Turkish Middle School Students' Cognitive Development Levels in Science

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Abstract
Students' abstract reasoning abilities can differ from one society to another. Students' profiles play significant roles in these differences. The aim of the study is to determine the relationship between middle school students' cognitive development levels and their profiles (age, gender, and science achievement) using the Science Cognitive Development Test (SCDT) in Turkey. The subjects (N=445) were drawn form 7th and 8th grade students at private and public middle schools in five cities. While significant relationships were not found between students' cognitive developments and their genders and ages, a relationship was found with science achievement.

Introduction

Understanding the effects of constructivist and inquiry approaches in science education and studying students' abstract reasoning abilities have become very important. In this process, cognitive growth is considered as a highly desirable educational goal, and many curricula are designed to develop students' particular cognitive skills. The meaning of cognitive development can be defined as students' understanding levels of the concepts or principles, students' operational stages; the concrete operational stage or the formal operational stage, and thinking abilities (Bybee & Sund, 1990).

Many science educators have studied different subjects such as planning and developing instructional programs, classroom activities, laboratory activities, teaching materials, measurement-assessment methods and pre-service teacher education strategies for the purpose of developing students' cognitive thinking abilities (Schneider & Renner, 1980; Moshman & Thompson, 1981; Lawson, 1982; Akdeniz, 1993; Çepni & Özsevgeç, 2002; Özsevgeç; 2002).

Espojo, Good and Westmeyer (1975), and Cohen (1980), express the view that one of the important aims of science education is to develop students' formal reasoning or thinking abilities. Lawson, Karplus and Adi (1978), defend the idea that students should reach a formal operation level to understand abstract science concepts and the processes of scientific investigation. Çepni and Özsevgeç (2002) argue that if assessment questions do not match students' cognitive development levels they would not contribute to developing students' cognitive reasoning. These types of questions also demolish their self-confidence and their enthusiasm towards science lessons and as a result, they would not progress in the cognitive domain as expected.

Many studies showed that the majority of middle and even secondary school students do not reach formal operation level (Shayer, Kucherman, & Wylam, 1976; Lawson, Karplus, & Adi, 1978; Shemesh, Eckstein, & Lazarowitz, 1992; Adey & Shayer, 1990, 1994). Some cross-national (Karplus, et al. 1977; Keats, 1985; Mwamwenda & Mwamwenda 1989; Valanides & Markoulis, 2000) and cultural studies (Wilson & Wilson, 1984; Mwamwenda, 1993a, 1999; Iqbal & Shayer, 2000) have been carried out to determine students' reasoning abilities in order to compare cultural effects on cognitive development levels.

Piburn (1980) investigated the connection among spatial reasoning (the ability to perceive spatial patterns or to maintain orientation with respect to objects in space) and formal thought, especially the schema of proportionality, and science achievement of 6th-form (11 years) high schools students in New Zealand. The subjects were found to be 18% concrete reasoners and 35% formal reasoners and the others were at a transitional level. Male students were more successful on a science achievement test and a Piagetian task, but no significant differences were observed on other tasks and spatial ability. Ehindero (1982) found that in Nigeria there was no significant difference between the mean scores of male and female performance on content-free Piagetian tasks.

A study was done by Mwamwenda (1999) to determine the effects of both age and education levels among African undergraduate students in their performance on combinatorial reasoning tasks. He used a questionnaire consisting of biographical information about participants and combinatorial reasoning questions. At the end of the study, he found that performance on the combinatorial reasoning tasks were related to both students' ages and education levels for African students.

Wilson and Wilson (1984) observed formal operational thought for two-year-National High School and one-year Preliminary Year program students in Papua New Guinea. The study was designed to investigate 11th grade students' Piagetian levels, determine developments in cognitive level during a two year instructional program and examine the relationship between level of cognitive development and science achievement at a National High School (NHS) and one year Preliminary Year program (PY). After the trial, a Pendulum task was used to assess students' cognitive levels. The task was adapted to a group format and responded to by the subjects (N = 739 for NHS and N = 165 for PY) by using the structured answer sheets. They found that there were significant developments in students' cognitive domain for the NHS program. However, most of the students were at the transitional level. In addition to this, a low correlation between cognitive development and science grade was found.

Iqbal and Shayer (2000) investigated Pakistanian secondary school students' development of formal thinking with an intervention program; CASE (Cognitive Acceleration Through Science Education). The study was implemented between "1992 and 1996". The study involved students of two private schools and one public school, in Pakistan. A pendulum, volume and heaviness test was used to determine students' cognitive development levels with a pre-and post-test approach. Students' science and math achievements were tested at the end-of-year examinations at each school. Results show that males' cognitive developments were better than females in the public school. Private school students had higher thinking abilities and science achievement than their public school peers.

