among college freshmen at the University of Southern Mindanao are not sex related.

**Definition of Terms**

For the purpose of clarification, terms which are frequently used in this study are defined.

**Intelligence.** Piaget offered several definitions of intelligence, all couched in general terms. These definitions reflect Piaget's biological orientation. For example, "... intelligence is a particular instance of biological adaptation..." (Origin of Intelligence, pp. 3-4). Another definition states that intelligence "is the form of equilibrium towards which the successive adaptations and exchanges between the organism and
environment are directed" (Psychology of Intelligence, p. 6). The use of the term "equilibrium" borrowed from Physics, suggests a balance, a harmonious adjustment between at least two factors -- in this case between the person or his cognitive abilities and his environment. Although the balance may be disturbed, the individual can perform actions to restore it. Intelligence is the "instrument" which enables the individual to achieve this equilibrium, or to adapt by means of certain actions carried out in the environment. The definition also implies that equilibrium is not immediately achieved; as the child develops, the type of actions that he/she is able to carry out on the environment will change and so, too, will the resulting equilibrium. Thus, for Piaget there is no single and final intelligence, but rather a succession of intellectual stages.

Another definition stresses that intelligence is "a system of living and acting operations" (Psychology of Intelligence, p. 7). Piaget is interested in mental activity, in how the individual performs in his interaction with the world. He believes that knowledge is not given to a passive observer, rather, knowledge or reality must be discovered and constructed by the activity of the child (Piaget's Theory of Intellectual Development, p. 14).

Sensori-Motor Period. This is the period of mental
development which begins with capacity for new reflexes, and ends with the first appearance of language and other symbolic ways of representing the world. It is the characteristic mode of knowledge of the first stage of intelligence in which the form of knowledge is tied to the content of specific sensory input. It is also referred to as practical intelligence.

**Pre-Operational Period.** In Piaget's stages of cognitive development, this is period IIA which is also referred to as the pre-conceptual sub-stage. This is a period of preparation for concrete operations, which covers the transition from the sensori-motor structure of intelligence to operational thinking. It is also used to designate the period after the sensori-motor stage but prior to the formation of the first operational thinking in the strict sense. The pre-operational period is the preparatory part of the stage of concrete operational intelligence, characterized by the deforming need for symbolic support, hence egocentrism.

**Concrete-Operational Period.** This is period IIB which is also referred to as sub-stage of concrete operations. This period begins when formation of classes and series takes place mentally: that is when physical actions begins to be "internalized" as mental actions or operations. It is the
characteristics of the first stage of operational intelligence. A concrete operation implies underlying general system of "grouping" such as classification, seriation, and number. Its applicability is limited to objects considered as real (concrete).

**Formal-Operational Period.** In this period of cognitive development, the adolescent develops the ability to imagine the possibilities inherent in a situation. Before acting on a problem which confronts him, the adolescent, at the formal period, analyzes the problem and attempts to develop hypotheses concerning what might occur. These hypotheses are numerous and complex because the adolescent, at this period of mental development, takes into account all possible combinations of eventualities in a somewhat exhaustive way. As the adolescent proceeds to test his idea, he designs experiments which are quite efficient in terms of supporting some hypotheses and disproving others. He observes the results of the experiment, and from them draws the proper conclusion (Piaget's Theory of Intellectual Development, p. 204).

**Equilibrium.** The internal regulatory factor underlying a biological organization. It is manifested in all life, particularly in the development and activity of intelligence. Intelligence makes explicit the regulations
inherent in organization. As a process, it is the regulatory factor that unifies evolution and development, and as a state (an equilibrium), it is a continuously changing balance of active compensations.

**Cognitive Development.** It is defined as the development of the ability to organize perceptions, understand the working of the environment, and use logical thought processes.

**Concepts.** Are groups of ideas or thought patterns surrounding a term. They represent to us the unique generalized features of the sets of things the terms are designed to convey, and discriminate a specific set from sets of different things included in the term (Science Concepts in a Pacific culture, p. 8).

**Periods and Stages.** The terms periods and stages are often used by different authors to represent different meanings. For the purpose of this study, periods are used to describe four major divisions of Piaget's cognitive development namely: Sensori-motor Intelligence, Pre-operational Intelligence, Concrete Operational Intelligence, and Formal Operational Intelligence. Stages are used to designate the division within the periods.

**SRTs.** Science Reasoning Tasks. These testing materials have been developed by the CSMS (Concepts in Secondary
Mathematics and Science) team as research tools to be used as an adjunct to curriculum development in science teaching. SRTs are valid and reliable tests for assessing the ability of students (young and adults) to use concrete and formal reasoning strategies. They have a precision comparable with conventional psychometric tests, and they estimate the same abilities which Piaget originally described by individual interviews.

College Freshmen. For the purpose of this study, college freshmen are those students who are presently enrolled in first year college courses at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines during the school year 1984-1985.

NCEE. The National College Entrance Examination administered to all high school graduates who desire to pursue a Philippine-post-secondary degree program having a minimum of four years study. Presidential Decree No. 146, 1973, requires all institutions of higher learning to admit only those who pass the NCEE.

Significance of the Study

The intellectual development model of Piaget asserts that as each individual matures, he/she passes through
various intellectual stages, the recognition of which can furnish guidance for what the individual can learn. Traditionally, a person's intellectual development was considered to be a function of all his/her educational experiences; in other words, learning determines intellectual development. The Piagetian model states the converse - intellectual development determines what can be learned. This frame of reference clearly implies that the school has the responsibility of assessing and considering each individual's level of intellectual development when selecting what is to be learned (Renner, 1980).

Having secondary and college teachers able to distinguish between concrete operational structures and formal operational structures becomes a necessity if educational institutions have the intellectual development of the individual as one of their goals. Educators need to be concerned because students who operate with concrete operational structures may not be able to assimilate formal concepts and ideas. Lack of assimilation thus means that accommodation has not taken place. The mental functions of the individual have not been changed and no intellectual development has resulted. In other words, concepts that require formal reasoning, in order to result in assimilation and accommodation, are not assimilated and accommodated by those who are at the concrete operations.
Formal concepts are not understood by those reasoning concretely (Renner, 1979).

The present study may be valuable in the following ways to faculty in developing countries, particularly at the University of Southern Mindanao:

1. Provide information that could be used as bases for judging:

   a) Whether the test used to determine admission to the University of Southern Mindanao permits the admission of those not at the formal level of intellectual development.

   b) Whether the developmental level of the students matches the curriculum, assuming that learning the curriculum requires functioning at the formal level for optimum success.

   c) Whether the teacher's perception of the factors that contribute to successful performance by students is related to Piagetian theory of cognitive development.

2. Provide data that would be valuable for planning staff development, making curriculum changes and studying admission policies.

3. Provide information about whether or not the teachers are aware of the need to adjust their instruction to the developmental functioning of their students, and
whether their perception of why some students might do poorly in classes is related to the level of cognitive functioning of these students.

4. Provide information that will assist those who are responsible for making decisions whether or not to begin using the University of Southern Mindanao Entrance Test (USMET) in the future.

Delimitation of the Study

Any conclusions that can be drawn from the findings of this study are necessarily limited by the following:

1. The assumption that the instrument (CSMS Science Reasoning Tasks, the Pendulum and the Equilibrium in the Balance), Wylam and Shayer (1978), does measure the Piagetian stages of cognitive development.

2. The assumption that the instrument (CSMS Science Reasoning Tasks, the Pendulum and the Equilibrium in the Balance), Wylam and Shayer (1978), can be used to elicit valid data concerning the cognitive development of college freshmen at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines.

3. That the sample of students is limited to the college freshmen enrolled at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines during the

4. That the sample of teachers is limited to the BS'Biology, BS'Chemistry and college freshmen English and Math instructors at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines.

5. The assumption that at the University of Southern Mindanao much of the curriculum in Science, English and Math subjects does require that students be able to think at the formal level.

Outline of the Remaining Chapters

The first chapter has introduced the main part of the study and has provided background and theory which motivated the researcher to address the relationships, if there are any, between cognitive development and performance on the National College Entrance Examination and achievement in class (Science, English and Math subjects), and to discover the teacher's perception of the factors that contribute to the poor performance of some students in class.

Chapter II includes a review of the literature related to the topic of study and will focus on three major areas; (1) Piaget's theory of cognitive development and its applications to science education; (2) the teacher's
perception of the factors related to achievement; and (3) studies on the results of NCEE.

Chapter III and IV will describe and give results of the study conducted during the academic year 1984-1985 at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines. Involved were 148 college freshmen including the BS'Biology, BS'Chemistry curricula and 30 college freshmen Science, English, and Math teachers.

Chapter V provides a summary, conclusion, and suggestions for further research. Also included are a bibliography and appendices which contain letters of request to conduct the study, consent forms, and instruments used for data collection.
CHAPTER II
REVIEW OF THE LITERATURE

In this chapter, assumptions and propositions upon which the study is based will be substantiated through a review of relevant literature. In the first section of the chapter, Piaget's theory of intellectual development and its application to science education (science curriculum and instruction) will be described in order to demonstrate their utility and to establish guidelines for this study. In the second section, literature will also be reviewed to determine what teachers perceive to be the important factors related to achievement, and section three will review some studies on the results of the National College Entrance Examination (NCEE).

Piaget's theory of Cognitive Development

The theory of Jean Piaget is primarily concerned with cognitive development. Piaget hypothesizes that development involves movement through a series of four periods, each period is characterized by particular types of schemata --- internal plans which determine the direction of thought, fantasy and action. For example, sucking and grasping schemata are characteristics of the
first developmental period: any stimulus in the perceptual field triggers a grasping and/or sucking response (Breger, 1974).

Growth and development occur through assimilation and accommodation. Assimilation involves incorporation of reality into existing mental patterns or schemata, leaving the mind unchanged. For example, the infant who grasps a ball assimilates the object using existing schemata. Accommodation occurs when a schema is modified as a result of being inadequate to deal with the environment. For example, the child who attempts to grasp a hot object may learn a new schema -- not to grasp certain objects. The balance of assimilation and accommodation produces an equilibrium which is characteristics of each period. (Ibid.)

At the Sensori-Motor period, schemata are all at the level of sensations and actions. Assimilation is based upon reflexes. There is no awareness that objects exist in space and persist through time; nor is there any differentiation between self and environment. However, by the end of this period, the infant has a sense of a permanent object: a young infant notices objects only when they are in the immediate perceptual field whereas an older one will look underneath a covering for one. By the end of this period, the infant also has a sense of the self
existing apart from others. (Ibid.)

At the **Pre-operational period**, schemata involve crude symbolic functions. Symbols are initially expressed physically as imitative gesture and actions, but eventually they develop to include internalized images unrelated to movements. Symbols begin as private and individualistic but gradually become accommodated to shared meaning. Thus, language is initially characterized by words whose meaning is unknown to others but becomes understandable with time. At this period, schemata are presently centered and closely linked to concrete reality. They can be manipulated only in simple ways. (Ibid., p. 123)

At the period of **Concrete Operation**, the child's cognitive developmental patterns involve the ability to perform complex mental transformations: uniting of classes, ordering of events, conservation, reversal, and application to other situations. Schemata need to be limited to specific actions and present events. They can also include formation of hypotheses and construction of explanations. (Ibid., p. 236)

At the period of **Formal Operations**, thinking involves abstract conceptualizations; no longer is thought tied to concrete reality. A person can conceptualize the past and future as well as the present and is able to make thought the object of reflection. At the preceding period, the
child was able to organize and manipulate the present reality; now, the adolescent is able to deal with possibilities and test them out against reality. (Ibid.)

Piaget bases his theory upon the results of intensive interviews with children of different ages. He poses problems designed to produce problem-solving behavior that is the characteristic of different periods and questions the children in order to understand the nature of their reasoning process. For example, a child may be shown a tall beaker filled with water. The water is transferred to a short, wide-diameter beaker and the child asked whether or not the amount of water has changed. A child at the pre-operational period will conclude that the taller beaker has more water because the height has changed; this child can maintain awareness of only one quality that is immediately visible. A child at concrete operations will conclude that the volume has not changed because he/she is able to maintain awareness of abstract qualities as well as concrete ones.

Piaget has said that he is not an educationalist and this has no doubt led to the multitude of books and articles which interpret Piaget and the implication of his theory for education. Briefly, however, if we educators begin to accept his theory of cognitive development there are some important implications for teaching. One
implication that has received a large amount of attention is that children should be actively involved in their learning. This point has been emphasized in many pre-school and elementary school programs. However, this emphasis has been criticized as Anthony (1977), argues that children can learn by watching rather than doing and that while children's activity on materials is important such activity has been over-valued and the role of observation under-valued. Another implication is that children can not learn by verbal instruction if the ideas and knowledge being presented do not match their cognitive development.

**Applications of Piagetian Theory**

Piaget has not advocated or suggested practical applications of his own theory; his interests lie primarily in describing the developmental process more elaborately and completely (Piaget, 1967). Nonetheless, his ideas have been widely applied.

The most comprehensive applications have been made in the field of education; curriculum reform in subjects such as mathematics, science, and reading have been guided by Piagetian ideas. Teaching methods, for example, have been modified to insure more "hands on" physical experience for children at an early period of development. Similarly,
cognitive abilities and needs have been considered in determining when children should be exposed to specific concepts (Furth, 1968).

