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AN ANALYSIS OF TURKISH HIGH SCHOOL STUDENTS' PERFORMANCE ON CONCEPTUAL, ALGORITHMIC AND GRAPHICAL PHYSICS PROBLEMS

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ABSTRACT

The aim of this study was to investigate performances of high school students regarding the conceptual, algorithmic and graphical physics questions by comparatively. The study was carried out with participant of 68 students. Data of the study was gathered with 15 open-ended questions. The results of the study showed that students performed better on the algorithmic and conceptual questions than the graphical questions. It was concluded that students' competence in each question types may be affected from ratio of question types asked in university entrance examinations.

Keywords: Conceptual questions, Algorithmic questions, Graphical questions

INTRODUCTION

Just like other lessons, physics subjects in schools possess an unsettled quality, in terms of teaching and learning of contents and objectives. High school physics contents generally reflects the simplified and (or) reduced version of the physics subjects in college. Researchers in the field of education agree upon that the ultimate goal of the high school curriculum should not be considered only as training physicians. The content of high school physics lessons is expected to train individuals, who can generate solutions and make decisions when they encounter with problems, which involve the society (National Education Standards., 1993). In this sense, the primary objective of the recently-structured physics curricula in Turkey is to train productive and creative individuals who have internalized the fact that physics is a discipline that is derived from the real life, and who can explain the meaning of the basic concepts of physics accurately and solve problems (MEB, 2007). However, high school students in Turkey are required for university entrance to be successful in the exam of Transition to Higher Education (THE) and Undergraduate Placement Exam (UPE), which do not include any open-ended questions that allow to assess students' understandings of the physics concepts and to evaluate their solution processes rather than the final product. THE and UPE examinations include questions from the subjects of core lessons, including physics, that are taught in high school.

Some studies, which investigated the effects of these examinations, present interesting results. Özden (2010) indicates that students' performance (scores) in these exams affect their choices of profession. Other studies (Ayvacı, 2010; Baştürk, 2011) emphasize that these examinations have an effect on the instruction approaches of teachers. In his study, Ayvacı (2010) attracts attention to the fact that teachers worry that teaching environments that were grounded on conceptual learning will not be compatible with concepts of THE and UPE examinations. (Baştürk, 2011) states that teachers, during their instruction, attach importance to the exercises with short and practical solutions in their lessons, since the students are required to answer the questions within a limited time during the university entrance examinations. Having similar reasons, Ates and Cataloglu (2007) state that a great number of teachers highlight the algorithmic questions, similar to the ones in the examinations, that needs a numerical answer and that do not inquire explanations. As a consequence, THE and UPE inevitably change classroom instruction and urge students to study with an intensive tempo and practice a lot of questions in order to successful in the examinations. There are explicitly some questions to be asked right here: Is it sufficient for achievement to practice a lot of questions? To what extent does solving a lot of questions actualize/develop the conceptual learning? To what extent does solving a lot of algorithmic (and multiple-choice) questions develop the conceptual learning? Kim and Pak (2002) compared the conceptual perceptions of students who solve a lot of physics questions (an average of 1500 questions) with their skills of applying the physics formulas and mathematical operations. The results that were obtained by researchers showed that while students who solve a lot of physics questions do not have difficulty in using the physics formulas and mathematical operations, they have difficulties in conceptual learning. A typical study that was performed with college students in Turkey revealed that (Kurnaz, 2007) students are able to solve the questions with the help of algebraic equations; however, they have limited information about the truth, in other words the physics laws behind their solution. Moreover, he also indicates that students solve an algorithmic question by using the formula that is compatible with the concepts in the question (e.g. the problem has the initial velocity, acceleration and displacement, and the final velocity is asked. Then the velocity formula without time shall be used); however, they are unable or have difficulty to explain the physics law behind the formula they apply. Mazur (1996) expresses that even though students have the skills of recalling the formulas and solving the questions in his physics lessons, they were found insufficient in terms of conceptual questions. A further discussion is made by Maloney (1994). He thinks that novice students try the formula and equations in order to find the unknown for the solution. In case of failure, they try to apply the next formula and equation they remember without considering the reason of the failure.