From the literature, some studies from both western and non-western countries show that students' gender and age affect their cognitive developmental levels. In addition to this, private school students are determined to have higher reasoning abilities than their peers in public schools. It is concluded that apart from cognitive equilibrium (balance between old learning and learning new things) (Lefrancois, 1995) and ages, students' attitudes, beliefs, academic achievement, gender differences, experiences with teaching materials, and social and environmental conditions also affect students' cognitive development. Although many studies related to this issue have been implemented in many countries; these types of studies have not been given attention in Turkey up to now. Having some unique characters, Turkey differs from other countries. These are; religious differences (almost % 99 percent Muslim), socio-economic levels (less industrial, more agriculture), teaching approaches (teacher-centred and content oriented approaches are dominant), students' and their families expectations from the schools (to have high score from the LGS; a nation-wide selection examination for high schools), culture differences (carrying main characteristics of European and Asian culture and values), place of female students in Turkish society (primary and middle schools are compulsory for each individual in Turkey regardless of their gender). We believe that all these characters make Turkey different from the other countries.

Aim of the study

The aim of the study is to determine 7th and 8th grade middle school students' cognitive development levels by using a SCDT (Science Cognitive Development Test) based on Piagetian theory and to reveal the relationships between students' cognitive development levels and their profiles (age, gender, and science achievement) in Turkey.

Method

a) Subjects

The subjects were 445 seventh-to-eighth-grade students in schools chosen to reflect a cross-section of middle to high socio-economic levels at private and public middle schools in five cities in Turkey. Within these schools, the participating students were chosen using random selection from the classes. While 247 (55.5%) subjects were male, 198 (44.5%) subjects were female. Students' ages are between 107 and 199 months, mean = 147 months, and standard deviation = 10.9 months. All participants live in the central areas of five different cities in Turkey. The reasons for selecting those five cities in five regions are because of the fact that they are economically, socially, culturally, climatically, geographically slightly different from each other. City B and D' socio-economic levels are considered as medium. The economies of these cities are mostly based on agriculture. City A has a high population and its economy would be accepted as medium. City C is a big and modern city and its economy mostly based on tourism. City E is a quite small city and has a low income and social level. Students' success rates on the LGS for city A, B and C is above the average. While city D is the average, students from city E is under the average. Because of these reasons, students live in city C and D in the western part of Turkey are suppose to have higher cognitive developments than city A, B and E in the east part of Turkey.

Private schools are also different from the public schools with some points. They select their students with a nation-wide private schools examination (PSE). Students in these schools come from socially and economically high class and pay quite high tuition. Technical and physical environments of these schools are well designed, classrooms are not crowed and generally qualified and well-known teachers are employed with high salary. They follow the same curriculum with public schools developed by the National Ministry of Education. For the time being, approximately five percent of the middle school students go to these types of private schools. Although public schools are very common all over the country, there are a few private schools in each city. However, the new government tries to improve the numbers of these schools in each city by financially supporting all successful students at public schools. The profiles of the subjects, by school type, year level, and city are shown in Table 1.

Table1. Distribution of subjects according to school type, year level and city

Cities	Public 7	Public 8	Private 7	Private 8	Total
City A	27	30	19	19	95
City B	28	29	20	20	97
City C	30	30	20	20	100
City D	19	29	29	-	77
City E	38	38	-	-	76
Total	142	156	88	59	445

From Table 1, it can be seen that the sample consists of ten public school classes and seven private school classes.

The reasons for this particular selection of middle school students are;

1 According to the Piaget's theory, 7th and 8th grade middle school students should be in transition between concrete and formal operational level such that instructional strategies in schools have substantial effect on their cognitive development.

2. Students come across many science concepts for the first time at 7th and 8th grade and their

knowledge in science concepts is limited. Therefore, they could be expected to directly use their thinking abilities while answering the questions.

b) Developing and validating the instrument

In order to diagnose the cognitive development of children, Piaget pioneered the one-to-one clinical interview. Administering the Piagetian tasks individually has traditionally been recognized as the preferable method for assessing the formal reasoning abilities of an individual. Because of the difficulty of standardizing the methods employed by several interviewers, this technique is not objective (Tschopp & Kurdek, 1981; Ahlawat & Billeh, 1987), and it requires experienced interviewers, significant budgets, and special materials and equipments. In addition, it is too time-consuming and, not objectively and easily assessed (Lawson, 1978). Therefore, a number of authors have considered developing open-ended and structured tests related to cognitive development which can be used to assess individuals in groups of 20 or more at one time (Shayer, Adey & Wylam, 1981). If one's concern is to estimate subjects' optimum level of thinking, group tests may offer further advantages for gathering data from large samples. Besides, they can be at least as valid as, and may be more reliable than clinical interviews. In this study, a group format test was used.

