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EVALUATION OF TURKISH STUDENTS SELECTION EXAMINATION QUESTIONS FOR MATHEMATICS 2/ALGEBRA

(Penilaian Soalan Peperiksaan Pemilihan Pelajar Turki untuk Matematik 2/Aljabar)

ERCAN ÖZDEMİR, GÜRSEL GÜLER & RAMAZAN DİKİCİ

ABSTRACT

This study examines the 2006, 2007 and 2008 Students Selection Examination questions (Mathematics 2/Algebra) in terms of level and content. The knowledge and skills necessary to answer these questions correctly were examined using questions administered according to the subject areas. The questions were administered to 627 1st grade students studying in different departments of the Faculty of Education of Atatürk University and Rize University. Their answers were used to calculate the item difficulty index of each question. The questions of each year were applied to the 1st grade university students taking the examination and entering the university in that year. Overall, results indicate that students who scored well in the Student Selection Examination, and succeeded in gaining university entrance, had difficulty answering the questions requiring the collective use of conceptual and operational knowledge.

Keywords: Student Selection Examination - Mathematics 2/Algebra questions; item difficulty; level and content analysis

ABSTRAK

Dalam kajian ini dinilai soalan-soalan Peperiksaan Pemilihan Pelajar Matematik 2/Aljabar bagi tahun 2006, 2007 dan 2008 dari segi tahap dan kandungan. Pengetahuan dan kemahiran yang diperlukan untuk menjawab soalan-soalan ini dengan betul telah dinilai melalui soalan yang disediakan mengikut bidang. Soalan-soalan tersebut telah diberikan kepada 627 orang pelajar gred 1 daripada jabatan-jabatan yang berbeza dalam Fakulti Pendidikan, Universiti Atatürk dan Universiti Rize. Jawapan mereka telah digunakan untuk mengira indeks kesukaran item bagi setiap soalan. Soalan pada setiap tahun telah diuji ke atas pelajar universiti gred 1 yang memasuki universiti tersebut pada tahun berkenaan. Secara keseluruhannya, keputusan menunjukkan bahawa pelajar yang mendapat tempat yang baik dalam Peperiksaan Pemilihan Pelajar, dan berjaya ditawarkan ke universiti, menghadapi kesukaran untuk menjawab soalan-soalan yang memerlukan gabungan pengetahuan berbentuk konsep dengan operasian.

Kata kunci: Peperiksaan Pemilihan Pelajar - soalan Matematik 2/Aljabar; kesukaran item; analisis tahap dan kandungan

1. Introduction

The transition to higher education is an important issue in Turkey, as it is throughout the world. The base lines of the Turkish Educational System were regulated under the basic Law of Education. According to this, Law No. 1739, the educational system consists of two main sections: formal education and non-formal education. Formal education includes preschool education, primary education, secondary education and institutions of higher education. Graduates of secondary educational institutions are eligible to be candidates for enrolment in higher educational institutions. The requirements that determine which graduates will enter institutions of higher education and who is eligible for university enrolment are determined by the Council of Higher Education through collaboration with Ministry of National Education (official gazette dated 24.06.1973).

A significant number of the students who complete a secondary education and wish to receive a university education in Turkey can benefit from the right of higher education by achieving a minimum score on the Student Selection Examination, implemented by *Student Selection and Placement Center* (SSPC). These examination(s) are used for the transition from secondary to higher education in countries like China, Spain and Japan, as well as here in Turkey.

Examinations are defined as measurement cases prepared with the objective of observing and quantifying student behaviour; and they can be examined as selection, competition, proficiency, classification and scanning, according their intended uses. Examinations used for selective purposes are administered in order to measure required qualities among candidates with different characteristics (Turgut 1992).

The number of graduates from secondary educational institutions is higher than the places available at higher educational institutions. It is necessary to determine how candidates who wish to progress to higher educational institutions can be more successful in related programs. To compare candidates requires a selection process (Baykul 1989; Doymuş *et al.* 2000; Ekici 2005; Kelecioğlu 2002; 2003).