In some studies, the relation between the algorithmic understanding and conceptual understanding is discussed in relation with whether the students are algorithmic or conceptual problem solvers. In comparison of achievement of students regarding conceptual and algorithmic questions, the first study was conducted by Nurrenbern and Pickering (1987) who investigated the relationship between algorithmic problem solving and having the knowledge of the basic concepts behind these problems. Then, some other studies (e.g. (Nakhleh, 1993; Nakhleh and Mitchell, 1993; Kim and

Pak, 2002; Erkan, 2011) attempted to determine whether the students are conceptual problem solvers or algorithmic problem solvers. The frequently-used instrument in these studies includes two questions about the same subject, one of which requires the conceptual understanding and the other requires algorithmic skills (e.g. (Nurrenbern and Pickering, 1987; Sawrey, 1990; Nakhleh, 1993; Nakhleh and Mitchell, 1993; Lin *et al.*, 1996; Mason *et al.*, 1997). In some of the well-known studies that were performed within this framework, Nurrenbern and Pickering (1987) determined that 65 % of students gave correct answers to the algorithmic questions, 35 % gave correct answers to conceptual questions; and Nakhleh (1993) determined that 85 % of students gave correct answers to algorithmic questions and 49 % gave correct answers to conceptual questions. Moreover, studies also reveal that outstanding achievement in algorithmic questions does not warrant the conceptual understanding (Mazur, 1996; McDermott, 2001; Kim and Pak, 2002; Redish, 2005; Kurnaz, 2007; Ateş, 2008; Erkan, 2011).

Some researchers take part in the discussion of conceptual and algorithmic understanding by emphasizing the importance of graphical understanding, as well. Graphics have such properties that they can ease the reflection of relations between the variables being examined for the solution of problems (Beichner, 1994; Ates and Stevens, 2003; Sağlam Arslan, 2009). Moreover, drawing and/or interpreting graphics are among actions that will be presented by students in the process of acting like scientists who were examining, analyzing, accomplishing and reporting (Roth, 2004; Bowen and Roth, 2005). Additionally, since graphics are frequently used in social information networks (such as TV, newspaper and internet), everyone is expected to have the skill of explaining the meaning of graphics (Tairab and Khalaf Al-Naqbi, 2004; Kekule, 2008). Van Dyke and White (2004) state that graphical interpretation will support the abstract thinking skills of students. In addition, since different graphic representations could be used for different purposes, it is suggested to have the skill of selecting the convenient graphical representation for an information set that is given (Kosslyn, 1985). Additionally, within the context of physics lessons, graphics are also used to explain the results of tests that are performed in laboratories. Thus, graphics could also be considered a communication medium between teacher-student and student-student.

Just like other lessons, physics teaching/learning also attaches a great importance to reading, forming and interpreting graphics. However, a number of studies express that students have common deficiencies in terms of forming and interpreting graphics (McDermott *et al.*, 1987; Beichner, 1994; Berg and Smith, 1994; Ates and Stevens, 2003; Kekule, 2008; Sağlam Arslan, 2009). For example, in his two-stage study that was previously performed with 480 and then with 700 students, Kekule (2008) emphasizes the fact that students describe graphics as the outline or picture of reality. Berg and Smith (1994) also reported that students perceive graphics as a picture, instead of a symbolic depiction of knowledge. Sağlam Arslan (2009) conducted their study with a total of 243 students from different level of education (high school students, undergraduate and graduate students). The researcher states that students from different education level have a great difficulty in using graphics for the purpose of analyzing the relation between different variables and thereby, they cannot realize the graphical depiction of the information. However, it is known that information is frequently illustrated with graphical representations in many school books. As a matter of fact, most of the standard examinations are developed in such a way to involve the skills of reading, forming and interpreting graphics (Forster, 2004). Similarly, examining the question types in THE and UPE examinations in Turkey, it is seen that the questions are not only conceptual and algorithmic; they involve graphical questions as well. The studies comparing students' performances on graphical, conceptual and algorithmic questions were very few in number compared to the ones focusing on the students' performances on conceptual and algorithmic questions (Coştu, 2007; Coştu, 2010). Especially, when considering the importance of graphics within the context of physics lessons and school books and question types in THE and UPE examinations, it is believed that the research of the relationship among graphical, conceptual and algorithmic question performances is also important.

To this end, the objective of this study is to compare the performances of students regarding the conceptual, algorithmic and graphical physics questions and determine the differences, if exists.

METHODOLOGY

Case study was used as the research method in this study. The case that is examined within the scope of the study involves the performances of students at conceptual, algorithmic and graphical physics questions.

Study Group

The study group was consisted of a total of 68 high school students in a city in the Black Sea region of Turkey. A criterion-based purposive sampling strategy was applied in forming of the study group. The criteria for selection were for all students to be in the twelve-grade and to have a score four or five (out of five) in physics lesson. The reason of selecting the study group from the students with high grades was to control the deviations that would be caused by unsuccessful students during the performance comparison.

