An Investigation of the Mathematical Literacy of Students Aged 15 in terms of Pisa 2003 Mathematical Literacy Questions: Results from Turkey[1]

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Abstract
The purpose of this study is to investigate the mathematical literacy of the 15-year-old students in terms of PISA mathematical literacy questions. The research model of this study is the survey model in the quantitative models. The sample of this study was composed of 1.227 students who received formal education in five different types of schools (science high schools, Anatolian high schools, private high schools, public high schools and vocational high schools) of various cities, each of which was selected from each of seven geographical regions in Turkey. Nine questions were applied and revealed in the mathematical area in PISA in 2003 as a data collection tool. The results of this study show that, in terms of the proportion of answering the assessment questions, the best performing type of school is science high schools. It was shown that a great number of students still cannot answer the proficiency level questions in the desired way and only half can answer the lower-intermediate and intermediate questions.

Keywords: Programme for International Student Assessment (PISA), Mathematical literacy, 15-year-old students

[1] This paper uses some of the findings of first authors's PhD research at Ataturk University, supervised by the second author. Furthermore, this study was presented in X. National Science and Mathematics Education Congress.

Introduction and Literature Review

The fact that there is no long-established education system as yet in Turkey also reveals itself in the low success levels that are acquired in national and international examinations (Berberoğlu and Kalender, 2005; MEB [Ministry of National Education], 2003a; MEB 2003b; MEB, 2005). By participating in national examinations such as YGS (Transition to the Higher Education Examination), LYS (Undergraduate Placement Exam), SBS (Level Assessment Examination), ÖBBS (Student Success Assessment Examination) along with international examinations, Turkey has had the opportunity to compare and evaluate its education system and student success levels with other countries on an international scale. Among the international examinations in which we participate are the "Progress in International The Reading Literacy Study" (PIRLS) Project, which is organised by the International Association for the Evaluation of Educational Achievement (IEA), the Third "Trends in International Mathematics and Science Study" (TIMSS) Project and the "Programme for International Student Assessment" (PISA), which is organised by the Organisation for Economic Co-operation and Development (OECD). PISA is an initiative of the OECD (Cosgrove, Shiel, Sofroniou, Zastrutzki &Shortt, 2005; Duru-Bellat and Suchaut, 2005; Eivers, Shiel & Cunningham, 2008; Satıcı, 2008; Shiel, Cosgrove, Sofroniou & Kelly, 2001; Xie, 2005), which was first implemented in 2000. The objective of international student comparison projects such as TIMSS, PIRLS and PISA is to evaluate the education systems of the countries that participate in these programmes and ensure the yearly follow-up of the development in the knowledge and skills of the students of these countries in the literacy, mathematics and science fields rather than creating competition between these countries (Anıl, 2009; Martins and Vegia, 2010; OECD, 2007; Schwab, 2007). The increase in international evaluations is discussed,examining in particular the impact that comparative studies have at the national, local education authority and school levels and the potential for tension between the different levels (Livingston, 2003). The authors suggest that it is necessary to recognize the relationships between the different levels of evaluation with a view to developing a coherent learning organization that works together towards the common purpose of raising pupil achievement (Livingston & McCall, 2005). Turkey has found an opportunity to evaluate its education system on a global scale by participating in international examinations such as PISA, TIMSS and PIRLS. Cognitive domain tests, in which only multiple-choice questions are included in national examinations in a general sense, provide very limited information for studying our education policy in detail. Results obtained from the evaluation framework in which questions of different types and scopes are included in the international examinations as well as the information about students, teachers, parents, curriculums, schools, classrooms and house environments obtained from the conducted surveys were ensured the obtainment of various information for our education policy. Therefore, the insufficiencies, which must be worked out in our education system, have come into prominence and precautions, which must be taken and were determined. Dimensions, which are not present in our current curriculums, were included, and a reconstruction commenced in our education system in view of these evaluations.

Mathematical Literacy in PISA

The framework of the four subject areas determined by PISA in mathematics – which will ensure setting forth the generative, correlative and reflective skills for detecting the solutions that can be introduced by the person in response to not just mathematics in school life but also problem situations in which he/she can utilise his/her mathematical skills in every environment that he/she is in – is as follows (MEB, 2005; OECD, 2004):

- Space and Shape (Geometry) covers the features of the spatial and geometrical phenomena or situations and objects that are mostly related to drawing included in the geometry curriculum. It requires an understanding of the features of objects and their relative locations as well as searching for the similarities and differences among

the shapes when they are broken into parts and recognising the shapes in different representations and different dimensions.

- Change and Relationships (Algebra) contain the relationships and equations among variables as well as knowledge and understanding regarding the methods that are used in presenting these relationships and equations. Change and relationships contain the connection between functional relationships and variables along with mathematical indications of change. This content area is most clearly related to algebra. Mathematical relationships are usually represented by equations or inequations, but they are also rather related to the relationships of a general content. Relationships are given as different representations that contain symbolic, algebraic, graphical, tangential and geometrical representations. Since different representations serve different purposes and have different features, the transition among the representations is extremely important in understanding and solving mathematical problems.
- Quantity (Number-Arithmetic) contains numerical situations or circumstances, relationships and patterns. It is related to understanding relative magnitude, recognising numerical situations and using the numbers that explain the amounts and measurable features of real-life objects. In addition to this, quantity incorporates operation and comprehension of the numbers that are represented in different ways. An important aspect of studying quantity is quantitative thinking that contains number perceptions, expressing numbers, comprehending the meaning of operations, mental arithmetic and calculation. The most common branch of mathematics curriculum, which is combined with quantitative thinking, is arithmetic.
- Uncertainty (Probability) contains statistical situations or circumstances that are expressed in accordance with probabilities that constitute a subject of statistics and probability.

