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The Cognitive Abilities of Children: Reflections from an Entrance Exam

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The basic determiner for the school in which the children who completed their primary education will in at an upper education level in Turkey is the entrance exam carried our nationwide. The items of national exam, called as LED (Level Determination Exam) which the primary education pupils (aged between 12 and 15) will participate in Turkey were analyzed according to Piaget's theory of cognitive development in this study. The purpose of this analysis is to examine whether this exam contributes to the development of children's cognitive ability or not, and how much each question was accomplished by the students who was focused on. The students' condition to cope with the concrete and formal operational stage cognitive abilities were tried to be determined in this way. The study was carried out through document analysis method. Most of the questions of the exam were aimed at evaluating the formal operational stage abilities. According to the findings obtained from more than three million students, Turkish children were rather unsuccessful in correlational cognitive ability. The children's hypothetical thinking ability is weak, too. Some suggestions were made to take LDE and help the students acquire formal operational stage cognitive abilities.

Keywords: Piagets' theory of cognitive domain, LED (Level Determination Exam), science education

Introduction

Today, it is an indisputable reality that the main purpose of education systems is to teach the students how to think. The high order cognitive skills, such as logical thinking and critical thinking, are the basic skills for daily life, apart from the academic achievements in the schools (Gürol, 2011; Marshall and Horton, 2011; McCormack, 2009). In order to make the standards of education better, the nature of development of cognitive skills is required to be understood in all components of education, such as curriculum development, teaching practices and assessment and evaluation (Gödek, 2005; Kuhn, 1979). But, unfortunately, cognitive development is used more to discuss whether the syllabus subjects are suitable for the level of students or not (Hinde & Perry, 2007). The teachers do not practice teaching in their courses which will support the development of high order cognitive abilities in students (Ewing, Foster, & Whittington, 2011). The teachers are also not aware of whether their teaching practices contribute to the development of students' cognitive ability or not (Newcomb & Trefz, 2005).

Evaluation is the basic component of education. Evaluation has many functions, except presenting data

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about how many educational objectives are reached. One of them is that evaluation affects the students' learning strategies and cognitive development (Gipps & James, 1996; Black & Wiliam, 1998; Wilson & Scalise, 2006). For example, if the teacher does not ask questions which require transferring the subject studied in the class, he/she can hinder the development of deep learning strategies and high order cognitive abilities for the students. The studies reveal that the teachers usually are not aware of which cognitive ability they are evaluating with the questions they ask, which deepen/take root low order cognitive abilities in the students (Ayvacı & Türkdoğan, 2010; Çalışkan, 2011; Çepni, 2003; Gray, 1978; S. Karamustafaoğlu, M. Karamustafaoğlu, Bacanak, & Değirmenci, 2011; Vendlinski, Nagashima, & Herman, 2007).

Education systems are under the control of large-scale exams in most European and Asian countries and the USA (Stanley, 2012; Tienken, 2011). The students sit for national or/and regional scale evaluations, such as matriculation or exit exam, entrance exam, standardized admission test, while they are still at basic education level. By using the points taken from these exams either separately or combining them with school achievement, special ability tests and acceptance letters, the students are accepted to the stage of higher education school in which they will pursue for their study. For example, Secondary school admission test was used as an indicator for the admission of students by a lot of elite schools in Canada and the USA (The Stress-Free Guide to the ISE **(**Independent School Entrance Exam)-HSPT (High School Placement Test)-SSAT (Secondary School Admission Test), 2004). In the Caribbean countries, basic education students have to take large scale assessments known in different names, such as Eleven plus Examinations, Secondary Entrance Assessment and Common Entrance Examination, during the process of election or placement for secondary education (Lisle, Smith, Keller, & Jules, 2012). The students who completed their basic education and wanted to be accepted by the schools giving that academic education take 11 plus exam (Leonard, 2006). The 12-year-old South Korean students compete in the exams in order to continue their education (Seth, 2002).

