THE RELATIONSHIP BETWEEN SCIENCE ACHIEVEMENT AND LOGICAL REASONING ABILITIES AMONG SEVENTH GRADE STUDENTS

by

Dilek Ardaç

B.S in Chemistry, Boğaziçi University, 1981

Submitted to the Institude for Graduate Studies in Social Sciences in partial fulfillment of the requirements for the degree of

Master of Arts

in

Education

Boğaziçi University

1984

This project, submitted by Dilek Ardaç to the Faculty of Education, Department of Educational Sciences of Boğaziçi University in partial fulfillment of the requirements of the Degree of Master of Arts is approved.

Thesis Advisor ______________________

Necla Öner, Ph. D.

Committee Member ______________________

Ali Baykal, Ph. D.

Committee Member ______________________

Diane, Sunar, Ph. D.

Date ______________________

ACKNOWLEGMENT

I wish to express my sincere thanks to those who have encouraged and assisted me throughout the preparation of this thesis. Without their assistence, this study would not have been possible.

My thesis advisor, Doç. Dr. Necla Öner, with her flexibility in the choice of my thesis topic has encouraged me to work on a topic which I really desired and enjoyed. By her constructive critisism and careful assistence, she has always encouraged and leaded me towards the better. I appreciate and thank her for all the time and effort she has devoted for this study.

I also owe my sincere thanks to Dr. Ali Baykal, whose help was very valuable in the preparation of most parts, especially those concerning the statistical analysis and the translation of the test used in the study. I appreciate the help provided by Dr. Diane Sunar for the completion of this study and her kind assistance.

I also thank the other members of Education Department for their ready help and the staff members from Physics, Mathematics and Chemistry Departments for their help in the translation of the test used in the study, and Dr. Füsun Akarsu from Education Department in Middle East Technical University, who has provided the English form of the Logical Reasoning Test.

The counseler services of Yeni Levent Lisesi and Şişli Terakki Lisesi have always been very cooperative, if it wasn't for their cooperation, the application part of the study wouldn't have been carried out with such an ease.

I also received great help from my friends in various ways. I really did benefit from their discussions and advices and from the care which they have given in providing me the material necessary for this study.

THE RELATIONSHIP BETWEEN SCIENCE ACHIEVEMENT AND LOGICAL REASONING ABILITIES AMONG SEVENTH GRADE STUDENTS

The purpose of the study was to look for a relationship between logical reasoning ability level and science achievement of seventh graders in Yeni Levent Lisesi and Şişli Terakki Lisesi. Fiftynine seventh graders in Yeni Levent Lisesi and 25 seventh graders in Şişli Terakki Lisesi participated in the study. Logical reasoning abilities of the students was assessed by an adapted and modified form of the Logical Reasoning Test (Burney, 1974), a paper and pencil test based on the Piagetion Cognitive Development Theory. Science achievement of the students was assessed by their fall term science grades of the academic year 1983-84.

The Pearson product moment correlation technique was used in determining the relationship between the level of logical reasoning and science achievement, and the correlation coefficient was found to be 0.79. This result indicates that 62.41 percent of variation in science achievement could be explained by the Logical reasoning ability level of the students.

When the students were classified into formal, concrete and transitional cattgories on the basis of their logical reasoning test scores, only seven percent was found to be functioning in the formal operational category, with a 40 percent in concrete operations and 53 percent in transition from concrete to formal operations. A scrutiny of the textbook used in science, however, showed that most of the topics and concepts covered in the seventh grade require the use of formal

operations. The fact that most students do not possess the operations of formal period reflects a major inconsistency between the operational level of the seventh graders and the science course expectations. The science curriculum content does not match with the reasoning level of these students. For success in achievement, it seems important to match the material to be taught with the operational level of the learner. Since the present findings reveal that most seventh graders are at the nonformal, rather than the expected formal level of operations, it is suggested that seventh grade science topics are adjusted for the nonformal thinker instead of the formal thinker.

YEDİNCİ SINIF ÖĞRENCİLERİNİN FEN BAŞARILARI İLE MANTIKSAL DEĞERLENDİRME YETENEKLERİ ARASINDAKİ İLİŞKİ

Bu çalışmanın amacı, Yeni Levent Lisesi ve Şişli Terakki Lisesi'ndeki yedinci sınıf öğrencilerinin mantıksal değerlendirme yetenekleri ile fen başarıları arasındaki ilişkiyi araştırmaktı. Çalışmaya Yeni Levent Lisesinden 59, Şişli Terakki Lisesinden 25 yedinci sınıf öğrencisi katıldı. Öğrencilerin mantıksal değerlendirme yeteneklerini ölçmek için Piaget'nin Zihinsel (Bilişsel) Gelişim Kuramını esas alarak geliştirilmiş bir test olan, Mantıksal Değerlendirme Testi'nin (Logical Reasoning Test, Burney, 1974) Türkçe'ye uyarlanmış ve değiştirilmiş bir formu kullanıldı. Öğrencilerin fen başarısını belirlemede ise, ölçüt olarak, 1983-84 ders yılı I. dönem fen notları kullanıldı.

Mantıksal değerlendirme yeteneği ile fen başarısı arasındaki ilişkiyi saptamak için Pearson Momentler Çarpımı korelasyon tekniği kullanıldı ve 0.79'luk bir korelasyon katsayısı bulundu. Bu bulgu fen başarısındaki varyansın yüzde 62.41'inin, öğrencilerin mantıksal değerlendirme yetenekleri ile açıklanabileceğini göstermektedir.

Öğrenciler, somut işlemler, formal işlemler veya somut işlemlerden formal işlemlere geçiş dönemi olarak belirlenen gelişim süreçlerine göre sınıflandırıldı. Bunun için mantıksal değerlendirme testinde aldıkları puanlar kullanıldı. Sonuçta öğrencilerin ancak yüzde yedisi formal işlemler sınıfına girerken, yüzde 40'ının somut işlemler döneminde, yüzde 53'ünün ise somut işlemlerden formal işlemlere geçiş döneminde olduğu

görüldü. Bu sonuç, yedinci sınıf öğrencilerinin yüzde 93'ünün henüz formal işlemler dönemine geçmediğini göstermektedir. Oysa yedinci sınıfta kullanılan fen kitaplarındaki konuların çoğunlukla formal işlemlerin kullanımını gerektirdiği görülmektedir. Bu da yedinci sınıf öğrencilerinin zihinsel gelişim düzeyleri ile, fen derslerinde kendilerinden beklenen gelişim düzeyi arasında önemli ölçüde bir uyumsuzluğa işaret etmektedir. Fen derslerinde izlenen müfredatın içeriği, öğrencilerin zihinsel gelişim süreçleri ile uyum içinde değildir. Öğrencilerin derslerde başarılı olabilmesinde önemli görülen bir etken ise, zihinsel gelişim süreçleri ile verilen bilgilerin uyum sağlamasıdır.

Bu çalışmamızın sonuçları yedinci sınıf öğrencilerinin büyük bir bölümünün, formal işlemler yerine, somut veya somut işlemlerden formal işlemlere geçiş döneminde olduklarını göstermektedir. Bu bulgular çerçevesinde yedinci sınıf fen konularının, formal işlemler seviyesine göre değil de, geçiş döneminde bulunan öğrencilerin seviyesinde olması önerilmektedir.

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I. INTRODUCTION

One of the main goals of education is to develop the rational powers of students. Science is a national vehicle to use in helping the students to develop their rational powers (Renner and Stafford, 1972). Studying science may make an important contribution to the general goal of education. In order for science subjects to make a contribution, however, it is important to match the reasoning ability level of the students with the reasoning level of the science subjects they are studying. In developing a science curriculum the science courses should be suitable to the age and ability level of the students (OECD Conference, 1960). It is essential to assess the cognitive developmental level of the student and the nature of corresponding reasoning abilities in order to establish relevant levels of curriculum content.

"What's to be taught?" and "When should it be taught?" are questions which seek answers in the works of curriculum designers. A match between subject matter and student ability level is implicit in this querry. A third important question, very much related to the first two, is "How should it be taught?" With this concern, the teaching strategies for a given subject matter comes to the fore for the teachers. Knowing the mental operations and the reasoning abilities of the students can be a useful guide in deciding on the teaching strategy and the classroom activities. A teacher must not attempt to force the students, to use levels of thinking far above that, which they are capable of. If he does, he will cause these children to become frustrated. Students whose reasoning abilities are at a lower level than is required by the subject matter, will not benefit from that course. On the other hand, those students whose reasoning abilities are at a higher level, will not only extend their knowledge in science but will also further their reasoning powers. Differences in the reasoning levels of students will result in differences in the way they benefit from the course, as often reflected in their achievement scores.

This study aims to look for a relationship between the reasoning ability levels of students and their achievement in science. If a positive relationship exists between the two, it will be possible to associate low science achievement with lower levels of reasoning ability.

Data obtained here may provide empirical support for a conceptual framework for teachers and curriculum designers. Within this conceptual framework, it is deemed important to match content and teaching strategies with students' level of reasoning abilities.

II. THEORY AND BACKGROUND

Many studes which attempted to find a relationship between the thought processes used by the students and their achievement in science were based on the Cognitive Development Theory of Jean Piaget. "According to the theories of cognitive development, thinking depends on how a person represents the world, and the ways in which a person can act upon or manipulate his internal representation"[1].

A. Piagetian Theory of Cognitive Development

In Piagetian conceptualization, the way a person represents the world changes with development. If there were no changes in the way a person represented the world, there would be no development. His theory provides an insight into the qualities of thought processes. It "attempts to distinguish stages of development in the evolution of thought, and to show how each stage reveals a progressive sequence from simpler to more complex levels of organizations"[2]. Within the framework of this theory, cognitive development is explained by two major concepts: Structure and functions. In processing information through which cognitive development takes its course, the organism is in a continual interaction with its environment. Structure refers to the systematic properties of an event or an act, both internal and external. It is a framework onto which incoming sensory data can fit. With every interaction this framework changes its shape systematically to better make use of those data. This change is referred to as development. If it weren't for the transitory nature of structures, there would be no development (Phillips, 1969, 7).

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[1] Mayer, E. Richard, Thinking and Problem Solving, Illinois, Foresman, 1977, 172.

[2] Helmore, G.A., Piaget-A Practical Consideration, Oxford, Pergamon Press, 1969, 5.

Function refers to biologically intented modes of interacting with the environment. Two basic functions are organization and adaptation. Every act is organized, and the dynamic aspect of organization is adaptation. Throughout development, functions remain invariant and their dynamism impose certain necessary conditions on structures, which are variant.

The need for a well-organized, internally consistant and orderly representation of the world disrupts the internal organization but leads to a better survival of the organism and adaptation to the reality of the external world. The need to bring in now information is in conflict with the need for a well-organized representation of the world. In Piaget's Theory of cognitive development, the mechanisms used for balancing this conflict are equilibration, assimilation and accomodation (Mayer, 1977, 175).

Through the mechanism of assimilation, the organism takes something from its environment, utilizes and incorporates it into the system. The thing taken in may be nourishment; sensation or experience. People, ideas, customs and tastes can be incorporated into one's activity through assimilation. For example a child learns the inflections, the phrasing and the meaning of a language before he can talk. He does this by listening and incorporating what is talked around him (Pulaski, 1971). Another very obvious example is a biological one. It is the ingestion of food. By this process, something from the environment becomes part of us. The food is changed in this process. It is changed so that the organism can use it. As we grow older we eat different kinds of food; first milk, then baby and then solid food. In order for the body to take in the new food it must also change. The digestive system must also change so that it can assimilate new food.

The changing of existing internal structure to fit the newly assimilated input is called accomodation. Accomodation always accompanies assimilation. The two function simultaneously at all biological and intellectual levels (Boyle, 1969). According to Piaget, the mechanisms of assimilation and accomodation are similar in biological and intellectual functioning. Just as simultaneous functioning of accomodation and assimilation results in physical growth at biological level, it results in cognitive growth at intellectual level (Pulaski, 1971). This simultaneous process of assimilation and accomodation is called adaptation (Pulaski, 1971).

Adaptation occurs as a result of organism-environment interchange. This results in the modification of the organism, such that it faciliates further interchanges necessary for the organism (Flavel, 1964, 45).

Accomodation and assimilation are not always in balance. For example, when a child is imitating, accomodation is dominant or when the child is playing, assimilation is dominant. The most adaptive behaviour occurs when accomodation and assimilation are in balance (Phillips, 1969, 11). This balancing process is called equilibration. Equilibration is not an exact or automatic balance, however. Rather it is a compensation for an external disturbance. When there is an external disturbance, the organism compensates this by an activity. Equilibrium is a system of compensating actions to maintain a steady state, not a state of rest. During this steadly state, internal activities of an organism compensate external disturbances completely.

For better survival people need to take information from their environment. But they cannot take all possible information that exists, just as the newborn baby cannot start with solid food. Information which is different from existing knowledge will not be understood or encoded, because it cannot be related to the existing knowledge. Information which is similar to the existing knowledge structures will be assimilated, and the prior structure will be acomodated.

Cognitive growth involves assimilating new knowledge and accomodating to existing knowledge. By the process of equilibration, some of the new information is incorporated, while some of the prior information is retained but organized in a more efficient way (Mayer, 1977, 176). Organization is a function and remains invariant all through development. As a result of more efficiently organized information, a new cognitive structure arises. The new cognitive structure is more complex than the cognitive structure prior to assimilation, accomodation, equilibration and organization. It includes more knowledge in a more efficiently organized way. This represents cognitive development which is "the growth of the ability to achieve equilibrium at an increasingly high level of complexity"[3].