An instructional technique has been developed by Robert Karplus and others at the Science Curriculum Improvement Study (SCIS), University of California, Berkeley (1974). This approach incorporates much of Piaget's theory of cognitive development. The process basically includes three phases (1) exploration, (2) invention, and (3) discovery. This approach of exploration, concept invention, and discovery or application constitute what Karplus called the Learning Cycle. This instructional technique is a change from the teacher-centered to the student-centered type of learning. It allows each student the opportunity to think for himself. The role of the teacher is to direct the activity by providing the appropriate questions, hints and encouragement to keep the student thinking for himself.

For the past few years, many programs in the United States have adapted the Learning Cycle for higher education. Fuller et al (1984) described several such programs in their recent publication, Piagetian Programs in Higher Education, one such program is the ADAPT (Accent on Developing Abstract Process of Thought) developed at the University of Nebraska by selected college instructors.
The ADAPT program is a multi-disciplinary college freshmen program including courses in Anthropology, Economics, English, History, Mathematics, and Physics. It was developed based on the need for a learning environment that could encourage higher level reasoning in college freshmen. The faculty involved in this program believed that experiences rather than textbooks should be the central core of the teaching-learning process.

The DOORS program at the Illinois Central College at East Peoria, Illinois is the coordinating institution for the Consortium for Offering and Managing Programs for the Advancement of Skills (Project COMPAS), a design for change. It is composed of six community and junior colleges throughout the United States. All of these colleges are using the Learning Cycle approach of teaching.

Much has been written on the importance of cognitive development as a variable that mediates science learning. Research has indicated that formal thought is required to learn many of the concepts taught in the high school and college science courses (Goldstein and Howe, 1978; Cantu and Herron, 1978). Evidence also suggests that the majority of students in middle and high school grades (Chiappetta, 1976) and a significant proportion of college students (Renner and Lawson, 1973) are unable to utilize formal operations in problem solving. Schwebel (1975), in
a research study conducted in Australia, measuring incoming college freshmen, agreed with the findings in the United States that a significant proportion of high school and college students are not at the level of formal operations (Blake, 1978).

There have been many studies to determine children's cognitive development in the pre-operational and concrete stages. Fewer studies have focused on formal operational thought with most research occurring in the period from 1972 to 1979 (Neimark, 1979).

Most of the research findings regarding formal operations indicated sex differences in formal thought with males operating at a high level than females (Elkind, 1962; McKinnon and Renner, 1978; Schwebel, 1975; Douglas, 1977). Goolishian (1981), in a study on Piaget's cognitive levels in a community college population found significant correlations between the achievement tests and the cognitive scores. However, in this latter study females performed significantly better than males.

The consensus of findings from research on cognitive development (Lawson, 1979; Lawson, Karplus and Adi, 1979; Lovell, 1961) is that science curricula need to be changed so that the cognitive development of learners becomes a focus. Teachers need to match instruction to the cognitive level of the learner; and research is needed to investigate
the nature of learning for students at different levels of cognitive development.

In recent years a large amount of research concerned with students' cognitive development has been published. Most of this research focuses on Piaget's theory of cognitive development. Piaget's theoretical position is that cognitive growth has its laws of internal growth, and its successive acquisitions are drawn by cumulative addition from the child's physical and social environment (Miao, 1970).

Piaget's numerous experiments have provided information about students' cognitive capabilities that should be studied by educators. Students' cognitive capabilities are a factor which a teacher should understand in order to be able to construct an appropriate model of teaching for any particular group of students (Raven, 1970).

There is really a need to assess the ability of a student to construct his own concepts from the information that is given to him. Piaget has shown how logical operations are used to construct concepts. The ability to diagnose concept acquisition difficulties and prescribe an instructional approach to remove these difficulties is the basis of individualized instruction. The teachers must be capable of determining the ability of the students to
comprehend the meaning of the concepts they use in their school work. If the student does not have the capacity of using a specific logical operation to work with written content, the teacher must be able to diagnose the problem (Raven, 1977). Many college professors assume college students in freshmen science courses to be at what Piaget has called the formal operational level of thought. Students at the formal level of thought can demonstrate abstract reasoning skills, such as manipulating variables in a systematic fashion (Kolodiy, 1975).

Once the characteristics of thinking at different periods have been described, curriculum writers and teachers can then produce and match materials to the level of the students. However, two large problems remain at this point. How can we assess the level of thinking of the students and what proportion of students at particular ages are in the different periods?

The answer to the first question - how to assess the level of thinking of students, has been available for many years. There are a large number of experiments described by Piaget and his fellow-workers that can be used in interviews with the students. This approach (the so-called clinical method) in which an experimenter sits down with a student and asks the student questions to elucidate the student's thinking has been crucial to the development of
Piaget's model. We have learned, and indeed will continue to learn, a great amount from such interviews. The obvious problem for curriculum writers, or for teachers of classes of over forty students, is that the clinical method takes a great deal of time. The group approach has been tried by many research workers (Karplus, 1976; Wollman, 1977; and Shayer, 1976). The work by Wylam and Shayer (1978) with the Chelsea Secondary Mathematics and Science Project (CSMS) is well described and is of particular interest because of the size of the sample of children tested (over 10,000 children between 9 and 14 initially and a further study of 1,200 15 to 16 year olds) and because of the links with science and mathematics curricula. The test instruments called "Class Tasks" were derived from a careful study of Piaget's writings. Essentially, students observe a demonstration by the teacher and are then asked to write answers to questions about the demonstration or about a similar situation. The answers are scored and because each question has been assigned a particular Piagetian level (e.g. early concrete or early formal thought and so on) the level of individual students can be found. The proportion for each level for the class can also be determined. Since it is not possible to describe in details the results of all the tasks, the results from one (The Pendulum) are given in Table 1 to indicate the
potential of such class tasks.

What the results indicate is that children seem to be reaching formal thinking later than the early work of Piaget suggested. There are qualitative differences in student's cognitive ability at late concrete thought. If curriculum experiences are offered to these students who may be at the same grade level then it would seem desirable that such experiences should be matched to the level of the students. If the experiences and activities are at early formal level then it is very unlikely that concrete thinkers will understand or be able to apply the learning outcomes. Mcgrath (1978) illustrates an example to this point. If we consider a common science topic "change of state of matter" then the topic can be presented in a number of ways as follows: A solid, for example ice, "turns" to a liquid, water, when heated. The water may "disappear" if heated further. This could be understood by a student at period 2A. The changes that occur when ice melts to water, or water changes to steam can be reversed. Heating causes melting, cooling causes freezing. This could be understood by a student at period 2B because at this period the ideas of reversability and causal thinking have formed.

Raven and Kingfa (1977) compared the Thai and American elementary school children on their achievement in
Physics at three levels of cognitive complexity. Their findings suggest that the logical operations that are used to solve the problems at the three levels of cognitive complexity were used differently by the students at the different age levels. The implications of their findings suggest that the information that is being taught by the teacher and learned by the student must be analyzed in terms of the culture and the level of the development of the learner. The comprehension of the concept occurs through the action of specific logical operations and the quality of learning is dependent upon these logical operations. In the same manner the quality of instruction must parallel these logical operations. A concept may be comprehended at one level of complexity and not at another level of complexity. A schema of cognitive complexity that corresponds to a schema of cognitive development is most desirable because it permits a differentiated assessment that is at the same time diagnostic for an individual's conceptual attainment at a specific level of development.

Many of the specific problems that students have with science concept learning are derived from the logical complexity of the concepts. Students can not understand the concept if the logical operation of the concept is more complex than his logical operations. Once the student's level of logical operations has been assessed, the teacher
can provide him with a conceptual structure that he can assimilate. The teacher can design the logical structure of an entire concept or part of the concept for a student after the cognitive capability of the student has been determined. This instrument enhances the capability of the teacher to individualize his instruction. Not all of the concepts that are taught to a class can be acquired by every student in that class. Those concepts can be designed in various ways so that their logical organization can correspond to the logical organizational capacities of the students (Raven, 1977).

Griffiths (1973), studied college students' thinking abilities at Rutgers university and Essex community college. His findings indicated little difference in mental development between university freshmen and inner city community college students. He concluded that many students seem to be at the concrete level of mental development. One possible inference from this study is that learning formal science concepts may be ineffective if students are at the concrete level of mental development.

Lawson and Karplus' (1979) contention is that students who have not yet developed formal operational reasoning patterns will not meaningfully comprehend theoretical concepts and principles of science. Chiappetta (1976) reviewed some Piagetian studies relevant to science
instruction at the secondary and college level, relating cognitive development to science achievement. Her findings indicate that the majority of adolescents and young adults function at the concrete operational level when it comes to understanding much of the science content taught at the secondary and the college level. According to her, this is borne out when the percentage of individuals who perform at the concrete operational level on Piagetian tasks is combined with those who perform at the formal operational level on Piagetian tasks but who primarily function at the concrete operational level with abstract science content.

Farell (1969) has stated that formal operational individuals have the capacity to use formal operations but are not compelled to do so. Many times individuals revert to earlier stages of cognitive functioning. Raven (1974) concluded, from his experience as coordinator in many research studies concerned with the facilitation of logical operations, that the level of reasonings used for inquiry and concept acquisition by every individual is substantially below his capacity. This is supported by Dunlop and Fazio's conclusion in the summary of their findings on the relationship between formal thought and abstract preference in problem solving.

The results of Lawson's (1974) study shows the regression effect demonstrated by students classified as
formal operational when tested on formal science concepts. Although the formal operational subjects understood significantly more formal concepts than the concrete operational subjects, they did not demonstrate full understanding of the majority of formal concepts on which they were tested. The formal operational thinkers demonstrated a great deal more understanding of concrete concepts than of formal concepts in science.

Lawson and Blake (1974) classified high school biology students into either concrete or formal thinkers by using Piagetian tasks and by using a written biology examination. When they assessed cognitive development by means of their performance on the Piagetian tasks, 53 percent of the students were rated at the formal level. When development was assessed within the context of biology, only 35 percent of the students were rated at the formal operational level. Their findings indicated that the majority of the students are functioning at the concrete level when assessed by using science course materials. Chiappetta (1974) investigated the relationship between proportional thought development and physical science achievement. The results indicated that a large percentage of individuals rated at the formal operational level functioned at the concrete operational level when tested on their understanding of physical science subject
matter. The relationship between cognitive development and achievement in science was also investigated by Sayre and Ball (1975). They reported that there were significant relationships (at the 0.01 level) between the number of tasks performed at the formal operational level and scholastic science grades of junior (r=.33) and high school students (r=.46). Wiseman (1981), Thornton and Fuller (1981), and Za'rour and Gholam (1981) reported significant relationships between level of cognitive development and student success in science courses.

Piaget describes intellectual development in terms of four periods; sensori-motor, pre-operational, concrete operational, and formal operational. According to him, we would expect students to enter the period of formal operational thought at about the age of twelve and to essentially complete his/her intellectual development by the age of fifteen. Unfortunately, evidence from a good number of studies suggests that this is not so. Lovell (1961) tested a number of students in England and found that only between 23 and 37 percent of a sample composed of 39 grammar school pupils, 10 training college students, and 3 adults demonstrated formal thought. In a study done by Dale in Australia, only 25 percent of the 15 year old students in his sample were able to completely solve a task designed to measure formal thought. A widely publicized
A study done at the University of Oklahoma indicated that 50 percent of the college freshmen tested were functioning completely at Piaget's concrete operational level and only 25 percent of the sample could be considered fully formal in their thought (McKinnon and Renner, 1971).

**Teacher's Perception of Factors Related to Achievement**

A pupil in the classroom may fail or succeed on tests given by the teacher. It is assumed that the teacher searches for causes that explain the outcome achieved by the students. The causes that the teacher uses to explain the outcome may have an effect on his or her expectation concerning the student's future achievement (Bar-Tal, 1979). In turn, the teacher's expectations may influence student's achievement behavior (Rosenthal and Jacobson, 1968).

The teacher may attribute the success or failure of the student to himself or herself, to external causes (neither to himself or herself nor to the student), or to the student (Beckman, 1970). Also, the teacher may use in the explanation either stable causes, which do not change over time (e.g., ability, task difficulty) or unstable causes, which can be modified in the future (e.g., effort, preparation for the test). The dimension of stability
affects the teacher's expectation regarding the student's future success (Weiner, 1974). Attribution of success or failure to stable causes indicates that similar outcomes will be repeated in the future, whereas attribution to unstable causes indicates that the outcome may not be repeated. For example, an attribution of a student's failure to low ability results in low expectancy for future success, since it is assumed that the student's ability will not increase greatly, and therefore, will show little improvement. Attribution of failure to lack of effort may result in high expectancy for future success, since effort is considered an unstable cause, internal to the student.

A number of studies have investigated the effect of a student's performance on the teacher's perception of causality. The results obtained in these studies were somewhat conflicting. While Johnson, Feigenbaum and Weiby (1964), Beckman (1970), and Brandt, Hayden and Brophy (1975) found that the student's performance may lead teachers to somewhat biased causal perceptions of the student's success and failure, Beckman (1973), Ross, Bierbrauer, and Polly (1974), and Ames (1975) did not find any biases in teacher's causal perceptions. The first three studies found that teachers tended to take credit when the student performed well and tended to attribute the responsibility to the student when the student performed
poorly. The later three studies showed that teachers tended to take responsibility for the student's failure and to give credit to the student if the student succeeded.