In Turkey, the schooling consists of three main components: basic Education (primary and middle schools, aged between seven and 15; eight years), secondary education (high schools, four years) and higher education (colleges and universities). The primary education which takes eight years is compulsory for every student. The purpose of basic education is to have the students to acquire basic knowledge, ability, attitude and values which are stated in national standards. In basic education, the students take courses, such as Turkish, mathematics, science and technology, social sciences, foreign language, art, music, physical education and ethics. Secondary schools are generally classified into two groups: one group is given academic education; the other group is given vocational and technical education. Science high schools which focus on science education and Anatolian high schools which concentrate on foreign language education are quite popular, because carrying on one's education in such schools after basic education is seen as a key to enter an elite university. An elite university increases the chance of getting a good job and a career after graduation (Kara & Çepni, 2011). Because the quota of schools giving academic education is limited, these schools admit students by combining the scores of LDE (determination exam) points carried out in national scale and weighted achievement point that the students obtained from the school where they are educated.

LDE is composed of native language, math, science, social sciences and foreign language questions. The questions are multiple-choice, and each question has four alternatives. The students, who are to complete the Grade 6 and Grade 7, and Grade 7, take these exams. At the end of the three years, the points obtained from these exams are collected together, and the students' general condition is determined. Seventy percent of LDE is added to the general evaluation for the admission of secondary education. All the processes of LDE (preparation of questions, application for the exam, administration of the exam, the evaluation of the results, and announcement of the exam results, etc.) are carried out by General Management of Education Technologies.

LDE, which opens the doors for a high-quality future, has quite a competitive structure. Every year more than a million students struggle to be the best among their peers. The students get prepared for LDE with supporting materials, such as tutors, private courses and a lot of preparatory test books for the exam in this merciless competition. The teachers suggest that the students should solve 300 to 500 questions in one day. The questions asked in LDE in the previous years and their parallels are used to guide the preparations. In this context, we think that it is inevitable for the students to develop a thinking system parallel to the exam questions. The analysis of large-scale exam questions in terms of cognitive stages and thinking skills has become the subject of some studies (Azar, 2005; Çepni et al., 2001; Çepni, Gökdere, & Özsevgeç, 2002; Çepni, Özsevgeç, & Gökdere, 2003; S. Karamustafaoğlu, Sevim, O. Karamustafaoğlu, & Çepni, 2003; Palmer, Duggan, Devitt, & Russell, 2010). In only few of these studies, the exam questions prepared for basic education were put under analysis. Moreover, the students' status to deal with these questions was studied. The questions which most of the students could not answer, and the association of cognitive abilities required with these questions can present important hints for curriculum developers, teachers and test makers. Two questions guided the study:

(1) Do the science questions in LDE have the potential to contribute to the development of formal operational stage abilities?

(2) What is the status of the students to handle the concrete and formal operational stage cognitive abilities?

Method

Design of Research

In this study, the method of document analysis was used. Document analysis is the systematic examination of written documents and records of the concept or event that is studied (Yıldırım & Şimşek, 2005). The science questions of 2010 LED (Level Determination Exam) booklets of the Grades 6, 7 and 8 were analyzed. The exam booklets can be obtained from the official Website of General Management of Science Technologies (Retrieved from http://egitek.meb.gov.tr).

Total 3,144,794 students, 1,077,749 of whom are Grade 6 students, 1,058,743 are the Grade 7 students and 1,008,302 are the Grade 8 students, participated in the exam in 2010. In order to determine the status of the students to deal with the concrete and formal operational cognitive abilities, the authors needed the information about how many questions were answered correctly by the participants in the exam. This statistical information was obtained from the "Level Determination Exam Item Analysis Report" prepared by General Management of Education Technologies. The authors report the question through making correspondences by means of Unversity Deanry, in other words, through making official applications.

Instruments

The data of the study were obtained using the Question Examination Form. This form was constructed by researchers. The form contains exam questions, the standard of the question matches with the curriculum, Piaget's cognitive ability required to solve the question, the ratio of the correct answers given to the question and the wrong choice which was marked most. A separate form was prepared for each LDE of Grades 6, 7 and 8.

Procedure

The authors asked three Ph.D., students in the field of science education to fill in the Question Examination Forms. First, the reviewers filled the form independently. After the analysis which was done separately was completed, a panel was done under the directorate of a professor of education. Sixteen science questions at the level of Grade 6, 18 science questions at the level of Grade 7, and 20 science questions at the level of Grade 8 were projected one by one on the screen in the panel, and the reviewers discussed the analysis they did with each other. During the panel, the authors observed that the analysis carried out independently had matched 90% with each other. The disagreements between the reviewers were solved by negotiations. Frequency and percentages distribution, cognitive abilities the LDE science questions in the Grades 6, 7, and 8 give places to, were done. The reason why we followed such a procedure is to provide inter-rater reliability (Çepni, 2010; Patton, 2002).