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[3]Helmore, G.A., Piaget-A Practical Consideration, Oxford, Pergamon Press, 1969, 6.

In the process of moving towards higher levels of equilibrium, the organism achieves an ability to develop operations. An operation is "an action that has been internalized into a thought process". Operations are "actions in thought as opposed to physical actions"[4].

There are four main operations in Piaget's system. These are composition, reversibility, associativity and identity (Helmore, 1969, 7). When any two units are combined to produce a new unit, it is called composition. Separation of the two combined units is called reversibility. It is going back to the starting point of composition. Associativity is obtaining the same result by combining the units in different ways. Identity is cancellation of a unit when it is combined with its inverse.

Operations form the basis of Piaget's developmental approach. For Piaget, cognitive growth is the growth in operational thinking.

During the course of cognitive development, four main stages of development can be identified. These stages build on top of each other. Each stage bears a larger, more complex cognitive structure and more powerful cognitive operations than the preceeding one. These stages follow the same sequence but their rate vary from person to person, and some do not reach the more advanced stages at all. It is also possible that an individual shows concrete operational thinking in one content area and formal thinking in another. Similarly a chronological difference is seen between the age of acquisition of different concepts, but the same structural laws hold. For example, during the intuitive stage. permanence of quantity develops before permanence of weight. These differentials in performance is called horizantal decalage by Piaget. It is a temporal gap occuring within the limits of one stage of development. Another sort of decalage, called vertical decalage, explains the fact that same problems can be solved at different stages, but that the child solves them in different ways according to the stage he is in.

"The idea of horizontal decalage points out the danger of regarding intellectual performance at any stage as homogeneous. The notion of

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[4]Pulaski , Marry Ann, S. Understanding Piaget. New York, Harper and Row Publishers, 1971.

vertical decalage warms us not to regard intellectual activity at different stages as too heterogeneous"[5]. The notion of decalage shows that there are gaps at certain parts of development and repetition at others.

The four stages of cognitive development are, the sensory motor stage, the preoperational stage, the concrete operations stage, and the formal operations stage. Thinking at these stages is described by defining the mental structures and the mental operations used by the thinker to solve a problem (Mayer, 1977). Between each stage there is a transitional period, a state of disequilibrium. Once the equilibration process is completed, the cognitive structures of the next stage arise.

Sensory Motor Stage: This stage extends from birth to two years of age. It is characterized by development from a state of reflex activity to an organized sensory motor action system (Modgil, 1974). Sensori-motor means that the infant learns to coordinate its senses with motor behaviour (e.g. adapting the sucking reflex to search for aniggle before sucking). This enables the child with an increasing mastery of objects in his environment. Cognitive structure lies on actions, movements and perceptions without language. The child acquires the concept of permenance during this stage. At birth when objects are out of sight, they don't exist for the child. The only reality is the ongoing sensory stimulation. The child is now able to retain mental images which are beyond the immediate sensory stimulation. By this he is able to anticipate the coming events. He can move the objects from place to place mentally. By the help of retained images, the child forms a picture of the world. He can anticipate to reach certain results, by using certain movements in certain directions. He can represent actions in a symbolic way. This helps the development of language.

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[5]Boyle, D.G., A Students' Guide to Piaget, Oxford, pergamon Press, 1969, 31.

Preoperational stage: This stage extends from two to approximately seven years of age. It is characterized by symbolic activity. The child develops symbolization and acquires more facility in language. During this period, he does not use logical operations in his thinking. He is perceptually oriented. He can make judgements only in terms of how things appear to him. He can generally ded with one variable at a time.

Stage of concrete operations: This stage extends from seven to approximately eleven years of age. During this stage thought is mobile and systematic. Therefore information can be organized and classified. Thought is not centered on one aspect of an object any more. This new quality in thought processes is called decentrization. It enables the child to use more than one variable at a time. The main feature in transition from preoperational to concrete operations is the act of being able to return to the starting point, known as reversibility. Reversibility is one of the four main operations. It helps the child to pass from preoperational stage, and frees him from being dominated by how things look. He can reverse the operation of composition and think of objects in terms of the variables which make them up. Instead of focusing on static perceptual images, the child begins to represent the world as concrete objects. He can act on these concrete objects mentally and change them in logical ways. This period is called concrete operations, because the child can operate on and change a concrete situation. He can also to logical operations in his head.

Stage of formal operations: This stage starts at approximately eleven years and extends from this age on. It is characterized by abstract and formal thought. The child can perform mental operations, not only on concrete objects, but also on symbols. He can form hypothesis and deduce possible consequences from them. He develops an ability to think in terms of possibilities. He can reason on the basis of objects and hypothesis. He can perform operations on operations in a systematic manner. When two concepts become operational, the adolescent can place them in a logical relationship to each other. Piaget refers to these as "second order operations". They are one of the fundemental characteristics of formal operations. Being able to generate hypotheses and deduce possible consequences results in hypothetico-deductive level of thinking. He can now consider all possible combinations and control variables one at a time. Although a concrete operational child canperform abstractions, he has limited ability to manipulate concrete materials. On starting formal operations, this dependence on physical world diminishes. He can think in terms of possible rather than concrete here and now.

In Piaget's Theory, learning proceeds in three steps, (1) interaction of the learner with something in his environment, (2) construction of mental structures from this interaction, and (3) accomodating the results of these interactions.

The materials and ideas which are selected for the learner to interact with must obviously be at his level of cognitive development, or structures cannot be developed.

Therefore the identification of the cognitive developmental stage of the learner may be helpful in selecting the appropriate material to be taught. This dimension of the theory makes it particularly relevant to education.

B. <u>Relevance of the Theory to Education</u>

Piaget's Cognitive Development Theory with its detailed information on "the acquisition of knowledge in terms of defined sequential behaviours"[6] makes it possible to identify the developmental level of the child and the thinking processes he uses at that level.

A lot of studies, (Bank, 1953; Bruner, 1960; Collis, 1971) point to the importance of using this theory as a conceptual framework in curriculum development and in teaching strategies.

Most studies try to answer questions about (1) the concent and timing of curriculum (are various courses placed at the appropriate grade level? is the child ready to understand the subjects presented?), and (2) the extend of a relationship between cognitive development and achievemnt.

Bank's (1953) study was one of the earlier attempts to show the significance of Piaget's work for curriculum development. Examining formal reasoning in students Bank concluded that secondary school pupils should analyse and reason specific phenomenon, rather than dwell on a formal

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[6]Elkind, David and Flavell H. John, <u>Studies in Cognitive Development</u> New York, Oxford University Press, 1969, 466.

representation of scientific concepts. In The Process of Education, Bruner (1960) draws attention to the relevance of Piaget's ideas to curriculum revision. In The Growth of Basic Mathematical and Scientific Concepts in Children, Lavell (1961) and in Religious Thinking from Childhood to Adolescence Goldman (1964) relate Piagetion Theory to the development of curriculum organization.

Collis (1971) in his attempts to distinguish mathematical material most suited to the abilities of concrete operational pupils, concludes that educators should be familiar with the characteristics of mental strategies at various Piagetion levels, and the curriculum content should be adjusted accordingly.

Renner (1972) in Teaching Science in The Secondary School, states that it is possible for science educators who are familiar with the learning process and cognitive development of adolescents to plan and teach in such a manner that students with less developed abilities can benefit from it. Studying secondary school students he found that 77% of the students were at the concrete operational level. Therefore it was proposed that secondary school science teaching must be more concerned with materials and ideas and less concerned with abstractions. The operational thinker can memorize the vocabulary associated with abstract ideas, but his logical operations are not adequate to allow him to utilize highly abstract models in his reasoning. In this book Renner also includes certain teaching methodologies is prepare the concrete operational child for formal operations. The main idea is that the learning experiences must be geared to the operational level of the student. This is identified as the best possible treatment to enable a student to benefit from a course he is taking.

c. Studies on the Relation of Cognitive Development and Science Achievement

Most of the studies or cognitive development and science achievement show the existence of a relationship between these two variables.

Babel (1981) in his attempts to compare the achievement of preconcrete and concrete fourth grade students in science found that, generally, concrete operational students achieve more than preconcrete operational students.

In a study by Benefield (1981) level of cognitive development was found to be consistantly related with achievement and retention in biology. Students at the formal level of cognitive development obtained significantly higher scores than those at the concrete level or in transition between the two. Similarly Haye's (1981) study or junior college students shows that formal operational thinkers achieve significantly higher than concrete operational thinkers in selected chemistry courses. Viravadhoya (1980) showed that the same relationship is true for eleventh grade students in biology, physics and chemistry.

Similar studies were also done by Cropley (1969), Payne (1981), El-Gospi (1982) and Farnsworth (1981) among different student populations. The results indicate the presence of a relationship between science achievement and cognitive developmental level regardless of the age group, grade or the nature of the science subject, the students are attending.

Chaoepit (1979) showed that this relationship exists regardless of the instructional method used. His study attempts to find the effects of logical thinking abilities and instructional approaches on learning outcomes in a chemistry course. Chaoepit used two instructional methods in his study traditional and inquiry, for both formal and concrete reasoners. The mean scores of the formal reasoners were found to be significantly higher than the mean scores of concrete reasoners, regardless of the insturctional method used.

Collody's (1975) follow-up study on college freshmen also shows similar results. At the end of the second year in college, Collody found that a large percentage of students had dropped out of the science curriculum or out of college, and that all of these drop-outs had scored below formal operations on Piaget's tasks.

Barbel (1979) compared formal and concrete operational students in terms of their understanding of formal and concrete concepts in formal and concrete language. His findings show that, students identified as formal operational could understand concrete concepts stated in concrete and formal language and formal concepts stated in concrete language. On the other hand, concrete operational students could understand only concrete concepts stated in concrete language.

III. STATEMENT OF THE PROBLEM

All studies comparing science achievement of students at different levels of cognitive development, show the existence of a relationship between science achievement and cognitive development levels. The relationship is such that students at higher cognitive level achieve better.

In the present study Cognitive Development Theory of Piaget is taken as a basis for determining the level of reasoning abilities possessed by the students. Piaget identifies four main stages in the course of cognitive development. During each stage, new operational structures are formed. These newly formed operational structures from the operational structures of the previous stage stage but they are more complex. Thus in order to determine the level of reasoning abilities, it is essential to identify the operational structures. Piaget's theory provides, detailed information on the operational structures used at each stage, and their identification. Piaget's method for identifying the operational structures and thus the cognitive level, is an interview method. Taking his interviews as a basis, studies like Tisher's (1971) and Bart's (1972) have attempted to develop tests to measure cognitive development level. Piaget's extensive work and the studies which follow it, make the identification of cognitive level possible. The identification of cognitive level has many implications for education. Though Piaget's Theory was not developed for educational purposes, at has often been used in the service of education. The present study makes use of his theory based on the fact that (1) it provides extensive information on the development of thought processes and reasoning abilities; and (2) it is relevant to teachers and curriculum planners.

In Piaget's Cognitive Developmental Theory, certain age ranges are identified as transitional from one stage to the next. Therefore in certain grades, the students within this age range are identified as transitional. Seventh grade in Turkish Lycées is a good example for such a grade. Students in this particular grade usually fall within the age range of 11-13 years. The transition from concrete operations to formal operations takes place during 11-13 years of age, as stated by the Cognitive Development Theory. This theory also states that although cognitive development follows the same sequence, it may change in rate from person to person. Therefore not all the students in the seventh grade are expected to reach formal operations. We may find students operating at formal, concrete or transitional levels during this particular grade. If this is the case, than it can be expected that the students show differences in their readiness to comprehend the material presented. Only those students who operate at the formal level are likely to benefit from the materials that require formal thought. In fact most seventh grade science text-books require formal level of thinking. This implies that seventh grade students are expected to function at the formal operational level.

If a relationship exists between achievement in science and cognitive maturity of the students, then it is conceivable to explain a portion of the variance in science achievement by cognitive maturity.

Seventh grade science curriculum is designed for the formal operational thinker. But majority of the students may be in a cognitive level other than the formal operations. This has certain implications for curriculum content and instructional method. If most of the students are in transition from concrete to formal, the instructional method can be such that it faciliates transition to formal operations. The theory states that the transition from one stage to the next is not smooth. It is in a form of disequilibrium. So transition can be faciliated by providing challenge and conflict. Facitiating transition to formal operations, will help students to comprehend the formal material better. This will have a positive effect on their science achievement. Similarly if most of the students are in the concrete level, their comprehension of science topics may be improved by providing them with concrete concepts and concrete topics. Formal concepts and topics may also be presented in concrete language to increase understanding.

Identification of the cognitive level of reasoning and its relation to achievement in science may be helpful in increasing students science achievement. Therefore this study aims to look for (1) the extent of the relationship between seventh grade science achievement and cognitive maturity, and (2) the implications of such a relationship to school curriculum and teachers.

IV. METHOD

A. Participants

The sample of the study consisted of eighty four seventh graders in Şişli Terakki Lisesi and Yeni Levent Lisesi. Three classes from which the sample was drawn were average in science achievement. Yeni Levent Lisesi is a public school in Istanbul, and has a heterogenous population in terms of the socioeconomic background of the students. The majority of the sample was drawn from this school. Şişli Terakki Lisesi, on the other hand, is rather homogenous in terms of socioeconomic background. It was chosen for comparison purposes.