The results of a study by Darom and Bar-Tal (1981) indicated that the causal perception of a student's success and failure by teachers might be somewhat biased. The success of the student was attributed mainly to home conditions, the teacher's good explanation, and, to a lesser extent, to the student's effort and interest. Failure was attributed mainly to the student's lack of preparation, low ability, and test difficulty. Thus, the teachers tended to share the credit for success with the students and to put the blame for failure on the student. In the case of success teachers expressed ego-enhancement attribution, and in the case of failure they expressed ego-defensive attributions. These results are in agreement with findings of Johnson et al. (1964), Beckman (1970) and Brandt et al. (1975), who found that teachers take credit when their students perform well and assign the attribution externally when their students perform poorly.

**Studies on the Results of the NCEE**

The Philippine National Educational Testing Center conducted studies on the effects of some variables on the
results of the NCEE. The study examined the following problems:

1. What percentage of the examinees (a) intend to go to college? (b) have no plans to go to college? (c) think they may go to college?

2. Is there a significant relationship between the examinees' performance on the NCEE and their educational plans?

3. To what extent are the examinees' course preference and the factor of who choose the program related to performance on the NCEE?

4. Is the performance on the 1975 NCEE related to the examinees' means of support in college?

The findings on problem No. 1 showed 69.02 percent of the 393,029 examinees had plans of pursuing college education. A sizeable 30.41 percent thought they may go to college. These figures indicate that practically all fourth year high school students aspire to go to college.

The study on problem No. 2 found a significant relationship between the 1975 NCEE performance and the student's plans about going to college. Examinees who were quite sure they could not go to college generally scored below the 13th percentile.

On problem No. 3, the study found examinees who obtained scores falling below the 14th percentile intended
to take courses which were the parent's choices.

Conversely, those who scored at the 15th percentile and above appeared more decisive about their life occupations. They chose the college program they planned to pursue.

On problem No. 4, the study found the relationship between the means of support and performance in the NCEE significant at 0.001 level of confidence. Most of those who scored below the 13th percentile tended to depend largely on their parents for support. Those who obtained scores above the eightieth percentile looked forward to getting scholarship grants. Self reliance seemed to be exhibited by the groups obtaining percentile scores between thirty and eighty. They intend to support themselves through college (MECS Memorandum No. 308 s. 1976).

The 1975 NCEE study showed in effect a relationship between high socioeconomic status of parents and high test performance by their children. The relationship, however, was not absolute. The observed frequencies of those who obtained percentile scores of seventy-one and above were greater in families with monthly income of one thousand pesos and up; but there were a sizeable number of students in the same percentile group who came from families belonging to the below five hundred pesos income bracket.

The examinees with percentile scores of eighty and above obtained high school marks in Science, History,
Mathematics, and English that ranged from eighty upwards. The General Scholastic Aptitude test scores correlated positively with high school grades in English, Mathematics, Science, and History.

Positive correlations of .45 and .37 respectively were also obtained between the Verbal Ability and Mathematics Ability areas of the NCEE and the high school grades in English and Mathematics. (Ibid.).

Summary

Cognitive development is considered as one of the variables that mediates science learning. Research has indicated that formal thought is required to learn many of the concepts taught in the high school and college science courses. However, the majority of adolescents and young adults function at the concrete operational level and not at the formal level in understanding a great deal of the science subject matter taught at the secondary and college level.

The consensus of findings from research on cognitive development is that science curricula need to be changed so that the cognitive development of learners becomes a focus. Teachers need to match instruction to the cognitive level of the learner; and research is needed to investigate the
nature of learning for students at different levels of cognitive development.

There are conflicting results obtained from the studies about causality. Teachers were found to attribute success to themselves, to home conditions and to effort and interest on the part of the student. They attributed failure to the student's lack of preparation, to student's low ability and to test difficulty. Teachers tended to take credit when the student performed well and tended to attribute the responsibility to the student when the student performed poorly. Others tended to take responsibility for student's failure and to give credit to the student if the student succeeded.

The NCEE, as a measuring instrument for academic achievement, has been found to have a relatively high degree of precision. It is expected to yield a similar GSA score again at another time when it is taken by the same student.
CHAPTER III
METHOD AND DESIGN OF THE STUDY

Method

Objectives

In the Philippines, in order to be admitted to a degree program in both private and public colleges and universities, one must pass the National College Entrance Examination (NCEE). This test is administered annually by the National Educational Testing Center (NETC) to all high school seniors throughout the country.

Students are not admitted to a degree program, if their NCEE scores are below the 40th percentile. These students may enroll in technical and vocational courses and/or retake the NCEE the following year.

The literature on cognitive development suggests that less than 50 percent of college students are reasoning at the formal level. It is also suggested that males usually achieve higher scores than females in abstract reasoning as measured by Piaget's test.

The problem is whether the National College Entrance Examination (NCEE) identifies the levels of a student's cognitive development and shows sex differences in reasoning ability. Do teachers perceive that the
student's poor performance in class is related to the problem of the low level of cognitive development of the students?

This research study proposes to test the following null hypotheses:

1. A substantial number of college freshmen at the University of Southern Mindanao are not reasoning at the formal level of cognitive development.

2. There is no correlation between their cognitive scores on the CSMS Science Reasoning Tasks and their National college Entrance Examination (NCEE) scores.

3. There is no correlation between their cognitive scores on the CSMS Science Reasoning Tasks and their achievement in class (Science, English, and Math subjects) as reflected in grades received.

4. There is no correlation between their NCEE scores and their achievement in class (Science, English, and Math subjects) as reflected in grades received.

5. The teacher's perception of why some students do poorly in class does not place primary responsibility for the problem on the low level of cognitive development of the students.

6. Differences in cognitive development among college freshmen at the University of Southern Mindanao are not sex related.
Design

In this section, the design of the study will be described. Aspects of the design to be covered include permission to conduct the study; identification of sample; administration of the test; description of the two tasks (the Pendulum and the Equilibrium in the Balance), the instruments to measure cognitive development; development, testing, and administration of the questionnaire; and discussion of statistical analysis to be performed.

Permission to conduct the study

A letter asking the President of the University of Southern Mindanao, Kabacan, North Cotabato, Philippines for permission to conduct the research study was sent, and subsequently approval was given.

Identification of sample

There were 148 student subjects used in this study. They were composed of two groups. The first group consisted of 100 students randomly selected from the total college freshmen population including those enrolled in BS'Biology and BS'Chemistry curricula at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines during the school year 1984-1985. The second group
consisted of the 50 college freshmen enrolled in BS' Biology and BS' Chemistry curricula at the same university and during the same school year. The random selection of the students was made from the official list of the registered first year college students of the same school year.

The teachers involved in this research study were the faculty members of two college science curricula, BS' Biology and BS' Chemistry, and all instructors teaching college freshmen English and Math subjects at the same university and during the same school year.

**Administration of the test**

The test is composed of two Piagetian tasks, the Pendulum and the Equilibrium in the Balance; administration of the test would require from about 85 to 95 minutes divided into two testing sessions. The test was administered based on the schedule prepared by the researcher in consultation with the teachers of the students involved in the study.

Consideration of the use of human subjects was followed. The participants were informed of their rights and the purpose of the study. A consent form, indicating the confidential treatment of their scores on the test and their voluntary participation in the research study was obtained from each student (see Appendix B).
Description of the two tasks

The pendulum task. This task investigates the students' ability to sort out the effects of three variables: how length, weight and push on a pendulum determine the period of oscillation. Of course only the length is important, but the student has to overcome strong intuitive feelings to realize this. To be successful the students must be able to design experiments which control the appropriate variables, and make deductions from demonstrated evidence. The task is introduced as a series of experiments to find out what factors determine how fast the pendulum swings. The first three questions are not assessed but are designed to help focus the student's attention on the problem. The task is based on Chapter 4 of Inhelder and Piaget's "The Growth of Logical Thinking," (1958).

The equilibrium in the balance task. This task, based on Chapter 2 of Inhelder and Piaget's "The Growth of Logical Thinking," investigates the student's ability to recognize and use inverse proportion in a simple beam balance. Piaget says that the late formal thinkers can understand the problem in terms of "Virtual Work", so toward the end of the task a work principle is introduced. However, most of the questions are not at the concrete and early formal levels. The other late formal items involves
proportion.

The task is introduced by reference to the seesaw. Students will be asked where a heavy man and a light man would have to sit if they wanted to balance the seesaw. To get them thinking about the problem they will be asked to sketch the two figures (the heavy man and the light man) on the seesaw. The introduction and the first two questions are not assessed but are designed to give the students a chance to learn about the system.

A standard assessment and scoring procedure are then used to assess stage development. Each result is scored "1" for adequate, and "0" for inadequate and recorded on the class assessment sheet. Each answer is treated only for the information it gives at the level specified for the question (see summary of answers and top of assessment sheet in the Appendix C). Thus for a "3A" question (as in B.5g for the Pendulum task and 13 for the Equilibrium in the Balance task) an ingenious reply at the 2B level will be ignored. Similarly a higher level response to a "2B" question will still only gain credit at the 2B level. Table 2 and 3 give a summary of scoring procedures for the two tasks.

The researcher selected the two tasks because both involve different schemes. The Pendulum involves the control of variables and the Equilibrium in the Balance
involves the three variables of a mechanical system thereby using different aspects of scientific thinking over and above the general organization of thinking which they both estimate.

The decision, by the researcher, to use the SRTs materials (the Pendulum and the Equilibrium in the Balance) for collecting his data about the cognitive functioning of Filipino college freshmen at the University of Southern Mindanao was prompted by the following considerations:

1. Since the SRTs evaluate students with respect to specific behaviours, rather than to population norms, they are not as culture bound as standardized intelligence test.

2. In the Philippines, English is the medium of instruction for secondary and college education. Tagalog, the national language, can be used to supplement instruction. The administration of SRTs materials allows for the explaining, or rephrasing of the questions in Tagalog where this is helpful.

3. The relative low importance of the actual wording on the student's sheet makes for easy translation to Tagalog.

See appendix C for details particular to each task.

Development, testing, and administration of questionnaire

The main part of the questionnaire which is composed
of a list of factors that may contribute to the poor achievement of some students in class, was developed based on a literature review.

The instrument was reviewed by a panel of four college faculty members at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines. The questions were evaluated based on high level of agreement among the panel members and on the bases of creating a questionnaire which would stimulate full responses from the teachers. Based on this review minor revisions were made in the questionnaire.

The instrument was tested in a pilot study involving a group of University of Southern Mindanao faculty members. The purpose of the pilot study was to test and assess the effectiveness of the questionnaire in stimulating adequate responses which could be scored simply. The pilot test also served to determine if other variables, such as questionnaire format, affected responses. Based on this test no major revisions were made on the questionnaire.

Questions used in the instrument included the following:

1. Students did not work conscientiously in the course.

2. Students did not study hard enough for the exam.
3. Subject matter was beyond the student's ability to comprehend.

4. Students did not know what they should have known prior to entering the university.

5. Students did not drill themselves enough on the things they were expected to know.

6. Explanations of concepts and ideas found in written materials (text, manuals, etc.) were inadequate.

7. Explanations of concepts and ideas offered in class by the teachers still left the ideas beyond the comprehension of the students.

8. Students were involved in too many extracurricular activities.

9. It was not possible to make the explanation simple enough for the students to understand.

10. Students failed to follow directions closely enough.

11. Students were having difficulty adjusting to life at the university.

12. Of the factors listed in 1 to 11 please indicate one factor that was probably most important in explaining students' poor performance.
Third most important

Please comment on any other factor which you believe may have contributed to the poor performance of the students in your class.

Statistical analysis

Data collected in this investigation included the following for each student participant:

2. Score on the National College Entrance Examination (NCEE).
3. Achievement in class (final grades in Science, English, and Math Subjects).
4. Age, sex, and educational level.

In addition, data have been collected from teachers about their perceptions of the factors that contribute to the poor performance of some students in classes they teach.

The achievement in class (final grades in Science, English, and Math subjects) and the National College Entrance Examination (NCEE) scores will be obtained from the college registrars' office, University of Southern Mindanao, Kabacan, North Cotabato, Philippines. A Frequency
Analysis will determine if a substantial number of college freshmen at the University of Southern Mindanao are not reasoning at the formal level of cognitive development. A one-way Analysis of Variance will be performed to test the differences between the following variables: the cognitive scores on the CSMS Science Reasoning Tasks and the National College Entrance Examination (NCEE) scores, and the cognitive scores on the CSMS Science Reasoning Tasks and achievement in class (Science, English, and Math subjects). A Pearson Correlation will be performed to find out if the National College Entrance Examination (NCEE) scores are correlated to achievement in class (Science, English, and Math subjects).

A Frequency Analysis will be used to determine the teachers' perception of the factors that may have contributed to the performance of some students in the classes that they teach. A Cross-Tabulation will be performed to determine the strength of the relationships between cognitive levels and sex.
CHAPTER IV
RESULTS OF INVESTIGATION

This chapter will include a description of the sample population and the analysis of data relating to the hypotheses proposed in this investigation.

Description of Sample Population

The two tasks (the Pendulum and the Equilibrium in the Balance) were administered to two groups of students. The first group was composed of 100 college students that were randomly selected from the total freshmen population including those enrolled in the BS'Biology and BS'Chemistry curricula at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines, during the school year 1984-1985. The second group was composed of the 50 college freshmen enrolled in two college science curricula, BS'Biology and BS'Chemistry, at the same university and during the same school year. The two sets of data obtained from these two groups will be analyzed and discussed accordingly.