Instrument

In line with the aims, this study used an achievement test consisted of question sets, which involve conceptual, graphical and algorithmic questions on the same subject. The achievement test involves 15 questions on four subjects and the questions were prepared by using different physics school books and question banks. In the achievement test, students were also asked about what kind of questions they preferred (at what kind of questions they felt more successful). The prepared questions were examined and approved by a field expert who studies in the field of physics and three physics teachers, in terms of its understandability and practicability. A pilot application of the achievement test conducted with 24 students, and its understandability was found sufficient. All of the questions are open-ended, and their features are given in Table 1.

Table-1. Distribution of question peers

Question peers	Topic of the question peers
1A, 1C, 1G	Constant motion
2A, 2C, 2G	Accelerated motion
3A, 3C, 3G	Accelerated motion
4A, 4C, 4G	Rotational motion
5A, 5C, 5G	Harmonic motion

A: algorithmic question, C: conceptual question, G: graphical question

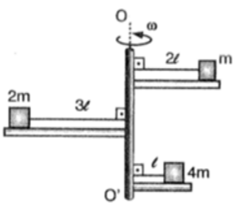
The data were collected with an exam-quality application in a single-session process of 90 minutes. The exam application was introduced to students as a preparation for THE and UPE exams, and the students tried to answer the whole question set. One set of questions, which were directed towards students on the subject of rotational motion, are given in Figure 1.

Figure-1. Sample questions, which were directed towards students on the same subject

Sample question of conceptual understanding

Question 3C

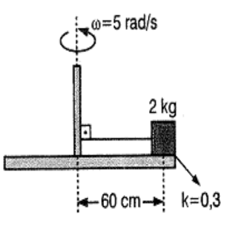
When the mechanism on the side is rotated with the constant angular velocity *w* around the OO' axis, the tensile forces, to which the substances with masses m, 2m and 4m are adhered and which occur on ropes with an extent of 2*l*, 3*l* and *l*, respectively become T_1, T_2 and T_3. Accordingly, explain the reason/reasons by comparing the tension on ropes.



Sample question of algorithmic problem solving

Question 3A

As the horizontal table rotates with an angular velocity of $w = 5$ rad/s, the substance with a mass of 2 kg, which is adhered to the table with a rope, rotates with it as well. Now that the friction coefficient of the table is k=0,3 and distance of the substance to the axis of rotation is 60 cm, what is the tension of the force?



Sample question of graphical understanding

Question 3G

Draw the acceleration-time graphic of the motion of the substance, which moves according to the values given in the table on the side?

t (s)	1	2	3	4	5	6
θ (rad)	$\frac{\pi}{2}$	π	$\frac{3\pi}{2}$	2π	$\frac{5\pi}{2}$	3π

As is seen in Figure 1, since Question 3C required students to use their conceptual information regarding the given condition, it was considered a conceptual question. Since Question 3A required students to make algorithmic calculations and reach a numerical value, it was accepted as an algorithmic question. Since Question 3G required students to express the given values on a graphic and draw the graphic, it was assessed as a graphical question.

Data Analysis

The data that were obtained were initially examined in terms of the success and (correct answers) and failure (wrong and no answers) states of students. During this process, the whole analysis was conducted by the researcher in company with an external expert, who holds a doctoral degree in the field of physics (Sample answers that were considered correct and wrong are given in Appendix-A). Then the researcher examined the distribution of preferred question types and students' performance on the question types that they preferred. In the final phase, the achievement distributions of students, who were successful at a question type, were compared with those at other question types.

RESULTS

Achievement distributions of students at each question set are given in Table 2. When the achievement and failure states are compared for five question sets in Table 2, it is seen that three question types –conceptual, algorithmic and graphical– give similar/close results with questions in each set. The fact that the questions of three question types have the approximate difficulty for students in each set could be remarked here. As is seen in the table, a great majority of students achieved the algorithmic and conceptual question types in all subjects. However, a good number of students had difficulty at the graphical question type. Approximately one third of students could give no correct answer to graphical questions on all subjects. Compared to other question types, students left the graphical question type unanswered at a greater rate at all question sets.