1. Students in Yeni Levent Lisesi:

A total of 59 students from Yeni Levent Lisesi were included in the study. The school has five different seventh grade sections. Two sections among those were chosen. Sections 7D and 7C which participated in the study had fall term science grade pointaverages of 56.25 and 53 percent respectively. Section 7C had a total of 32 students out of which 30 students, and section 7D had 31 students out of which 29 students participated in the study.

2. Students in Şişli Terakki Lisesi:

A total of 25 students from Şişli Terakki Lisesi were included in the study. The school has four different seventh grade sections. One section which had the fall term science grade average of 58 percent was chosen. This class contained 40 students, but 25 could take part in the study because the remaining 15 were already engaged in ongoing extracurricular activities in the school durin guidance-counseling hours.

B. Instruments and Measures

The two sources of assesment were (1) fall term science grade point averages, and (2) a logical reasoning test.

1. Science Grade Point Averages

Achievement in science was determined by the first term science grade point average of the seventh grade students in the 1983-84 academic year.

2. Test of Cognitive Development

The Logical Reasoning Test developed by Burney (1974) was adapted into Turkish for assessing the level of cognitive development of Turkish students. This Logical Reasonining Test is an objective, group, paper-and-pencil test. It was designed to assess Piaget's formal stage of development. The purpose in developing such a test was to enable its administration and evaluations by persons with minimal amount of training (Burney, 1974). Initially in the original English form there were fourty two items, which contained syllogisms verbal anologies, questions involving combinational and probabilistic reasoning, and questions similar to Piagetion tasks. (Burney, 1974). These items and a set of five Piagetion type tasks were administered to a sample of fifty students in grades nine, eleven and thirteen. After the computation of biserial correlation coefficients for each paper and pencil item, and using scores on the Piagetion task instrument as an outside criterion, the number of items were reduced to twenty four. The final form of the objective instrument and the five Piagetion type tasks were then administered to, a new sample of seventy eight students in ninth, eleventh and thirteenth grades.

In validating the test, item validity, internal consistency, concurrent and predictive validity techniques were used. For item validity, the biserial correlation coefficient was calculated for each item on the objective instrument, using interior scores. The interior scores were five Pragetion tasks.
For internal consistency, the biserial correlation coefficient was calculated using the total scores on the objective test.

For validity, the Pearson product moment correlation between the objective test scores and the scores on the Piagetion task instrument was calculated and found to be 0.853. This was taken as evidence for concurrent validity.

For predictive validity of the test, the students were classified into formal and nonformal (transitional and concrete) categories on the basis of scores obtained from (1) the objective test and (2) the Piagetion tasks. In classifying into formal/nonformal categories there was 88 percent agreement between the two measures. In a different classification where formal,transitional and concrete categories were used, the agreement was 84 percent. These data were considered as evidence for predictive validity.

The reliability of the test was determined using the Kuder Richardson 20 formula, and was found to be 0.825.

The Logical Reasoning Test used in this study was obtained from the book, Piaget for Educators (Sund, 1976), together with the keyed answer sheet and the classification criteria. This test was translated into Turkish and modified. The original form of the test which was included in the dissentation thesis The Construction and Validation of an Objective Formal Reasoning Instrument (Burney, 1974) was received by this researcher only after the modification and translation of the first form was completed. The two forms differed from each other in terms of the number of questions they contained. The original form contained 24 questions where as the test used in the study had 21 questions. No data were found concerning the reasons for reducing the number of questions from 24 to 21. It was observed that questions six, nine and 17 of the original form were eliminated. Studying the table (Burney, 1974) containing the internal consistency, the item validity and the item difficulty indexes of the original form with 24 questions, the researcher tried to speculate as to why these three items were eliminated in the later form.

Table I taken from Table II in Burney (1974, 45) shows the internal consistency, the item validity and the percent responding correctly for questions six, nine and 17.

TABLE I

INTERNAL CONSISTENCY, ITEM VALIDITY AND PERCENT RESPONDING CORRECTLY FOR THE ELIMINATED QUESTIONS[x]

Statistical Data/ Question Number	Correlation Coefficient		Percent Responding Correctly
	Internal Consistency	Item Validity	
6	0.966	0.916	96.2
9	0.376	0.217	44.9
17	0.322	0.217	67.9

[x]Taken from Table II in Burney (1974, 45).

Reading from this table it can be seen that, the internal consistency of question six was 0.966 and the item validity was 0.916. Also 96.2 percent of students answered this question correctly. This is the highest value for percent responding correctly among all other test questions, and shows that this question is too easy.

Questions nine and 17 were answered by nearly half of the students with a value of 44.9 and 67.9 in terms of percent responding correctly. But when considering their item validity and internal consistency these questions ranked the lowest with respect to other questions in the test. Both questions had an item validity of 0.217. The internal consistency for questions nine and 17 were 0.376 and 0.322, respectively.

In light of these data, the researcher decided that question six was probably eliminated due to its very low difficulty level; and questions nine and 17 were eliminated due to their low internal consistency and item validity. A further scrutiny of these items revealed that they were duplications of several other questions in the test. With no further data it was assumed that, the omission of these three questions did not result in a major change in the test, and this form of the test was regarded valid to be used in the study.

a. Translation and Adaptation of the Test

The Logical Reasoning Test was translated and adapted into Turkish by the researcher. This translated form was then separated into two parts. The first part consisted of questions one through 15, and these were mostly science based questions. The second part which consisted of questions 16 through 21 were language based verbal anologies type of questions.

The first part was given to be read by some staff members in Chemistry, Physics and Mathematics departments of Boğaziçi University. The questions were checked for their adequecy in terms of technical terminology, and the ease with which these questions could be comprehended by the students.

Language based questions of the first part (eight through ten) and questions 16 through 21 of the second part were read and edited by a professional translater and a staff member in the English language department of Marmara University.

The test was rewritten in Turkish considering the corrections and suggestions proposed by the readers. The new form was then administered to three seventh grade and two sixth grade students individually. The students were asked to read the test questions and think aloud while answering. The test was observed to be easily understand by all five students in terms of its language. In questions 16 through 21 the students had some difficulty answering. This may be due to the fact that certain different words in English had ony one meaning in Turkish, and some words which couldn't be directly translated into Turkish had to be adapted. Because of these difficulties in translation, the correct answers were hand to discriminate. Therefore the content of questions 16 through 21 were modified, but still kept as verbal anologies, like in the original form.

Another difficulty was related to the format of the test. For questions one through 15, alternative choices varied between two to six. To be consistent, the number of alternatives was decided to be fact for each item. A more confusing item structure was observed in questions 16 through 21. This time each question was composed of several parts. Number of parts varied between two and three, with no apparent regularity. For each part four alternatives were given to choose the answer from. Thus the questions with two parts of four choices had two correct answers and the questions with three parts of four choices had three correct answers. To prevent confusion, the format of these questions were also arrangedsuch that each question had four choices and one correct answer.

The modified form of the test was checked by a staff member in the Education Department of Boğaziçi University, and further changes were made. Questions 16 through 21 were readministered to the same five middle school students because the students were in frequent contact with the researcher. This time the revised questions were found to be easily understood in terms of language. Applying a different form of the questions to the same students may result in a carryover effect, therefore biasing the results. So to check this, a comparison of the translated and the modified forms was carried out on a different sample of 29 students. Results showed that the mean item difficulty of questions 16 through 21 had improved from 0.06 in the translated form to 0.22 in the modified form (Appendix IV).

A general comparison of the two forms was made in terms of their splithalf reliability and Kuder Richardson reliability, using Kuder Richardson formula 21.

Split half reliability coefficients of the two forms were found to be similar, with a reliability coefficient of 0.82 in the modified form and 0.86 in the translated form. The Kuder Richardson Reliability coefficients found using formula 21, was 0.66 for the modified form and 0.59 for the translated form. When compared with the translated form of the test, the modified form was found to be more appropriate for the purposes of this study. It had a higher reliability coefficient obtained by Kuder Richardson formula 21; and the mean difficulty index for questions 16 through 21 was increased considerably.

b. <u>The Reliability and the Validity of the Modified Form of the Logical Reasoning Test</u>

The data collected to test the reliability and the validity of the modified form of the reasoning test were obtained from students in Şişli Terakki Lisesi and Yeni Levent Lisesi.

<u>Kuder Richardson Reliability</u>: The Kuder Richardson reliability coefficient for the modified form of the test was calculated on all students who took the test. The obtained alpha coefficient was found 0.70.

<u>Internal Consistency:</u> The internal consistency of each particular item was assessed by biserial correlation coefficients between each item and the total score obtained from the modified form of the Logical Reasoning

Test.

The biserial correlation coefficients and the percent responding correctly for each question on the modified form was compared with those of the original form of the test in English.

For further comparison between the modified and the origanal English form of the test, the item validity indexes where calculated for both forms. The reason for this further comparison was that the data showing the biserial correlation coefficient and the percent responding correctly taken from the original form (Burney, 1974) were seen to be questionable.

Table II shows the biserial correlation coefficients, the percent responding correctly and the item validity index calculated for each item of the modified and original forms of the test.

TABLE II

BISERIAL CORRELATION COEFFICIENTS, PERCENT RESPONDING CORRECTLY AND THE ITEM VALIDITY INDEX FOR QUESTIONS OF THE MODIFIED AND ORIGINAL ENGLISH FORM OF THE TEST

	MODIFIED TURKISH FORM			ORIGINAL ENGLISH FORM		
Questions	Biserial Correlation Coefficient	Percent Responding Correctly	Item Validity Index	Biserial Correlation Coefficient	Percent Responding Correctly	Item Validity Index
1	0.40	0.53	0.20	0.57	0.74	0.25
2	0.40	0.59	0.20	0.81	0.85	0.29
3	0.66	0.61	0.32	0.54	0.76	0.23
4	0.38	0.59	0.19	0.80	0.72	0.36
5	0.43	0.41	0.21	0.56	0.95	0.12
6	0.82	0.86	0.29	0.74	0.78	0.31
7	0.37	0.44	0.18	0.78	0.86	0.27
8	0.33	0.53	0.17	0.92	0.92	0.25
9	0.48	0.51	0.24	0.92	0.39	0.45
10	0.65	0.71	0.30	0.54	0.51	0.13
11	0.64	0.33	0.30	0.71	0.56	0.18
12	0.49	0.47	0.25	0.71	0.95	0.16
13	0.75	0.54	0.35	0.39	0.91	0.11
14	0.32	0.63	0.16	0.64	0.59	0.32
15	0.84	0.66	0.40	0.91	0.49	0.23
16	0.43	0.19	0.17	0.54	0.28	0.24
17	0.43	0.31	0.20	0.52	0.56	0.26
18	0.70	0.39	0.34	0.43	0.60	0.21
19	0.47	0.26	0.21	0.57	0.60	0.28
20	0.40	0.23	0.17	0.71	0.65	0.34
21	0.49	0.31	0.23	0.63	0.80	0.25

The biserial correlation coefficients given in Table II were all significant at 0.001 level. These biserial correlation coefficients ranged from 0.32 to 0.84 in the Turkish modified form and from 0.39 to 0.92 in the original form. It can be easily seen that the coefficients obtained from the modified form are generally lower than in the original English form of the test.

The percent of students responding correctly to the questions in the modified form ranged from 0.19 to 0.86 with a median of 0.51. In the original English form of the test, the range of percent responding correctly was between 0.28 and 0.95 with a median of 0.72.

Both the range and the median percent responding correctly were higher in the original form. This may be due to different age range of the students who took the original English form and the modified Turkish form. Age of students on the original English form ranged from 14 years to 19 years 5 months with a mean of 16 years 9 months, where as the range of the Turkish students answering the modified form varied between 12 years 6 months and 15 years 3 months. The mean age was 13 years and 2 months.

It can be seen from Table II that; the modified and the original forms of the test were most similar to each other in terms of their item validity indices. The item validity indices of the modified form ranged between 0.16 and 0.40 with a median of 0.21. For the original English form these indices varied between 0.11 and 0.45 with a median of 0.25.

Despite the lower correlation coefficients of the modified form when compared with the original form, these data were considered satisfactory. Thus the modified Turkish form was used in this research.

c. Administration of the Logical Reasoning Test

The test was administered during the regular guidance-counseling hours of the two schools. In Şişli Terakki Lisesi, the test was administered by the counseler of the school. In Yeni Levent Lisesi, it was administered by the researcher in both classes. The guidance teacher and the school counseler were also present in both classes during the administration of the test.

d. Duration of the Test

The original form of the test which consisted of 24 items had a fifty minutes duration. This was used as a criterion in deciding for the duration of the test with 21 items. Approximately two minutes time was given to each item in the original test. Therefore the duration for the 21 item test was determined to be fourty four minutes. This is five minutes shorter than the time given in the original form. When the amount of time necessary for an additional three items is subtracted the duration of the test resulted to be 44 minutes, which was later rounded up to 45 minutes.

e. Scoring of the Test

Each correct answer in the test was assaigned a score of one, as indicated by the test constructor (Burney, 1974). The modified form of the test used in the study had 21-items. By assaigning one point for each correct answer, the total score of the test ranged from a maximum of 21 points to a minimum of zero.

Two sources were available in classifying the students in formal, transitional and concrete categories (1) the original English form with 24-items (Burney, 1974), and (2) the English form of the test with 21-items (Sund, 1976). The cutting points and class intervals in the two forms did not match exactly because of unequal number of items in three forms. To check for the agreement between the two forms, the intervals given in the 24-item test were adjusted to the 21-item test by proportioning. Thus a third source of classification was obtained.