PISA uses the term "literacy", which covers a number of broad-meaning competencies that deal with adult life. These competencies are based on meaningfulness and applicability belonging to adult life that has no special relationship with the curriculums of the participating countries. Evaluation focuses on students' abilities to implement their knowledge and skills in real-life problems and circumstances (Anderson, Lin, Treagust, Ross and Yore, 2007). In PISA, mathematical literacy is defined as "an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen" (Meyer, Pauly and Poele, 2005). "Mathematical Literacy takes notice of a wider and more functional use of mathematics, and covers the skill of recognising and formalising mathematical problems in various circumstances" (MEB, 2009). In this sense, students are expected to see mathematical relationships in the situations that they encounter in real life conditions and manifest their mathematical competencies to find potential or distinctive ways to a solution, when necessary, beyond routine problem solving skills and are not limited to the subjects that comprise the curriculum of the school. In order to understand the reasons for a general increase in emphasis on school-based evaluation, on the one hand, and international evaluations, on the other, it is necessary to understand the wider context that is driving change. In today's global society schools find themselves operating in a new educational context that brings a new set of challenges and opportunities (Livingston & McCall, 2005).

Turkey participated in the implementations of PISA studies conducted in 2003, 2006 and 2009 with different types of schools. General high schools, vocational high schools, Anatolian vocational high schools, science high schools, Anatolian high schools, private high schools, police colleges and elementary schools participated in implementation in 2003. In this implementation, it was observed that there are serious differences among school types in

terms of mathematics success (MEB, 2005). Berberoğlu and Kalender (2005), who found a similar result from the findings that they obtained in their study, stated that the differences among school types are in serious extents rather than regional differences in success levels of the students in both ÖSS and PISA evaluations. Elementary schools, general high schools, Anatolian high schools, foreign language intensive high schools, science high schools, vocational high schools, Anatolian vocational high schools and multi-programme high schools participated in implementation in 2006. In this implementation, just like in the implementation in 2003, it was observed that there are serious differences among school types (MEB, 2007). Elementary schools, general high schools, Anatolian high schools, science high schools, Anatolian teacher training high schools, Anatolian fine arts high schools, vocational high schools, Anatolian vocational high schools, technical high schools, Anatolian technical high schools and multi-programme high schools participated in the PISA implementation in 2009 implementation in the scope of mathematical literacy. Differences were also observed among school types in this application (MEB, 2010). It was determined that the type of school that showed the lowest performance in mathematical literacy is elementary schools (Akyüz and Pala, 2010; MEB, 2005; MEB, 2007; MEB, 2010). İş Güzel (2006) and İş (2003) found that the students who were the most successful in mathematical literacy are higher-grade students. In PISA studies it was observed that the mathematics performance of the male students was superior to that of the female students in many countries. McGaw (2004) stated that 15-year-old female students showed superior performance to male students in reading skills in every country in PISA 2000. However, male students showed superior performance compared to female students in mathematical literacy in all countries with th exception of Iceland and New Zealand. Ziya (2008) examined some factors that affect the mathematics successes of the students in Turkey according to PISA 2006. The findings of his study revealed that success scores of the students differ in accordance to gender. It was observed that the male students were more successful than the female students. Lydia Liu and Wilson (2009) examined gender differences on PISA 2003 mathematics success in certain fields, and researched similarities and differences in gender scores among students from USA and Hong Kong. In this study, it was stated that male students in both countries showed superior performance, especially in complicated multiple-choice problems, whereas female students had higher scores in probability, algebra and reconstruction problems. It was observed that the gender differences among Hong Kong students are greater than those of American students; students from Hong Kong showed superior performance than American students in problems that measure complex mathematical logic. The results – which were obtained from a study conducted by Demir, Kılıç and Ünal (2010) and sample of which was composed of a total of 4,942 15-year-old students who participated in the PISA 2006 study – showed that male students had better scores in mathematics compared to female students. Gilleece, Cosgrove and Sofroniou (2010) found significant gender differences in the distribution of low and high successes that changed according to the fields in their study in which they examined the features of school and student backgrounds regarding low and high success in mathematics and science in PISA. It was set forth that female students probably achieved lower success in mathematics, whereas male students achieved higher success. Gender in science was related to dropping out of school; male students who dropped out of school achieved lower success than the female students who dropped out of school. The results showed that target resources are required, which assist in increasing the equality in school-level acquisitions as well as student-level acquisitions. The questions in PISA are organised as questions types that are prepared as complex multiple-choice, multiple choice, open-ended, short-answered and semi-structured. Demir (2010) found that student reactions differ in Turkey in the mathematical literacy subtests of PISA 2003 and PISA 2006; 'multiple-choice' questions are the most-solved question type; and 'complex multiple-choice' questions are the least-unanswered question type in both implementations. He stated that there is a considerable decrease in the percentage successes of the students in Turkey at all levels of question types, primarily including multiple-choice questions according to the results of the PISA 2003 and PISA 2006 mathematical literacy subtest. In the study, it was generally concluded that the

success levels of the students in Turkey are superior in structured (multiple-choice, complex multiple-choice and semi-structured questions) question types compared to other question types (short-answer, open-ended) to which they are expected to form answers independently.

The questions directed at the students in PISA are studied as implementations that are not directly connected with any curriculum and that are formed for the purpose of discovering the degree to which the students can transfer their knowledge and skills into real life situations. Savran (2004) studied three question types that represent each field among the test questions used in the PISA project; examined the comparability and applicability consistency of these question types for the Turkish student profile in terms of the basic contents and linguistic features of question examples; stated that the question contents correspond with the main objective determined by PISA research; the questions were prepared by taking student psychology into account; motivation was maintained extremely successfully; that the aim is to measure students' success in creative thinking, using the skills of reading-understanding-interpreting-evaluating the given information, problem solving and inference. In the studies conducted on PISA implementations, it is observed that the studies were made into elements such as how and to what degree factors such as attitudes regarding the subject area, self-sufficiency, self-regulation, anxiety or disturbance, internal and external motivation, learning strategies, learning environment preference, classroom environment, teacher-student relationships, opinions about the school, school type, gender, socioeconomic and cultural index, education level and status of the family, use of technology and sources, education, mathematics teacher quality, question types and styles, problem solving skills, cross-cultural and cross-language equivalence of the cognitive tests and surveys affect academic success (Anderson, Chiu and Yore, 2010; Chu-Ho, 2010; Gilleece, Cosgrove and Sofroniou, 2010; Knipprath, 2010; Lydia Liu and Wilson, 2009; McConney and Perry, 2010; Neumann, Fischer and Kauertz, 2010; Yıldırım and Berberoğlu,2009). Several of these studies were conducted using the data of PISA implementations and other international implementations where data collected in general terms was analysed in more detail with secondary analyses; and few studies were encountered that examine the degree to which the curriculum that was formed in accordance with primary analyses and changed step by step.