The rate of the students who answered the exam questions intended for the cognitive abilities correctly and the rate of the cognitive abilities required by the exam questions were downloaded on excel program, so that the authors could determine which cognitive ability/abilities the students had difficulty in dealing with. The cognitive abilities required by the exam and the rate of accomplishment of this ability were put into a graph. These operations were done separately for Grades 6, 7, and 8.

Analysis of Data

The features of human mind and how the cognitive processes of human beings developed are studied in cognitive development. With the theory which Piaget developed in the middle of the last century, it is a fact that he printed his name in the field of cognitive development. There are some criticisms against Piaget's views. Maybe, the most important one of them is that Piaget underestimated the cognitive abilities of children at very young ages, while he exaggerated the abilities of the students aged 11 to 12. In other words, the pre-school children can succeed in doing a lot more sophisticated tasks than what Piaget told. On the other hand, the college students can fail the tasks mentioned in theory (McCormack, 2009; Ojose, 2008). Despite of all these criticisms, when literature was analyzed, it was found that Piaget's theory was taken as the foundation while designing the programs which support the cognitive development of the children, practicing and evaluating them (Adey, 2005; Shayer, & Adhami, 2006; McCormack, 2009; Oliver, Venville & Adey, 2010).

The collected data were analyzed according to the Piaget's theory of cognitive domain. Piaget divided cognitive development into four stages. The two of them which are sensorimotor (0-2 years) and preoperational (2-7 years) befit the preschool stage. Children can manage to classification, ordered and conservation tasks in concrete operational stage. The authors expected from the students at formal operational stage hypothetical, proportional, probabilistic, combinational and correlational thinking and identification of variables (Çepni & Çil, 2009; Ojose, 2008). The children in basic education level are in the concrete operational stage and it is expected from them to progress to formal operational stage before completing basic education (ages of 11-12).

Findings

The findings obtained in this section are presented under two headings according to the research questions.

The Analysis of LDE Questions According to Piaget's Cognitive Development

According to Piaget's cognitive abilities, the dispersion of LDE Questions of Grades 6 level in 2010 is presented in Table 1.

Table 1

The Dispersion of Grade 6 Questions Regarding Cognitive Ability

Stage of cognitive development	Cognitive ability	Frequency (*f*)	Percentage (%)
Concrete operational stage	Remember	-	-
	Classification	8	50
	Ordered	1	6
	Conservation	-	-
Formal operational stage	Hypothetical thinking	4	25
	Proportional thinking	1	6
	Identification of variables	-	-
	Probabilistic thinking	1	6
	Combinational thinking	-	-
	Correlational thinking	1	6

When Table 1 was analyzed, 56% of the questions for Grade 6 match with the concrete operational stage cognitive abilities. Half of the questions evaluate the ability of classification. Forty six percent of the questions could be solved with Piaget's theory of formal operational stage cognitive abilities. Such questions generally focus on hypothetical thinking. However, in the LDE done in the Grade 6 level, there is no question which could be answered to determine the variables and combinational thinking abilities. The dispersion of 18 questions of Grade 7 regarding cognitive ability was given in Table 2.

Table 2

The Dispersion of Grade 7 Questions Regarding Cognitive Ability

Stage of cognitive development	Cognitive ability	Frequency (*f*)	Percentage (%)
Concrete operational stage	Remember	-	-
	Classification	6	33
	Ordered	1	6
	Conservation	-	-
Formal operational stage	Hypothetical thinking	3	16
	Proportional thinking	1	6
	Identification of variables	6	33
	Probabilistic thinking	-	-
	Combinational thinking	-	-
	Correlational thinking	1	6

Approximately 40% of the Grade 7 level exam questions match with the concrete operational stage cognitive abilities (see Table 1). Most of the concrete operational stage questions evaluate classification ability. Approximately 60% of the Grade 7 LDE questions in 2010 necessitate the use of formal operational stage cognitive abilities. The questions of formal operational stage cognitive abilities focus on the determination and definition of variables. This is followed by hypothetical thinking ability. The rate of correlational thinking and proportional thinking make up 6% in the exam, respectively. The dispersion of questions at Grade 8 in 2010 regarding cognitive ability was given in Table 3.