Table III shows the class inetrvals obtained (1) from the 24-item English form of the test, (2) an adaptation of the 24-item test to 21-item test, and (3) the 21-item English form of the test, in classifying the students into formal, transitional and concrete categories.

TABLE III

SCORE INTERVALS OBTAINED (1) FROM THE 24-ITEM TEST, (2) BY THE ADAPTATION OF 24-ITEM TEST TO 21-ITEM TEST, AND (3) FROM THE 21-ITEM TEST

Operational Level/ Type of Score	Formal	Score Intervals Transitional	Concrete
I 24-Item Test	24-17	16-11	10-0
II Adaptation From 24-Items to 21-Items	21-15	14-10	9-0
III 21-Item Test	21-14	13-8	7-0

On Table III it is seen that in the original English form of the test (1) scores between 24 and 17 placed the student in formal operations, (2) scores between 16 and 11 placed the student in transitional stage, and (3) scores between zero and 10 placed them in concrete operations. For this classification, performance on Piagetion type tasks was used as criterion. The class intervals resulting from the adaptation of the 24-item test to 21-items by proportioning classifies the student as (1) formal operational if he scored between 14 and 21, (2) transitional if he scored between eight and 13 and (3) concrete if he scored between seven and zero.

These are not in agreement with the class intervals outlined in the 21-item English form of the test, (Sund, 1976, 173) where the student is classified as (1) formal operational, if he scored between 14 and 21, (2) transitional, if he scored between eight and 13, and (3) concrete, if he scored between seven and zero.

Because the test used in the study had 21-items,rows II and III of Table III were considered in deciding for the score intervals to be used in classifying the students into formal and nonformal (transitional and concrete) levels. But the classification standards identified by the adaptation of the 24-item test to 21-item test were not in agreement with those given in the 21-item test, and no further data were available to support one classification over the other. Therefore in order to choose the score intervals for classification of students, into formal or nonformal categories, the biserial correlation coefficients between science achievement and logical reasoning test scores were taken as criteria in deciding the cutting points.

Table III shows that the cutting point between formal and nonformal (transitional and concrete) categories is 15 in the adaptation of 24-items to 21-items, and 14 in the 21-item test. A range of four scores around 14 and 15 were tested in determining this cutting point. The tested scores were 13, 14, 15 and 16, and the score which gave the highest biserial correlation coefficient between science achievement and logical reasoning was then chosen to be used in classifying the students into formal and nonformal categories. (is can be seen in the table VI, in the Results and Discussion Section) The score of 15 gave the highest biserial correlation and it was chosen as the cutting point between formal and nonformal categories.

For the second type of classification that is, concrete versus non-concrete categories, the same procedure was used. A score which gave a high biserial coefficient between science achievement and logical reasoning was chosen as the cutting point. In table III it can be seen that the highest score a concrete operational student can get (that is the cutting point between concrete and nonconcrete categories) is 9 in the adoptation of 24-items to 21-items, and in the 21-item test. Therefore in determining the cutting point between concrete and non-concrete categories, four scores ranging between 7 and 10 were tested. Table VI in Results and Discussion section shows that the highest biserial correlation between science achievement and logical reasoning was obtained when the score 9 was used as the cutting point between concrete and nonconcrete categories.

These results gave direction to the researcher in classifying the students as (1) formal operational if he scores between 21 and 15, (2) transitional if he scores between 14 and 10, and (3) concrete operational if he scores between nine and zero.

The resultant criterian scores used in this classification were seen to be in agreement with the score intervals obtained by an adaptation of the classification standards of the 24-item test to the 21-item test.

Analysis of data obtained were partly based on such a system of classification

V. RESULTS AND DISCUSSION

The results presented in this section are based on 1983-84 academic year, first term science grades and the Logical Reasoning Test scores obtained from the modified form of the test.

The data were analyzed considering (1) the students in Şişli Terakki Lisesi, (2) the students in Yeni Levent Lisesi, and (3) the students from both schools, combined.

Descriptive data on table IV shows the means and the standard deviations of the Logical Reasoning Test scores and the first term science grades of students in (1) Şişli Terakki Lisesi, (2) Yeni Levent Lisesi, and (3) both schools, combined. The t-values were calculated to test the differences between the two schools in terms of the Logical Reasoning Test scores and the science grades.

TABLE IV

THE MEANS, THE STANDARD DEVIATIONS AND THE t-VALUES OF THE LOGICAL REASONING TEST SCORES AND THE FIRST TERM SCIENCE GRADES FOR ŞİŞLİ TERAKKİ LİSESİ AND YENİ LEVENT LİSESİ STUDENTS, SEPARATELY AND COMBINED

Source of Data/ Type of Group	Logical Reasoning Test Scores		First Term Science Grades	
	Mean	Standard Deviation	Mean	Standard Deviation
A Şişli Terakki Lisesi N=25	11.12	3.83	4.60	1.19
B Yeni Levent Lisesi N=45	9.74	3.65	5.38	1.65
Combined Group N=70	10.23	3.75	5.05	1.49
(AdB) t Values	1.62 (n.s)		2.12 (n.s)	

The Logical Reasoning Test mean scores were 11.12 and 9.74 for Şişli Terakki Lisesi and Yeni Levent Lisesi, respectively. Test of significance showed that the two schools did not differ from each other in their logical reasoning performance. The mean for the combined group was 10.23.

Similar results were obtained when two schools were compared in terms of their first term science grades. The first term science grade mean was 4.60 for Şişli Terakki Lisesi and 5.38 for Yeni Levent Lisesi, which were not significantly different from each other either. The mean for the first term science grades in the combined group was 5.05.

In assessing the relationship between the Logical Reasoning Test and science achievement two correlational analyses were used in three comparisons. The Pearson product moment correlations between the Logical Reasoning Test score and the first term science grades were calculated for three groups. Biserial product correlations were calculated after students were classified as formal and nonformal as well as concrete and nonconcrete.

The product moment correlation coefficients between the Logical Reasoning Test scores and first term science grades for the combined group was 0.79 at the 0.001 level of significience. The degree of relationship between logical reasoning and science achievement of the two schools were 0.66 for Şişli Terakki Lisesi and 0.86 for Yeni Levent Lisesi. Table V shows the product moment correlation coefficients between science achievement and the logical reasoning test scores.

TABLE V

THE PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN THE LOGICAL REASONING TEST SCORES AND SCIENCE ACHIEVEMENT FOR ŞİŞLİ TERAKKİ LİSESİ AND YENİ LEVENT LİSESİ SEPARATELY, AND COMBINED

Statistical Data/ Type of Group	Product Moment Correlation	Level of Significance
Şişli Terakki Lisesi	0.66	0.001
Yeni Levent Lisesi	0.86	0.001
Combined Group	0.79	0.001

A correlation coefficient of 0.79 for the combined group implies that 62.4 percent of variance in science achievement can be explained by the logical reasoning test scores of the students.

The correlation coefficient between science achievement and logical reasoning abilities is higher for Yeni Levent Lisesi than for Şişli Terakki Lisesi. Logical Reasoning ability accounts for 43.56 percent and 73.96 percent of variance in science achievement in Şişli Terakki Lisesi and Yeni Levent Lisesi, respectively. The lower correlation for Şişli Terakki Lisesi may be due to a standard deviation of 1.19 in science achievement. This is a smaller variance than that is found in Yeni Levent Lisesi.

The second technique used in determining the degree of relationship between science achievement and logical reasoning level was the biserial correlation coefficient method in which the students were classified as (1) concrete or nonconcrete and (2) formal or nonformal. This correlation technique was used mainly, to determine the appropriate score intervals to be used, in placing the students into concrete, transitional and formal categories.

In classifying the students as concrete or non-concrete scores of seven, eight, nine and 10 were tested as cutting points. As explained in the scoring of the test section the reason for choosing a range of four scores was to see that the score identified as the cutting point for concrete operations gave the maximum correlation coefficient between science achievement and logical reasoning ability level.

In classifying the students as formal or nonformal, scores of 13, 14, 15 and 16 were tested as cutting points. Similarly a range of four scores were also used in order to see that the score, identified as the cutting point for formal operations gave the maximum correlation coefficient between science achievement and logical reasoning ability level.

TABLE VI

BISERIAL CORRELATION COEFFICIENTS
(1) WHEN SCORES SEVEN, EIGHT, NINE AND 10 ARE USED AS CUTTING POINT BETWEEN CONCRETE OR NONCONCRETE CATEGORIES, (2) WHEN SCORES 13, 14, 15 AND 16 ARE USED AS CUTTING POINTS BETWEEN FORMAL AND NON-FORMAL CATEGORIES

Classification Categories	Scores Used	Biserial Correlation Coefficient
Concrete/ Non-Concrete	7	0.39
	8	0.34
	9	0.44
	10	0.40
Formal/ Non-Formal	13	0.18
	14	0.62
	15	0.83
	16	0.69

Table VI shows that when students were classified as concrete or nonconcrete a biserial correlation coefficient of 0.39 was obtained by using 7 as the cutting point. Correlation coefficients of 0.33, 0.44 and 0.40 were obtained when scores of eight, nine and 10 were used as cutting points, respectively.

When students were classified as formal or nonformal, biserial correlation coefficients of 0.18, 0.62, 0.83 and 0.69 were obtained by using scores of 13, 14, 15 and 16 as cutting points.

The score of nine was seen to have the highest biserial correlation coefficient between science achievement and logical reasoning ability level, when students were classified as concrete or nonconcrete. The score of 15 used as a cutting point resulted in the highest biserial correlation coefficient between science achievement and logical reasoning ability level when students were classified as formal or nonformal.

Thus the best tested cutting points were decided to be nine and fifteen in the classification of students into concrete and formal categories. Accordingly then, the student with a score of nine or below was classified as concrete; and a student with a score or fifteen or above was classified as formal. The scores falling in between, that is a score interval of eight through fourteen, was identified as representing the transitional category. This is also consistent with the adaptation of the classification standards of the 24-item test to 21-item test discussed earlier.

The number of students falling in each category was determined by using the score intervals identified above, and their percentages were calculated. Table VII shows the percentage of students at formal, transitional and concrete levels, for Şişli Terakki Lisesi and Yeni Levent Lisesi, separately and combined.

TABLE VII

PERCENTAGE OF STUDENTS OPERATING IN FORMAL OR NON-FORMAL (TRANSITIONAL AND CONCRETE) LEVELS IN ŞİŞLİ TERAKKİ LİSESİ, YENİ LEVENT LİSESİ, SEPARATELY AND COMBINED

Operational Level/ Type of Group	Formal Operations	Nonformal Operations	
		Transitional	Concrete
Şişli Terakki Lisesi N=25	0.08	0.64	0.28
Yeni Levent Lisesi N=45	0.07	0.47	0.47
Combined Group N=70	0.07	0.53	0.40

Table VII shows that the percentage of students operating at the formal level is eight in Şişli Terakki Lisesi, seven in Yeni Levent Lisesi and and seven in the combined group. This means that a very small portion (less than ten percent) of the seventh graders operate at formal level of thinking.

Examining the transitional category, the table indicates that, 64 percent of students in Şişli Terakki Lisesi, 47 percent in Yeni Levent Lisesi, and 53 percent in the combined group operate at this level. Thus the majority of the seventh graders fall between the formal and the concrete levels of logical operations. What proportion of this group however, comes close to the formal operations level cannot be told from these data.

Percentage of students operating at the concrete level is 47 for Yeni Levent Lisesi, and 28 for Şişli Terakki Lisesi, with 40 percent in the combined group.

These findings indicate that the majority of the seventh grade students in the sample function at the transitional level of operations. When the transitional and the concrete categories are combined as nonformal operational, it is seen that 92 percent of students in Şişli Terakki Lisesi, 94 percent in Yeni Levent Lisesi and 93 percent in the combined group fall into this category.

To summarize the findings reported so far, it can be stated that when both variables (grades and level of reasoning) are treated as continuos, different information is obtained than when one variable (level of reasoning) is treated as dichotomous. The correlation coefficients found by using the Pearson product moment technique was considered in determining the relationship between science achievement and level of reasoning ability.

The Pearson product moment correlation reflecting such a relationship was 0.79. This indicates that 62.41 percent of variance in science achievement can be explained by the logical reasoning ability level of our students.

When the level of reasoning is treated as a dichotomous variable the students are classified into formal/nonformal or concrete/nonconcrete classes according to their reasoning scores. In classifying the students as formal/nonformal, the biserial correlation coefficient come to 0.83 where as the use of concrete/nonconcrete classification resulted in a coefficient of 0.44. The apparent difference between the two biserial correlation coefficients obtained from two kinds of classifications may be indicating something about the validity of the classification used. Based on this, it can be speculated that the higher correlation coefficient indicates better validity. Therefore the formal/nonformal classification is more valid than the concrete/nonconcrete classification.

These coefficients found through the biserial correlation technique were used mainly in determining the optimum cutting points between formal/nonformal and concrete/nonconcrete operations.

SUMMARY AND CONCLUSIONS

The aim of the study was to look for a relationship between science achievement and the logical reasoning abilities of seventh grade students. The study was carried at in two lycées, Şişli Terakki Lisesi and Yeni LEvent Lisesi in Istanbul, during the academic year of 1983-84. One seventh grade section from Şişli Terakki Lisesi (N 25) and two seventh grade sections (N 45) from Yeni Levent Lisesi participated in the study.