The male/female ratio of the first group was fifty-eight percent male and forty-two percent female. Their ages ranged from fifteen years to twenty-two
years with a mean of eighteen years. For the second group, the male/female ratio was sixteen percent male and eighty-four percent female. Their ages ranged from fifteen years to twenty-one years with a mean of seventeen years. Tables 4 and 5 give the population distribution by age and sex for both groups.

The teacher participants were the faculty members of the BS'Biology and BS'Chemistry and all the college freshmen English and Math instructors at the University of Southern Mindanao. Fifty percent of the teachers who participated in this study had teaching experience of ten years and below with only one having one year of experience. The other fifty percent of the participants had teaching experience of more than ten years.

Among the teacher participants, fourteen were holders of Bachelor's degree, two had a Bachelor's degree but had earned some units leading to a Master's degree, twelve had completed their Master's degree, one was a doctoral candidate, and one was a holder of a doctoral degree. Table 6 gives the composition by sex of the teacher population for each subject field.

Analysis of Data

The data will be analyzed and the results will be
discussed in six major sections. Each section will contain the discussion of one hypothesis. For example, section one will present the data as it pertains to hypothesis number 1. This hypothesis stated that a substantial number of college freshmen at the University of Southern Mindanao are not reasoning at the formal level of cognitive development. A frequency analysis will be utilized to determine the percentage of students at each cognitive level.

In section two the results pertaining to hypothesis number 2 will be explained. This hypothesis stated that there is no correlation between the students' cognitive scores on the CSMS Science Reasoning Tasks and their National College Entrance Examination (NCEE) scores. An analysis of variance will test the difference between the cognitive levels and the National College Entrance Examination (NCEE) scores.

Section three deals with hypothesis number 3 in which it was stated that there is no correlation between the students' cognitive scores on the CSMS Science Reasoning Tasks and their achievement in class (Science, English, and Math subjects). An analysis of variance will be performed to test the difference between the cognitive levels and achievement in class (Science, English, and Math subjects).

In section four the results for hypothesis number 4
are presented. This hypothesis stated that there is no correlation between the students' National College Entrance Examination (NCEE) scores and their achievement in class (Science, English, and Math subjects). An analysis of variance will be utilized to determine whether these two variables are correlated.

In section five are presented the analyses for hypothesis number 5 which stated that teachers' perception of why some students do poorly in class does not place primary responsibility for the problem on the low level of cognitive development of the students. A frequency analysis of the teachers' responses to the questionnaire items will be performed to determine which factors they perceive may have contributed to the poor performance of some students in the classes that they teach.

In section six the results pertaining to hypothesis number 6 will be analyzed. This hypothesis stated that cognitive development of college freshmen at the University of Southern Mindanao is not sex related. A Cross-Tabulation will be used to prove or disprove this statement.

The University of Massachusetts Statistical Package for the Social Sciences (SPSS) computer program was used in the analyses of the statistical part of this study.
Section one

The first hypothesis stated that a substantial number of college freshmen at the University of Southern Mindanao are not reasoning at the formal level of cognitive development. A frequency analysis was performed to determine what percent of the college freshmen at the University of Southern Mindanao are reasoning at the formal level of cognitive development.

The results showed that twenty-two percent of the student subjects were reasoning at the middle concrete level, fifty-four percent were reasoning at the late concrete level, another twenty-two percent were reasoning at the mature concrete level, and only two percent were reasoning at the early formal level of cognitive development. The results of this investigation support the hypothesis that a substantial number of college freshmen at the University of Southern Mindanao are not reasoning at the formal level of cognitive development. It can be concluded that ninety-eight percent of college freshmen at the University of Southern Mindanao are reasoning at the concrete level of cognitive development. Only two percent are formal thinkers.

These results are very alarming considering the importance of cognitive development as a variable that mediates learning. These results can be used, by
elementary and secondary as well as college teachers, as a basis for developing instructional programs and providing learning environments appropriate to the students' cognitive development. It is hypothesized that these results can at least be partially explained by the fact that the majority of the college freshmen at the University of Southern Mindanao are graduates from the barrio/barangay high schools. It is a known fact that these schools very frequently lack necessary instructional facilities such as laboratory equipment, text and reference books, and to some extent tables and chairs.

Table 7 gives the frequency distribution of the students at each cognitive level.

For group two, the results show that four percent of the student subjects were reasoning at the middle concrete level, seventy percent were reasoning at the late concrete level, twenty-four percent were reasoning at the mature concrete level, and four percent were reasoning at the early formal level of cognitive development. These results suggest that a substantial number of college freshmen who are enrolled in the two college science curricula, BS'Biology and BS'Chemistry, at the University of Southern Mindanao are not reasoning at the formal level of cognitive development. Only four percent can be classified as formal thinkers.
Table 8 gives the frequency distribution of the students at each cognitive level.

Section two

Hypothesis number two stated that there is no correlation between the students' cognitive scores on the CSMS Science Reasoning Tasks and their National College Entrance Examinatin (NCEE) scores. A One-Way analysis of variance was performed to test the difference between cognitive levels and the National College Entrance Examination (NCEE) scores.

The results of this test for group one showed significant differences at .05 level between cognitive levels and the National College Entrance Examination (NCEE) scores. The results of the same test for group two showed no significant differences between cognitive levels and the National College Entrance Examination (NCEE) scores.

The results for group two can be due to several associated factors. First, the original population was not a random sample. Second, the selection process of choosing who can enroll in the two college science curricula, BS'Biology and BS'Chemistry, was based on high NCEE and high secondary school grades which resulted in a more homogeneous group of these students.
Tables 9 and 10 give the results of the analysis of variance and give the degrees of freedom, sum of squares, mean squares, F ratio, and F probability for both groups.

**Section three**

Hypothesis number three stated that there is no correlation between the students' scores on the CSMS Science Reasoning Tasks and their achievement in class (Science, English, and Math subjects). A One-Way analysis of variance was performed to test the difference between cognitive levels and achievement in class (Science, English, and Math subjects).

On the basis of the results of this test, it was found that for group one there were significant differences at .05 level between cognitive levels and achievement in Science and Math. However, it was also found that there were no significant differences between cognitive levels and achievement in English. Tables 11, 12, and 13 present the results of the analysis of variance for group one between cognitive levels and achievement in Science, English, and Math.

The results of the same test for group two indicated that there were no significant differences between cognitive levels and achievement in class (Science, English, and Math subjects). Tables 14, 15, and 16 give
the results of the analysis of variance for group two between cognitive levels and achievement in Science, English, and Math.

The results of the analyses for cognitive levels and achievement in English indicated no significant differences for either group. These findings could be attributed to the students' poor reading comprehension in English both in a course and as a medium of instruction. English as a course requires both vocabulary and reading comprehension skills. A student who has a deficit in either of these skills may have considerable difficulty successfully understanding a class discussion or completing a written assignment such as themes and the like. English courses in the Philippines are normally taught using only English language as the medium of instruction as contrasted to Science and Math which can be and very frequently are taught bilingually (English and Filipino).

Section four

Hypothesis number four stated that there is no correlation between the National College Entrance Examination (NCEE) scores and achievement in class (Science, English, and Math subjects). A Pearson Correlation was performed to find out if the two variables are correlated.
The results for group one showed significant correlation at .05 level between the National College Entrance Examination (NCEE) scores and achievement in Science and Math. However, it was also found that there were no significant correlations between the National College Entrance Examination (NCEE) scores and achievement in English. The National College Entrance Examination (NCEE) scores were found to be correlated $r = -.27$, $P = .003$ to Science and $r = -.25$, $P = .005$ to Math.

The results for group two showed no significant correlations between the National College Entrance Examination (NCEE) scores and achievement in Science, English, and Math courses.

Negative values of correlation were indicated in group one between the National College Entrance Examination (NCEE) scores and achievement in Science and Math because of the grading system used in this study. The higher is the number that represents a grade, the lower is the value of that grade. For example, 1 is higher than 3 ($1 = 99 - 100\%$ and $3 = 75 - 77\%$). The results suggest that if a student obtained a high score in the National College Entrance Examination (NCEE), it is more likely that he will perform well in Science and Math.

Tables 17 and 18 give the Pearson Correlation Coefficients between the National College Entrance
Examination (NCEE) scores and achievement in class (Science, English, and Math subjects).

Section five

Hypothesis number five stated that the teachers' perception of why some students do poorly in class does not place primary responsibility for the problem on the low level of cognitive development of the students. A frequency analysis was performed on the teachers' responses to the questionnaire to find out if they relate poor performance to students' inability to comprehend the subject matter taught in class.

The results indicated that only twenty-three percent of the respondents believed that the students' poor performance was greatly influenced by the fact that the subject matter was beyond the students' ability to comprehend. The highest percentage of the the respondents (56%) believed that when the students do not work conscientiously enough in the course, they will not perform well in class. Forty-six percent of the respondents believed that in question number two and five respectively (students did not study hard enough for the exam and students did not drill themselves enough on the things they were expected to know) have a great influence on the students' poor performance in class. The lowest percentage
of the respondents (6.7%) believed that involvement in too many extracurricular activities can be a factor in the students' not performing well in class. Another way of looking at it is the fact that of all eleven questions, question 3, subject matter was beyond the students' ability to comprehend, had the highest percentage saying slightly or no influence. This indicates that the majority of the respondents do not relate the students' poor performance to their inability to comprehend the subject matter taught in class. Table 19 gives the respondents' rating (by percent) of the importance of each question.

When the respondents were asked to rank the eleven questions from 1 to 3 according to their importance in explaining the students' poor performance in class, question number 1, students did not work conscientiously enough in the course, ranked first with thirty percent, followed by question number 2, students did not study hard enough for the exam, ranked second with twenty percent, and question number 4, students did not know what they should have known prior to entering the university, ranked third with sixteen percent. Table 20 shows the respondents' rating (by percent) of the importance of the eleven questions as most important, second most important, and third most important.

When the respondents were asked to list any other
factors which they believe may have contributed to the poor performance of some students in the classes that they teach, the following were listed: Poor reading comprehension in English (the language of instruction), poor background in Science, English, and Math, financial problem, poor study habits, home and school environment, lack of textbooks, no vacant period for study/library work, and lack of motivation to understand concepts and ideas.

Six of the respondents did not have any comments. Among the eight factors listed by the twenty-four respondents, poor background in Science, English, and Math was listed fourteen times which has the highest number of occurrence among the eight factors. Poor study habits and home and school environment were listed second with seven times each, poor reading comprehension in English (the language of instruction) was listed six times, lack of textbooks and lack of motivation to understand concepts and ideas were listed two times each, and only one respondent listed no vacant period for study/library work as a factor that may have contributed to the students' poor performance in class.

Based on the results of this study, it can be concluded that the college science instructors as well as the college freshmen English and Math instructors at the University of Southern Mindanao do not place primary
responsibility for the problem of poor performance of some students in the classes that they teach on the low level of cognitive development of the students. The majority of these teachers believed that incoming college freshmen have inadequate background in three subject areas: English, Math, and the Sciences. Moreover, they also believed that the students did not work and study hard enough either in the course or for the examination or that they did not drill themselves enough on the things they were expected to know.

Section six

Hypothesis number six stated that cognitive development among college freshmen at the University of Southern Mindanao is not sex related. A Cross-Tabulation of sex by cognitive levels was performed and the Chi Square was calculated to determine the strength of the relationships between the two variables for both groups.

Based on the results of this investigation, it was concluded that there were no significant relationships between sex of the students and cognitive levels for both groups.
CHAPTER V

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

Summary of Research Findings

The purpose of this study was to assess the cognitive functioning of Filipino college freshmen at the University of Southern Mindanao and then to determine the relationship between their cognitive functioning and their scores on the National College Entrance Examination (NCEE) and their achievement in class (Science, English, and Math subjects). The teachers' perception of the factors that may have contributed to the poor performance of some students in the classes that they teach was also determined. More specifically, the main purpose of this study was to investigate the following hypotheses:

1. A substantial number of college freshmen at the University of Southern Mindanao are not reasoning at the formal level of cognitive development.

2. There is no correlation between their scores on the CSMS Science Reasoning Tasks and their National College Entrance Examination (NCEE) scores.

3. There is no correlation between their scores on the CSMS Science Reasoning Tasks and their achievement in class (Science, English, and Math subjects) as reflected in
4. There is no correlation between their National College Entrance Examination (NCEE) scores and their achievement in class (Science, English, and Math subjects) as reflected in grades received.

5. The teachers' perception of why some students do poorly in class does not place primary responsibility for the problem on the low level of cognitive development of the students.

6. Differences in cognitive development among college freshmen at the University of Southern Mindanao are not sex related.

Two of the Piagetian tasks (the Pendulum and the Equilibrium in the Balance) were administered to assess the cognitive functioning of 148 college freshmen at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines, enrolled during the school year 1984-1985. They were composed of two groups. The first group consisted of 100 students that were randomly selected from the total college freshmen population including the BS'Biology and BS'Chemistry freshmen. The second group consisted of the 50 college freshmen enrolled in BS'Biology and BS'Chemistry curricula.

The students' National College Entrance Examination (NCEE) scores and their final grades in Science, English,
and Math were obtained from the Office of the Registrar, University of Southern Mindanao, Kabacan, North Cotabato, Philippines.

The teachers who participated in this study were the faculty members of the two college science curricula, BS'Biology and BS'Chemistry and all college freshmen English and Math instructors at the University of Southern Mindanao. A questionnaire was administered to the teachers to determine their perception of the factors that contribute to the poor performance of some students in the classes that they teach.