Since there was few secondary education graduates in Turkey before the 1960s, universities generally accepted candidates without subjecting them to any examinations (Arslan 2004). In the 1960s, higher educational institutions accepted students via the examinations administered by the individual university. As the number of students applying increased, this became a problem. Universities were administering examinations on the same dates, and students were denied alternatives if they did not pass that particular examination. From 1974, student transition to higher education was overseen by the *Intercollegiate Student Selection and Placement Center*, through a central system (Arslan 2004; Köse 1999). The name of this institution was changed to the SSPC in 1981 (Berberoğlu 1996). Examinations administered by this institution went through various changes over the years. The examination was administered in one stage between 1974 and 1981, in two stages between 1981 and 1998; and it has been conducted in one stage since 1999 (Arslan 2004; Atav & Morgil 1999; Dökmen 1992; İçbay 2005; Köse 1999).

The first section of the two-stage examination was intended for *selection* and the second section was intended for *placement*. From 1987, both examinations were intended for *selection* and placement purposes (Dökmen 1992). SSPC abolished the Student Placement Examination (SPE) through a change made in 1999. From this date, it conducted student selection and placement to higher education using the Student Selection Examination (SSE) (SSPC 1999). A test comprised of science and arts sections was given to all the candidates taking the SSE in 1999. The first part, the arts section, contained questions that assessed a candidate's' ability to use Turkish, and reasoning skills with regard to basic concepts and principles in social sciences. The second part, the science section, contained questions assessing a candidate's ability to use mathematical relationships and skills to reason with regard to basic concepts and principles in sciences (SSPC 1999). After the 1999 test revision, teachers serving their time in high schools complained that course programs could not be implemented, particularly in the final year. Students were focusing on test questions, to the detriment of course work that was not related to the questions on the examination (Kelecioğlu 2002).

In 2006, changes were made to the Student Selection and Placement Examination. The most important is the implementation of an examination consisting of two sections. The first section consists of a Turkish Test, Social Sciences-1 Test, Mathematics-1 Test and Sciences-1 Test, all relating to the common courses. The second section consists of a Literature-Social Sciences Test, Social Sciences-2 Test, Mathematics-2 Test and Sciences-2 Test, relating to field topics in high school. Tests relating to the common courses will be answered by every candidate. The

tests administered in the second section will vary, depending on the candidate's school types, fields and which higher education programs they wish to enter.

Candidates will complete the tests weighted according to the calculation of the SSE score used to admit students to their preferred higher education programs (SSPC 2006).

As a result of this change, the test questions in the second section of the exam are similar to the questions in SPE that was discontinued in 1999.

In 2006, the test was revised and questions covering the entire high school curriculum were asked in the SSE. This was aimed at ensuring content validity. Questions asked in the SPE have a closer correlation to predicting success in university; and these questions are more appropriate for student selection and placement within higher education (Kelecioğlu 2003).

The examinations for university entrance are in three main groups: the examinations administered in Japan, Continental Europe and Anglo-Saxon countries.

Students gain admittance to university through a two-stage examination in Japan. The first stage is a central examination, taken by all participants. The second stage is implemented independently by each university.

Students apply in accordance with the scores they have achieved in these two examinations, according to the percentages determined by universities. For instance, Tokyo University evaluates applications by taking 20% of the score in central examination and 80% of the examination organised by Tokyo University (Wu 1993). In Continental European countries like France, those succeeding in baccalaureate, or in an examination equivalent, gain entrance to some programs. In addition, selection examinations can be conducted also in the areas where there is excess demand. The third method is commonly used in the Anglo-Saxon countries. Here, student acceptance is completely determined by the university. Higher education institutions evaluate students according to the results of the centrally administered examinations (Atav *et al.* 2000).

Student selection and placement in higher education is a sensitive matter throughout the world. Many studies have been conducted on this subject, in Turkey and in other countries (Benincasa 1998; Davey *et al.* 2007; Farnham 1982; Laborda & Royo 2008; Sakurai 2004; Sanz & Fernandez 2005; Wu 1993).