Logical Reasoning abilities of the students were assessed by the Logical Reasoning Test (Burney, 1974). This was a paper and pencil test based on the Pragetion Cognitive Development Theory. The test was translated and adapted into Turkish by the researcher. It consisted of science based and language based (syllogrsms and verbal anologies) questions. The science based questions were read by the staff members in Physics, Chemistry and Mathematics departments of Boğaziçi University; and the language based questins were read by staff members in English language Department of Marmara University, Education Department of Boğaziçi University, and a professional translator. The readers checked the questions in terms of their language and the ease with which they could be comprehended. In light of the recommendations made by the readers and a piloting of the test on five middle school students, certain modifications were found necessary, especially on the second part of the test (questions 16 through 21). Those questions were modified in order to increase the clarity and ease of comprehension. Thus a modified form of the test was obtained. Later the translated and the modified forms were administered to one seventh grade section (section 7D) in Yeni Levent Lisesi. In this class 14 students took the translated form, and 15 students took the modified form. A comparison of the results obtained from the two forms showed that the second part of the modified form of the test was improved significantly. In comparing the reliability of the two forms calculated using the Kuder Richardson formula 21, reliability coefficient of 0.66 and 0.59 were obtained for the modified and the translated forms respectively. These results gave support for using the modified form of the test in this research.

The logical reasoning ability level of 45 seventh graders in Yeni Levent Lisesi, and 25 seventh graders in Şişli Terakki Lisesi was measured using the modified Turkish form of the Logical Reasoning Test (Burney, 1974).

Science achievement of these students was assessed by their first term science grade point averages in the academic year of 1983-84.

The data obtained were analyzed using the biserial correlation and the Pearson product moment correlation techniques. In the biserial technique, where the level of reasoning was treated as dichotomous, as the students were classified into formal/nonformal categories, the correlation coefficient obtained was 0.83, where as it was 0.44 when the students were classified into concrete/nonconcrete categories. The main purpose in finding the biseriol correlation coefficients was to determine the optimum cutting points between formal/nonformal and concrete/nonconcrete operations. Using the obtained cutting points then the students were classified into formal, transitional and concrete categories. The Pearson product moment correlation coeffient between science achievement and logical reasoning level, where both of the variables were treated as contirious, was found to be 0.79. This result was considered in interpreting the relationship between science achievement and logical reasoning ability level. This coefficient indicated that 62.41 percent of variation in science achievement could be explained by the logical reasoning ability level. In a similar study by Le Main (1982)which attempted to find a relationship between level of cognitive development and a standardized achievement test on language and science, 48 percent of variation in science achievement was explained by the students' cognitive level. Al Manroe (1982) and Smith (1980) in their studies also showed the existance of a positive correlation between science achievement and cognitive development as measured by the logical Reasoning Test (Burney, 1974).

The differences in the logical reasoning ability of the students seem to reflect differences in their science achievement. Studies by Lutes (1979), Viravadhaya (1981) and Margaret (1983) showed that when science achievement of concrete and formal reasoners were compared, the formal operational group scored significantly higher than the concrete operational group. Students differing in logical reasoning ability also differ in terms of the kind of information they can assimilate. A student can assimilate any new information only if this new information can be related to the existing structures (Mayer, 1977, 173). For example before a baby starts tolking he first listens and incorporates what is talked arround him, so that the words become familiar. A similar biological example is the indigestion of food. Before the body can assimilate solid food, it takes milk and baby food, so that the digestive system changes and gets ready to assimilate the solid food. Therefore information that is completely different from the existing structures will not be understood and coded, because it cannot be related to the existing knowledge. So it is possible to say that a nonformal operational learner, based on Piagetion classification, of cognitive level, will not be able to assimilate information based on formal concepts. This appears to be the case for 93 percent of students in this study who could not be placed within the formal category of operations based on their logical reasoning test scores.

The data obtained from the logical reasoning test scores of the students in this study showed that on teh developmental level of logical reasoning from nonformal to formal, 40 percent were concrete operational and 53 percent were in transition from concrete to formal operations. In a study by Renner and Stafford (1971) which attempted to identify the operational level of students in grades seven through 12, parallel results were obtained. Ninety percent of the total sample was found to be operating at the nonformal operational level. Similarly in a study by Smith (1980) on 722 highschool students 88 percent of the students were placed in the nonformal operational level, based on the Logical Reasoning Test (Burney, 1974). The percentage of concrete operational students was 49; and 29 percent were operating at the transitional level. These results are consistent with the findings of the present study, and indicate that the majority of the young secondary school students are operating at the nonformal level. However since the findings of the present study are limited to the sevent grade of the secondary school, the percentage operating at the nonformal operational level was higher than the percentage of nonformal students in the other two studies. Where the samples covered seventh through 12th grades. The fact that these seventh grade students are not in the formal operations period indicates that any information based on formal concepts are not likely to be easily assimilated and accomodated to their existing structures.

Although only seven percent of the seventh graders in our study were assessed to be formal operational, a scrutiny of the textbook used in science showed that most of the topics and concepts covered in the seventh grade require the use of formal operations. In fact, however as found in this study the students do not possess the operations of the formal period. This reflects a major inconsistency between the operational level of the seventh graders and the science course expectations. The science curriculum content does not match the reasoning level of those students.

The results of this study show that the logical reasoning ability level of the seventh grade students, as far as the schools sampled in this study are concerned, is below the level required for the seventh grade science curriculum. This is an important fact to consider is teaching the seventh grade science topics.

Although Praget has not consturcted a theory of teaching his theory on cognitive development has certain implications for education. Praget proposes four factors that influence cognitive development: physical motivation, experience, social transmission and equilibration.

Physical motivation, refers to genetic influences on development. Experience results from the interaction of the learner with objects in his environment and the environment itself. Social transmission is the interaction of the learner with other people. Acquisition of knowledge from another person occurs through social transmission. Equilibration integrates all these factors. Cognitive development takes place by changing the learner's cognitive structures through the processes of equilibration and disequilibration. The equilibrium of the learner is disturbed and reestablished through interaction with the objects and people in his environment. Therefore, in moving towards the more complex stages of development, greater opportunity of interaction with people and objects has a positive effect on cognitive development. In providing this interaction the physical and cognitive maturity of the learner must also be considered. It is essential to establish an optimal dicrepancy between environmental inputs and existing cognitive structures. Therefore the suggestion of matching the cognitive level of the student with the level of instruction implies the identification of the optimal range of discrepancy between the new input and the established structure.

In the present study most of the students were found to be in transition from concrete to formal operations. Therefore, courses which are based on formal concepts will not be assimilated because they do not fit the existing structure. On the other hand, concrete concepts will fit exactly to the existing structures. This will not cause disequilibrium which could lead to further cognitive development when equilibrated. For students who are in transition from concrete to formal operations, it is better to start with the presentation of concrete concepts in the science textbook, and progressively move on to formal concepts. That is, the learner should first operate on objects, and by internalizing his actions, build up operations necessary for formal concepts. In encountering a new notion the learner must have physical or interactive experience, because in learning something new, basic cognitive structures must build.

Social interaction, as well as interaction with objects, is important in faciliating development. Through social interaction, the student will learn different frames of reference which will lead to conflict, thus disequilibration. This will result in equilibration and further cognitive development.

In short the fact that most of the sampled seventh graders in this study are transitional between concrete and formal operations and that the seventh grade science textbook covers mainly formal concepts presents educational limitations. To overcome such limitations, the seventh grade science students must be prepared for formal operations and thus their transition to formal operations must be faciliated. This can be done by (1) providing social and physical interaction with the enviroment and, (2) teaching formal concepts on concrete level. Here instead of relying on formulas and abstractions, instruction is based on experimentation and labotory work.

In preparing the concrete operatinal or transitional student toward formal operations or faciliating this transition to formal operations, importance of experience and discovery learning is recommended. In Teaching Science in the Second School (Renner and Stafford, 1972, 281) and the Development of Cognitive Processes (Hamilton and Vernon, 1976, 374) the autors consider experience on cognitive materials to be effective in faciliating transition to formal operations. Similarly in Teaching Science by Inquiry in the Secondary School (Sund, Throwbridge, 1973, 55) use of experiments and hypothesis formation were stated as powerful methods in preparing the student for formal operations. In Origins of Intellect, Phillips (1969, 120) proposed the inquiry method in preparing the concrete learner to formal operations. This method stresses the role of discovery made by the students with minimal help from the teacher.

This paper does not propose a specific instructional method in preparing the concrete operational student to formal operations. What it proposes is that both the teachers and the curriculum designers be aware of and informed about the level of logical reasoning abilities of their students. If in fact approximately 64 percent of variation in science achievement can be attributed to the students level of logical reasoning ability as demonstrated by this study, information or the logical reasoning abilities is of great importance for learning, enjoying and achieving in the science subjects. To faciliate success, it is essential to gear both the content and the method of insturction to the operational level of the majority of the students.

LIMITATIONS OF THE STUDY

The sample of this study was drawn from two schools in Istanbul. Therefore the generalizability of the results is very low. The number of schools which participated in the study was limited to two, due to time shortage, and lack of guidance and counseling services in most schools. The extent to which these schools represent seventh graders in Turkey or even in Istanbul is not known definitely.

A second major limitation of the study is that the logical reasonin test used in this study was not standardized. No data concerning the standardization of the original form of the logical reasoning test used in the study were available. The English form used here had 21 items instead of 24 items as in the first original test. This might have resulted in deviations from the original test form. In translating the 21-item test into Turkish, major changes were made on the form and a modified test was obtained. The reason for these changes were in order to provide greater similarity between the Turkish form and the original English form. The limited data at hand, indicated that the modified form used in this study measured something close to the original form of the test.

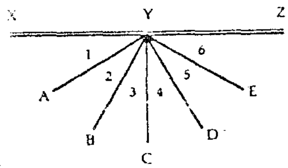
In comparing the biserial correlation coefficients (internal consistency) calculated for each question of the modified form of the test, used in this study with those of the original English for, it was seen that the correlation coefficients obtained from the modified form were somewhat lower than those of the original form.

Similarly both the range and the median for percent of students responding correctly were higher in the original form than in the modified Turkish form. Although this can be explained by the foot that the age mean (16 years 9 months) of students who took the original English form was higher than the age mean (13 years 2 months) of those who took the modified Turkish form, it may still be regarded as a limitation of the test. Perhaps this test is more appropriate for older students than those included in the present sample.

APPENDIX A

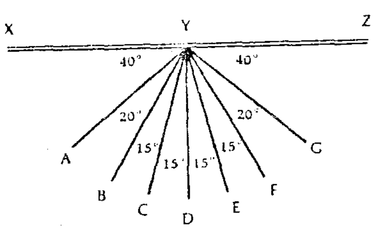
ORIGINAL FORM OF THE LOGICAL REASONING TEST IN ENGLISH

1. In the diagram following the line XYZ represents a wall. A ball is thrown at the wall so that it always hits at point Y. Angle 1 equals angle 6, angle 2 equals angle 5 and angle 3 equals angle 4.



If a ball bounces from point Y to point B it must have been thrown from:
(a) A (b) B (c) C (d) D (e) E

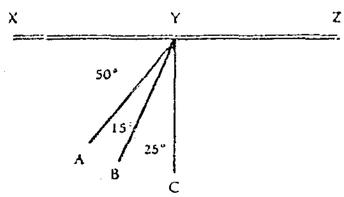
Here is a new diagram similar to the first one. Study it carefully and use it to answer questions 2 and 3.



2. If a ball is thrown from point B to point Y on the wall, it will bounce to:
(a) A (b) E (c) C (d) F (e) G

3. If a ball bounces from point Y on the wall, to point A, it must have been thrown from:
(a) A (b) E (c) C (d) F (e) G

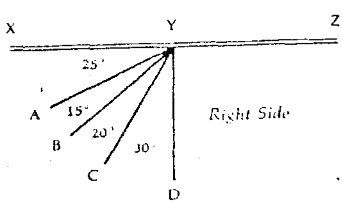
4. In the diagram below, a ball is thrown from point A to point Y on the wall



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

(a) 50^{0} (b) 75^{0} (c) 65^{0} (d) 40^{0} (e) 25^{0}

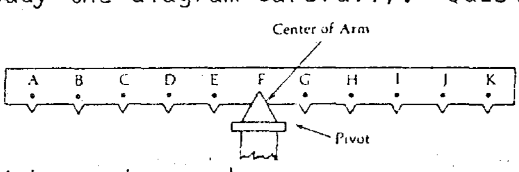
5. A ball is thrown from somewhere in the section marked "Right Side" in the diagram following. The ball hits the wall at point Y and bounces to point C.



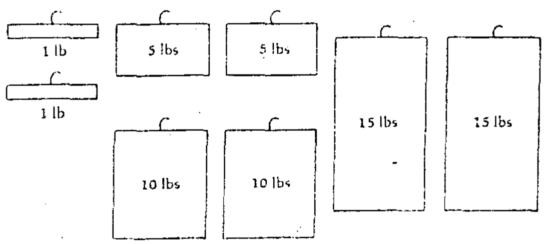
The size of the angle from YZ, the point from which the ball must be thrown is

(a) 25^{0} (b) 40^{0} (c) 65^{0} (d) 60^{0} (e) 50^{0}

Suppose you have a balance scale similar to the one in the diagram below. Study the diagram carefully. Questions 8-14 refer to it.



Weights which can be used



6. A five pound weight is hung at point D. How can you balance the arm?
   (a) Hang a one pound weight at A.
   (b) Hang a ten pound weight at J.
   (c) Hang a five pound weight at H.
   (d) Hang a ten pound weight at E.
   (e) Hang a five pound weight at K.
   (f) It is impossible.