On the basis of the frequency analysis, the first hypothesis was confirmed, indicating that a substantial number of college freshmen at the University of Southern Mindanao were not reasoning at the formal level of cognitive development. It was also found that the great majority of the college freshmen enrolled in the two college science curricula, BS'Biology and BS'Chemistry were not reasoning at the formal level of cognitive development. The majority of the students in both groups, 54 percent for group one and 70 percent for group two, were at the late concrete level. Only 2 percent for group one and 4 percent for group two were considered to be at the formal level of cognitive development.

On the basis of the analysis of variance to test the
relationship between cognitive levels and the National College Entrance Examination (NCEE) scores, it was confirmed for group one but not for group two. The analysis indicated that there were significant differences at .05 level between cognitive levels and the National College Entrance Examination (NCEE) scores for group one. There were no significant differences between cognitive levels and the National College Entrance Examination (NCEE) scores for group two.

The results for the analysis of variance between cognitive levels and achievement in class (Science, English, and Math subjects) indicated that for group one there were significant differences at .05 level between cognitive levels and achievement in Science and Math but not for English. The results for group two showed no significant differences between cognitive levels and achievement in class (Science, English, and Math subjects).

A Pearson Correlation for group one indicated significant correlations at .05 level between the National College Entrance Examination (NCEE) scores and achievement in Science and Math. There were no correlations between the National College Entrance Examination (NCEE) scores and achievement in English.

A Pearson Correlation for group two indicated no correlations between the National College Entrance
Examination (NCEE) scores and achievement in class (Science, English, and Math subjects).

A frequency analysis of the teachers' responses to the questionnaire confirms the hypothesis that the teachers' perception of why some students do poorly in the classes that they teach does not place primary responsibility on the low level of cognitive development of the students. They seem to agree that the reason why some students do not perform well in class is because they do not work and study hard enough either in the course or for the examination. They also attributed poor performance in class to inadequate background in English, Math, and the Sciences. The implication of these findings suggests that the teachers tended to place responsibility for students' poor performance entirely or almost entirely within the students' sphere and largely within the students' power to remedy. It might also be hypothesized from the findings that they believed that there was little that they might do that could significantly affect achievement in class.

A Cross-Tabulation between sex and cognitive levels showed no significant relationships for either group. This result supports the finding of previous research that sex related differences at the earlier levels of cognitive development are not apparent (Goolishian, Hinkleman, and Wadsworth, 1971). Sex differences tend to show only in

**Implications of the Study**

The findings of this study have implications both for secondary and college education in the Philippines, particularly at the University of Southern Mindanao.

1. For secondary education: The majority of high school graduates, who are prospective college freshmen at the University of Southern Mindanao and other institutions of higher education in the Philippines to the extent they are like the University of Southern Mindanao, are not at the formal level in cognitive functioning. This problem can be due to several factors. First, high school teachers may not have enough time for effective teaching in terms of all they are expected to teach. Second, the equipment, instructional materials, and laboratory facilities are inadequate and in most cases completely lacking. Third, classrooms are overcrowded thereby tending to preclude activity-oriented lessons which results in less opportunity for the students to participate in class or in the laboratory. This situation presents a serious problem not only for the teachers but also for the students themselves.
Research has indicated that formal thought is required to understand many if not all of the important concepts and theories taught in high school and college courses.

In designing programs for the development and improvement of the Philippine secondary education curriculum, important considerations should be given to the physical aspects of the learning environments as well as the psychological aspects of the learners. Secondary education curriculum in the Philippines and other developing countries should be developed by taking into account the students' cognitive development and providing them with learning environments appropriate to their cognitive abilities.

Secondary education curriculum in subjects such as Science and Math should be guided by Piagetian theory of cognitive development. Teaching methods should be given considerable attention by modifying them to insure more "Hands on" physical experience. Exploratory activities may also be introduced to allow and encourage the students to use concrete experiences to consider new ideas. Subject matter can also be related to real life situation to enable the students to experience learning with concrete materials and to actively engage in the learning process which may help them develop their abilities and interest in learning. In short, they should be actively involved in
their learning, if the development of the students' cognitive functioning is one of our educational goals.

2. For college education: College teachers in the Philippines particularly at the University of Southern Mindanao should not make the assumption that their students are reasoning on what Piaget has called the formal operational level of thought. They should be aware of the students' present levels of reasoning abilities and the cognitive requirements of the subject that they teach. Careful selection and arrangement of learning activities should be made based on the present abilities of the students so that successful learning can be maximized. It appears from the results of this study that the developmental level of most of the college freshmen at the University of Southern Mindanao does not match the curriculum being taught, assuming that learning the curriculum requires functioning at the formal level for optimum success. College teachers at the University of Southern Mindanao and other institutions of higher education in the Philippines should be aware that there is a need to adjust instruction to the developmental functioning of the students. They should adjust to the needs of the students instead of the students having to adjust to them. Finally, they should be aware that successful performance in college courses requires not only
hard work but also the ability to comprehend the important concepts and theories presented in the class.

**Recommendations for Further Study**

Recommendations for further research and study include the following:

1. A study should be conducted to determine what might be done at the University of Southern Mindanao and other similar institutions of higher education in the Philippines to facilitate the cognitive development of students.

2. A study should be done to determine the faculty and staff development practices that promote faculty awareness at the University of Southern Mindanao and other similar institutions of higher education in the Philippines of the importance of cognitive development for learning.

3. Studies are needed to examine the environmental influences that may have contributed to the low level of cognitive abilities of many of the high school graduates at the University of Southern Mindanao and perhaps at other Philippine institutions of higher education in order to better understand and to formulate programs to remedy the present situation. Particular attention should be given to the factors such as: laboratory equipment, textbooks, and
other instructional facilities as well as the instructional strategies utilized by instructors. The results would provide valuable information which would facilitate long range and effective planning for curriculum and instruction, faculty development, and improving admission policies.

4. Finally, although this study has focused on teachers' perception of the factors that may have contributed to the poor performance of some students in class, the students themselves undoubtedly may have their own perception of why they perform as they do so that valuable contribution would be made by conducting a study that will include the students' perception of the factors that contribute to their poor performance in class. The students' opinion and perceptive comments would perhaps provide valuable insight for selecting effective teaching strategies.
Table 1

Percentage of Children at Different Stages  
(refer to Wylam and Shayer, 1978)

<table>
<thead>
<tr>
<th>Mean Age</th>
<th>Pre-operational to middle concrete 1 to 2B-</th>
<th>Late Concrete 2B</th>
<th>Mature Concrete 2B/3A</th>
<th>Early Formal 3A</th>
<th>Late Formal 3B</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 years 9 months</td>
<td>15.1</td>
<td>25.1</td>
<td>26.6</td>
<td>17.4</td>
<td>13.9</td>
</tr>
<tr>
<td>15 years 3 months</td>
<td>14.1</td>
<td>25.9</td>
<td>27.8</td>
<td>19.6</td>
<td>12.6</td>
</tr>
<tr>
<td>14 years 4 months</td>
<td>29.4</td>
<td>25.2</td>
<td>23.6</td>
<td>14.8</td>
<td>7.1</td>
</tr>
<tr>
<td>13 years 4 months</td>
<td>35.3</td>
<td>23.8</td>
<td>23.1</td>
<td>14.1</td>
<td>3.8</td>
</tr>
<tr>
<td>12 years 3 months</td>
<td>40.1</td>
<td>20.5</td>
<td>25.4</td>
<td>12.6</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Table 2

Summary of Scoring Procedures for the Pendulum Task

<table>
<thead>
<tr>
<th>Test Scores</th>
<th>Cognitive Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three or more 3B items right</td>
<td>3B</td>
</tr>
<tr>
<td>Four or more 3A or 3B items right, with two effects right (remember that the effect of Length (B5a) is a 2B item and cannot be counted in the four higher items, but the effects of Weight (B5c) and Push (B5e) can).</td>
<td>3A</td>
</tr>
<tr>
<td>Four or more 3A or 3B items right, but without two effects.</td>
<td>2B/3A</td>
</tr>
<tr>
<td>Three 3A or 3B items right</td>
<td>2B/3A</td>
</tr>
<tr>
<td>Two 3A or 3B items right plus B5 Length (2B)</td>
<td>2B/3A</td>
</tr>
<tr>
<td>One 3A or 3B item right plus A.4a</td>
<td>2B</td>
</tr>
<tr>
<td>B5 Length (2B) right</td>
<td>2B</td>
</tr>
<tr>
<td>Two or less right, without A.4a</td>
<td>2B</td>
</tr>
</tbody>
</table>

Read from the top, go down this table until you find a combination which fits the student.

Note that these rules only formalize a 2/3 success principle: If the students can give responses characteristic of a stage in 2 out of every 3 possible occasions, then we assume that this, at least, is their capacity most of the time.
Table 3

Summary of Scoring Procedures for the Equilibrium in the Balance Task

<table>
<thead>
<tr>
<th>Test Scores</th>
<th>Cognitive Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two or more 3B items right</td>
<td>3B</td>
</tr>
<tr>
<td>Five or more 3A or 3B items right</td>
<td>3A</td>
</tr>
<tr>
<td>Three 3A or higher items right plus one or more 2B items</td>
<td>2B/3A</td>
</tr>
<tr>
<td>Two 3A or higher items right plus two or more 2B items</td>
<td>2B/3A</td>
</tr>
<tr>
<td>Two 2B or higher items right</td>
<td>2B</td>
</tr>
<tr>
<td>Less than the above</td>
<td>2B-</td>
</tr>
</tbody>
</table>

Read from the top, go down this table until you find a combination which fits the student.
Table 4
Group One Population Distribution by Age and Sex

<table>
<thead>
<tr>
<th>Sex</th>
<th>Number</th>
<th>Percent</th>
<th>Range</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>58</td>
<td>58.0</td>
<td>16-22</td>
<td>18</td>
<td>1.11</td>
</tr>
<tr>
<td>Females</td>
<td>42</td>
<td>42.0</td>
<td>15-21</td>
<td>17</td>
<td>1.51</td>
</tr>
</tbody>
</table>

N = 100

Table 5
Group Two Population Distribution by Age and Sex

<table>
<thead>
<tr>
<th>Sex</th>
<th>Number</th>
<th>Percent</th>
<th>Range</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>8</td>
<td>16.0</td>
<td>16-20</td>
<td>18</td>
<td>1.32</td>
</tr>
<tr>
<td>Females</td>
<td>42</td>
<td>84.0</td>
<td>15-21</td>
<td>17</td>
<td>1.11</td>
</tr>
</tbody>
</table>

N = 50
Table 6
Composition by Sex of the Teacher Population for each Subject Field

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Description of Group</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bio Teachers</td>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Chem Teachers</td>
<td>1</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Eng Teachers</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Math Teachers</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>7</td>
<td>23</td>
<td>30</td>
</tr>
</tbody>
</table>
Table 7

Frequency Distribution of Group One Students at each Cognitive Level

<table>
<thead>
<tr>
<th>Cognitive Levels</th>
<th>Absolute Freq</th>
<th>Relative Freq (PCT)</th>
<th>Adjusted Freq (PCT)</th>
<th>Cum Freq (PCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-operational (2A)</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Middle Concrete (2B-)</td>
<td>22</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
</tr>
<tr>
<td>Late Concrete (2B)</td>
<td>54</td>
<td>54.0</td>
<td>54.0</td>
<td>76.0</td>
</tr>
<tr>
<td>Mature Concrete (2B/3A)</td>
<td>22</td>
<td>22.0</td>
<td>22.0</td>
<td>98.0</td>
</tr>
<tr>
<td>Early Formal (3A)</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Late Formal (3B)</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 8

Frequency Distribution of Group Two Students at each Cognitive Level

<table>
<thead>
<tr>
<th>Cognitive Levels</th>
<th>Absolute Freq</th>
<th>Relative Freq (PCT)</th>
<th>Adjusted Freq (PCT)</th>
<th>Cum Freq (PCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-operational (2A)</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Middle Concrete (2B-)</td>
<td>1</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Late Concrete (2B)</td>
<td>35</td>
<td>70.0</td>
<td>70.0</td>
<td>72.0</td>
</tr>
<tr>
<td>Mature Concrete (2B/3A)</td>
<td>12</td>
<td>24.0</td>
<td>24.0</td>
<td>96.0</td>
</tr>
<tr>
<td>Early Formal (3A)</td>
<td>2</td>
<td>4.0</td>
<td>4.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Late Formal (3B)</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
Table 9

Analysis of Variance (Cognitive Levels and NCEE) for Group One

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>6162.7222</td>
<td>2054.2407</td>
<td>10.474</td>
<td>.0000 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>96</td>
<td>18828.1178</td>
<td>196.1262</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>24990.8400</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level.

Table 10

Analysis of Variance (Cognitive Levels and NCEE) for Group Two

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>411.2843</td>
<td>137.0948</td>
<td>1.056</td>
<td>.3769 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>46</td>
<td>5970.6357</td>
<td>129.7964</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>6381.9200</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Not significant at .05 level.
Table 11

Analysis of Variance (Cognitive Levels and Science Achievement) for Group One

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>23.07</td>
<td>7.69</td>
<td>5.751</td>
<td>.001 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>96</td>
<td>128.37</td>
<td>1.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>151.44</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level.

Table 12

Analysis of Variance (Cognitive Levels and English Achievement) for Group One

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>3.34</td>
<td>1.11</td>
<td>1.177</td>
<td>.323 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>96</td>
<td>90.94</td>
<td>.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>94.28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Not significant at .05 level.
Table 13
Analysis of Variance (Cognitive Levels and Math Achievement) for Group One

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>25.89</td>
<td>8.63</td>
<td>4.022</td>
<td>.010 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>96</td>
<td>205.98</td>
<td>2.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>231.88</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level.