Table-2. Percentage distribution of students' responses according to achievement

Question	C2		C1		C0		A2		A1		A0		G2		G1		G0	
peers	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
1C, 1A and 1G	56	82,4	10	14,7	2	2,9	56	82,4	9	13,2	3	4,4	34	50,0	23	33,8	11	16,2
2C, 2A and 2G	52	76,5	14	20,6	2	2,9	52	76,5	10	14,7	6	8,8	36	52,9	22	32,4	10	14,7
3C, 3A and 3G	48	70,6	18	26,5	2	2,9	54	79,4	7	10,3	7	10,3	38	55,9	22	32,4	8	11,8
4C, 4A and 4G	54	79,4	11	16,2	3	4,4	53	77,9	10	14,7	5	7,4	35	51,5	26	38,2	7	10,3
5C, 5A and 5G	54	79,4	11	16,2	3	4,4	60	88,2	8	11,8	0	0	32	47,1	27	39,7	9	13,2
Total	264	77,7	64	18,8	12	3,5	275	80,9	44	12,9	21	6,2	175	51,5	120	35,3	45	13,2

C2: conceptual question correct, C1: conceptual question wrong, C0: no response to conceptual question, A2: algorithmic question correct, A1: algorithmic question wrong, A0: no response to algorithmic question, G2: graphical question correct, G1: graphical question wrong, G0: no response to graphical question.

The achievement distributions of students, which are observed at three, two or one of the conceptual, algorithmic and graphical question types, are presented in Table 3 for all of the questions.

Table-3. Distribution of correct answers according to question types

NCA	C, A and G		C and A		C and G		A and G		C		A		G	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%
5	0	0	8	11,8	0	0	1	1,5	22	32,4	26	38,2	6	8,8
4	2	2,9	6	8,8	1	1,5	2	2,9	23	33,8	25	36,8	7	10,3
3	2	2,9	2	2,9	4	5,9	2	2,9	16	23,5	12	17,6	23	33,8
2	0	0	1	1,5	1	1,5	0	0	6	8,8	5	7,4	17	25,0
1	0	0	0	0	0	0	0	0	1	1,5	0	0	10	14,7
0	0	0	0	0	0	0	0	0	0	0	0	0	5	7,4

NCA: Number of Correct Answer, C: conceptual question, A: algorithmic question, G: graphical question

As is seen in Table 3, no student gave correct answers to all of the questions at three question types (C, A and G) (0 %). This failure is also valid for the limited number of correct answers (NCA). Achievements at both question types are also very low. The number of students who gave correct answers to both conceptual and algorithmic (C and A) questions is very few (11.8 %). No student gave correct answers to both conceptual and graphic (C and G) questions (0 %). Only one student gave correct answers to all of the algorithmic and graphic (A and G) questions. Regarding the more limited number of correct answers (NCA), on the other hand, the rate of students to answer both the conceptual and algorithmic (C and A) questions together is higher than the rate of answering the conceptual and graphical (C and G) questions and the rate of answering the algorithmic and graphical (A and G) questions.

Examining Table 3 in terms of giving correct answers to all of the questions at one question type, it is seen that students are more successful at conceptual (32.4 %) and algorithmic (38.2 %) questions. On the other hand, the number of students who gave correct answers to all of the graphical questions is very few (8.8 %). Additionally, while there is no student who could answer none of the conceptual and algorithmic questions, there are 5 students who could answer none of the graphical questions (7.4 %). Examining the limited number of correct answers (NCA), it is seen that majority of students are successful at conceptual and algorithmic questions, as from 4 correct answers (downward). Majority of students show achievement as from 4 correct answers (downward). Majority of students start to show achievement at graphical questions as from 3 correct answers (downward). In this examination which is from 5 correct answers to 1 correct answer, the fact that the achievement change is more qualified at especially algorithmic questions is remarkable.

The question type in which students feel successful (that they prefer) and the achievement distributions at these question types are given in Table 4. The coding scheme that is seen in Table 4 was formed by modifying the classifications that were paid attention in previous studies (Nakhleh, 1993; Mason *et al.*, 1997; Chiu, 2001; Coştu, 2007; Coştu, 2010). Accordingly, the relevant classifications were performed by considering five and four correct answers high achievement, three correct answers middle achievement and finally considering correct answers less than three low achievement.

Table-4. Achievement distributions of students at the question type they prefer

			High Achievement		Middle Achievement		Low Achievement	
	f	% *	f	% **	f	% **	f	% **
Conceptual	23	33,8	15	65,2	4	17,4	4	17,4
Algorithmic	35	51,5	30	85,7	4	11,4	1	2,9
Graphical	10	14,7	7	70,0	3	30,0	0	0

* Percentage distribution according to all of the students, ** Percentage distribution among the preferred students

As is seen in Table 4, approximately half of all students (51,5 %) preferred the algorithmic question type, approximately one third of them (33,8 %) preferred the conceptual question type and a few of them (14,7 %) preferred the graphical questions. This distribution is explicitly in parallel with the general achievement distribution of students that is seen in Table 2 and with the achievement state of giving correct answers to all of the questions at a question type that is seen in Table 3. The graphical question type that is preferred by students at the least tallies with the achievement states at this question type.