Firstly, a science cognitive development test (The SCDT) covering motion and energy units in the middle school science curriculum, consisting of 30 questions, was prepared to determine students' cognitive development by taking into consideration the characteristic of the Piaget's concrete and formal operational stages. After developing questions, six experts in science education independently examined each question to check whether it is suitable in terms of characteristics of the developmental levels. If 95% of the experts agreed on an item, this item was put on The SCDT. Further, five middle school science teachers examined deeply the test's reading ability and appropriateness of the items for their instructional program. In this way, The SCDT's content and validity was assured. The first SCDT consisted of two subtests. One subtest consisted of 10 questions involving concrete operational abilities. Another subtest comprised 20 questions involving formal operational abilities.

Two pilot studies were carried out for The SCDT. In the first pilot study, reading ability was tested with 30 seventh middle school students and item analysis was done. The number of test questions was reduced from 30 to 27. A second pilot study involved another 35 seventh middle school students who ranged in age from 133 to 151 month. The mean age = 4.39 month. In the process of second pilot study item analysis was done again and the final SCDT consisted of total 22 questions.

Finally, The SCDT's reliability coefficient was calculated ($r = 0.66$). Saunders and Shepardson (1987), developed a cognitive test to determine student's thinking ability and found a reliability coefficient ($r = 0.63$). They stated that their reliability coefficient was sufficient to determine student's thinking abilities. In this respect, our reliability coefficient is capable of determining students' cognitive development.

The final SCDT (see Appendix) comprises of 22 science context questions. The first 20 questions were multiple choice and the 21st and 22nd questions are open-ended. The concrete operational part consists of 7 questions: seriation, 3 questions; classification, 2 questions and conservation, 2 questions. The formal operational part comprises 15 questions: probability reasoning, 5 questions; proportional reasoning, 1 questions; combinatorial reasoning, 2 questions; correlational reasoning, 2 questions; controlling variables, 2 questions and hypothetical reasoning, 3 questions.

c) Data analysis

Teachers to both public and private 7th and 8th grade middle school students in the five cities administered The SCDT, during a 50-minute school session. Within this time limit, students were generally able to complete and revise the test items.

To analyse the data basic statistical techniques and the SPSS statistical programme were used to determine significance levels. Two different scales were used to assess the correct answers. In the first scale, one point was given for each multiple-choice question. In the second scale, each open-ended question consisting of four propositions, for each correct proposition 0.25 point was given. Students' total points were calculated in The SCDT. According to students total point score their cognitive development was categorized as concrete (II) or formal (III). Each category includes A and B classification; early concrete 2A, fully concrete 2B, early formal 3A and fully formal 3B levels of cognitive development (Rowell & Hoffmann, 1975). Meanings of each category as concrete 2A, 2B, formal 3A and 3B were given in detail by Nordland, Lawson and Kahle (1974). The scores of the entire sample on The SCDT ranged from 0 to 22. Responses were categorized and points awarded as follows: 0-6 points = concrete 2A; 7-14 points = concrete 2B; 15-20 points = formal 3A and 21-22 points = formal 3B (Nordland, Lawson & DeVito, 1974).

In this way, each class and school's score was calculated. Descriptive and basic statistical methods were then used to determine the distribution of students' development levels regarding stage and sub-stages, gender and stage cross tabulation, percentage of students' answers in the concrete and formal questions by school type.

Findings

In this part, the distribution of subjects' gender, developmental levels in respect of stages and sub-stages, gender and stages cross tabulation and percentage of students' correct answers in the concrete and formal questions regarding school type, is given. Relationships between cognitive development and students' profiles were investigated by means of SPSS. Table 2 shows the participant's cognitive development levels and sub-levels.

Table 2. Distribution of students' development levels according to stage and sub-stages

Stage	Sub-stage	N*	Frequencies	Percent	Total percent
Concrete	Concrete 2A	387	102	22.9%	86.9%
	Concrete 2B		285	64%	
Formal	Formal 3A	58	55	12.4%	13.%
	Formal 3B		3	0.7%	
	Total	445			100

*N; refer to number of students

From the table, the majority of the sample (86.9%) is at the concrete stage and a few of them (0.7%) are able to reach formal 3B.