Table 3
The Dispersion of Grade 8 Questions Regarding Cognitive Ability

Stage of cognitive development	Cognitive ability	Frequency (f)	Percentage (%)
Concrete operational stage	Remember	1	5
	Classification	6	30
	Ordered	1	5
	Conservation	-	-
Formal operational stage	Hypothetical thinking	1	5
	Proportional thinking	1	5
	Identification of variables	1	5
	Probabilistic thinking	-	-
	Combinational thinking	-	-
	Correlational thinking	9	45

According to Table 1, in a small section of the exam which makes up 5% of the questions for Grade 8, it is enough for the students to remember the information which they learned previously to find the correct answer. Thirty percent of the questions could be answered by classification abilities. Sixty percent of the Grade 8 LDE questions in 2010 evaluate formal operational stage cognitive abilities. Forty five percent of the formal operational stage questions take the correlational thinking into consideration. A point which must not be overlooked is that these questions have the highest ratio throughout the exam. There are no questions intended for probabilistic thinking and combinational thinking, which are formal operational stage abilities. The other formal operational stage cognitive abilities constitute 5% of the exam.

The Cognitive Abilities Which the Children Have Difficulty in Dealing

The cognitive abilities which 16 questions evaluate in the Grade 6's LDE and the children's ratio of accomplishing these abilities are presented in Figure 1.

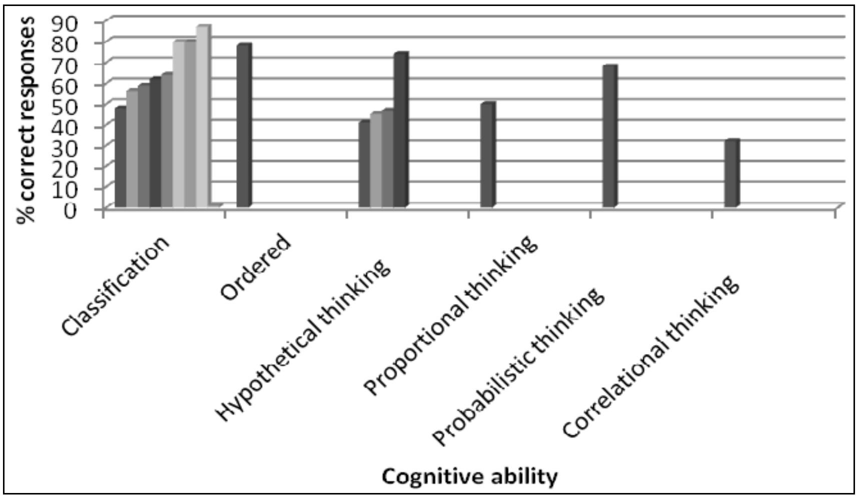

Figure 1. The performance of Grade 6 students for cognitive abilities.

About 1,077,749 students who were about to finish the Grade 6 in 2010 took LDE. Half of the students and nearly 90% of them succeeded in answering the classification questions. Nearly 80% of the students answered the question which required classification ability correctly. Between 40% and 50% of the students answered three out of four questions which could be solved with hypothetical thinking ability correctly. With the other hypothetical thinking ability question, this ration went up to 74%. Most of Grade 6 students were successful with proportional and probabilistic thinking abilities. When the graph was analyzed, it was observed that the success ratio of correlational thinking was rather low. How the rate of correct answerability of the questions for Grade 7 changed according to the thinking abilities, was summarized in Figure 2.