In view of the investigation of these studies, it was decided in this study to collect data from the first graduates of the changed curriculum and determine the ratios of the students in answering Pisa 2003 mathematical literacy questions cognitive domain test regarding mathematical literacy in a general sense in terms of school types.

Methodology

Since the aim of this study is to reveal the mathematical literacy of the students within the context of the PISA 2003 examination, the survey model, which is among the descriptive methods, was used in this study. Descriptive researches describe a given circumstance as fully and carefully as possible. The most common descriptive method in research studies conducted in the field of education is the survey model because the researchers summarise the features (abilities, preferences, behaviours, etc.) of individuals, groups or (sometimes) physical environments (e.g. schools) (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz and Demirel, 2009).

The population of this study was composed of 15-year-old students who continued their formal education in Turkey in the 2009-2010 school year. The sample of this study was composed of one province selected from each of the seven geographical regions that are present in our country and 1.227 students (621 female students and 606 male students) who studied in five different school types (science high school, Anatolian high school, private high school, general high school and vocational high school) from these provinces.

Table 1. Frequency of the sample according to school types

School Type	Frequency
Anatolian High School	238
Science High School	248
General High School	247
Vocational High School	246
Private High School	248

A nine-question test (see Appendix) was used as a data collection tool and was prepared by focusing on four subject areas (Geometry, Algebra, Arithmetic and Probability) that are trageted in PISA mathematical literacy out of 10 evaluation questions (a total of 18 questions including the sub-questions) that were implemented in the mathematics section of PISA 2003 and the confidentiality of which was removed. The data was collected by the researcher himself during the 2009-2010 school year. Multiple-choice, complex multiple-choice and semi-structured questions, in which students are expected to reach previously-determined answers, were asked along with open-ended questions and short-answer questions to which students were required to form their answers independently. A duration of approximately 50 minutes was allowed for the written exam. It was observed that $\alpha = 0.878$ (Cronbach's Alpha) according to the results of the reliability analysis that was conducted for 18 evaluation the questions. In view of this, since $0.80 \leq \alpha = 0.878 < 1$, it can be stated that the scale, which is composed of 18 questions, is reliable at a high level. In grading the questions in the cognitive domain test that was implemented on the selected students, the questions were evaluated as "fully correct", "partially correct","incorrect", "just correct" or "just incorrect" and in accordance with the instructions included in the grading guide that was prepared for PISA 2003 implementation. It was observed that the grading reliability was maintained with a ratio of 95% by evaluating the given answers by two mathematics teachers apart from the researcher and as a result of the opinion of three graders. Points, which were observed as incoherent in the grading, were discussed, and the definite grading was decided.

The answers given by the students to PISA 2003 mathematics question examples were examined in detail in the data analysis section. As stated in the data collection tools and data collection section, each question was graded as "fully correct", "partially correct", "incorrect" or "unanswered" in accordance with the grade given. These scores, which were given to the students as a result of nine questions, are presented in the findings section with frequency and percentage tables according to school types. PISA scores can be located along specific scales developed for each subject area, designed to show the general competencies tested by PISA. These scales are divided into levels that represent groups of PISA test questions, beginning at Level 1 (OECD, 2000)

Students at Level 1 are capable of completing only the least complex reading tasks, such as:

- Locating a single piece of information.
- Identifying the main theme of a text.
- Or making a simple connection with everyday knowledge.

Students at Level 2 can:

- Interpret and recognize situations in contexts that require no more than direct inference.

- Extract relevant information from a single source and make use of a single representational mode.
- Employ basic algorithms, formulae, procedures, or conventions.
- Reason and make literal interpretations of the results

Students at Level 3 can:

- Execute clearly described procedures, including those that require sequential decisions.
- Select and apply simple problem-solving strategies.
- Interpret and use representations based on different information sources and reason directly from them.
- Develop short communications reporting their interpretations, results and reasoning.

Students at Level 4 can:

- Work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions.
- Select and integrate different representations, including symbolic ones, linking them directly to aspects of real-world situations.
- Use well-developed skills and reason.
- Construct and communicate explanations and arguments based on their interpretations, arguments and actions.

Students at Level 5 can:

- Develop and work with models for complex situations, identifying constraints and specifying assumptions.
- Select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models.
- Work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterizations, and insight pertaining to these situations.
- Reflect on their actions and formulate and communicate their interpretations and reasoning.

Students at Level 6 can:

- Conceptualize, generalize, and utilize information based on their investigations and modeling of complex problem situations.
- Link different information sources and representations and flexibly translate among them.
- Do advanced mathematical thinking and reasoning.

- Apply insight and understanding along with mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for dealing with novel situations.
- Formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments and appropriateness of these to the original situations.

Results

The frequency and distribution percentages of the answers given by the students who participated in this study in the PISA 2003 questions cognitive domain test are presented in this section. The results were compared with the PISA 2003 results. Furthermore, the frequency and percentage distributions of these questions according to school types are separately examined and presented. Also the results are presented according to competency level of each PISA question

"Exchange Rate" Question: Mei-Ling from Singapore was preparing to go to South Africa for 3 months as an exchange student. She needed to change some Singaporean Dollars (SGD) into South African Rand (ZAR).

"Exchange Rate 1" Question: Mei-Ling found out that the exchange rate between the Singaporean dollar and the South African rand was:

1 SGD = 4.2 ZAR

Mei-Ling changed 3,000 Singaporean dollars into South African rand at this exchange rate.

How much money in South African rand did Mei-Ling get?

The ratio of students who received a score of zero by not answering or incorrectly answering the "exchange rate 1" question was 47.4% (581 students), whereas it can be seen that this ratio was 30.3% in the 2003 implementation. The ratio of students who received a full score by correctly answering the same question was 52.6% (646 students) in this study, whereas it can be seen that this ratio was 69.7% in PISA 2003 (MEB, 2005). When distribution percentages are examined for the "exchange rate 1" question, it can be stated that there is an increase with a ratio of 17.1% for students who received a score of zero; there is a decrease with the ratio of 17.1% for the students who received a full score compared to the PISA 2003 results. Furthermore, when it is considered that this question was determined at the 1st competency level in the PISA 2003 implementation, it can be stated that nearly half of the students who participated in the research were able to give an entirely correct answer to a question that is at the 1st competency level.