Benincasa expressed views and opinions about the importance of university entrance examination in the social life and how it is evaluated, in qualitative research conducted in 1998. At the conclusion of observations and interviews with 72 students, 14 teachers and 15 parents, it was noted that universities have a significant role in terms of providing good job opportunities and prestige, as well as familiarity with local cultures and history. Manos (1992) introduced university entrance examinations in China and Japan by emphasizing that the university entrance examination has an important role in a student's career choice. Wu (1993) emphasised that mathematics success is the most distinctive feature in the development of a nation. In this study, Wu provided the number and percentages of the students who answered mathematics questions correctly in the university entrance examination given in Japan in 1990. What difficulties students encountered in math problems were determined according to the answers they gave, and solution suggestions were made accordingly. In addition, ways of restructuring the schools were explained, and it was suggested that it is necessary to examine the educational systems of developed countries. In this study, Wu explained the university entrance examination and the method of admitting students to universities in Japan, and provided the questions and answers of the student selection examination implemented by Tokyo University, Shiga University, Shiga Medical University and Hokkaido University in 1991. Laborda and Royo (2008) emphasised that the foreign language section one of the six sections of the university entrance examination in Spain- has an important impact on the exam score, and so

they argued that preparing for the language test using a computer would improve examination scores. It was noted that institutions must also make an effort in addition to individual efforts. Sanz and Fernandez (2005) examined the difference in the scores of students in the Selectivity and QPT (Quick Placement Test) in the study they conducted on the English examination- one of the steps in the university entrance examination in Spain. They also questioned whether or not student achievement in the Selectivity examination predicts success in the first grade of university. Results suggested that the Selectivity was not predictive and some changes were necessary. Davey *et al.* (2007) explored the examination system, student scores, problems in the examination system and differences between western universities and Chinese universities, in the study where they examined the university entrance examination in China. Sakurai (2004) compared the pre-revolution and post-revolution entrance examination, noting that students must specifically be in a metropolitan area in order to receive a quality education and analyzed the influence of politics on the examination. The questions on the exam were not analyzed, but the scores and admittance rates for female and male candidates were given. Okur and Dikici (2006) evaluated mathematics and geometry questions on the student selection examination implemented in Turkey between 2001 and 2004, in terms of level and content. The questions on the SSE for those years were given to 593 university students and their difficulty indexes determined. In the study, questions were grouped as easy, average and difficult. In addition, the table included information about the knowledge and skill levels that were necessary in order to solve each question. In the final section, suggestions were given for teacher focus, with regard to topic lectures and question-solving. The same study also provided information about the SSE for university entrance. This study can be considered as a continuance of Okur and Dikici (2006). There are a number of similar studies in the literature. Students turn to private teaching institutions since it is more difficult to get into universities and there is increased competition (Köse 1999; Tansel & Bircan 2006). There is research on the role of private teaching institutions in student success (Bilgin 2003; Köse 1999) the relationship between high school type and university entrance (Köse 1999) exam questions in terms of level and content (Doymuş *et al.* 2000; Efe & Temelli 2003; Okur & Dikici 2004, 2006) opinions, attitudes, anxieties and anxiety scale (Ekici 2005; İçbay 2005; Kelecioğlu 2002) comparison of the SSE scores (Atav *et al.* 2000; Kelecioğlu 2003; 2004) importance of vocational schools and analysis of their current problems (Arslan 2004); the influence of various factors on SSE scores (Ekici 2005); and investigation of student scores according to gender (Berberoğlu 1995).

These examinations must provide an accurate assessment of a student's success in the secondary education program, as well as the skills and knowledge acquired by the student (Baykul 1989).

The SSE scores are determined by the exam questions, secondary education course programs and knowledge levels of the teachers. For that reason, the examination questions must be connected to secondary education programs, and students should be taught the skills and knowledge that will enable them to answer those questions correctly (Akbulut & Soran 2000).

*Mathematics 2/A*lgebra questions figure prominently on the test, particularly in the fields of *Science* and *Turkish-Mathematics*.

In this study, the Math 2/Algebra questions on the 2006, 2007 and 2008 SSE are examined in terms of level and content; and the skill set required in order to solve these questions is examined. This may be useful for students who are preparing for the university entrance examination, as well as their families and teachers – all of whom are stakeholders in this test.