Table 3. Gender and stage cross tabulation

Gender		Concrete 2A	Concrete 2B	Formal 3A	Formal 3B	Total
Male	N	54	155	38	----	247
	Percent of gender	21.9%	62.8%	15.4%	----	100%
Female	N	48	130	17	3	198
	Percent of gender	24.2%	65.7%	8.6%	1.5%	100%
Total	N	102	285	55	3	445

This table shows that majority of male students (62.8%) and female students (65.7%) were found at the concrete 2B level. Only 3 female students (1.5%) are classified as formal 3B thinkers.

Table 4. Percentage of students' correct answers in the concrete and formal questions according to year level and school type

Year level and school type	Concrete%	Formal%
Year 7, Public classrooms (N* = 142)	46.4	38.9
Year 8, Public classrooms (N = 156)	44.1	36.2
Year 7, Private classrooms (N = 88)	52.6	44
Year 8, Private classrooms (N = 59)	68.3	49.4

*N; refer to number of students

Table 4 shows both public and private school students' correct answers to the concrete and formal operational questions. The private school sample gives more correct answers both concrete and formal questions (ranging from 44% to 68.3%) than public school peers (ranging from 36.2% to 46.4%).

Table 5. Comparison of gender differences, t and significance level

Stages/Gender	N	Means	S.D	t	p
Male	247	38.62	15.98	.810	.418
Female	198	37.40	15.51		

Table 5 shows a comparison of gender regarding students' cognitive development level. Mean scores for the male students are slightly higher than the female students. However, gender differences were not significant at .05 level ($t_{(445)} = .81$, $p = .418$).

Table 6. Comparison of students' cognitive development with ages and science achievements

Variables	df	F	p
Stages & Ages	4 & 437	.491	.742
Stages & Achievement	4 & 437	39.05	.000

One-way ANOVA was used to determine differences between students' cognitive development levels and their ages. F ratio ($F_{(4,437)}$ = .491, p>.05) shows that there is not a significant difference between their age and their cognitive development levels.

Subjects' science achievement scores were determined by using the standard test results. In Turkey, almost all science teachers do not set their own papers for their students' assessments. Since the purpose of these teachers is to prepare their students for the LGS, they usually use the standard tests developed by private companies. Reading ability, validity and reliability of these standard tests are done professionally by the experts. Therefore, both public and private science teachers use these types of tests to assess their students' achievements in schools. For this study, we obtain students' science achievement test results from each science teachers in the samples. Subjects' science achievements in the schools and their cognitive development levels in The SCDT were investigated with one-way ANOVA test. Students' cognitive development levels and science achievement scores showed that significant difference ($F_{(4,437)}$ = 39.05, p< .05) were found.

Table 7. Differences between the 7th grade public and private schools students

Schools	N	Means	S.D	t	p
Public 7th classrooms	142	36.32	11.87	-4.04	.000
Private 7th classrooms	78	44.26	17.09		

From the comparison of seventh grade middle school students in terms of cognitive development levels between public and private school, a significant difference ($t_{(220)}$ = - 4.04, p< .05) was found.

Table 8. Differences between the 8th grade public and private schools students

Schools	N	Means	S.D	t	p
Public 8th classrooms	154	34.11	14.89	-6.38	.000
Private 8th classrooms	59	48.74	15.19		

The 8th grade private middle school students' mean was rather higher than public middle school students mean in The SCDT. Differences between two school types for the same grade were found significant at .05 level ($t_{(213)} = -6.38$, $p < .05$).

Discussion and Results

Data obtained from this study shows that the sample was 22.9% concrete 2A and 64% concrete 2B reasoners and 12.4% formal 3A and only 0.7% formal 3B reasoners. These results show evidence that the majority of the sample have not reached the formal operation level yet. However, the majority of the subject's ages were over 11 years who are supposed to have the characteristics of formal operational thinking of the Piagetian theory. In the related literature, the universality of the first three stage of cognitive development has been substantially confirmed, however the stage in the development of formal operational thinking, have not been so confirmed (Lawson, 1995). Nordland, Lawson and Kahle (1974) found out that 83.4% of seventh grade Hispanic middle school students were at concrete and 15.6% of them were at formal level. Some research results show middle school students generally are at a concrete developmental level, the percentage ranging from 77% to 83.4% (Renner & Stafford, 1972; Chiappetta, 1976). In our study, findings concerning concrete development level were 86.9%, which is parallel to the existing literature results.