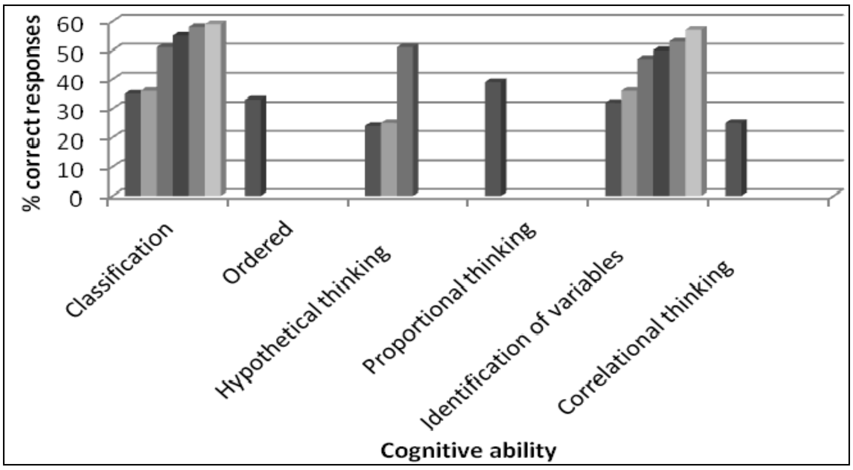

Figure 2. The performance of Grade 7 students for cognitive abilities.

About 1,058,743 students who were about to finish Grade 7 in 2010 took LDE. Half of the students and more succeeded in four questions which required classification abilities. There were no questions in the exam to be solved by classification abilities. Although classification is formal operational stage ability, this question's being answered correctly by only 33% of the students attracted attention. There were three hypothetical thinking ability questions. Only 25% of the students answered two of these questions correctly. But, this rate rose up to 50% with the other question. Nearly 40% of the students succeeded in answering the proportional thinking ability question. Less than half of the students were usually able to do the identification of variables questions. The correct answerability rate of the two identification of variables questions did not reach to 35%. There were no questions to be answered by correlational thinking. This question was accomplished by only one fourth of the students. About 1,008,302 students who were about to finish the Grade 8 in 2010 took LDE. Figure 3 was obtained when the item analysis of the answers which the students gave to the questions that was associated with the thinking ability which the questions were aimed at evaluating.

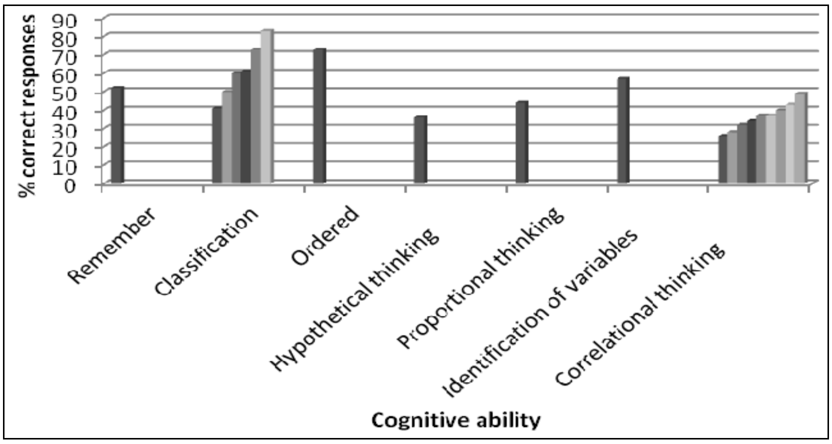

Figure 3. The performance of the Grade 8 students for cognitive abilities.

Nearly half of the students were successful with the question which said that remembering the information acquired previously was enough to reach the correct result. Most of the students (50%-83%) were successful with the five out of six questions intended for classification abilities. Most of the participants (73%) accomplished the classification question. There were no questions which focused on identification of variables. Almost 60% of the students found the correct answer. When Figure 3 was analyzed, more than half of the students were unsuccessful with the questions of hypothetical thinking, correlational thinking and proportional thinking. Only 26% to 37% of the students were successful with the six out of nine questions which were to be solved with correlational thinking ability. The other three questions were answered correctly by 40% to 49% of the students.

Conclusions and Recommendation

Nearly half or more of the science questions in LDE, by which millions of students struggle to be the best among their peers every year, evaluate formal operational stage abilities. It was also recorded in some studies that national tests, such as entrance test, admission test, and international assessments, such as PISA (The Programme for International Student Assessment) and TIMSS (Trends In International Mathematics And Science Study) required the use of high level thinking abilities (Azar, 2005; Bybee, 2008; Çepni et al., 2001; Çepni et al., 2002; Çepni et al., 2003; Karamustafaoğlu et al., 2003; Marshall & Horton, 2011).