The answers given by the students who participated in this study to the "exchange rate 1" question are summarised in the table below in the form of frequency and answer percentages in accordance with school types.

Table 2. Frequency and percentage distribution of the exchange rate 1 question in accordance with school types

School Type	Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	184	77.3%	54	22.7%	238
Science High School	213	85.9%	35	14.1%	248
General High School	54	21.8%	193	78.2%	247
Vocational High School	31	12.6%	215	87.4%	246
Private High School	164	66.1%	84	33.9%	248
Total	646	52.6%	581	47.4%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of giving an entirely correct answer to the "exchange rate 1" question is highest in science high schools. These schools are followed respectively by Anatolian high schools, private high schools, general high schools and vocational high schools. It is a noteworthy fact that the ratios of giving an incorrect answer or not answering the "exchange rate 1" question in vocational high schools and general high schools are extremely high.

"Exchange Rate 2" Question: On returning to Singapore after 3 months, Mei-Ling had 3,900 ZAR left. She changed this back to Singaporean dollars, noting that the exchange rate had changed to:

1 SGD = 4.0 ZAR

How much money in Singapore dollars did Mei-Ling get?

The ratio of students who received a score of zero by not answering or incorrectly answering the "exchange rate 2" question was 48.2% (592 students), whereas it can be seen that this ratio was 45.7% in the 2003 implementation. The ratio of students who received a full score by correctly answering this question was 51.8% (635 students), whereas it can be seen that this ratio was 54.3% in PISA 2003 (MEB, 2005). When distribution percentages are examined for the "exchange rate 2" question, it can be stated that there is an increase with a ratio of 2.5% for students who received a score of zero, whereas there is a decrease with the ratio of 2.5% for students who received a full score compared to PISA 2003 results. Furthermore, when it is considered that this question was determined at the 2nd competency level in the PISA 2003 implementation, it can be stated that nearly half of students who participated in the research were able to give an entirely correct answer to a question that is at the 2nd competency level.

The answers given by the students who participated in this study to the "exchange rate 2" question are given in the table below in the form of frequency and answer percentages in accordance with school types.

Table 3. Frequency and percentage distribution of the exchange rate 2 question in accordance with school types

School Type	Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	179	75.2%	59	24.8%	238
Science High School	194	78.2%	54	21.8%	248
General High School	58	23.5%	189	76.5%	247
Vocational High School	35	14.2%	211	85.8%	246
Private High School	169	68.1%	79	31.9%	248
Total	635	51.8%	592	48.2%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of giving an entirely correct answer to the "exchange rate 2" question is highest in science high schools. These schools are followed respectively by Anatolian high schools, private high schools, general high schools and vocational high schools. It is a noteworthy fact that the ratios of giving an incorrect answer to or not answering the exchange rate 2 question in vocational high schools and general high schools are extremely high.

"Exports 1" Question: What was the total value (in millions of zeds) of exports from Zedland in 1998?

The ratio of students who received a score of zero by not answering or incorrectly answering the "exports 1" question was 35.9% (441 students), whereas it can be seen that this ratio was 78.2% in the 2003 implementation. The ratio of students who received a full score by correctly answering this question was 64.1%, whereas it can be seen that this ratio was 21.8% in the 2003 implementation (MEB, 2005). When distribution percentages are examined for the "exports 1" question, it can be stated that there is a decrease with a ratio of 42.3% for students who received a score of zero, whereas there is an increase with the ratio of 42.1% for students who received a full score compared to the PISA 2003 results. Furthermore, when it is considered that this question was determined at the 2nd competency level in the PISA 2003 implementation, it can be stated that the vast majority of the students who participated in the research were able to correctly answer a question at the 2nd competency level.

The answers given to the "exports 1" question are by the students who participated in this study are given in the table below in the form of frequency and answer percentages in accordance with school types.

Table 4. Frequency and percentage distribution of the exports 1 question in accordance with school types

School Type	Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	180	75.6%	58	24.4%	238
Science High School	215	86.7%	33	13.3%	248
General High School	110	44.5%	137	55.5%	247
Vocational High School	100	40.7%	146	59.3%	246
Private High School	181	73%	67	27%	248
Total	786	64.1%	441	35.9%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of giving an entirely correct answer to the "exports 1" question is highest in science high schools. These schools are followed respectively by Anatolian high schools, private high schools, general high schools and vocational high schools. Vocational high schools and general high schools are the school types that have the highest ratio in giving an incorrect answer or not answering the "exports 1" question.

The question entitled "growing up", which is the second question example in the change and relationships (algebra) subject area, was asked as 3 questions in a common item root. In this question, "growing up 1" and "growing up 3" questions were asked in a semi-structured question type, whereas the "growing up 2" question is a question type that was prepared as an open-ended question type.

"Growing up 1" Question: Since 1980, the average height of 20-year-old females has increased by 2.3 cm to 170.6 cm. What was the average height of a 20-year-old female in 1980?

"Growing up 1" is a question that is determined in the 2nd competency level in PISA 2003. Answers given to the question were evaluated as either "correct" or "incorrect". People who gave the answer "168.3cm" to this question received a full score, whereas people who gave "other answers" and people who did not answer the question received a score of zero.

The answers given by the students who participated in this study to the "growing up 1" question are given in the table below in the form of frequency and answer percentages in accordance with school types.

Table 5. Frequency and percentage distribution of the "growing up 1" question in accordance with school types

School Type	Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	159	66.8%	79	33.2%	238
Science High School	186	75%	62	25%	248
General High School	72	29.1%	175	70.9%	247
Vocational High School	60	24.4%	186	75.6%	246
Private High School	145	58.5%	103	41.5%	248
Total	622	50.7%	605	49.3%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of people correctly answering the "growing up 1" question is highest in science high schools. These schools are followed respectively by Anatolian high schools, private high schools, general high schools and vocational high schools. The ratio of people who gave an incorrect answer or did not answer the "growing up 1" question is extremely high in vocational high schools and general high schools.