When we began to plan this study, firstly we hoped to find gradually increasing students' cognitive development levels from east to west. But, at the end of the study it was surprised that seventh grade student's public school in one city, which is rural area and has socially, economically and physically insufficient conditions, were more successful from other cities. At the same time, another interesting result, all the formal 3B thinkers are female and private school students. This result support Wilson and Wilson’s (1984) view that cognitive abilities can be differ from one society to another and even differs among students who are in the same classes.

However, students performed poorly on almost all items of The SCDT and the sample was more successful in concrete questions than formal questions. Private school students gave more correct answers (44%-68.3%) than public school students (36.2%-46.4%) to The SCDT. This shows that private school students are more successful for both concrete and formal questions than their peers at public schools.

Generally private school students had higher cognitive development levels than their peers in the public schools. Comparison of seventh grade public (mean = 36.32) and private middle school (mean = 44.26) students in terms of cognitive development levels showed significant difference ($t_{(220)} = -4.04$, $p < .05$). Eighth grade private middle school students mean was (48.74) rather higher than public middle school students mean (34.11) in The SCDT and differences between 8th grade students were found significant at .05 level ($t_{(213)} = -6.38$, $p < .05$). A study by Iqbal and Shayer (2000) showed that scores related to private school students’ cognitive development were higher than public school students’ cognitive development. All these results show that socio-cultural factors seem to have a more important effect on cognitive development than the Piaget’s prediction. In our case, the majority of our sample has not reached at formal operational stage. However, the test results indicated that many students were in the process of developing their reasoning abilities. As mentioned earlier, these results may arise from socio-cultural differences of Turkey. It is believed that cultural or educational environments have a supporting role, that is, they may help speed up or slow down cognitive development. But, they cannot change the very nature of development (Dasen & Heron, 1981), because cognitive development could be explained more from a biological point of view (Moessinger, 2000).

Various studies have identified factors that may explain why private school students have higher cognitive development levels than students at public schools. These factors are; laboratory possibility and conditions, instructional techniques, textbooks, measurement-assessment methods, socio-economic levels and using up to date technologies in the teaching-learning process (Lawson, 2000; Valanides & Markoulis, 2000; Çepni & Özsevgeç, 2002; Özsevgeç, 2002).

An important characteristic of Piagetian theory is the relationship between cognitive development and individuals' age. In this study, the relation between students' ages and cognitive development levels were examined but significant relation ($F_{(4,437)} = .491$, $p>.05$) was not found. The similar result was found by Wilson and Wilson (1984) that students 'cognitive development levels were not related to subjects' age in Papua New Guinea, if subjects' ages are close to each other. However, if we are looking for a relationship between age and cognitive development, sample age intervals should be taken over a wide scale. In our study, we took only seventh and eighth grade students. Therefore, our non-result may be due to the narrow age distribution of our sample.

In many studies gender differences have been linked to cognitive development, but other studies have claimed the contrary. In our own study, while there were gender differences in the distribution of scores, the mean difference between the two groups was not significant. There was no significant relationship between cognitive development and gender ($t_{(445)} = .81$, $p> .05$). Ehindero's (1982) and Mwamwenda (1993a), also did not find a significant relationship between students' cognitive development and their ages in Nigeria, and Africa generally.

Piaget's theory is considered to predict a relationship between students' cognitive development and science achievement. Many studies in the literature have reported a meaningful relationship between them. In our study, an important significant relationship was also found between students' cognitive development and their science achievement ($F_{(4,437)} = 39.05$, $p<.05$). Lawson (1983), Mwamwenda (1993b) and Vass et al. (2000) found similar results; students who are at the upper cognitive levels have higher scores in science lessons. At the same time, Adey and Shayer (1994) argue that it is possible to intervene in students' cognitive development with effective science teaching. In this way formal reasoning abilities could be significantly increased, and it is claimed that such efforts affect students' academic achievement positively.

However, socio-economic and cultural factors affect individuals' cognitive developments, regardless of industrial or agriculture society, majority of children has not been fully able to reach the expected levels or the formal operational levels. All these results would show that there were not too many differences among developed and developing countries children in terms of cognitive development levels.