2. Method

In this SSE, Mathematics 2, there were 30 questions. Of the 30, 9 were geometry questions and not taken into consideration for this research. The study examined 63 Mathematics 2/Algebra questions; geometry questions must be handled separately. This study was completed in three stages. In the first stage, the 2006 SSE Mathematics 2/Algebra questions were extracted from the address www.osym.gov.tr. Questions were rewritten in a computer environment without making any change in order and answer choices. The questions were rewritten because they were labelled as SSE and SSPC as taken from the internet.

In this way, students were prevented from memorising the questions and answers. These questions were administered to 212 1st grade students taking the 2006 SSE for university entrance. The same process was used for the 2007 SSE Mathematics 2/Algebra questions. In the second stage of the study, the 2007 SSE Mathematics 2/Algebra questions were administered to 195 1st grade students taking the 2007 SSE for university entrance. In the third stage of the study, the first stage process was repeated and the 2008 SSE Mathematics 2/Algebra questions were administered to 220 1st grade students. In total, questions were given to 627 1st grade students.

Of these, 588 were 1st grade students at Ataturk University Kazım Karabekir Faculty of Education Primary School Mathematics Teaching, Biology Teaching, Physics Teaching, Chemistry Teaching and Secondary Education Mathematics Teaching Departments. 39 were 1st grade students in Rize University Primary School Mathematics Teaching department. Results were obtained by calculating the difficulty index of each question and are presented in tables. Questions were collected in three groups according to their item difficulty values. Item difficulties can take values between 0.00 and 1.00 (Atılgan 2006; Karip 2008; Tekin, 1993). Those with item difficulty indexes between 0.00 and 0.39 are designated difficult, those with item difficulty indexes between 0.40 and 0.69 are designated *average*, and those with item difficulty indexes between 0.70 and 1.00 are designated *easy* (Marshall & Hales 1971). The ideal difficulty index is considered to be approximately 0.50 (Atılgan 2006; Karip 2008; Tekin 1993). Questions with item difficulty between 0.00 and 0.39 examine the behaviours in *application* level of Bloom taxonomy, questions with item difficulty between 0.40 and 0.69 examine the behaviours in *comprehension* level, and questions with item difficulty between 0.70 and 1.00 examine the behaviours in *knowledge* level (Atılgan 2006; Tekin 1993).

3. Findings and Discussions

The distribution of 2006, 2007 and 2008 SSE Mathematics 2/Algebra questions, according to secondary education mathematics curriculum, is given in Table 1. It indicates that Mathematics 2 /Algebra questions were compatible with the MEB secondary education curriculum (Journal of Communiques 1992), 2005 secondary education new mathematics curriculum (www.ttkb.meb.gov.tr/yeniöğretim/programları/programdosyaları, 2005) and course books (Bağrıaçık *et al.* 2009a, 2009b, 2009c; Sağlam *et al.* 2009).

Table 1: Distribution of 2006, 2007 and 2008 SSE mathematics 2/ algebra questions according to secondary education mathematics curriculum

Subject fields	Question number (2006)	Question number (2007)	Question number (2008)
Factorisation	11, 12	7, 8	2, 3
Functions	15	17, 18, 21	9
Operation	14	-	8
Parabola	16	-	-
Lateral and quadratic equations and inequalities	17	-	1, 10
Trigonometry	18, 19, 20	2, 3, 4	12, 13
Complex numbers	13	1	6
Logarithm	21	5	11
Induction	-	6	7
Arithmetic Series and Sequences	2	-	-
Matrix and Determinant	10	12	-
Limit	1	13, 19	14, 15
Derivative	3, 4, 5, 6	14, 15, 16, 20	16, 17, 18
Integral	7, 8, 9	9, 10, 11	19, 20 21

Data in Table 1 indicates that no question about induction was included in 2006, but there were a total of 10 questions in the subjects of trigonometry, derivatives and integrals. In 2007, no question was included in the subjects of operation, parabola, arithmetic series and sequences, lateral and quadratic equations and inequalities. However, there were 3 questions about functions, trigonometry and integrals, and 4 questions were included in the subject of derivatives. As for 2008, it is observed that no question was included in the subjects of parabola, arithmetic series and sequences, matrix-determinant, but 3 questions were asked in the subject of integrals and 3 questions were included in the subject of derivatives. Data indicates that, even though there was no change in number of the questions administered to the students in the subjects of factorisation, complex numbers, logarithm and integrals in 2006, 2007 and 2008, there was a change in number of the questions in the other subjects. Also in Table 1, there was 1 question in 2006 in the subjects of parabola and arithmetic series and sequences, but no question was included about these subjects in 2007 and 2008.