Examining the distribution in Table 4, it is seen that majority of students are successful at the question type, where they describe themselves to be successful. Additionally, it could be thought that some students –even if just a few in number- have difficulty in assessing themselves regarding at which question type they are more effective, since they cannot be successful at the question type they prefer. In this sense, it could be stated that especially those who consider themselves successful at the algorithmic question type are consistent. This condition was examined in detail in the comparison of achievement distributions of students at one question type with their achievements at other question types and in the comparison of their achievements at the question type they prefer with their achievement states at other question types. In order to compare the achievements of students at one question type with their achievements at other question types, their achievement states at each question type were coded as high, middle and low achievement as is indicated above. Possible situations for the comparison of these codings are as follows.

HC: high achievement at conceptual questions; **HA**: high achievement at algorithmic questions; **HG** high achievement at graphical questions; **MC**: middle achievement at conceptual questions; **MA**: middle achievement at algorithmic questions; **MG**; middle achievement at graphical questions; **LC**; low achievement at conceptual questions; **LA**; low achievement at algorithmic questions; **LG**; low achievement at graphical questions. Possible situations: HGHA, HGMA, HGLA, HGHC, HGMC, HGLC, HAHC, HAMC, HALC, MGHA, MGMA, MGLA, MGHC, MGMC, MGLC, MAHC, MAMC, MALC, LGHA, LGMA, LGLA, LGHC,LGMC, LGLC, LAHC, LAMC, LALC. Since this study focuses on the student group with a high achievement level, the comparison of these students with their achievement states at conceptual, algorithmic and graphical question types is given below. Findings regarding other comparisons are presented in Appendix-B. Since those who gave 5 and 4 correct answers are considered together in this classification in order to determine the students with overachievement, the distribution that is presented in Table 3 for 5 or 4 correct answers is required to be rearranged according to the achievement classification, which is presented in Table 4. The distribution, which occurs when the distribution that is presented in Table 3 for 5 or 4 correct answers is rearranged according to the achievement classification in Table 4, becomes as follows: The number of students who gave 5 or 4 correct answers at three questions types is 4 (5,9 %). The number of students who gave 5 or 4 correct answers at two of conceptual and algorithmic (C and A) questions is 33 (48,5 %). The number of students who gave 5 or 4 correct answers at two of conceptual and graphical (C and G) questions is 6 (8,8 %). The number of students who gave 5 or 4 correct answers at two of algorithmic and graphical (A and G) questions is 10 (14,7 %). Finally, the number of students who gave 5 or 4 correct answers at conceptual questions is 45 (66,2 %). The number of students who gave 5 or 4 correct answers at algorithmic questions is 51 (75 %). The number of students who gave 5 or 4 correct answers at graphical questions is 13 (19,1 %).

Achievement distributions of 45 students, who showed overachievement at conceptual questions, at algorithmic and graphical question types are comparatively reflected in Figure 2. Values in parentheses show the distribution of overachieving 15 students, who preferred the conceptual question type.

Figure 2. Achievement distributions of 45 students, who showed overachievement at the conceptual question type, at algorithmic and graphical question types

Expected Performance Cluster	HGHA 4 students 8,8 % 1C	MGHA 9 students 20,0 % 2C	LGHA 20 students (8) 44,4 % 3C	
	HGMA 1 student 2,2 % 4C	MGMA 2 students (1) 4,4 % 5C	LGMA 5 students (3) 11,1 % 6C	
	HGLA 1 student 2,2 % 7C	MGLA 3 students (3) 6,6 % 8C	LGLA - 9C	Unexpected Performance Cluster

Total performances of students, who showed overachievement at the conceptual question type, at algorithmic and graphical questions are as follows: HGHA, 8,8 %; HGMA, 2,2 %; HGLA, 2,2 %; MGHA, 20,0 %; MGMA, 4,4 %; MGLA, 6,6 %; LGHA, 44,4 %; LGMA, 11,1 %. Distributions and explanations of student performances are presented in Figure 2. Indeed, what is expected from students is to group in the cell coded 1C or at least in cells coded 2C or 4C. However, the cell where the grouping intensifies is the cell coded 3C. Considering the cell coded 2C, this condition indicates that majority of students show achievement at conceptual questions and also algorithmic questions; however, they are not successful at graphical questions. In other words, it is clear that there are deficiencies in skills of students, whose conceptual and algorithmic comprehensions are considered high, regarding the formation and interpretation of graphics. Moreover, 8 out of 20 students who are grouped in the cell coded 3C are also the students that prefer the conceptual question type. Thus, it could be stated that there is a relation between the self-confidence and achievements of these students at conceptual questions and their achievements at algorithmic questions. As a matter of fact, 12 out of 20 students preferred the algorithmic questions and showed overachievement at both conceptual and algorithmic questions (see, Figure 3 cell 3A). On the other hand, it should be remarked that some of the students who preferred conceptual questions are grouped in the cells 5C, 6C and 8C (a total of 7 students). Even though it could be asserted that students obtained the conceptual learning and gained self-confidence at conceptual questions, the required achievement could not be depicted at algorithmic and graphical questions. Indeed, the fact that they preferred conceptual questions could be interpreted in such a way that they well know that they cannot be successful enough at algorithmic and graphical questions.