Implications

It is recommended that the use of The SCDT test appears to be a useful tool for science teachers to get to know their students' reasoning ability levels. In this way, science teachers are able to determine their students' cognitive capacities. Then, they are able to construct their instruction accordingly. If the students' cognitive development lags behind the cognitive demands of curriculum and teaching, then teachers need to become aware of the limitations of their students. In this process, to promote students' reasoning skills, it becomes necessary for science teachers to use some concrete materials in their science classroom. Knowing intelligence-stages can also facilitate and stimulate discovery learning and problem-solving behaviours and promote students' inquiry abilities. In this way, science teachers would extent students' cognitive development and accelerate it in the transitional levels (Collette & Chiappetta, 1989).

Science teachers should be aware of the fact that cognitive progress is not completely depended on biological factors, but also the particular activities stimulated and reinforced by the cultural and educational environments. Teachers' duties in this process are to implement ethnographic research to draw out cultural and social patterns of their students. To develop students' cognitive and conceptual development, apart from the learning cycle approach (Ayas, 1993), currently using 5E and 7E models at science teaching learning process are strictly recommended (Çepni et al. 2001). Therefore, all science teachers should take in-service courses related to the philosophies of constructivism, and developing materials carrying characteristics of the 5E and 7E models.

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Appendix

THE SCIENCE COGNITIVE DEVELOPMENT TEST (THE SCDT)

1- *(Classificational reasoning):* An airplane is flying in a straight line at a constant speed and it has energy. Which of the choice below similar with the airplane's energy?

A) A vehicle moving at a constant velocity on a motorway

B) A child skating on a ice pond

C) Water flowing down from high to low place

D) A man not moving

2- *(Classificational reasoning):* "An object takes equal distances in the equal time intervals"

"An object's velocity changes in the course of time"

According to this information, which of the following object hasn't acceleration?

A) A plane landing

B) A motorbike speeding up

C) A vehicle slowing down

D) A car with a steady velocity

3- *(Classificational reasoning):* Some forces affect our daily life such as; they can change objects' shapes and move objects from one point to another. How do you categorize the statements below according to the influences of the forces on changing object shapes and moving objects?

I- Spring passing the flexibility limit

II- Magnet pulling up iron powders

III- A car moving upward

IV- Metal tablet flatten

A) I with III; II with IV B) I with IV; II with III

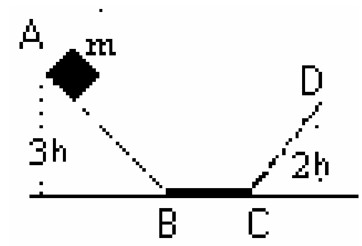
C) I with II; III with IV D) II, III and IV

4- *(Seriational reasoning):* The Car K, the Car L and the Car M take difference distances in different time and their velocities are V_K, V_L and V_M. Which choice below makes a correct comparison among three cars' velocities?

Vehicle	Way	Time	Velocity
K	20 m	10 sn	V_K
L	12 m	12 sn	V_L
M	10 m	8 sn	V_M

A) $V_M = V_L > VK$ B) $V_K > V_M > V_L$ C) $V_L >_M = V_K$ D) $V_L > V_K > V_M$

5- *(Seriational reasoning):* An object of mass m released from point A initially at rest. After passing between B-C has a frictional surface, it reaches the highest point D and then turns back again. V_B, V_C and V_D are the objects' velocities in the points B, C and D; EA, E_B and E_D are the objects' potential energies in the points A, B and D. Which choice below makes a correct comparison among velocities and potential energies?



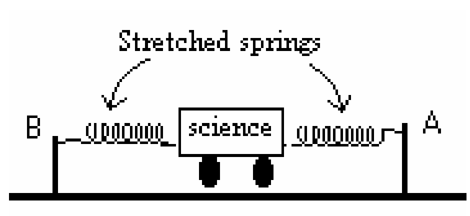
A) $V_B > V_C > V_D$ $E_B < E_D < E_A$

B) $V_B = V_D > V_C$ $E_A < E_B < E_D$

C) $V_C > V_B > V_D$ $E_B = E_A < E_D$

D) $V_B > V_C = V_D$ $E_B < E_A = E_D$

6 – *(Conservational reasoning):* The picture shows a vehicle is balanced with two homogeny stretched springs at the points A and B. When one of the springs breaks off, the vehicle began to move. Which of the statements does explain this situation the best?



A) If forces are balanced, the vehicle moves

B) Whenever two equal opposite forces act on the vehicle, it doesn't move

C) If the vehicle moves, forces do not balanced

D) A stretched spring moves all of the objects

7- *(Conservational reasoning):* An archer is putting his arrow on his arch and pulling back it. Then, he is shooting the arrow on the target. Which of the situation below occurs while the arrow reaches on the target? (Frictions are ignored)

A) When an arch is stretched, physically no work done

B) The total energy of the arrow at the end is bigger than the beginning time energy of the arrow.