7. A five pound weight is hung at point E and a ten pound weight at point C. How can you balance the arm?
   (a) Hang a five pound weight at G and a ten pound weight at J.
   (b) Hang a ten pound weight at H and a one pound weight at K.
   (c) Hang a fifteen pound weight at I and a one pound weight at H.
   (d) Hang a ten pound weight at I and a five pound weight at G.
   (e) It is impossible.
   (f) Hang a five pound weight at I and a ten pound weight at G.

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

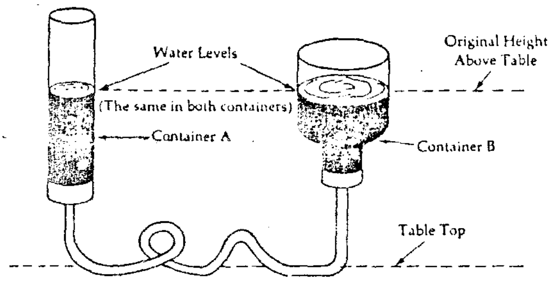
Example:
P_1: No one-year-old babies can walk.
P_2: Paul is a one-year-old baby.
C : Paul cannot walk
This is a valid conclusion.

8. P_1: Not all R's are T's
   P_2: All T's are M's
   C : Some R's may not be M's
   (a) True (b) False

9. P_1: All coal is white
   P_2: All white coal produces red smoke when burning
   C : Therefore when coal burns, the smoke is grey
   (a) True (b) False

10. P_1: When John gets angry at Mary he hits her
    P_2: John is not angry at Mary
    C : Therefore John will not hit Mary
    (a) True (b) False

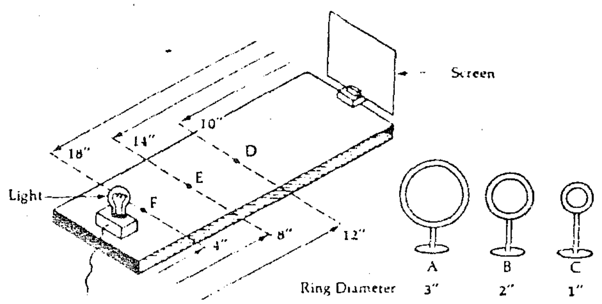
The diagram following represents two open top containers with water in them. There is a length of hose connecting them that will allow water to pass from one container to the other. Container B has a larger diameter than container A. Use the diagram to answer questions 11 and 12.



11. Container A and container B are moved down an equal distance. What will the water levels in the containers do?
    (a) stay at the original height above the table.
    (b) change so that the level in A is above the original height and the level in B is below the original height.
    (c) change so that the level in B is above the original height and the level in A is below the original height.
    (d) change so that the levels in A and B are the same distance above the oriainal height.
    (e) change so that the levels in A and B are the same distance below the original height.

12. Container A and container B are moved up an equal distance. What call the water levels in the containers do?
    (a) stay at the original height above the table.
    (b) change so that the levels in A and B are the same distance below the original height.
    (c) change so that the level in A is above the original height and the level in B is below the original height.
    (d) change so that the levels in A and B are the same distance above the original height.
    (e) Change so that the level in B is above the original height and the level in A is below the original height.

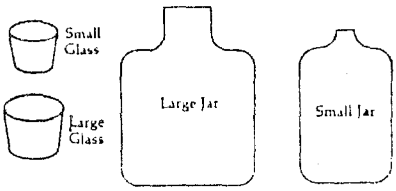
The appratus fololwing can be used to throw shadows onto a screen. The rings pictured can be placed at points D, E, F or any where along lines through each of the three points between the light and screen. The shadows that are referred to in the questions are the circular shadows of the ring only, not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



13. Ring A is placed at point D and when its shadow falls onto the screen the size of its shadow is measured. Ring A is removed and ring B is placed at D. The size of B's shadow is measured. The two shadows formed:
    (a) will be of equal size.
    (b) will be of unequal size, the shadow of A being larger than the shadow of B.
    (c) will be of unequal size, the shadow of B being larger than the shadow of A.
    (d) will be of unequal size, the shadow of A being smaller than the shadow of B.

14. Ring B is placed at point D and when its shadow falls onto the screen the size of its shadow is measured. Ring B is removed and ring C is placed at D. The size of C's shadow on the screen is measured. The two shadows formed:
    (a) will be of equal size
    (b) will be of unequal size, the shadow of B being larger than the shadow of C.
    (c) will be of unequal size, the shadow of C being larger than the shadow of B.
    (d) will be of unequals size, the shadow of B being smaller than the shadow of C.

The diagram following represents two glasses (a small one and a large one) and two jars (a small one and a large one). Use this diagram for question 15.



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

(a) 10 (b) 15 (c) 11 (d) 16 (e) 21

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

Example:

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

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

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

Be careful to mark all the required answers for each question on the answer sheet.

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

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

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

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

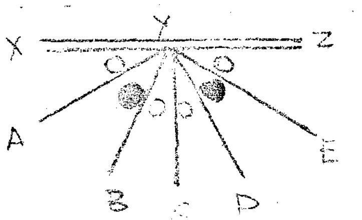
20. (a) brain	is to "head" as	(e) spring	is to	(i) bedpost
(b) eye		(f) blanket		(j) ticking
(c) hat		(g) caster		(k) bed
(d) ear		(h) pillow		(l) summer

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

APPENDIX B

TRANSLATED FORM OF THE LOGICAL REASONING TEST

1. Aşağıdaki şekilde XYZ doğrusu bir duvarı göstermektedir. Bir top hep Y noktasına çarpacak şekilde duvara atılmaktadır.

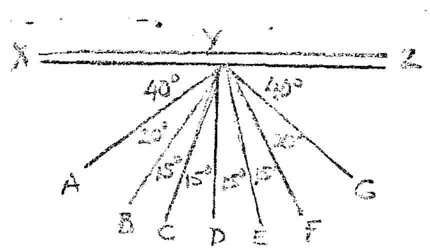


Aynı renkteki açılar birbirine eşittir.

Eğer top Y notkasından B'ye giderse hangi noktadan atılmıştır?

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

Aşağıdaki şekil I. soruda verilen şekle çok benzemektedir. 2. ve 3. soruları cevaplamak için bu şekli kullanın.



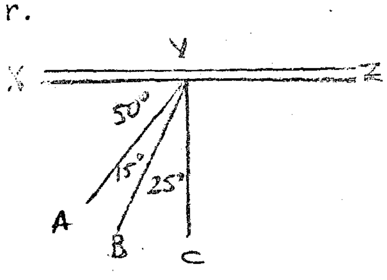
2. Eğer top B noktasından duvardaki Y noktasına atılırsa, hangi noktaya gidecektir?

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

3. Eğer top duvardaki Y noktasından, A noktasına giderse hangi noktadan atılmıştır?

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

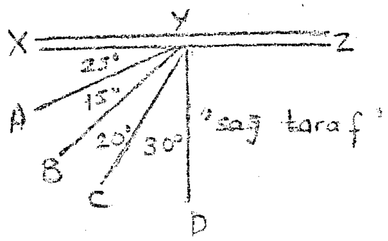
4. Aşağıdaki şekilde bir top A noktasından duvardaki Y noktasına atılmıştır.



Top duvara çarptıktan sonra dönüşte izlediği yol, CY doğrusu ile kaç derecelik bir açı yapar?

(a) 50^0 (b) 75^0 (c) 65^0 (d) 40^0 (e) 25^0

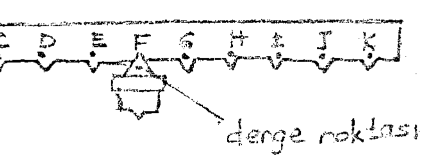
5.

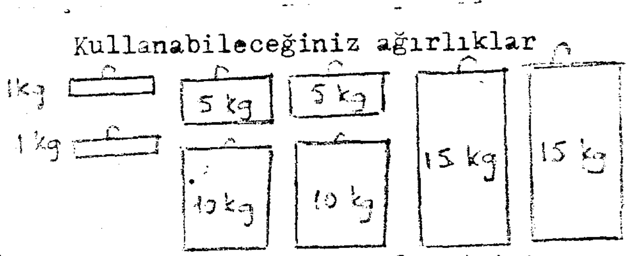


Bir top şekilde "sağ taraf" yazılı kısımdan atılıyor. Y noktasında duvara çarpıyor ve C noktasına gidiyor. Topun atıldığı noktayı Y noktasına birleştiren doğru ile ZY çizgisi arasında kalan açı kaç derecedir?

(a) 25^0 (b) 40^0 (c) 65^0 (d) 60^0 (e) 50^0

Elinizde aşağıdaki şekilde gösterilene benzer bir terazi olduğunu düşünün. Şekli dikkatle inceleyin ve 6-7. sorulara bu şekli kullanarak cevap verin.





6. D noktasına 5 kg'lık bir yük takılırsa, teraziyi nasıl dengelersiniz?

(a) A'ya 1 kg takarak
(b) J'ye 10 kg takarak
(c) H'ye 5 kg takarak
(d) E'ye 10 kg takarak
(e) K'ye 5 kg takarak
(f) dengeleyemem

7. E noktasına 5 kg'lık, C noktasına da 10 kg'lık bir yük takılırsa, teraziyi nasıl dengelersiniz?
   (a) G'ye 5 kg ve J'ye 10 kg takarak
   (b) H'ye 10 kg ve K'ye 1 kg takarak
   (c) I'ya 15 kg ve H'ye 1 kg takarak
   (d) I'ya 10 kg ve G'ye 5 kg takarak
   (e) dengeleyemem
   (f) I'ya 5 kg ve G'ye 10 kg takarak

8-10 sorular kıyaslamalı sorulardır. Herbiri iki önerme ve bir sonuçtan oluşur. Aşağıdaki sorularda iki önermenin birleşmesinden meydana gelen sonucun doğru olup olmadığını bulunuz.

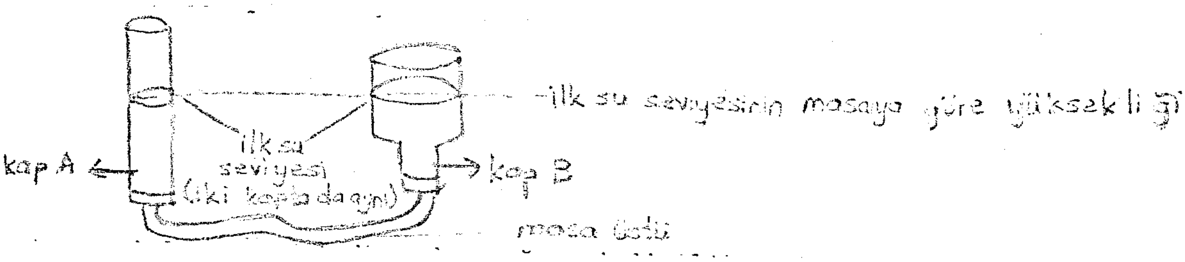
Örnek:
I. önerme: Bir yaşındaki hiçbir bebek yürüyemez.
II. önerme: Ali bir yaşında bir bebektir.
Sonuç : Ali yürüyemez.
Bu doğru bir sonuçtur.

8. I. önerme: Bazı R'ler T değildir.
   II. önerme: Bütün T'ler M'dir.
   Sonuç: Bazı R'ler M değildir.
   (a) Bu doğru bir sonuçtur.
   (b) Bu yanlış bir sonuçtur.

9. I. önerme: Bütün kömürler beyazdır.
   II. önerme: Bütün beyaz kömürler yanarken kırmızı duman çıkartır.
   Sonuç : Bu nedenle kömür yandığında dumanı gri olur.
   (a) Bu doğru bir sonuçtur.
   (b) Bu yanlış bir sonuçtur.

10. I. önerme: Ali Ayşe'ye kızdığında ona vurur.
   II. önerme: Ali şimdi Ayşe'ye kızgın değil.
   Sonuç : Bu nedenle Ali şimdi Ayşe'ye vurmayacak.
   (a) Bu doğru bir sonuçtur.
   (b) Bu yanlış bir sonuçtur.

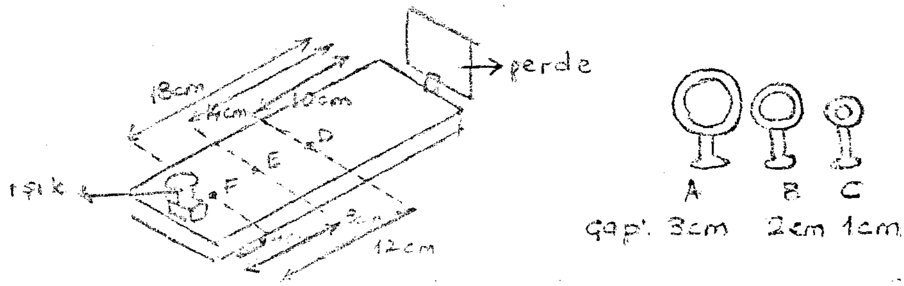
Aşağıdaki şekil içi su dolu bir kabı göstermektedir. İki kabı birbirine bağlıyan hortum sayesinde birindeki su diğerine geçebilmektedir. B kabının çapı A kabının çapından daha büyüktür. 11. ve 12. soruları cevaplamak için bu şekli kullanın.