Table 14
Analysis of Variance (Cognitive Levels and Science Achievement) for Group Two

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>4.34</td>
<td>1.45</td>
<td>.834</td>
<td>.482 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>46</td>
<td>79.72</td>
<td>1.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>84.06</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Not significant at .05 level.
Table 13
Analysis of Variance (Cognitive Levels and Math Achievement) for Group One

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>25.89</td>
<td>8.63</td>
<td>4.022</td>
<td>.010 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>96</td>
<td>205.98</td>
<td>2.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>231.88</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level.

Table 14
Analysis of Variance (Cognitive Levels and Science Achievement) for Group Two

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>4.34</td>
<td>1.45</td>
<td>.834</td>
<td>.482 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>46</td>
<td>79.72</td>
<td>1.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>84.06</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Not significant at .05 level.
Table 15
Analysis of Variance (Cognitive Levels and English Achievement) for Group Two

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>1.29</td>
<td>.43</td>
<td>.451</td>
<td>.718 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>46</td>
<td>43.71</td>
<td>.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>45.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
* Significant at .05 level.

Table 16
Analysis of Variance (Cognitive Levels and Math Achievement) for Group Two

<table>
<thead>
<tr>
<th>Source</th>
<th>D.f</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>14.46</td>
<td>4.82</td>
<td>1.965</td>
<td>.132 *</td>
</tr>
<tr>
<td>Within Groups</td>
<td>46</td>
<td>112.81</td>
<td>2.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>127.27</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
* Not significant at .05 level.
Table 17
Pearson Correlation Coefficients Between NCEE and Achievement in Class for Group One

<table>
<thead>
<tr>
<th>Science</th>
<th>English</th>
<th>Math</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = -.27</td>
<td>r = -.12</td>
<td>r = -.25</td>
</tr>
<tr>
<td>NCEE P = .003</td>
<td>p = .113</td>
<td>p = .005</td>
</tr>
</tbody>
</table>

N = 100

Table 18
Pearson Correlation Coefficients Between NCEE and Achievement in Class for Group Two

<table>
<thead>
<tr>
<th>Science</th>
<th>English</th>
<th>Math</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = -.02</td>
<td>r = -.05</td>
<td>r = -.06</td>
</tr>
<tr>
<td>NCEE P = .427</td>
<td>p = .340</td>
<td>p = .338</td>
</tr>
</tbody>
</table>

N = 50
### Table 19

Respondents Rating (by Percent) of the Importance of Each Question

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Little/No Influence</th>
<th>Slight Influence</th>
<th>Moderate Influence</th>
<th>Great Influence</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.3</td>
<td>16.7</td>
<td>23.3</td>
<td>56.7</td>
<td>100.0</td>
</tr>
<tr>
<td>2</td>
<td>6.7</td>
<td>6.7</td>
<td>40.0</td>
<td>46.7</td>
<td>100.0</td>
</tr>
<tr>
<td>3</td>
<td>20.0</td>
<td>46.7</td>
<td>10.0</td>
<td>23.3</td>
<td>100.0</td>
</tr>
<tr>
<td>4</td>
<td>13.3</td>
<td>23.3</td>
<td>30.3</td>
<td>33.3</td>
<td>100.0</td>
</tr>
<tr>
<td>5</td>
<td>3.3</td>
<td>20.0</td>
<td>30.0</td>
<td>46.7</td>
<td>100.0</td>
</tr>
<tr>
<td>6</td>
<td>23.3</td>
<td>26.7</td>
<td>30.0</td>
<td>20.0</td>
<td>100.0</td>
</tr>
<tr>
<td>7</td>
<td>10.0</td>
<td>30.0</td>
<td>36.0</td>
<td>23.3</td>
<td>100.0</td>
</tr>
<tr>
<td>8</td>
<td>20.0</td>
<td>33.3</td>
<td>40.0</td>
<td>6.7</td>
<td>100.0</td>
</tr>
<tr>
<td>9</td>
<td>13.3</td>
<td>46.7</td>
<td>26.7</td>
<td>13.3</td>
<td>100.0</td>
</tr>
<tr>
<td>10</td>
<td>6.7</td>
<td>30.0</td>
<td>20.0</td>
<td>43.3</td>
<td>100.0</td>
</tr>
<tr>
<td>11</td>
<td>13.3</td>
<td>30.0</td>
<td>43.3</td>
<td>13.3</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 20

Respondents Rating (By Percent) of the Importance of the Eleven Questions as Most Important, Second Most Important, and Third Most Important

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Rank 1 (PCT)</th>
<th>Rank 2 (PCT)</th>
<th>Rank 3 (PCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30.0</td>
<td>13.3</td>
<td>13.3</td>
</tr>
<tr>
<td>2</td>
<td>20.0</td>
<td>3.3</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>6.7</td>
<td>16.7</td>
<td>13.3</td>
</tr>
<tr>
<td>4</td>
<td>16.0</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>5</td>
<td>6.7</td>
<td>33.3</td>
<td>13.3</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
<td>6.7</td>
<td>6.7</td>
</tr>
<tr>
<td>7</td>
<td>3.3</td>
<td>10.0</td>
<td>6.7</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>-</td>
<td>3.3</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>6.7</td>
<td>6.7</td>
<td>30.0</td>
</tr>
<tr>
<td>11</td>
<td>-</td>
<td>3.3</td>
<td>13.3</td>
</tr>
</tbody>
</table>
BIBLIOGRAPHY


APPENDIX A
The President  
University of Southern Mindanao  
Kabacan, North Cotabato  
Philippines 9311

Sir:

One of the requirements for Ed.D. degree is the performance of some original research. I am proposing to do a study involving the application of Piaget's theory of cognitive development and the teachers' perception of the factors that contribute to the performance of some students who do poorly in class. Two of the Piagetian tasks (the Pendulum and the Equilibrium in the Balance) and a questionnaire will be administered to the students and the teachers respectively. The cognitive functioning of the students will be matched with their scores on the National College Entrance Examination (NCEE) and their achievement in class (Science, English, and Math subjects). Data concerning the teachers' perception of the factors that may have contributed to the poor performance of some students in the classes that they teach will be collected. The results of the research should be very useful to our university as one of the bases for considering curriculum changes, planning faculty development, and formulating admission policies.

In this connection, may I have the honor to request permission to do the following:

1. To administer two of the Piagetian tasks (the Pendulum and the Equilibrium in the Balance) to selected USM college freshmen plus all BS'Biology and BS'Chemistry freshmen enrolled during the school year 1984-1985; administration of the test would require from 85 to 95 minutes divided into two testing sessions.

2. To use any of our science equipment that is needed to administer the test. The equipment used will consist of non-expendable items.
3. To have access to the NCEE grades and the first and second semester (1984-1985) grades in Science, English, and Math subjects of those students who will be selected to participate in the study.

4. To administer a questionnaire to the BS'Biology and BS'Chemistry faculty members and all college freshmen English and Math instructors. This process will be used to get information about their perception of the factors that contribute to the poor performance of some students in the classes that they teach.

All information secured from the institution, as well as that secured from testing and the questionnaire will remain confidential and no names of students and teachers will be used or released, or will conclusions ever be presented in such a way that individual participants can be identified.

If there are any additional questions that you wish answered before you feel able to make a decision, I will be happy to answer them.

Hoping for your favorable action. With gratitude, I remain

Very truly yours,

Kalinggalan B. Abdulsani

1st Indorsement
June 6, 1984

Respectfully forwarded to the president, University of Southern Mindanao, recommending approval of the request of Mr. Kalinggalan Abdulsani to investigate the relationship between the National College Entrance Examination and the students achievement in basic science and mathematics subjects, for his dissertation in the doctoral program. This study will benefit the College of Arts and Sciences in the upgrading of student competencies in the basic science subjects.

LIBRADA C. PABLEO
Dean
College of Arts and Sciences
2nd Indorsement
June 7, 1984

Respectfully forwarded to the President recommending approval of the request to conduct dissertation/research study at the University of Southern Mindanao as favorably endorsed earlier by the Dean, College of Arts and Sciences.

VINCE A. CAHAGAN, Ph.D.
Assistant for Academic Affairs
The President
University of Southern Mindanao
Kabacan, North Cotabato
Philippines 9311

Thru: The Dean
College of Arts and Sciences
University of Southern Mindanao
Kabacan, North Cotabato
Philippines 9311

Gentlemen:

This is a letter of support for Kalinggalan Abdulsani's research proposal. I believe the proposal is a very good proposal, and the results of his research will be both useful to Mr. Abdulsani personally and also to the University of Southern Mindanao.

Kaling's proposal is based on what we have found to be true in the United States: that many entering freshmen are not so cognitively developed that they can succeed in college. Mr. Abdulsani proposes to administer a test that will give a measure of a student's cognitive functioning, and then compare this with a student's score on the NCEE and their grades in science and mathematics courses. The conclusions reached should be useful to faculty at the University of Southern Mindanao, and to other institutions of higher education in the Philippines that use the NCEE.

This letter is being written at this time so that the research can go forward and before an inordinate amount of time is invested in the research, and then only to find out that some needed data is not available. In the interest of Kaling's steady progress toward the degree I would appreciate an answer to Kaling's request at your earliest opportunity.

Sincerely yours,

Verne Thelen
Professor

VT:te
22nd February 1985

Kalinggalan B. Abdulsani  
The Commonwealth of Massachusetts  
University of Massachusetts  
Amherst 01002  
U.S.A.

Dear Kalinggalan B. Abdulsani

Thank you for your letter of February 6th requesting permission to reproduce the Pendulum and Equilibrium in the Balance Tasks from our CSMS Science Reasoning Tasks in your dissertation.

We are happy to grant permission for this on condition that a proper acknowledgement is shown, and that copies are not subsequently made.

Yours sincerely

NFER-NELSON

KATH BRADLEY (Miss)  
Publishing Manager - Educational Tests
APPENDIX B
The Editor/Manager  
NFER-NELSON Publishing Company Ltd.  
Darville House, 2 Oxford Road East  
Windsor, Berkshire SL4 1DF  
Great Britain

Dear Sir/Madam:

I am a graduate student at the School of Education, University of Massachusetts, Amherst, Massachusetts. My dissertation deals with Piaget's theory of cognitive development. I used two of the Piagetian tasks, from your CSMS Science Reasoning Tasks, to assess the cognitive functioning of the students involved in the study.

In this connection, may I request your permission to reproduce the two tasks, the Pendulum and the Equilibrium in the Balance, to be included in my dissertation.

Hoping for your favorable action.

Very truly yours,

Kalinggalan B. Abdul Sami
Dear Parents/Guardian,

1. I am Kalinggalan B. Abdulsani, a doctoral candidate at the School of Education, University of Massachusetts, Amherst, Massachusetts, U.S.A.

2. As a requirement for my degree, I am doing a study involving the application of Piaget's theory of cognitive development and the teachers' perception of the factors that contribute to the performance of some students who do poorly in class. Two of the Piagetian tasks (the Pendulum and the Equilibrium in the Balance) and a questionnaire will be administered to the students and the teachers respectively. The cognitive functioning of the students will be matched with their scores on the National College Entrance Examination (NCEE) and their achievement in class (Science, English, and Math subjects). Data concerning the teachers' perception of the factors that may have contributed to the poor performance of some students in the classes that they teach will be collected.

3. The purpose of this study is to assess the cognitive functioning of Filipino college freshmen at the University of Southern Mindanao and matching it with their scores on the National College Entrance Examination (NCEE) and their achievement in class (Science, English, and Math subjects). The teachers' perception of the factors that may have contributed to the poor performance of some students in the classes that they teach will be determined.

4. The results of this study should be very useful to the University of Southern Mindanao in particular and the Philippines in general as one of the bases for considering curriculum changes, planning staff development, and formulating admission policies.

5. There are no foreseeable discomforts and risks as a result of your child's participation in this study.
6. If you have questions regarding the study, please feel free to contact me at the Office, Biology Department, College of Arts and Sciences, University of Southern Mindanao, Kabacan, North Cotabato, Philippines.

7. At anytime during the course of the study your child can withdraw his/her consent and discontinue his/her participation without prejudice to him/her. His/her grades will not in anyway be affected by his/her decision to participate or not.

8. **CONSENT FORM**

Those students who are eighteen years old and above should fill in and sign consent form A. Those who are below eighteen years old should request their parents/guardians to fill and sign consent form B.

**CONSENT FORM A**

I, __________________________ am willing to
(Name of Student)
participate in the research study conducted by Mr. Kalinggalan B. Abdulsani.

Signed____________________

**CONSENT FORM B**

This is to certify that I, __________________________ (Parent/Guardian)
am giving my consent to allow __________________________ (Name of Student)
to participate in a research study conducted by Mr. Kalinggalan B. Abdulsani.

Signed____________________
Dear Fellow Teachers,

1. I am Kalinggalan B. Abdulsani, a doctoral candidate at the School of Education, University of Massachusetts, Amherst, Massachusetts, U.S.A.

2. As a requirement for my degree, I am doing a study involving the application of Piaget's theory of cognitive development and the teachers' perception of the factors that contribute to the performance of some students who do poorly in class. Two of the Piagetian tasks (the Pendulum and the Equilibrium in the Balance) and a questionnaire will be administered to the students and the teachers respectively. The cognitive functioning of the students will be matched with their scores on the National College Entrance Examination (NCEE) and their achievement in class (Science, English, and Math subjects). Data concerning the teachers' perception of the factors that may have contributed to the poor performance of some students in the classes that they teach will be collected.