Large-scale exams are one of the subjects which are intensively discussed in education field. According to Bishop (1998) and Wößmann (2005), these exams affect the performance of the students positively. Even these exams provide useful benefits for the teachers and schools to renew themselves and increase the quality of education they give. Contrary to this belief, some researchers (Bjork & Tsuneyoshi, 2005; Lisle, Smith, & Jules, 2005; Youell, 2005) argued that central exams affect the teachers' teaching methods and techniques negatively. Teachers give up student-centered education and learning by doing education in order to make their students answer questions more correctly and teach them test techniques. In other words, the teachers, by putting aside providing conceptual understanding, can lead the students to memorize some practical ways and rules which will help them to find the correct solution of the question. There is a fact among all these discussions that large-scale exams are competitions in which the students, their families and teachers all together make an attempt and take great pains and struggle for success. As long as such exams are employed in education system, it is important to prepare high-quality questions which will both prevent students from memorization and also support students' cognitive development (Brualdi, 1998; Çepni & Azar, 1998; Liang & Yuan, 2008; Özsevgeç & Çepni, 2006; Vendlinski et al., 2007; Yiğit & Akdeniz, 2002). The authors can state that the science questions of LDE which was carried out for the students aged between 11 and 15 have the quality to support the development of high level thinking abilities. Another striking point which attracts attention about the dispersion of LDE science questions according to Piaget's thinking (cognitive) abilities is that concrete operational stage questions of Grades 6, 7 and 8 levels accumulate in classification ability. The questions about classification ability are quite few in number, and there are no questions to evaluate conservation ability. Similar situation is observed with the formal operational stage questions, too. There are no science questions in LDE in 2010 to be solved with combinational thinking ability. There was scarcely any probabilistic thinking ability taking part in the exam. We had expected to meet all of the formal operational stage abilities which were represented in a balanced way, in other words, question structures like a large and very colorful hand fan. But, unfortunately, the findings of this study did not meet the authors' expectations. In this context, the authors can say that the content reliability of LDE science questions in terms of thinking abilities was weak. The design of exam questions to wrap up all of the thinking abilities can provide to form a big and integrated picture about the students' structure of mind.

The data obtained from more than three million students in this study revealed that the students acquired classification and ordered abilities. The students of the Grades 6, 7 and 8 had difficulty especially in correlational thinking. The hypothetical thinking abilities of the students were also weak. It was noted in TIMSS 2007 evaluation result report that the Turkish students were successful in intermediate and low level benchmarks, but they were not successful in high level abilities (TIMSS 2007 science report). It was emphasized in a lot of studies that the students were able to acquire formal operational stage abilities all throughout their basic education, high school and even college education in different countries of the world (Bradbery, 2007; Endler & Bond, 2008; Naidoo & Ranjeeth, 2007; Ojose, 2008; Oliver et al., 2010). These results made the authors think this question in their mind: Do they have to expect from the students to perform their low level cognitive abilities after reviewing the learning outcomes in the schools? Or do they have to design the teaching in the schools in such a way that they can support the acquisition of high level cognitive abilities? They accept the second choice, because it is not a correct approach by which children will acquire high level thinking abilities spontaneously as soon as they mature biologically. Supporting cognitive development is a long and difficult process, the students need time and support to acquire high level thinking abilities (Schwartz, 2009). This support is the well-designed learning environments and evaluations by the students (Ewing et al., 2011; Kuhn, 2008; Ojose, 2008). Maybe, the best example which supports this view is cognitive acceleration programme which was developed in England and later adapted to other countries, such as the USA, Australia and Ireland. Cognitive acceleration program which takes its foundation from Piaget's and Vygotsky's theories presents activities which will support the students to acquire formal operational stage abilities in different disciplines, such as science, mathematics and technology. The experimental studies revealed that the program has positive effects on cognitive development and academic achievement (Adey, 2005; Endler and Bond, 2008; McCormack, 2009; Oliver et al., 2010). In this context, the authors believed that the development of other special programmes to support the cognitive development of the students and to evaluate its effects will contribute to the students, teachers and science education literature.

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