C) The arrow energy doesn't change during the distance

D) By stretching the arch some potential energy is gained, and this energy turns kinetic energy when the arrow began to move.

8- *(Probability reasoning):* Two horizontal forces in the same direction are acting on an object, which is on a horizontal frictional surface, and it is speeding up. Which choice(s) should be done to speed down the object's velocity?

I- Less frictional surface should be chosen

II- The object's weight should be reduced

III- An opposite force should be applied on the object

A) Only I   B) I and II   C) II and III   D) Only III

9- *(Probability reasoning):* An object is originally at rest and began to move by the help of three forces. In this condition, which of the following statements about the forces are wrong?

I- Two forces may be in the same direction

II- All of the forces may be in the same direction

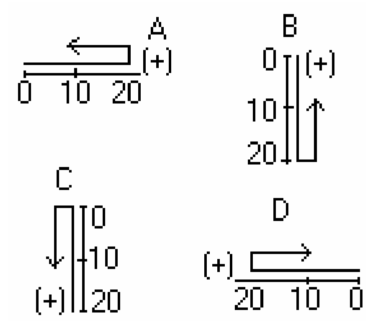
III- Net force is zero

A) Only I   B) Only II   C) Only III   D) I- II

10- *(Probability reasoning):* Both a-4 Newton horizontal force and a-5 Newton horizontal force are acting on an object, but the directions of the forces are not known. According to this information, what is the possible range of the magnitude F for the net force acting on the object?

A) $1 \leq F \leq 4$ B) $1 \leq F \leq 9$ C) $4 \leq F \leq 5$ D) $1 \leq F \leq 5$

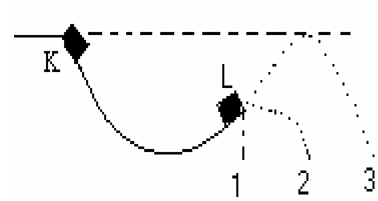
11- *(Probability reasoning):* A car can move at every direction on a horizontal or a vertical line. It is moving 20 meters positive direction and then turning back and moving 10 meters. Which of these pictures show the car's moving?



A) A and D   B) A and C

C) B and D   D) All

12- *(Probability reasoning):* An object released from initially at rest at the point K and any information is not given about friction.



Which of the dotted lines best show the trajectories that the object would follow after it leaves from the point L.

A) Only 1 B) Only 2 C) Only 3 D) All

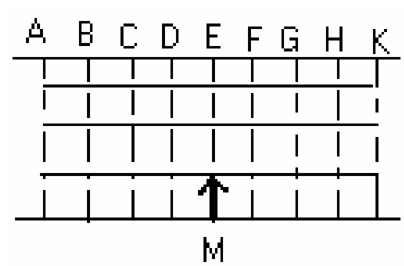
13- *(Proportional reasoning):* If an object makes free falling from a height point, after 1, 2 and 3 seconds it takes 5, 20 and 45 meters respectively. After 4 seconds what meters does it take?

A) 55 m B) 70 m C) 80 m D) 95 m

14- *(Combinatorial reasoning):* The Car A and Car B are moving parallel in the same direction. You make hypothesis that for a moment, the Car A's velocity is exceeding the Car B's velocity. Which of the following statements below are valid?

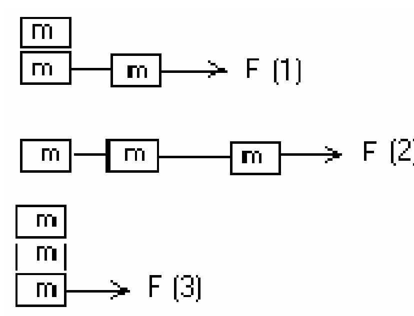
A) The car B takes more distance than the car A
B) The car A takes less distance than the car B
C) The instantaneous acceleration of the car A bigger than the car B
D) The instantaneous acceleration of the car B bigger than the car A

15- *(Combinatorial reasoning):* A swimmer starts to swim the point M with a first speed V. He also knows that the river flows with a speed V, but he hasn't knowledge about direction of the river's flow. According to this information, at which points do the swimmer could reach to the other side?



A) A-K B) B-H C) D-F D) C-G

16- *(Correlational reasoning):* The pictures show three objects tied together with same rubber bands being pulled to right across a horizontal frictionless surface by a horizontal force F. All the objects have the same mass; all rubber bands obey Hooke's law, have the same equilibrium and the same force constant. Which one of these systems does move at first?