3. The purpose of this study is to assess the cognitive functioning of Filipino college freshmen at the University of Southern Mindanao and matching it with their scores on the National College Entrance Examination (NCEE) and their achievement in class (Science, English, and Math subjects). The teachers' perception of the factors that may have contributed to the poor performance of some students in the classes that they teach will be determined.

4. The results of this study should be very useful to the University of Southern Mindanao in particular and the Philippines in general as one of the bases for considering curriculum changes, planning staff development, and formulating admission policies.

5. There are no foreseeable discomforts and risks as a result of your participation in this study.
6. If you have questions regarding the study, please feel free to contact me at the Office, Biology Department, College of Arts and Sciences, University of Southern Mindanao, Kabacan, North Cotabato, Philippines.

7. At anytime during the course of the study you can withdraw your consent and discontinue your participation without prejudice to you.

8. **CONSENT FORM**

   This is to certify that I, ____________________________ (Name)

   am willing to participate in a research study conducted by Mr. Kalinggalan B. Abdulsani as one of the requirements for his doctoral degree.

   Signed__________________________
Dear (Name of Teacher)

I am writing to you to ask for your participation in a research study which I think is very important. As a requirement for my doctoral degree, I am doing a study involving the intellectual functioning of a sample of our college freshmen. The proposed research will more specifically investigate the relationship between the students' cognitive functioning with their scores on the National College Entrance Examination (NCEE) and their achievement in class (Science, English, and Math). Data concerning the teacher's perception of the factors that may have contributed to the poor performance of some students in the classes that they teach will be collected. The results of the research should be very useful to our university as one of the bases for considering curriculum changes, planning faculty development, and formulating admission policies.

In this connection, I need your help in finding out your perception of the factors that contribute to the performance of some students who do poorly in your class.

Any conclusions that can be drawn from this questionnaire will be presented in such a manner that no individual participants can be identified.

Thank you very much for your time and cooperation.

Very truly yours,

Kalinggalan B. Abdulsani
Part I

Name ____________________________

Age level (Please check)

20-30 ____
31-40 ____
41-50 ____
51-60 ____
61-70 ____

Subject(s) taught__________

No. of years in teaching_______

Highest degree obtained_______

Part II

On the basis of your knowledge of the factors that contribute to the performance of some students who do poorly in the classes you teach, please check in the appropriate box to the right of each item how important it was in explaining students poor performance.

Boxes under 1 indicate little or no influence

Boxes under 2 indicate slight influence

Boxes under 3 indicate moderate influence

Boxes under 4 indicate great influence
1. Students did not work conscientiously in the course.
2. Students did not study hard enough for the exam.
3. Subject matter was beyond the students' ability to comprehend.
4. Students did not know what they should have known prior to entering the university.
5. Students did not drill themselves enough on the things they were expected to know.
6. Explanations of concepts and ideas found in written materials (texts, manuals, etc.) were inadequate.
7. Explanations of concepts and ideas offered in class by the teachers still left the ideas beyond the comprehension of the students.
8. Students were involved in too many extracurricular activities.
9. It was not possible to make the explanations simple enough for the students to understand.
10. Students failed to follow directions closely enough.
11. Students were having difficulty adjusting to life at the university.

12. Of the factors listed in 1 to 11 please indicate which one factor was probably most important in explaining students' poor performance

Second most important

Third most important

Please comment on any other factors which you believe may have contributed to the poor performance of the students in your class.
Administration

There are not many questions in this Task, so your skill as a teacher should be used for creating a comparatively relaxed and slow-moving situation in which your pupils get the maximum opportunity to reflect on the questions which are asked. At any stage feel free to re-phrase any question in any way so that the problem for the pupils is the one on the page, and not that of understanding what the question is about. Here we are trying to maximise the possibility of finding the same range of responses which one might obtain by individual interview. Allow about 45 minutes to complete the task.

A.1 Introduce the Task as a series of experiments to find out what factors determine how fast a pendulum swings. Talk through the first page showing them the combinations, with your apparatus, which are given on the cover of their response-sheets. "Gentle" and "Hard" may seem loose to you as a trained scientist but they do not worry the pupils. Occasionally at the end of the task a few students complain that the push was not standardised, but there is no evidence to indicate that their performances were affected. Make sure they understand that 'how fast' means "How many swings in a given time" and not the velocity of the weights while swinging. Ask them to turn over, and write in the first combination of variables in the columns in the box opposite A.1, and to make a wild guess about the number of swings. Perform the experiment by starting the weight at the bottom, and swinging it very gently out (keep a slight tension on the string so that it doesn't 'bounce'). Time whole swings, "Zero", "One", "Two", etc., and stop the pendulum after half a minute. Round off the number of swings to a whole number. Ask pupils to record the result. The first three questions (A1, A2 and A3) are not assessed but are designed to help focus the pupil's attention on the problem.

A.2 Ask them to write in the new combination of variables in the box opposite A2, tell them that their guess is again a 'free' one, and is just there to help them think, and perform as in A1. Again, ask the pupils to record the result.

A.3 Ask for their ideas about how the three variables affect the number of swings. We want answers of the form: "If it is longer then..."
A.4a  It is hoped that by asking for their ideas in question A3 some pupils will then distinguish between their ideas and the evidence in A4. They will probably think that the two questions are the same, so point out that "here we are interested in what, if anything, this particular couple of experiments show". If they feel they have already answered this question, then of course they can write "see above". The "if anything" is a hint to the intelligent child who might be worried that he must deduce something from every experiment. Do not labour the point.

A.4b  Make sure they realise that there are THREE parts to their answers. - 1) a new combination of Length, Weight and Push, 2) a reason for choosing it, and 3) an explanation of how it ties in with the first two.

A.5  This page tests their experimental economy, (a typical concrete operational strategy is to "try everything") and their awareness that variables must be controlled. Explain in your own words that here we are trying to find out how they would have investigated this on their own. "How would they plan the experiments?" Let them write their combinations, and then draw their attention to the note in brackets, about being economical.

A.7a  Say that for this pendulum the "LONG", "HEAVY" etc. weren't quite the same as for the one you demonstrated, ask them to imagine they are looking critically at someone else's experiment, so they cannot compare the values with A1 and A2. In this question we get the 3A response from the last part of the question, so for question a) "What do they tell us about the effect of the PUSH?" emphasise that it is just these two results they should use, and ask them for a fairly explicit answer, i.e. their deduction and also their reason for making it. This should enable them to give us a 3B response by pointing out that no proper deduction can be made. Read through the last part (b). Make sure they have all finished, and only then ask them to turn over to the last side.

Section 3, page four is the most crucial part of the task. Two more combinations of variables are demonstrated. B5 tests their ability to analyze the data reflectively. Here is where most of the evidence is gained as to whether a pupil is using late Formal Operational thinking.

Note that the four combinations set up in Section B control the variables so as to allow for unambiguous deductions about the effect of LENGTH (Exp.2 and Exp.4), and WEIGHT (Exp.1 and Exp.4), but appear not to control the other variables in respect of PUSH. In fact, once the effect of WEIGHT has been deduced, then Exp.2 and Exp.3 can be used to deduce the (non) effect of PUSH, and the pupil is given a chance to show this, either in B5e (PUSH), or in B5g. It is difficult to spot that the evidence is still sufficient for PUSH, so in B5g a 3B assessment can be reached by the alternative strategy of explaining that, for PUSH, the other variables were not controlled.

It is important that the data is as clear as possible. Ask them to write in the values from A1 and A2, to fill in the details for B3, and to have a guess about the number of swings. Remind them that their guesses are not assessed, but are designed to help their in their thinking: if their guess is close to the experimental result then their thoughts are probably on the
right track, but if not, then they know that they have to think again. Demonstrate B3 and ENSURE that the answer is the same as B2, ask them to record. For the Hard push, swing the pendulum about 30° from the vertical. Repeat the above for B4 and this time make sure the answer is the same as B1.

Explain in your own words that using just these four experiments we want them to deduce the effect, and direction of each factor, e.g. "If you think they show that weight has an effect, then don't just write 'it has an effect' but say 'if the weight is heavier then you get fewer/more swings in half a minute'. Explain also that different combinations of the four experiments may be necessary for their various conclusions. Ask them to write in the box labelled "experiments" only those (from B1 - B4) they really need in order to make their deductions.

B.5g In your own words point out that "maybe you found one of the factors rather more difficult to determine than the other two. If so, say which (and if not, that's O.K.), and then you've a choice of answers. EITHER show how you used the evidence to make your deduction, OR explain why you think the data is insufficient".

Assessment

Score each result as "1" for adequate, and "0" for inadequate and record on the class assessment sheet. Treat each answer only for the information it gives at the level specified for the question (see Summary of Answers and top of Assessment Sheet). Thus if it a "3B" question as in B5g ignore ingenious replies at the 2B level. Similarly a higher level response to a "2B" question still only gains credit at the 2B level.

Summary of Answers

Although these notes on assessment cannot be exhaustive, try and follow them as closely as possible; remember, however, that we do not want you to be just a scoring-machine, but rather to maximise your understanding of how your pupils think.

A.1, A.2 & A.3 Do not assess

A.4a LENGTH Score "1" either for "Can't tell because you haven't controlled variables" (a 3B response OR "longer string: less swings" (a 2B response). Score "0" for "Length has a large effect". Use A.3 answer if in doubt. (2B)

A.4b WEIGHT & PUSH Score "1" only for a 3B response: an argued refusal to deduce anything positive. For example, "You can't tell because you've varied everything at once". (3B)

A.4c Score only for a 3A level of response, that is, a new experiment which explicitly combined with A.1, and A.2 would enable the effect of one named variable to be decided. For example, "Long, Light, Hard with A.2 tells you about PUSH". (3A)
A.5 Score "0" for a whole list of experiments.
Score "1" if they have given you LONG, HEAVY, GENTLE, and starred the others (if any). Score "1" if they have given one more correct pair (like SHORT, LIGHT, GENTLE and LONG, LIGHT, GENTLE), but they must be correctly ordered, (do not allow SHG, LHH, LHG, SHH), OR, just such a pair with the original experiment starred.

A.6 As in A.5, score "0" for a whole list of experiments. Score "1" if they have given you SHORT, LIGHT, GENTLE, and/or one other pair.

A.7a Effect of Push Score "1" for "nothing, because you've varied length", etc. Score "0" if they have concluded anything positive about PUSH.

A.7b Other arrangements Score "1" for LONG, HEAVY, GENTLE or SHORT, HEAVY, HARD, or both, or another sensible pair, but ignore a long list.

B.3 & B.4 Do not assess their guesses.

B.5a, b LENGTH Score "1" in 2B column if they've given the effect of length right and only then, score "1" in 3B column for B.2 + B.4 ONLY. Do not give the 3B rating without the effect correct.

B.5c, d WEIGHT Score "1" in 3A column for correct deduction that weight has no effect and only then, score "1" in 3B column for B.1 & B.4 ONLY. Do not give the 3B rating without the effect correct.

B.5e, f, z PUSH Score both these questions for one 3A and one 3B response. There are two acceptable strategies: either a deduction that push has no effect or a realisation that since the variables have not been controlled it is difficult to draw any conclusions.

So, score "1" in 3A column for deduction that push has no effect, then score "1" in 3B column if they have chosen B.1 and B.4, followed by B.2 and B.3 for the experiments. They can also gain a 3B rating by arguing in B5e that since they have eliminated weight as a variable, then by comparing B.2 and B.3 they can see that push has no effect.

Alternatively, score "1" in 3A column if they have said "you cannot tell about push" but only if this is supported by an answer to at least the 3A level in B.6, e.g. "you need two experiments like L,H,G, and L,H,H". This reply is no higher than that necessary for the 3A question A.7. To score "1" in the 3B column they must argue that no deduction is possible since the variables have not been adequately controlled.
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<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
<th>B5 Length</th>
<th>B5 Weight</th>
<th>B5 Push</th>
<th>Level</th>
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Scoring rules

(Read from the top, go down this list until you find a combination which fits the pupil.)

THREE or more 3B items right

FOUR or more 3A or 3B items right, with TWO effects right (remember that the effect of LENGTH (B5a) is a 2B item and cannot be counted in the FOUR higher items, but the effects of WEIGHT (B5c) and PUSH (B5e) can).

FOUR or more 3A or 3B items right, but without TWO effects.

THREE 3A or 3B items right

TWO 3A or 3B items right plus B5 LENGTH (2B)

ONE 3A or 3B item right plus A.4a

B5 LENGTH (2B) right

TWO or less right, without A.4a

Note that these rules only formalise a 2/3 success principle: If the pupils can give responses characteristic of a stage in 2 out of every 3 possible occasions, then we assume that this, at least, is their capacity most of the time.
CONCEPTS IN SCIENCE TASKS

NAME ...................................................... TODAY'S DATE ..........................................
BOY OR GIRL ............................................. CLASS ..................................................
SCHOOL .................................................. DATE OR BIRTH .....................................

THE PENDULUM

We are going to make a pendulum, using either a SHORT or LONG string, and a LIGHT or HEAVY weight, and we will exert a GENTLE or HARD push.

<table>
<thead>
<tr>
<th>SHORT string</th>
<th>LONG string</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

This task will be about the number of swings the pendulum makes in a given time (1/2 minute).
A1. SHORT string, HEAVY weight, GENTLE push.