"Growing Up 2" Question: According to this graph, on average, during which period in their life are females taller than males of the same age?

The ratio of students who received a score of zero by not answering or incorrectly answering the "growing up 2" question was 19.3% (236 students), whereas it can be seen that this ratio was 26.5% in PISA 2003. The ratio of students who received a partial score by partially answering this question was 38.6% (474 students), whereas it can be seen that this ratio was 36% in 2003. The ratio of students who received a full score by fully answering the same question was 42.1% (517 students), whereas it can be seen that this ratio was 37.4% in 2003 (MEB, 2005). When distribution percentages are examined for the "growing up 2" question, it can be stated that there is a decrease with a ratio of 7.2% for students who received a score of zero, whereas there is an increase with a ratio of 2.6% for students who received a partial score; and there is also an increase with a ratio of 4.7% for students who received a full score compared to PISA 2003. Furthermore, when it is considered that this question was determined at the 3rd competency level in the PISA 2003 implementation, it can be stated that nearly half of the students who participated in the study were able to give an entirely correct answer to a question that is at the 3rd competency level, and a vast majority were able to give an entirely correct answer or a partially correct answer.

The answers given by the students who participated in this study to the "growing up 2" question are given in the table below in the form of frequency and answer percentages in accordance with school types.

Table 6. Frequency and percentage distribution of the "growing up 2" question in accordance with school types

School Type	Fully Correct		Partially Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	139	58.4%	76	31.9%	23	9.7%	238
Science High School	161	64.9%	68	27.4%	19	7.7%	248
General High School	47	19.1%	131	53%	69	27.9%	247
Vocational High School	58	23.6%	94	38.2%	94	38.2%	246
Private High School	112	45.1%	105	42.3%	31	12.6%	248
Total	517	42.1%	474	38.6%	236	19.3%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of students correctly answering the "growing up 2" question is highest in science high schools. These schools are followed respectively by Anatolian high schools, private high schools, vocational high schools and general high schools. The vocational high school is the school type that has the highest ratio of giving an incorrect answer or not answering the "growing up 2" question.

"Growing Up 3" Question: This question was formed in the following way: "Explain how the graph shows that on average, the growth rate for girls slows down after 12 years of age".

In this study, the ratio of students who received a score of zero by either not answering or incorrectly answering the "growing up 2" question was 71.4% (876 students), whereas it can be seen that this ratio was 60.6% in 2003. The ratio of students who received a full score by correctly answering the "growing up 2" question was 28.6% (351 students), whereas it can be seen that this ratio was 39.5% in PISA 2003 (MEB, 2005). When distribution percentages are examined for the "growing up 2" question, it can be stated that there is an increase with a ratio of 10.8% for students who received a score of zero and there is a decrease with a ratio of 10.9% for students who received a full score compared to PISA 2003. Furthermore, when it is considered that this question was determined at the 4th competency level in the PISA 2003 implementation, it can be stated that the vast majority of students who participated in the study were not able to correctly answer a question at the 4th competency level.

The answers given by the students who participated in this study to the "growing up 2" question are given in the table below in the form of frequency and answer percentages in accordance with school types.

Table 7. Frequency and percentage distribution of the "growing up 3" question in accordance with school types

School Type	Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	95	40%	143	60%	238
Science High School	131	52.8%	117	47.2%	248
General High School	32	12.9%	215	87.1%	247
Vocational High School	17	6.9%	229	93.1%	246
Private High School	76	30.6%	172	69.4%	248
Total	351	28.6%	876	71.4%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of correctly answering the "growing up 3" question is highest in science high schools. These schools are followed respectively by Anatolian high schools, private high schools, general high schools and vocational high schools. The ratio of giving an incorrect answer or not answering the "growing up 3" question is extremely high in vocational high schools and general high schools.

"Exchange Rate 3" Question: During these 3 months, the exchange rate had changed from 4.2 to 4.0 ZAR per SGD.

Was it in Mei-Ling's favour that the exchange rate now was 4.0 ZAR instead of 4.2 ZAR, when she changed her South African rand back to Singaporean dollars? Give an explanation to support your answer.

The ratio of students who received a score of zero by not answering or incorrectly answering the "exchange rate 3" question was 73.8% (906 students), whereas it can be seen that this ratio was 78.2% in 2003 implementation. The ratio of students who received a full score by correctly answering the same question was 26.2% (321 students) in this study, whereas it can be seen that this ratio was 21.8% in the 2003 implementation (MEB, 2005). When distribution percentages are examined for the "exchange rate 3" question, it can be stated that there is a decrease with a ratio of 4.4% for students who received a score of zero, whereas there is an increase with the ratio of 4.4% for students who received a full score compared to the PISA 2003 results. Furthermore, when it is considered that this question was determined at the 4th competency level in the PISA 2003 implementation, it can be stated that the vast majority of students who participated in this study were unable to correctly answer a question at the 4th competency level.

The answers given by the students who participated in this study to the "exchange rate 3" question are given in the table below in the form of frequency and answer percentages in accordance with school types.

Table 8. Frequency and percentage distribution of the exchange rate 3 question in accordance with school types

School Type	Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	94	39.5%	144	60.5%	238
Science High School	126	50.8%	122	49.2%	248
General High School	18	7.3%	229	92.7%	247
Vocational High School	8	3.3%	238	96.7%	246
Private High School	75	30.2%	173	69.8%	248
Total	321	26.2%	906	73.8%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of giving an entirely correct answer to the "exchange rate 3" question is highest in science high schools. These schools are followed respectively by Anatolian high schools, private high schools, general high schools and vocational high schools. It is a noteworthy fact that the ratios of giving incorrect answer or not answering the "exchange rate 3" question in vocational high schools and general high schools are extremely high.

"Exports 2" Question: What was the value of fruit juice exported from Zedland in 2000?

A) 1.8 million zeds. B) 2.3 million zeds. C) 2.4 million zeds. D) 3.4 million zeds. E) 3.8 million zeds.