11. A ve B kabı birlikte eşit miktarda aşağıya indirildi. Kapların içindeki su seviyesi ilk su seviyesine göre ne olacaktır.
    (a) Her iki kaptaki su seviyesinin de masaya göre yüksekliği değişmeyecektir.
    (b) A'daki su seviyesi daha yukarıda, B'deki su seviyesi daha aşağıda olacaktır.
    (c) B'deki su seviyesi daha yukarıda, A'daki su seviyesi daha aşağıda olacaktır.
    (d) Her iki kaptaki su seviyesi de eşit miktarda yukarıda olacaktır.
    (e) Her iki kaptaki su seviyesi de eşit miktarda aşağıda olacaktır.

12. A ve B kabı eşit miktarda yukarıya kaldırıldı. Kapların içindeki su seviyesi ilk su seviyesine göre ne olacaktır?
    (a) Her iki kaptaki su seviyesinin masaya göre yüksekliği değişmeyecektir.
    (b) Her iki kaptaki su seviyesi de eşit miktarda aşağıda olacaktır.
    (c) Her iki kaptaki su seviyesi de eşit miktarda yukarıda olacaktır.
    (d) A kabının su seviyesi daha yukarıda, B kabının su seviyesi daha aşağıda olacaktır.

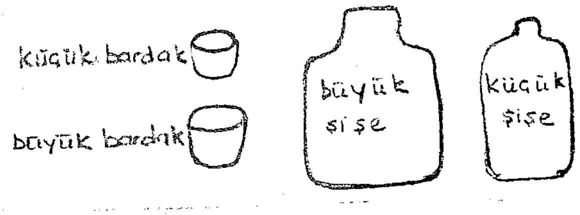
Aşağıdaki alet perdede gölgeler oluşturmak için kullanılır. A, B ve C halkaları perde ile ışık arasındaki herhangi bir noktaya yerleştirilebilir. Şekilde D, E ve F noktalarının perdeye olan uzaklıkları üstte, bu noktaların ığıa olan uzaklıkları ise altta gösterilmiştir. 13. ve 14. sorular için bu şekli kullanın. (Sorularda sözü edilen gölgeler, halkaların yuvarlak kısımlarının gölgeleridir.)



13. A halkası D noktasına yerleştirildi ve perdedeki gölgesinin büyüklüğü ölçüldü. Sonra A halkası kaldırıldı ve yeni D noktasına B halkası yerleştirilip, gölgesinin büyüklüğü ölçüldü. A ve B'nin gölgeleri:
    (a) Aynı büyüklükte olur.
    (b) A'nın gölgesi B'nin gölgesinden büyük olur.
    (c) B'nin gölgesi A'nın gölgesinden büyük olur.
    (d) A'nın gölgesi B'nin gölgesinden küçük olur.

14. D noktasına önce B halkası yerleştirildi ve perdedeki gölgesinin büyüklüğü ölçüldü. Sonra B halkası kaldırıldı ve yine D noktasına C halkası yerleştirildi ve perdedeki gölgesinin büyüklüğü ölçüldü. B ve C'nin gölgeleri:
    (a) Aynı büyüklükte olur.
    (b) B'nin gölgesi C'nin gölgesinden daha büyük olur.
    (c) C'nin gölgesi B'nin gölgesinden daha büyük olur.
    (d) B'nin gölgesi C'nin gölgesinden daha küçük olur.

Aşağıdaki şekilde iki şişe (bir büyük, bir küçük) ve iki bardak (bir büyük, bir küçük) görüyorsunuz. 15. soru için bu şekli kullanın.



15. Küçük şişeyi doldurmak için 6 büyük bardak veya 9 küçük bardak su gerekiyor. Eğer büyük şişe 8 büyük bardak su ile doluyorsa, yine büyük şişeyi doldurmak için kaç küçük bardak su gereklidir?
(a) 10 (b) 12 (c) 15 (d) 16 (e) 11

16-21. sorulara sözel ilişkiler adı verilir. Sözel ilişkiler aynı ilişkiyi içeren iki sözcük çiftinden oluşur. Örneğin "içeri" ve "dışarı" sözcükleriyle "yukarı" ve "aşağı" sözcükleri arasında aynı ilişki vardır. "İçeri-dışarı" ve "aşağı-yukarı" sözcük çiftleri arasındaki ortak özellik, birbirinin zıttı olmalarıdır. Aşağıdaki sorularda her ilişkiyi en iyi biçimde tamamlayacak iki veya üç sözcük seçmeniz gerekiyor. Bazı sorularda iki bazılarında üç yanıt vardır.

Örnek:

(a) lastik
(b) motor
(c) karayolu
(d) harita

ile "araba" arasındaki ilişki

(e) çapa
(f) güverte
(g) kaptan
(h) deniz

ile "gemi" arasında da vardır.

Bu örnekteki ilişkiyi tamamlamak için kullanabileceğimiz en iyi sözcükler, "karayolu" ve "deniz"dir. Sonuçta şu ilişkiyi elde ederiz. "Karayolu" ve "otomobil" arasında, "deniz" ve "gemi" arasında olan ilişki vardır. Bu durumda ortak ilişkiyi hareket kavramı oluşturur. "Otomobil" "karayolu"nda, "gemi" deniz"de hareket eder. Yukardaki soru, cevap kağıdında, aşağıdaki gösterildiği gibi yanıtlanmalıdır.

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

16. "görev" ile

(a) girişim
(b) tamamlama
(c) çalışma
(d) soru

arasındaki ilişki

(e) problem
(f) çözelti
(g) kişi
(h) cevap

ile "çözüm" arasında da vardır.

17\. "ampul" ile
(a) elektrik düğmesi
(b) tel
(c) priz
(d) elektrik
arasındaki ilişki

(e) makina
(f) sandal
(g) motor
(h) buhar
ile
(i) gemi
(j) makine
(k) traktör
(l) kürek
arasında da vardır.

18\. (a) yürüyüş
(b) parmak
(c) diz
(d) ayak
ile "vücut" arasındaki ilişki

"tekerlek" ile
(e) yuvarlanma
(f) makine
(g) bisiklet
(h) fren
arasında da vardır.

19\. (a) at
(b) inek
(c) koyun
(d) ayak
ile "sürü arasındaki ilişki

(e) asker
(f) yığın
(g) takım
(h) döküntü
ile
(i) arı
(j) domuz
(k) tabur
(l) kurt
arasında da vardır.

20\. (a) beyin
(b) göz
(c) şapka
(d) kulak
ile "kafa" arasındaki ilişki

(e) ilkbahar
(f) yorgan
(g) koltuk
(h) yastık
ile
(i) dokuma
(j) minder
(k) yatak
(l) yaz
arasında da vardır.

21. (a) müzik
    (b) ev
    (c) tabure
    (d) ses ayarı

ile "piano" arasındaki ilişki

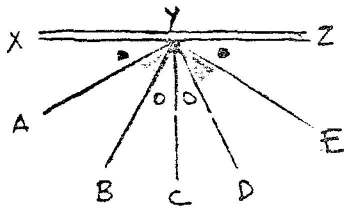
(e) iskemle
(f) bacak
(g) yemek
(h) eşya

ile "masa" arasında da vardır.

APPENDIX C

MODIFIED FORM OF THE LOGICAL REASONING TEST

1. Aşağıdaki şekilde XYZ doğrusu bir duvarı göstermektedir. Bir top hep Y noktasına çarpacak şekilde duvara atılmaktadır.

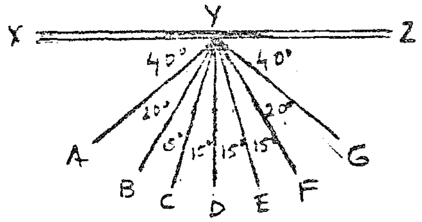


Aynı renkteki açılar birbirine eşittir

Eğer top Y noktasından B'ye giderse hangi noktadan atılmıştır.

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

Aşağıdaki şekil birinci soruda verilen şekle çok benzemektedir. 2. ve 3. soruları cevaplamak için bu şekli kullanın.



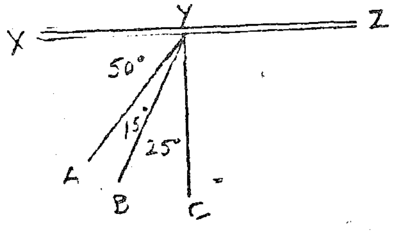
2. Eğer top B noktasından duvardaki Y noktasına atılırsa, hangi noktaya gidecektir?

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

3. Eğer top duvardaki Y noktasından, A noktasına giderse, hangi noktadan atılmıştır?

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

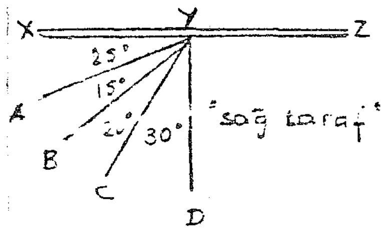
4. Aşağıdaki şekilde bir top A noktasından, duvardaki Y noktasına atılmıştır.



Top duvara çarptıktan sonra dönüşte izlediği yol, CY doğrusu ile kaç derecelik bir açı yapar?

(a) 15 (b) 25 (c) 40 (d) 50

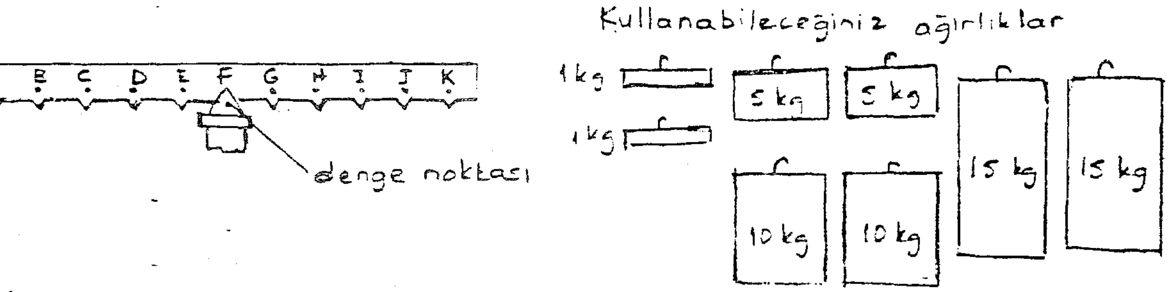
5.



Bir top şekilde "sağ taraf" yazılı kısımdan atılıyor. Y noktasında duvara çarpıyor ve C noktasına gidiyor. Topun atıldığı noktayı Y noktasına birleştiren doğru ile ZY çizgisi arasında kalan açı kaç derecedir?

(a) 60 (b) 40 (c) 50 (d) 65

Elinizde aşağıdaki şekilde gösterilene benzer bir terazi olduğunu düşünün. Şekli dikkatle inceleyin ve 6-7. sorulara bu şekli kullanarak cevap verin.



6. D noktasına 5 kg'lık bir yük takılırsa, teraziyi nasıl dengelersiniz?

(a) A'ya 1 kg takarak

(b) J'ye 10 kg takarak

(c) H'ye 5 kg takarak

(d) K'ye 5 kg takarak

7. E noktasına 5 kg'lık, C noktasına da 10 kg'lık bir yük takılırsa, teraziyi nasıl dengelersiniz?
   (a) G'ye 5 kg ve J'ye 10 kg takarak
   (b) H'ye 10 kg ve K'ye 1 kg takarak
   (c) I'ya 15 kg ve H'ye 1 kg takarak
   (d) I'ya 10 kg ve G'ye 5 kg takarak

8-10 sorular kıyaslamalı sorulardır. Herbiri iki önerme ve bir sonuçtan oluşur. Sonuç iki önermenin birleşmesinden meydana gelir. Aşağıdaki sorularda iki önermenin birleşmesinden meydana gelen sonucu bulunuz.

Örnek:
I. önerme: Bir yaşındaki hiçbir bebek yürüyemez.
II. önerme: Ali bir yaşında bir bebektir.
(a) Ali yürüyebilir.
(b) Ali yürüyemez.
(c) Bütün bebekler bir yaşındadır.
(d) Bebekler yürüyemez.

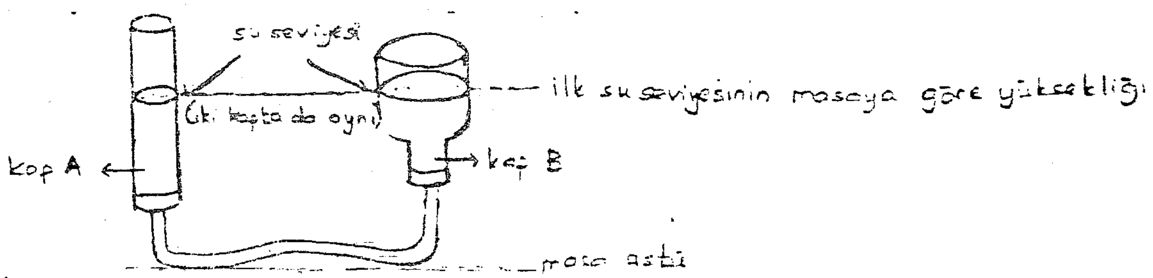
Bu soruda iki önermenin birleşmesinden "Ali yürüyemez" sonucunu çıkarırız. Buna göre doğru cevap (a) seçeneğidir.

8. I. önerme: Bazı R'ler T değildir.
   II. önerme: Bütün T'ler M'dir.
   (a) Bütün T'ler R'dir.
   (b) Bazı T'ler M değildir.
   (c) Bütün R'ler M'dir.
   (d) Bazı R'ler M değildir.

9. I. önerme: Bütün kömürler beyazdır.
   II. önerme: Bütün beyaz kömürler yanarken kırmızı duman çıkartır.
   (a) Kömür yanarken dumanı gri olur.
   (b) Kömür yanarken dumanı kırmızı olur.
   (c) Beyaz olmayan kömürler yanmaz.
   (d) Bazı kömürler siyahtır.