Your guess: ____ swings. Experiment →

A2. LONG string, LIGHT weight, GENTLE push.

Your guess: ____ swings. Experiment →

A3. What effect do you think LENGTH, WEIGHT, and PUSH have on the number of swings in half a minute?

LENGTH:

WEIGHT:

PUSH:

A4a. Now, what can we tell, just from these experiments, about the effect of LENGTH, WEIGHT and PUSH on the number of swings?

LENGTH:

WEIGHT:

PUSH:

A4b. Write down one more experiment that you think would be worth trying next, and explain why you have chosen it. Also explain how this new experiment ties in with experiment 1 or 2.
A3. Imagine that we start again with experiment 1 →

Which other arrangements would you use to TEST the effect that LENGTH has on the number of swings? →

(But please use as few arrangements as possible; put a star(*) next to any arrangements that you don't really need.)

<table>
<thead>
<tr>
<th>length</th>
<th>weight</th>
<th>push</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHORT</td>
<td>HEAVY</td>
<td>GENTLE</td>
</tr>
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</table>

A6. Again starting with experiment 1 →

how would you test for the effect that WEIGHT has? →

(But again, use as few arrangements as possible; again put a star(*) next to any arrangements that you don't really need.)

<table>
<thead>
<tr>
<th>length</th>
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<th>push</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHORT</td>
<td>HEAVY</td>
<td>GENTLE</td>
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</table>

A7. Imagine we tried these two arrangements (with another pendulum) →

What do they tell us about the effect of the push?

If there are any other arrangements that you think you would really need to be sure of the effect of the push, write them down →

(and cross-out any of the original two arrangements that you don't need).
81. Experiment 1

82. Experiment 2

83. LONG string, HEAVY weight, HARD push.
   your guess: ___ swings. Experiment 3

84. SHORT string, LIGHT weight, GENTLE push.
   your guess: ___ swings. Experiment 4

85. Now write down what these four experiments alone tell us about the effect of LENGTH, WEIGHT and PUSH on the number of swings, and, for each factor, note down only those experiments that you need to use:

   LENGTH: experiments

   WEIGHT: experiments

   PUSH: experiments

86. Is the evidence weaker for deciding about one of the factors than it is for the others? ___________
   If so, say which factor: ___________

   and either show that the evidence is still sufficient, or explain why it is insufficient.
EQUILIBRIUM IN THE BALANCE

Introduction

This task is one of a series developed by the team 'Concepts in Secondary Maths & Science' at Chelsea College, University of London in the period 1973/78 in order to investigate the relationship between the optimum Piagetian level at which a pupil can function and the understanding of Science which he or she can achieve.

This Task, based on chapter 11 of Inhelder and Piaget's "The Growth of Logical Thinking", Routledge, London, 1958, investigates the pupil's ability to recognise and use inverse proportions in a simple beam balance. Piaget says that the late formal thinker can understand the problem in terms of virtual work, so towards the end of the task a work principle is introduced. However, most of the questions are at the concrete and early formal levels.

Equipment: 2 metre rules, one with numbered holes every 10 centimetres.

(It should balance by itself, if it does not add some "blu-tak")
At least six 100 gram slotted-weights and two hangers which fit holes.
2 retort stands, 2 boss-head clamps
2 nails which fit easily through holes
Administration

The task has been set up in such a way as to rely as little as possible on previous scientific training. The questions are framed so that your pupils will get as much "feedback" as possible. That is why they are often asked to guess or work out a result, and then you actually demonstrate and probe for explanations. Remember that the task is designed to give the child evidence he could have gained while experimenting with the apparatus.

Please make sure you are fairly fluent with the moves involved. A practice run without pupils is recommended.

There is another annotated copy of the Task which gives all the cues you need during the administration, provided you have read this manual carefully first.

Allow about 35 minutes to complete the Task.

Introduce the task by reference to the seesaw. Ask where a heavy man and a light man would have to sit if they wanted to balance. To get them thinking about the problem ask them to sketch the two figures on the seesaw. Discuss their answers and check to see that everybody understands that the heavier of the two should sit nearer the middle.

A.1 In your own words say that in science we can do better than saying "heavy and light, and nearer and farther; we can measure things". Show them the beam balance and then hold up a 100 gram hanger and a 300 gram hanger. Make sure you have the 300 grams on their right, that is, the same as the diagram (and if you are facing the class, on your left). Ask them to guess where the weights should be hung to balance and to draw in their guess in the middle box. Make sure they get used to writing the weights next to each hanger. This makes it much easier to assess their answers later on in the task. Neither the introduction, nor the first two questions are assessed but are designed to give the pupils a chance to learn about the system. Give them some feedback on their guesses by showing them this wrong, though common, arrangement:

Then show them the correct solution and ask them to copy this in the "ans." box and where it says "Explain", to say why this particular arrangement balances.
A.2 Put 400 grams on the ruler

and ask them to draw and explain where a 200 gram weight must be hung to make it balance. When they have finished show them the correct solution

and ask them to copy

A.3 Keep the solution to question 2. Now add 100 grams to the 400 while reading the question. They answer under "1st cry". To give more feedback show "the perfectly reasonable strategy" of adding 100 grams to the 200, which of course is not the correct solution. Tell them that if they wish to change their answer, to write it in under "2nd try" and if they think they got it right the first time to write it in again.

A.4 This question gives feedback on relative distances from the pivot. Show them that you have again set up the solution to question 2.

Move the 400 grams out one space to hole number 2 while reading the question. They answer under "1st cry". When they have finished show them that if they try moving the 200 grams out the same distance (i.e. to position 3) that the ruler does not balance. Once again if they wish to change their answer ask them to do so under "2nd try", and if they think they were correct at the first attempt, to write it in again.

A.5 Just talk through the question with reference to the diagram. Ask what weight would be needed on the 4th hole out on the left hand side to balance 600 grams on the 2nd hole on the right. Do not demonstrate the answer.

A.6 Set up

Ask them to guess where these weights must be positioned if they are to balance. They draw in their guess in the middle box. Check that they all write in the number of weights next to each hanger, and when they have finished show them the correct solution

and ask them to record.
A.7 Now clamp the solution to question 6 by sticking the second nail (again clamped to a wreck stand) through a hole at the end of the ruler. Make sure they are aware that the ruler was balanced and then move each weight in one hole. "They were balanced, I've moved them both in the same amount, how will it look now? Put your guesses in the middle box." Again check the numerals next to each hanger, and when they have all finished gently release the clamp. There should be some dismay and rejoicing, but fairly quickly, ask them to explain in the right hand box why the ruler drops on the light-weight side. "Why does it go down in the 2-weight side?"

A.8 Just talk through the question with reference to the diagram. Explain that the hangers are not to be moved and that they are only to re-arrange the 3 weights shown. They cannot add any new ones. They answer by drawing in on the right hand diagram.

A.9 Explain that now things are a bit more complex and that the diagram is not necessarily to scale. Here we are giving them the weights (3 and 2) but we are not telling them where they are hung; beyond the fact that they balance. Say that if you move the (3) out one unit, how many units must the (2) be moved in order to restore the balance. Tell them the units must be centimetres, inches, feet, etc.

A.10 Another difficult problem. Explain that the square and round shapes balance at distances of two and three arbitrary units. Ask a) "which is the heavier?", and the b) "How much heavier is the one you have chosen than the other? If, for instance, you think the round shape is heavier, then how much heavier than the square is it?" If they ask "can we use grams!", tell them that they may if they wish, but remind them that there is no information as to how heavy either one is.

A.11 Explain that this asks for a summary of all they have learned so far; a general rule. They may use the notation shown, invent one of their own, or write the whole answer out in words.

(While they are answering, lower the ruler until the bases of the hangers are 20 cm above the bench.)

A.12 In your own words explain that this is another way of looking at the problem, this time dynamic. Talk about levers, now focusing on the forces and how far they have to act. You could open and close the classroom door, demonstrating that you do not need to push very hard near the handle, but that you do need to push it a long way. Show them the converse.

With the ruler set up thus:

```
\[ \text{Diagram of ruler with weights and distances indicated.} \]
```

Show them that by allowing a heavy weight (400 grams on hole number 2) to drop a short way, you can lift a weight a long way. Point out that we can measure the weights and distances, and then do so. Get them to record your measurements (the 400 gram weight on
hole 2 drops 10 cm which raises the 200 gram weight on hole 4 through 20 cm.)

Because these are fiddly experiments to demonstrate point out that the results for the next two are written in for them. Just talk through them, then ask the question.

A.13 Piaget says that an explanation of the balance equilibrium in terms of virtual work is a late formal (3B) mode of interpretation. If your pupil is at all capable of this, he must be given as much background as possible. So first explain that they may find the concept of work useful. Introduce this semi-quantitatively by saying something like "if you carry a 50 kilo (1/2 cwt) sack up a flight of stairs you will certainly be aware of having done some work. If you take it up twice as many stairs you will certainly know you have done more work - twice as much, in fact. But if you increase the weight you will also have to do more work. For example, if you carried 100 kilos, you would do twice the work. But if you carried twice as much weight up two flights of stairs, you would have done four times as much work. So the work you do depends on both the weight and how far you lift it up". Pose the question. Emphasise that they should direct their answer to the weights and the vertical heights they rise and fall. They can use the notation given at the beginning of this section, or any other they may wish to invent.

Assessment

Score each result as "1" for adequate, and "0" for inadequate and record on the class assessment sheet. Treat each answer only for the information it gives at the level specified for the question (see Summary of Answers and top of Assessment Sheet). Thus if it a "3B" question (as in 13) ignore ingenious replies at the 2B level. Similarly a higher level response to a "2B" question still only gains credit at the 2B level.

Summary of Answers

Although these notes on assessment cannot be exhaustive, try and follow them as closely as possible; remember, however, that we do not want you to be just a scoring-machine, but rather to maximise your understanding of how your pupils think.

<table>
<thead>
<tr>
<th>Introduction, 1 and 2</th>
<th>Ignore replies in assessment</th>
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<tbody>
<tr>
<td>3. 1st try</td>
<td>50 (grams)</td>
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<tr>
<td>3. 2nd try</td>
<td>50 (grams)</td>
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</tbody>
</table>
4. 1st try

4

4. 2nd try

Ignore replies in assessment

5.

3 or

6.

7.a

7.b

Allow a quantitative answer like "Although the 2 is 1½ times lighter than the 3 it is twice as far out. Therefore it is more effective."

or "2 x 2 > 3 x 1"

8.

9.

1½

10.a

1½ or "half as much again" or 50%, but not just "½". They must have both a) and b) right for a 3B rating.

10.b

11.

H.a = L.b or "The ratio of the weights must be inversely proportional to the ratio of the distances."

Do not allow a concrete answer of the form: "The heavier weight must be nearer the middle".

12.

5 (cm)

13.

\[ W_1h_1 = W_2h_2 \]

or an explanation in terms of the work done.

e.g. "A light weight can lift a heavy weight provided it drops a long way while the heavy weight only rises a short way".

Do not allow an answer in terms of weights and horizontal distances such as would have been adequate for the 3A question 11.
### S.R.T. IV EQUILIBRIUM IN THE BALANCE

<table>
<thead>
<tr>
<th>SCHOOL</th>
<th>CLASS</th>
<th>TEACHER</th>
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Scoring Rules

(Read from the top: go down this list until you find a combination which fits the pupil)

- TWO or more 3B items right 3B
- FIVE or more 3A or 3B items right 3A
- THREE 3A or higher items right plus ONE or more 2B items 2B/3A
- TWO 3A or higher items right plus TWO or more 2B items 2B/3A
- TWO 2B or higher items right 2B
- LESS than the above 2B-
## EQUILIBRIUM IN THE BALANCE

<table>
<thead>
<tr>
<th></th>
<th>1st try</th>
<th>2nd try</th>
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<tbody>
<tr>
<td>1. Explain:</td>
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<td></td>
<td>? ↑ ?</td>
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<tr>
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<td>(1) (2)</td>
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<tr>
<td>2. Explain:</td>
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<td></td>
<td>(4)</td>
<td>(7)</td>
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<tbody>
<tr>
<td>3. If I add 100 grams to the 400 how much must I add to the 200 to keep it balanced?</td>
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<tr>
<td>4. If I move the 400 to position 1, to which hole must I move the 200?</td>
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<tbody>
<tr>
<td>5. What must I hang here to make this balance?</td>
<td>? (4)</td>
<td></td>
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</tbody>
</table>
Make this balance by moving the weights.

Moving in one place. How will it look?

Without changing the position of the hangers, rearrange the weights to make this balance.

These are in balance. If I move the (3) out one unit, how far must I move the (2) to keep the balance? ........ units

These two balance.

Can you now give a general rule which connects weights and distances and whether the system balances?
Another way of looking at the problem

"How are the rises and falls of weights related?"

The 400 gram weight on hole 2 drops .... cm which raises the 200 gram weight on hole 4 through .... cm.

Here one weight rises 13 cm.
while the other falls 13 cm.

And in this case the 300 gram weight is raised 6 cm by the 100 grams falling 13 cm.

How far must the 400 gram weight fall in order to lift the 100 gram weight through 20 cm?

13. What explanation might you give to an intelligent friend who wanted to understand WHY it is that a LIGHT weight can lift a HEAVY weight and come to balance?

Look at the WEIGHTS ($W_1$ and $W_2$) and the HEIGHTS ($h_1$ and $h_2$).