The ratio of students who received a score of zero by not answering or incorrectly answering the "exports 2" question, which was prepared as a multiple-choice question, was 50.3% (617 students), whereas it can be seen that this ratio was 63.5% in the 2003 implementation. The ratio of students who received a full score by correctly answering the same question was 49.7% (610 students), whereas it can be seen that this ratio was 36.6% in PISA 2003 (MEB, 2005). When distribution percentages are examined for the "exports 2" question, it can be stated that there is a decrease with a ratio of 13.2% for students who received a score of zero, whereas there is an increase with the ratio of 13.1% for students who received a full score compared to the PISA 2003 results. Furthermore, when it is considered that this question was determined at the 4th competency level in the PISA 2003 implementation, it can be stated that nearly half of the students who participated in the research were unable to give an entirely correct answer to a question that is at the 4th competency level.

The answers given by the students who participated in this study to the "exports 2" question are given in the table below in the form of frequency and answer percentages in accordance with school types.

Table 9. Frequency and percentage distribution of the "exports 2" question in accordance with school types

School Type	Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	162	68.1%	76	31.9%	238
Science High School	202	81.5%	46	18.5%	248
General High School	52	21.1%	195	78.9%	247
Vocational High School	49	19.9%	197	80.1%	246
Private High School	145	58.5%	103	41.5%	248
Total	610	49.7%	617	50.3%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of giving an entirely correct answer to the "exports 2" question is highest in science high schools. These schools are followed respectively by Anatolian high schools, private high schools, general high schools and vocational high schools. It is a noteworthy fact that the ratios of giving an incorrect answer or not answering the "exports" 2 question in school types such as general high schools and vocational high schools are extremely high.

The question entitled "carpenter", which was asked in the space and shape (geometry) area, is a question that was determined at the 6th competency level in the PISA 2003 implementation. This question is a question example that was prepared in the complex multiple-choice question type. Answers given to the questions were evaluated as "fully correct", "partially correct" and "incorrect". In this question, people who gave four correct answers as "yes, no, yes, yes" received a full score; people who gave "exactly three correct answers" received a partial score; and people who gave "two or fewer correct answers" and people who did not answer the question received a score of zero. The ratio of the students who received a score of zero by not answering or incorrectly answering the question was 46.7% (573 students), whereas it can be seen that this ratio was 62.6% in the 2003 implementation. The ratio of students who received a partial score by giving three correct answers to this question was 25.3% (310 students), whereas it can be seen that this ratio was 25.6% in PISA 2003. The percentage of students who received a full score by giving 4 correct answers to the same question was 28%, whereas it can be seen that this ratio was 11.8% in 2003 (MEB, 2005). When distribution percentages are examined for the "carpenter" question, it can be stated that there is a decrease with a ratio of 15.9% for students who received a score of zero; there is a decrease with a ratio of 0.3% for students who received a partial score, whereas there is an increase with the ratio of 16.2% for students who received a full score compared to PISA 2003. Furthermore, when it is considered that this question was determined at the 6th competency level in the PISA 2003 implementation, it can be stated that nearly 30% of the students who participated in the study were able to give an entirely correct answer to a question that is at the 6th competency level, and nearly 55% were able to give an entirely correct answer or a partially correct answer.

The answers given by the students who participated in this study to the "carpenter" question are given in the table below in the form of frequency and answer percentages in accordance with school types.

Table 10. Frequency and percentage distribution of the carpenter question in accordance with school types

School Type	Fully Correct		Partially Correct		Incorrect/Unanswered		Total
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency
Anatolian High School	80	33.6%	76	31.9%	82	34.4%	238
Science High School	143	57.7%	49	19.8%	56	22.6%	248
General High School	16	6.5%	58	23.5%	173	70%	247
Vocational High School	13	5.3%	56	22.8%	177	72%	246
Private High School	92	37.1%	71	28.6%	85	34.3%	248
Total	344	28%	310	25.3%	573	46.7%	1227

When distribution percentages are examined in accordance with school types, it is observed that the ratio of giving an entirely correct answer to the "carpenter" question is highest in science high schools. These schools are followed respectively by private high schools, Anatolian high schools, general high schools and vocational high schools. It is a noteworthy fact that the ratios of giving an incorrect answer or not answering the carpenter question in vocational high schools and general high schools are high.

Discussion and Conclusion

According to the results obtained in this study, an improvement is observed in half of the PISA 2003 evaluation questions in a general sense compared to the PISA 2003 results. A decrease was detected in other questions. It is understood that a vast majority of the students who answered the evaluation questions were unable to give an entirely correct answer to a question at the 6th competency levels in terms of distribution percentages. It is observed that a vast majority or half of the students were unable to give an entirely correct answer or correct answer to the questions at the 4th and 5th competency levels. When answer distributions in the 1st, 2nd and 3rd competency levels are examined, it is observed that nearly half or more of the students were able to give an entirely correct answer or correct answer to these questions. It is concluded that a vast majority of our students still cannot give answers to questions at high competency levels in the desired manner, and just under half can give answers to questions at low and medium competency levels. According to the results of the PISA 2003 implementation, it is observed that more than half of the students who participated in the implementation scored below the 2nd competency level in mathematical literacy scale, and their average score is 425. Similar results were also observed in 2006. Turkey raised its average score to 446 with an increase of over 20 points in mathematical literacy in the PISA 2009 implementation (MEB, 2009). In parallel with the findings of this study, in a study in which Turkey's condition regarding the education system was evaluated by examining the results of PISA studies, and it was detected that Turkey made progress, though slight, when the results of PISA 2003 and PISA 2009 were compared (Çelen, Çelik and Seferoğlu, 2011). Although Turkey is among the countries that increased their scores the most, the country was