Table 2: Item difficulty index of 2006-2008 SSE mathematics 2/ algebra questions

Item Difficulty	Question Number (2006)	Question Number (2007)	Question Number (2008)
0.70-1.00 (easy)	4, 5, 6, 8, 10, 11, 12, 13, 14, 18, 19, 20, 21	1, 2, 3, 4, 5, 6, 7, 8, 19	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 16, 17
0.40-0.69 (normal)	1, 2, 3, 9, 16, 17	12, 13, 15, 16, 17, 18, 20, 21	11, 13, 14, 15, 18, 19, 21
0.00-039 (difficult)	7, 15	9, 10, 11, 14	12, 20

Table 2 indicates that questions fall into 3 groups according to item difficulty index. Results indicate that questions with item difficulty between 0.70 and 1.00 were answered correctly by a majority of the students. According to item difficulty index, these questions are considered *easy* (Atılgan 2006; Tekin 1993). An example of the questions from this group follows:
2006 SSE 5th question:

$$f(x) = \frac{2x^3}{3} - \frac{x^2}{2} + 5$$

In which interval below is the function above decreasing?

A)$\left(\frac{-3}{2}, -1\right)$ B)$\left(-1, \frac{-1}{2}\right)$ C) $\left(\frac{-1}{2}, 0\right)$ D) $\left(0, \frac{1}{2}\right)$ E) $\left(\frac{1}{2}, \frac{3}{2}\right)$

Questions with item difficulty between 0.40 and 0.69 are *normal*. It is suggested that item difficulty index of the questions administered to the students be approximately 0.50, i.e. *normal* (Karip 2008; Tekin 1993). An example of the questions from this group follows:

2007 SSE 13th question:

$$\lim_{x \to 0^+} \frac{1 - cos\sqrt{x}}{x}$$

What is the value of the limit above?

A) 0 B) $\frac{1}{2}$ C) 1 D) 2 E) $\sqrt{2}$

Questions with item difficulty between 0.00 and 0.39 are considered *difficult*.

2008 SSE 12th question: If

$$sin2x = a$$

What is the value of the expression of $(sinx + cosx)^2$ in terms of a?

A)$a + 1$ B)$2a + 1$ C)$2a + 2$ D)$a^2 + 1$ E)$2a^2 + 1$

The question above was given to students in 2008 and is in the difficult group according to item difficulty index. This question was answered correctly by the fewest number of students.

Table 3 presents knowledge and skills considered necessary to solve a total of 63 Mathematics 2/Algebra questions on the 2006, 2007 and 2008 SSE Mathematics 2 section, and the grades in which the secondary education curriculum covered the subjects relating to these questions.

Table 3: Knowledge and skills considered necessary to solve 2006, 2007 and 2008 SSE mathematics 2 test question

Knowledge and Skills Necessary to Solve Questions	Question number (2006)	Question number (2007)	Question number (2008)	The grade in which subjects covered
Having operational skill in factorisation	11, 12	7, 8	2, 3	9th grade
Ability to apply definitions of one-to-one, subjective and compound function in an operation and facility to find image set of a function whose domain is given	15	17	9	9th grade
Ability to find the breakpoint of two functions and to write one of the given functions in terms of the other	-	18, 21	-	9th grade
Ability to calculate the power of an element in a given table and to find the inverse element	14	-	8	9th grade
Ability to write the equation of a function whose graph is given or to write the equation of a parabola whose peak point and points intersecting the axes are known.	16	-	-	9th grade
Ability to analyze the roots of an equation according to the parameter it involves, to form an operation by finding the roots of a quadratic equation and to solve a lateral equation with one unknown	17	-	1, 10	10th grade
Ability to write one of the trigonometric functions in terms of the other, to apply half angle and sum formulas on operation, and to calculate trigonometric value of an angle in a given geometric figure	18, 19, 20	2, 3, 4	12, 13	10th grade
Ability to find root, calculate module and to perform addition and multiplication operations in complex numbers	13	1	6	11th grade
Ability to calculate determinant of a matrix in type of 2×2 and to perform multiplication operation in that type of matrixes	10	12	-	12th grade
Ability to add up any term of a function whose general term is given beside its sum symbol and to calculate the sum of its terms in a particular number	-	6	7	11th grade
Ability to calculate the partial sum of a series whose general term is given.	2	-	-	11th grade
Ability to form an inequality and equality solution using logarithmic features and to find the inverse of a logarithmic function	21	5	11	11th grade
Ability to calculate a function's limit on right and left on any point, and to find the result by eradicating uncertainty in uncertainty situations in limit	1	13, 19	14, 15	12th grade