Achievement distributions of 51 students, who showed overachievement at algorithmic questions, at conceptual and graphical question types are presented in Figure 3 in a comparative way. Values in parentheses show the distribution of overachieving 30 students, who preferred the algorithmic question type.

Figure 3. Achievement distributions of 51 students, who showed over achievement at the algorithmic question type, at conceptual and graphical question types

Expected Performance Cluster	HGHC 4 students (3) 7,8 % — 1A	MGHC 9 students (7) 17 % — 2A	LGHC 20 students (12) 39,2 % — 3A	
	HGMC 4 students (1) 7,8 % — 4A	MGMC 4 students (3) 7,8 % — 5A	LGMC 3 students (2) 5,9 % — 6A	
	HGLC 2 students (1) 3,9 % — 7A	MGLC 4 students (1) 7,8 % — 8A	LGLC 1 student 2,0 % — 9A	Unexpected Performance Cluster

As is seen in Figure 3, total performances of students, who showed overachievement at the algorithmic question type, at conceptual and graphical questions are as follows: HGHC, 7,8 %; HGMC, 7,8 %; HGLC, 3,9 %; MGHC, 17 %; MGMC, 7,8; MGLC, 7,8 %; LGHC, 39,2 %; LGMC, 5,9 %; LGLC, 2,0 %. Similarly, what is expected from students is to get grouped in the cell 1A or at least in one of the cells 2A or 4A here. However, as is seen in the figure, the grouping is performed in the cell coded 3A. Examining the distributions in cells 2A and 3A, it is explicitly seen that almost half of students who showed overachievement at algorithmic questions showed overachievement at conceptual questions, as well. On the other hand, considering the cells 4A and 7A, it is seen that some of the students (a total of 6 students, 20 %) showed the achievement that were shown at algorithmic questions also at graphical questions. Additionally, examining the distribution of students (30 students) who preferred algorithmic questions in the figure, it is seen that majority of them (a total of 19 students, 63 %) are in the cells 2A and 3A. From this point of view, it could be asserted that majority of students who preferred algorithmic questions have high levels of conceptual understandings.

Achievement distributions of 13 students, who showed overachievement at graphical questions, at conceptual and algorithmic question types are presented in Figure 4 in a comparative way. Values in parentheses show the distribution of overachieving 7 students, who preferred the graphical question type.

Figure 4. Achievement distributions of 13 students, who showed overachievement at the graphical question type, at conceptual and algorithmic question types

Expected Performance Cluster	HAHC 4 students (1) 30,8 % 1G	MAHC 1 student (1) 7,7 % 2G	LAHC 1 student (1) 7,7 % 3G	
	HAMC 4 students (3) 30,8 % 4G	MAMC 1 student 7,7 % 5G	LAMC - 6G	
	HALC 2 students (1) 15,3 7G	MALC - 8G	LALC - 9G	Unexpected Performance Cluster

As is seen in Figure 4, total performances of students, who showed overachievement at the graphical question type, at conceptual and algorithmic questions are as follows: HAHC, 30,8 %; HAMC, 30,8 %; HALC, 15,3 %; MAHC, 7,7 %; MAMC, 7,7; LAHC, 7,7 %. Similarly, what is expected from students is to get grouped in the cell 1G or at least in one of the cells 2G or 4G here. As is seen in the figure, the distribution of majority of students (61,5 %) was realized in the cells 1G and 4G. In fact, the general distribution is in the cells 1G, 4G and 7G, in other words, on the left side of the figure. This condition reveals the fact that majority of students, who showed overachievement at graphical questions, also showed overachievement at algorithmic questions. This finding shows a remarkable difference compared to the distribution in Figure 3 in effect. To be clearer, while Figure 3 reveals that those who showed overachievement at algorithmic questions also showed overachievement at conceptual questions; Figure 4 reveals that those who showed overachievement at graphical questions also showed overachievement at algorithmic questions. Similarly, while the students who preferred algorithmic questions were generally successful at conceptual questions (see, Figure 3), students who preferred graphical questions were also successful at algorithmic questions (see, Figure 4). On the other hand, these students who showed overachievement at graphical questions could not display a remarkable achievement at conceptual questions.