unable to raise its level and remains at the 2nd level in mathematics, science and reading skills in PISA 2003 and PISA 2009 (Çalışkan, 2008; Özenç and Arslanhan, 2010). The question types, to which the vast majority of students were unable to give an entirely correct answer or correct answer in a general sense, are question types that were generally prepared in an open-ended format at the 4th, 5th and 6th competency levels. Among the reasons for this condition, we can state the fact that our students generally encounter multiple-choice question types in the national examinations in which they participate. It is observed that students experience difficulty with the question types that are prepared as open-ended for that reason. In the study conducted by Demir (2010), as a general result, it was concluded that the success levels of the students in Turkey are higher in structured (multiple-choice, complex multiple-choice and semi structured) question types than the other question types (short-answer, open-ended) to which they are expected to form the answers on their own. Furthermore, in the results of a conducted research, it was observed that questions, problems, exercises and examples, which were at the 1st (23%), 2nd (47%), 3rd (24%) and 4th (6%) competency levels, were given an elementary mathematics 8th grade textbook. As it can be seen from the ratios, it was observed that the 2nd level questions are featured the most among these levels, and the ratio of the questions at the 4th level is only 6%. It is another striking result that there are no questions at the 5th and 6th levels, which are the highest among mathematics levels (Aydoğdu İskenderoğlu and Baki, 2011). According to the results of the study, a decrease was observed regarding the ratios of correctly answering half of the PISA 2003 evaluation questions, whereas an increase was observed regarding the ratios of correctly answering over half of the PISA 2003 evaluation questions compared to 2003. However, it was observed that the students still cannot sufficiently answer questions at a high competency level, and the ratio of giving correct answers to questions at a low competence level is not at the expected level. The students who participated in this study are students who completed their education with the changed elementary mathematics curriculum. It was observed that they were unable to give correct answers to the questions at a desired level. Whether or not the changed curriculum, which is aimed at in the study, is sufficiently effective can be reviewed by conducting various different studies. Its inadequate and failing aspects can be determined, and its effectiveness can be increased.

When the findings obtained from this study are examined according to the subject area, a general improvement is observed in questions of in probability area. The reason for this can be determined by the fact that this area, which was not predominantly featured in our previous curriculums, was predominantly featured in our new curriculums. In the algebra area, the results either show parallelism with PISA 2003 results or a decrease is observed. It is observed that the students were unable to give entirely correct answers to a question at the 6th competency level in the geometry area; however, there is improvement compared to the PISA 2003 results. The reason for this improvement can be determined by the fact that geometry instruction is distributed to every class level in the changed curriculum. A General improvement was observed in questions in the arithmetic area. It was determined that the performances of the students who participated in the PISA 2003 implementation in four areas of mathematics are similar to each other (MEB, 2005).

According to the findings obtained from this study, it was observed that the school type that showed the best performance regarding the ratio of answering the evaluation questions was science high schools, as expected. It is observed that school types in which the ratio of not answering or incorrectly answering the questions is highest are vocational high schools and general high schools. When the results in PISA implementations are examined, it can be observed that science high schools are the most successful school type among the school types that participated in the implementation. Differences of serious extents were observed among the school types in terms of mathematics success in the PISA 2003 and 2006 implementations (MEB, 2005; MEB, 2007). Berberoğlu and Kalender (2005), who found a similar result from the findings that they obtained in their study, stated that the differences

among school types are in serious extents rather than regional differences in success levels of the students in both ÖSS and PISA evaluations. Differences were also observed among school types in the PISA 2009 implementation (MEB, 2010). It was determined that the school type that showed the lowest performance in mathematical literacy is elementary schools. When mathematics average scores of secondary level schools were examined, it was observed that the lowest averages belonged to school types such as general high schools, Anatolian vocational high schools, vocational high schools and multi-programme high schools (MEB, 2005; MEB, 2007; MEB, 2010). According to the results of this study, the school types that have the lowest success levels among all the school types are vocational high schools and general high schools. In view of these results, the reasons for this condition can be identified by conducting qualitative and quantitative research studies in these school types in more detail, and necessary precautions can be taken. It is observed that success differences among the school types are still continuing in serious extents. It is a noteworthy fact that the ratio of correctly answering the questions in vocational high schools and general high schools is low in many questions. The effectiveness of the changed curriculum can also be reviewed for these school types.

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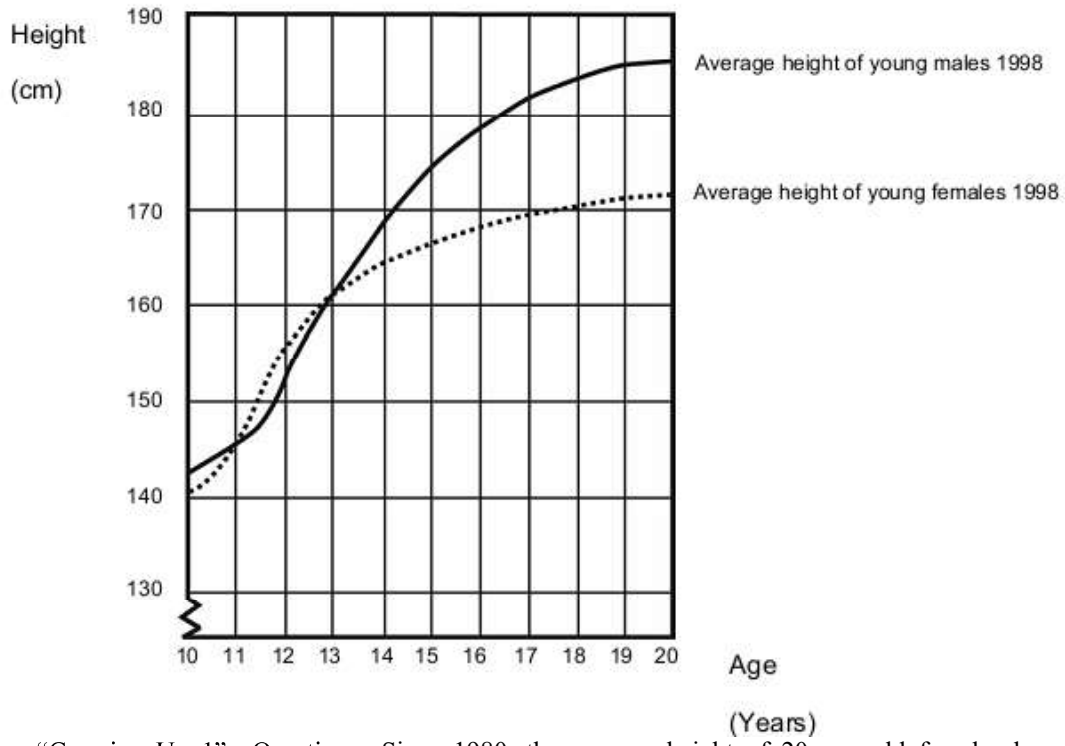
APPENDIX

GROWING UP

YOUTH GROWS TALLER

In 1998 the average height of both young males and young females in the Netherlands is represented in this graph.