10. I. önerme: Ali Ayşe'ye kızdığında ona vurur.
    II. önerme: Ali şimdi Ayşe'ye kızgın değil.
    (a) Ali Ayşe'ye kızmaz.
    (b) Ali şimdi Ayşe'ye vuracak.
    (c) Ayşe Ali'ye hiç vurmaz.
    (d) Ali şimdi Ayşe'ye vurmayacak.

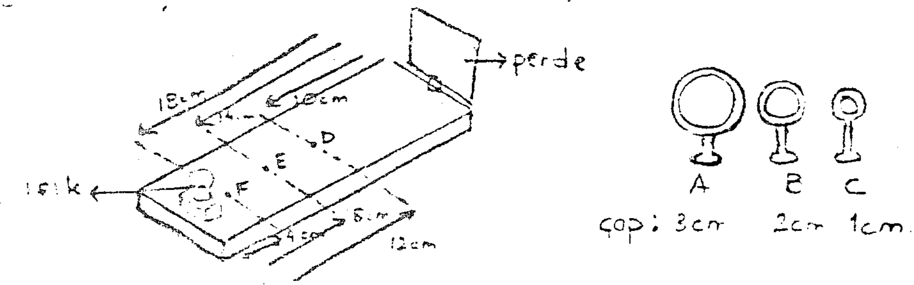
Aşağıdaki şekil içi su dolu üstü açık, iki kabı göstermektedir. İki kabı birbirine bağlıyan hortum sayesinde, birindeki su diğerine geçebilmektedir. B kabının çapı A kabının çapından büyüktür. 11. ve 12. soruları cevaplamak için bu şekli kullanın.



11. A ve B kabı birlikte eşit miktarda aşağıya indirildi. Kapların içindeki su seviyesi ilk su seviyesine göre ne olacaktır?
    (a) A'daki su seviyesi daha yukarda, B'deki su seviyesi daha aşağıda olacaktır.
    (b) B'deki su seviyesi daha yukarda, A'daki su seviyesi daha aşağıda olacaktır.
    (c) Her iki kaptaki su seviyesi de eşit miktarda yukarda olacaktır.
    (d) Her iki kaptaki su seviyesi de eşit miktarda aşağıda olacaktır.

12. A ve B kabı birlikte eşit miktarda yukarıya kaldırıldı. Kapların içindeki su seviyesi ilk su seviyesine göre ne olacaktır?
    (a) Her iki kaptaki su seviyesi de eşit miktarda aşağıda olacaktır.
    (b) Her iki kaptaki su seviyesi de eşit miktarda yukarda olacaktır.
    (c) A kabındaki su seviyesi, daha yukarda, B kabındaki su seviyesi daha aşağıda olacaktır.
    (d) B kabındaki su seviyesi daha yukarda, A kabındaki su seviyesi daha aşağıda olacaktır.

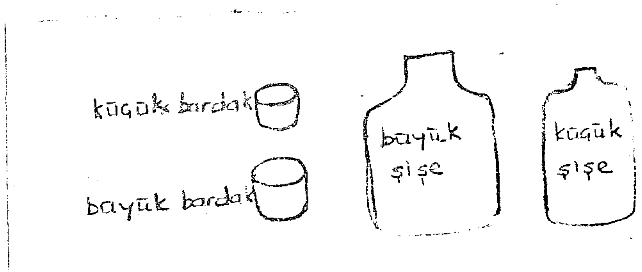
Aşağıdaki alet perdede gölgeler oluşturmak için kullanılır. A, B ve C halkaları perde ile ışık arasında herhangi bir noktaya yerleştirilebilir. Şekilde D, E ve F noktalarının perdeye olan uzaklıkları üstte, bu noktaların ışığa olan uzaklıkları ise altta gösterilmiştir. 13. ve 14. sorular için bu şekli kullanın. (Sorularda sözü edilen gölgeler, halkaların yuvarlak kısımlarının gölgeleridir.)



13. A halkası D noktasına yerleştirildi ve perdedeki gölgesinin büyüklüğü ölçüldü. Sonra A halkası kaldırıldı ve yine D noktasına B halkası yerleştirilip, gölgesinin büyüklüğü ölçüldü. A ve B'nin gölgeleri:
    (a) Aynı büyüklükte olur.
    (b) A'nın gölgesi B'nin gölgesinden büyük olur.
    (c) B'nin gölgesi A'nın gölgesinden büyük olur.
    (d) A'nın gölgesi B'nin gölgesinden küçük olur.

14. D noktasına önce B halkası yerleştirildi ve pardedeki gölgesinin büyüklüğü ölçüldü. Sonra B halkası kaldırıldı ve yine D noktasına C halkası yerleştirildi ve perdedeki gölgesinin büyüklüğü ölçüldü. B ve C'nin gölgeleri:
    (a) Aynı büyüklükte olur.
    (b) B'nin gölgesi C'nin gölgesinden daha büyük olur.
    (c) C'nin gölgesi B'nin gölgesinden daha büyük olur.
    (d) B'nin gölgesi C'nin gölgesinden daha küçük olur.

Aşağıdaki şekilde iki şişe (bir büyük, bir küçük) ve iki bardak (bir büyük, bir küçük) görüyorsunuz. 15. soru için bu şekli kullanın.



15. Küçük şişeyi doldurmak için 6 büyük bardak veya 9 küçük bardak su gerekiyor. Eğer büyük şişe 8 büyük bardak su ile doluyorsa, yine büyük şişeyi doldurmak için kaç küçük bardak su gereklidir?
(a) 10 (b) 12 (c) 15 (d) 16

16-21. sorulara sözel ilişkiler adı verilir. Sözel ilişkiler, aynı ilişkiyi içeren iki sözcük çiftinden oluşur. Aşağıdaki sorularda aynı ilişkiye sahip iki sözcük çiftinden oluşan seçeneği bulun.

Örnek:

(a) "içeri-dışarı"	ile	"aşağı-yukarı"
(b) "açık-kapalı"	ile	"yanlış-hata"
(c) "eski-yeni"	ile	"yaşlı-ihtiyar"
(d) "güzel-çirkin"	ile	"soğuk-serin"

Bu örnekte doğru cevap (a) seçeneğidir. "İçeri-dışarı" ile "aşağı-yukarı" sözcük çiftleri arasındaki ortak ilişki ikisinin de birbirinin zıttı olmasıdır. Diğer seçeneklerde iki sözcük çifti arasında ortak bir ilişki yoktur.

16.	(a) "ders-çalışma"	ile	"soru-cevap"
	(b) "görev-tamamlama"	ile	"problem-çözüm"
	(c) "sınav-hazırlanma"	ile	"yarış-kazanma"
	(d) "dönem-karne"	ile	"deney-inceleme"
17.	(a) "ampul-elektrik"	ile	"kibrit-alev"
	(b) "ütü-priz"	ile	"bitki-su"
	(c) "bisiklet-pedal"	ile	"sandal-kürek"
	(d) "araba-motor"	ile	"gemi-buhar"
18.	(a) "yürümek-insan"	ile	"uçmak-kanat"
	(b) "ayak-vücut"	ile	"tekerlek-bisiklet"
	(c) "ağaç-kök"	ile	"araba-fren"
	(d) "parmak-el"	ile	"at-nal"
19.	(a) "arı-kovan"	ile	"ağaç-orman"
	(b) "koyun-sürü"	ile	"asker-tabur"
	(c) "çiçek-demet"	ile	"yaprak-dal"
	(d) "tavuk-kümes"	ile	"iskambil-deste"

20. (a) "göz-gözkapağı" ile "koltuk-minder"
    (b) "şapka-kafa" ile "battaniye-yatak"
    (c) "kürk-tilki" ile "deri-çanta"
    (d) "resim-boya" ile "mektup-zarf"

21. (a) "telefon-ses" ile "radyo-müzik"
    (b) "daktilo-zarf" ile "piano-nota"
    (c) "televizyon-anten" ile "makine-vida"
    (d) "saat-yelkovan" ile "termometre-derece"

APPENDIX D

DIFFICULTY INDEX OF QUESTIONS IN THE TRANSLATED AND MODIFIED FORMS OF THE TEST (including the difficultyindex means for questions one through 15 and 15 through 21)

QUESTION	DIFFICULTY INDEX TRANSLATED FORM	 MODIFIED FORM
1	0.43	0.53
2	0.50	0.60
3	0.43	0.47
4	0.57	0.53
5	0.36	0.33
6	0.64	0.53
7	0.71	0.27
8	0.36	0.47
9	0.43	0.47
10	0.71	0.53
11	0.50	0.27
12	0.36	0.44
13	0.29	0.47
14	0.50	0.47
15	0.50	0.60
Mean for questions 1-15	0.486	0.467
16	0.00	0.13
17	0.00	0.20
18	0.07	0.40
19	0.29	0.13
20	0.00	0.27
21	0.00	0.20
Mean for questions 16-21	0.06	0.22

APPENDIX E

LOGICAL REASONING TEST SCORES AND FIRST TERM SCIENCE GRADES (of academic year 1983-84) OF THE STUDENTS IN ŞİŞLİ TERAKKİ LİSESİ AND YENİ LEVENT LİSESİ

STUDENT NAME	SCHOOL	LOGICAL REASONING TEST SCORE	FIRST TERM SCIENCE GRADE
Emir Kunt	Şişli Terakki	1	3
Hakan Mimaroğlu	Şişli Terakki	3	3
Murat Sabahat	Y.Levent (7D)	3	3
Turkan Sargın	Y.Levent (7C)	4	3
Funda Tuncer	Y.Levent (7D)	4	3
Mustafa Çakar	Y.Levent (7C)	5	3
Asiye Şahin	Y.Levent (7D)	5	4
Arzu Eriş	Y.Levent (7D)	5	5
Engin Kurtuluş	Y.Levent (7C)	5	4
Mete Memiş	Y.Levent (7D)	6	5
Rıza Gül	Y.Levent (7C)	6	4
Figen Arel	Y.Levent (7C)	6	7
Serpil Ergin	Y.Levent (7D)	7	6
Aysel Serdar	Y.Levent (7D)	7	4
Erdem Sözen	Şişli Terakki	7	5
Saruhan Tan	Şişli Terakki	7	3
Nurhan Bingöl	Y.Levent (7C)	8	5
Murat Yuvakuran	Y.Levent (7C)	8	4
Okan Ulus	Y.Levent (7D)	8	4
Serhat Erkek	Y.Levent (7C)	8	8
Nurten Sadıç	Y.Levent (7D)	8	4
Selim Özakın	Şişli Terakki	8	5
Ayşe Dumral	Şişli Terakki	9	5
Saip Tezel	Şişli Terakki	9	4
Canan Duman	Y.Levent (7C)	9	4
Tulay Çankaya	Y.Levent (7D)	9	4
Gönül Özçelik	Y.Levent (7C)	9	4
Çim Göl	Y.Levent (7C)	10	5
Nihan Teker	Şişli Terakki	10	4
Murat Hepgüler	Y.Levent (7C)	10	4
Ramazan Akgür	Y.Levent (7C)	10	4

STUDENT NAME	SCHOOL	LOGICAL REASONING TEST SCORE	FIRST TREM SCIENCE GRADE
Handan Çakıl	Y.Levent (7C)	10	5
Zeynep Çerperekli	Y.Levent (7D)	10	4
Ayşe Nil Dinler	Y.Levent (7C)	10	7
Handan Kamer	Y.Levent (7C)	10	7
Engin Aykanat	Şişli Terakki	11	4
Vedat Morhayım	Şişli Terakki	11	4
Yasemin Kahraman	Şişli Terakki	11	3
Alp Atakan	Şişli Terakki	12	6
Pınar Türel	Şişli Terakki	12	5
İpek Aydın	Şişli Terakki	12	3
Esra Tolun	Şişli Terakki	12	4
Derya Oğutlu	Y.Levent (7D)	12	7
Seyhan Aslan	Y.Levent (7C)	12	8
Türkan Zilbastı	Y.Levent (7C)	12	7
Abdulkadir Yazıcı	Y.Levent (7C)	12	6
Aren Kalecik	Y.Levent (7C)	12	5
Murat Sadıç	Y.Levent (7C)	12	5
Tolga Çetinkasap	Y.Levent (7C)	12	7
Döndü Neşeci	Y.Levent (7C)	12	5
Yurdagöl Elibol	Y.Levent (7D)	13	3
Koray Dinsel	Şişli Terakki	13	5
Murat Vanlı	Şişli Terakki	13	4
Bertan Doğru	Şişli Terakki	13	5
Arzu Göknar	Şişli Terakki	13	5
Evren Doruk	Şişli Terakki	13	5
Altan Kosova	Şişli Terakki	13	6
Aloz Albay	Şişli Terakki	14	4
Nurten Aykun	Y.Levent (7C)	14	4
Eyüp Günay	Y.Levent (7C)	14	5
Meltem Atalık	Y.Levent (7D)	14	7
Çağla Üçer	Şişli Terakki	15	7
Sevda Tüfekçi	Y.Levent (7D)	15	8
Ersan Divrikoğlu	Y.Levent (7C)	15	7
Dilek Yazıcı	Y.Levent (7C)	16	8
Serhan Sorguç	Şişli Terakki	17	7
Hami Özbek	Y.Levent (7D)	17	7
Murat Erdoğdu	Y.Levent (7C)	18	7
Turgut Derman	Şişli Terakki	18	6

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