CONCLUSIONS AND DISCUSSIONS

This study compared the performances of students, who showed overachievement in high school physics lessons, at conceptual, algorithmic and graphical questions. The study is limited with the examination of performance of successful students on the achievement test. Analyzing achievement states of students, who showed high performance at a question type during practices, at other question types is another limitation of the current study.

Among the results of the study was that students performed better on the algorithmic and conceptual questions than the graphical questions. Moreover, algorithmic questions were the most preferred question types by students. In addition, the students who prefer algorithmic questions were found more successful than those who prefer other questions. One could make a general assumption from these findings that students tended to select algorithmic questions and showed a better performance. According to the results of the study, the performances that are shown by students for conceptual questions were also high. While these results do not entirely correspond to the results of some other studies (e.g. (Nurrenbern and Pickering, 1987; Nakhleh, 1993; Coştu, 2007; Coştu, 2010), they are partially in line with the results of some others (e.g. (Lin *et al.*, 1996; Erkan, 2011). For instance, being similar to this study, Lin *et al.* (1996) determined that there was not a significant difference between conceptual and algorithmic performances of students. Similarly, Erkan (2011), who worked with pre-service chemistry teachers in Turkey, investigated performances of pre-service teachers in conceptual and algorithmic questions and determined that there was not a significant difference between them. Erkan (2011) also compared the performances of pre-service teachers at conceptual, algorithmic and graphical questions and determined that the achievement was in favor of conceptual questions. Moreover, Coştu (2007) presented that eleventh-grade students performed better conceptual chemistry questions than algorithmic and graphical chemistry questions. In another study (Coştu, 2010) that was performed with the twelfth grade students, algorithmic questions were the only question types that students performed high. The results of (Coştu, 2007; Coştu, 2010) and Erkan (2011) that are related with student performances at graphical questions show a parallelism with the results that were obtained in this study since students' performance on graphical questions were found enough in none of them. Based on the scores obtained from the achievement test, this study revealed students' difficulty in graphical questions. This result is consistent with the results of many different studies, which assert that students have issues with graphical questions/operations (McKenzie and Pandilla, 1986; Erkan, 2011). Within the scope of this study, the fact that students have higher general performances at algorithmic and conceptual questions could be based on different reasons. The first and major contributing factor can be considered as the content and question style of THE and UPE examinations. Examining the total 178 physics questions that have been asked in THE and UPE during last five years, it is seen that 83 of the questions are conceptual, 85 of them are algorithmic and 10 are graphical (URL-1, 2012) It could be thought that the types of questions that have been asked recently affect the performances of students at algorithmic, graphical and conceptual questions in a positive or negative way. In other words, students could be expected to be motivated more towards the question types that are include more in the examinations. Moreover, this motivation might cause for students to practice more on these question types. Another factor could be the fact that teachers prefer algorithmic questions in their lessons since it is emphasized that in Turkey, the development of graphical skills is ignored (Kağan-Temiz and Tan, 2009) and algorithmic questions are motivated especially in science lessons (İpek *et al.*, 2005; Soylu and Aydın, 2006; Birgin and Gürbüz, 2009). Probably as a consequence of this condition, students in this study generally preferred algorithmic questions. It could also be stated that students are aware of their failures at graphical questions. Maybe students do not pay attention to this question type by considering the fewness of graphical questions in university entrance exams or their insufficient use in lessons. Thus, it is suggested to attach importance to applications in such a way to develop the graphical comprehensions of students in physics lessons and increase the graphical questions to be asked in the university entrance exam in such a way that they reflect the importance of graphics in physics and by this way, motivate the students.

The study revealed interesting results in terms of achievement rates of students on other question types, who showed overachievement at a question type. Approximately one-third of students, who displayed a high performance at conceptual/algorithmic questions, showed a considerable achievement at algorithmic/conceptual and graphical questions. In addition, approximately two-third of students, who displayed a high performance at graphical questions, showed a considerable achievement at conceptual and algorithmic questions. Interpreting these two results in general, it could be asserted that approximately only a few (two-tenth) students showed an achievement that is acceptable for three question types in such a way that it reflects their school grades. This result may bring a contradictory argument about students' evaluation (grades) in schools. A further analysis of this situation would be beneficiary to reinforce the results of the current study.