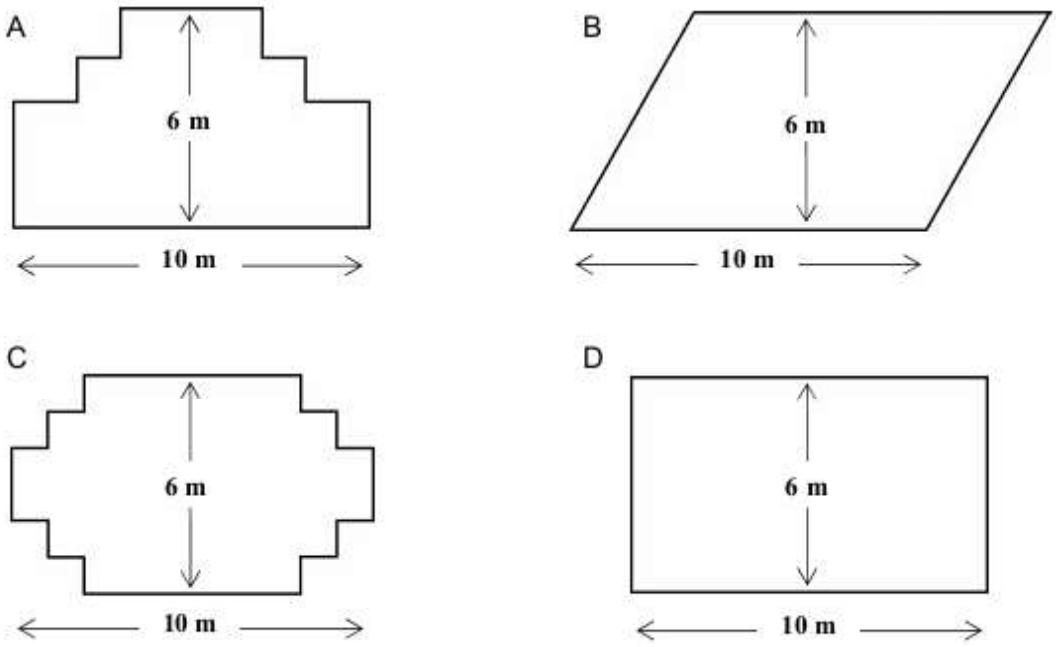
"Growing Up 1" Question: Since 1980, the average height of 20-year-old females has increased by 2.3 cm to 170.6 cm. What was the average height of a 20-year-old female in 1980?

"Growing Up 2" Question: According to this graph, on average, during which period in their life are females taller than males of the same age?

"Growing Up 3" Question: This question was formed in the following way: "Explain how the graph shows that on average, the growth rate for girls slows down after 12 years of age".

Question 1: CARPENTER

A carpenter has 32 metres of timber and wants to make a border around a garden bed. He is considering the following designs for the garden bed.



"Exchange Rate" Question: Mei-Ling from Singapore was preparing to go to South Africa for 3 months as an exchange student. She needed to change some Singaporean Dollars (SGD) into South African Rand (ZAR).

"Exchange Rate 1" Question: Mei-Ling found out that the exchange rate between the Singaporean dollar and the South African rand was:

1 SGD = 4.2 ZAR

Mei-Ling changed 3,000 Singaporean dollars into South African rand at this exchange rate.

How much money in South African rand did Mei-Ling get?

"Exchange Rate 2" Question: On returning to Singapore after 3 months, Mei-Ling had 3,900 ZAR left. She changed this back to Singaporean dollars, noting that the exchange rate had changed to:

1 SGD = 4.0 ZAR

How much money in Singapore dollars did Mei-Ling get?

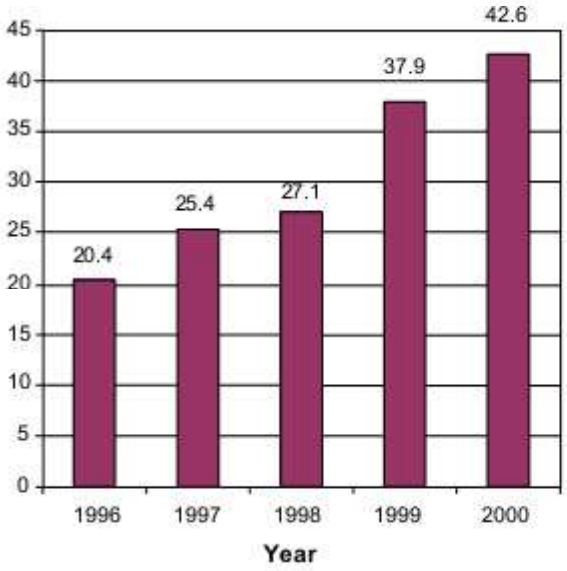
"Exchange Rate 3" Question: During these 3 months, the exchange rate had changed from 4.2 to 4.0 ZAR per SGD.

Was it in Mei-Ling's favour that the exchange rate now was 4.0 ZAR instead of 4.2 ZAR, when she changed her South African rand back to Singaporean dollars? Give an explanation to support your answer.

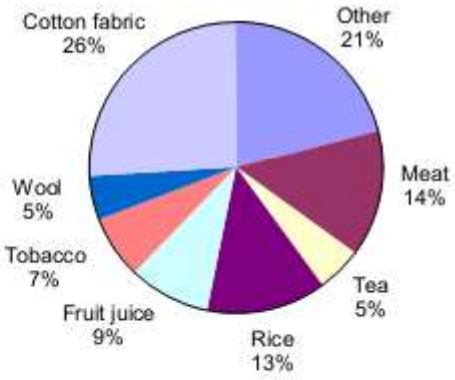
EXPORTS

The graphics below show information about exports from Zedland, a country that uses zeds as its currency.

Total annual exports from Zedland in millions of zeds, 1996-2000



Distribution of exports from Zedland in 2000



"Exports 1" Question: What was the total value (in millions of zeds) of exports from Zedland in 1998?

"Exports 2" Question: What was the value of fruit juice exported from Zedland in 2000?

A) 1.8 million zeds. B) 2.3 million zeds. C) 2.4 million zeds. D) 3.4 million zeds. E) 3.8 million zeds.