To be continued...

...Continuation

Ability to apply the definition of derivative on an operation or to perform operation in uncertainty situations in limit, to apply the features of first derivative on graph or other questions and to apply the features of second derivative	3, 4, 5, 6	14, 15, 16, 20	16, 17, 18	12th grade
Ability to comprehend the relationship between derivative and integral, to solve questions by applying features such as changing variable, dividing dividend to denominator, and to calculate area by the help of definite integral.	7, 8, 9	9, 10, 11	19, 20 21	12th grade

Kelecioğlu (2002) noted that since questions from the high school final year curriculum did not appear on the Stage 1 SSE (implemented from 1999), the students were reluctant to pay attention to these subjects and teachers felt uncomfortable, as they could not adequately explain these subjects. Table 3 indicates that approximately 45% of the 2006, 2007 and 2008 SSE Mathematics 2/Algebra questions were included in the 12th grade curriculum. It is seen that the negations mentioned by Kelecioğlu (2002) were eliminated with the new regulation.

4. Conclusion and Suggestions

The distribution of 2006, 2007 and 2008 SSE Mathematics 2/Algebra questions according to subject areas is given in Table 1; distribution according to item difficulties is given in Table 2; knowledge and skills considered necessary for solving each question are given in Table 3. The questions with item difficulty index between 0.70 and 1.00 were designated *easy*; and these questions examine mathematical knowledge in *knowledge* and *remembering* level according to the Bloom taxonomy. Questions in which students obtained the correct result most often, are included in this group. Questions with item difficulty index between 0.40 and 0.69 are designated *normal*, and these questions examine mathematical skills in *comprehension* level according to Bloom taxonomy. Questions with item difficulty index between 0.00 and 0.39 are considered *difficult*; and students must have behavioural and reasoning skills in *application* level, which is the third step of Bloom taxonomy, in order to answer these questions. The questions answered correctly by the least number of students are included in this group. This result is in accordance with results from research conducted by Okur and Dikici (2004; 2006), Doymuş *et al.* (2000).

Students were particularly challenged by questions that required them to use conceptual knowledge and operational knowledge together. This corresponds to the results of the study conducted by Baki and Kartal (2004). Most of the questions cover 12th grade curriculum, and the least number of questions covered 11th grade curriculum. In addition, students had the most success answering the questions related to subjects in 10th grade curriculum and had the least success in answering the questions relating to the subjects in 12th grade curriculum. In accordance with these data, we can make the following suggestions:

1. Students should be given questions which will require them to use high level reasoning skills. Courses should be planned, and teachers guided, accordingly (Olkun & Uçar 2006, p.8)
2. Different teaching methods and different questions relating to any taught subject should be presented. If the taught subject is related to the previous subjects, students should be given problems in which conceptual and operational knowledge will be used together in a way that includes the previous subjects.
3. Problem-establishing activities should be presented to enable students to comprehend the subject thoroughly and participate in the class actively. This is because problem-establishing is an important activity involving problem solving and teaching high level reasoning skills.
4. Examples about the subject chosen for the course should not be ordinary; they should drive students to thought and thus reinforce the subject (Okur & Dikici 2006).

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Department of Secondary Science and Mathematics Education
Kazım Karabekir Education Faculty
Atatürk University
25240 Erzurum, TURKEY
E-mail: ercan.ozdemir@atauni.edu.tr, gguler@atauni.edu.tr, rdikici@atauni.edu.tr*

*Corrresponding author