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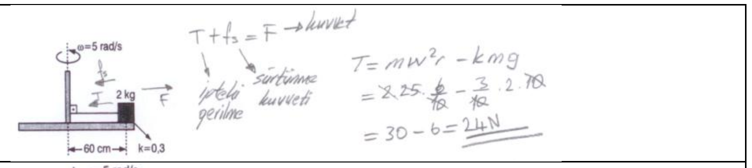
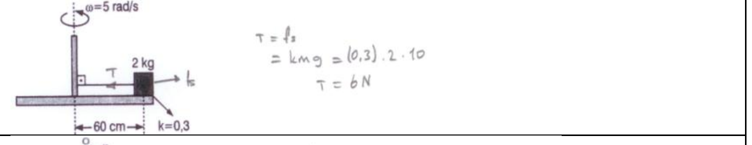
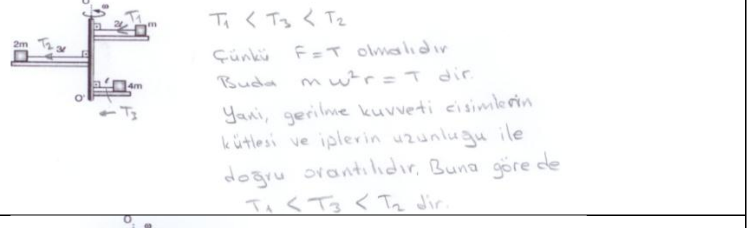
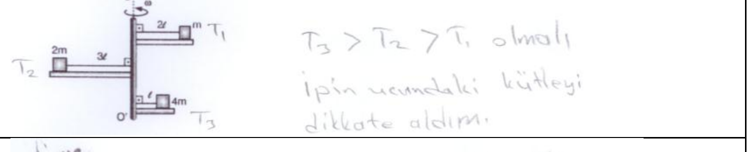
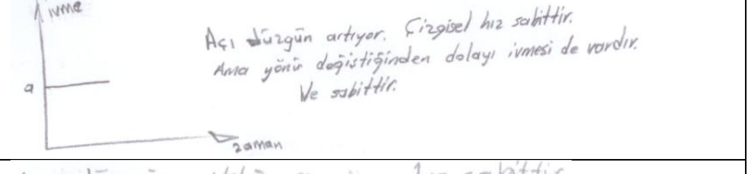
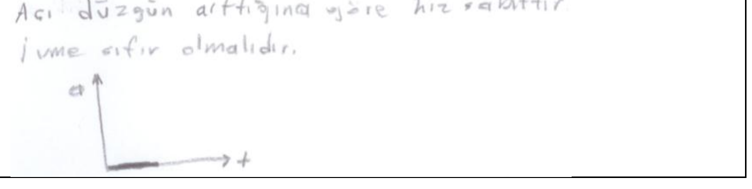
Appendix A

Question 3C	Example of correct answer	
	Example of wrong answer	
Question 3A	Example of correct answer	
	Example of wrong answer	
Question 3G	Example of correct answer	
	Example of wrong answer	

Appendix B

Achievement distributions of 16 students, who showed middle achievement at the conceptual question type, at graphical and algorithmic question types		
HGHA 4 students	MGHA 4 students	LGHA 4 students
HGMA 1 student	MGMA 2 students	LGMA 1 students
HGLA -	MGLA -	LGLA -
Achievement distributions of 12 students, who showed middle achievement at the algorithmic question type, at graphical and conceptual question types		
HGHC 1 student	MGHC 2 students	LGHC 5 students
HGMC 1 student	MGMC 2 students	LGMC 1 students
HGLC -	MGLC -	LGLC -
Achievement distributions of 23 students, who showed middle achievement at the graphical question type, at conceptual and algorithmic question types		
HAHC 9 students	MAHC 2 students	LAHC 3 students
HAMC 4 students	MAMC 2 students	LAMC -
HALC 3 students	MALC -	LALC -
Achievement distributions of 7 students, who showed low achievement at the conceptual question type, at graphical and algorithmic question types		
HGHA 2 students	MGHA 3 students	LGHA 1 students
HGMA -	MGMA -	LGMA -
HGLA -	MGLA -	LGLA 1 student
Achievement distributions of 5 students, who showed middle achievement at the algorithmic question type, at graphical and conceptual question types		
HGHC 1 student	MGHC 3 students	LGHC -
HGMC -	MGMC -	LGMC -
HGLC -	MGLC -	LGLC 1 student
Achievement distributions of 32 students, who showed middle achievement at the graphical question type, at conceptual and algorithmic question types		
HAHC 20 students	MAHC 5 students	LAHC -
HAMC 4 students	MAMC 1 students	LAMC -
HALC 1 students	MALC -	LALC 1 student