A) Only 1 B) 1 and 2 C) 2 and 3 D) All

17- *(Correlational reasoning):* An object's weight, height and gravity acceleration are given below.

Height	Gravity	Weight
10 meter	9.8 m/sn^2	98 N
900 meter	9.6 m/sn^2	96 N
840 meter	9.7 m/sn^2	97 N

Which choice or choices below are correct?

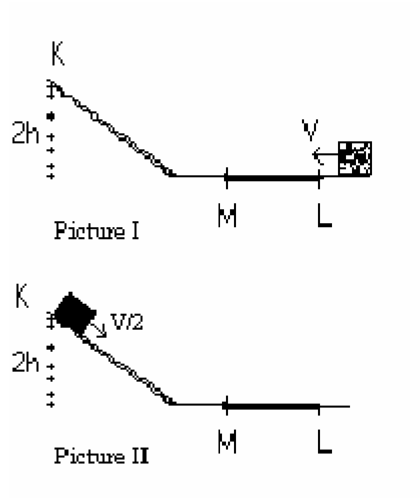
I- When height goes up, weight goes up

II- Weight has a reverse proportion with the gravity

III- When height goes down, the gravity goes up

A) Only II   B) Only III   C) I and II   D) II and III

18- *(Controlling variables):* The picture 1 shows movement of the object thrown from point L with a first speed V. It is passing from the frictional distance (LM) and reaching the highest point K. Then, it is turning back and stopping at point L.

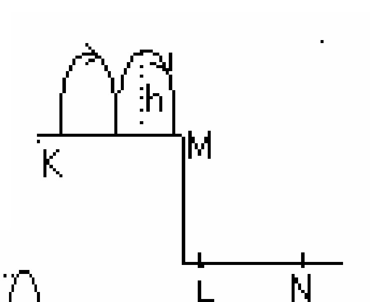


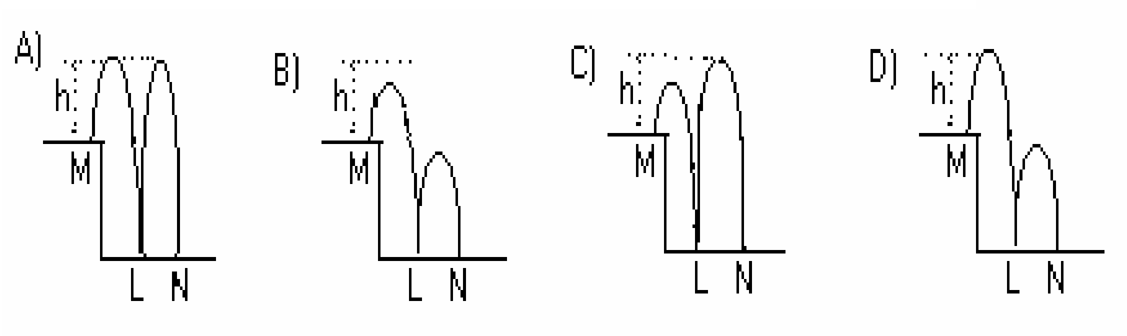
In the picture II, if the object thrown from point K with a first speed V/2, where is it stop?

A) Between K- M   B) M

C) L   D) Between L- M

19- *(Controlling variables):* The picture shows an object's motion between points K-M and all the floors (K-N) have the same properties (no friction). After point M, which of these pictures show the object's motion between M and N?

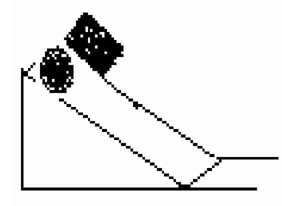




20-

(Hypothetical reasoning): If a horizontal force moves an object at rest on the frictional surface, what do you say about net force?

A) Net force is in the same direction with frictional force
B) The downward force doesn't effect the resultant force
C) Net force is zero
D) Net force is bigger than frictional force



21- *(Hypothetical reasoning):* In the frictional surface, spherical and rectangular objects, which are have the same mass, released from at rest the highest point an the inclined ramp. At the end of inclined ramp, which of the object does firstly reach the down ramp? Explain your reasons.

22- *(Hypothetical reasoning):* When a force is applied to the flexible objects, it changes their shapes. After the force removing, they are turning back their old shapes. If there isn't any flexibility of objects, which challenges do, we come across our daily life? Give at least four examples.