Evaluation of the Common Biology Exam Questions for High School

By

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Abstract

The present study has been carried out with the aim of evaluating the questions of the common biology exams administered at the end of each term, in terms of item analysis, reliability coefficient and objectives. Within this scope, the questions of the common biology exam administered across all 9th and 11th grade students at the end of the first term of 2012-2013 education year were analyzed. With the application of the common exam questions for 9th grade to 127 students and those for 11th grade to 129 students in another Anatolian High School, item difficulty index (P), item discrimination index (D), Spearman Brown and KR-20 reliability coefficients were determined while the qualities of the questions were assessed within the framework of the curriculum. In conclusion, it was determined that the exam questions for the 9th grade were of a medium-level difficulty, had distinctive characteristics, content validity and reliability while the questions for the 11th grade were easy but not distinctive though their reliability coefficient was sufficient; the content validity was also not ensured fully. It is considered that the number of application-oriented questions was unnecessarily more than needed, thus the number of reasoning questions should be increased.

Keywords: *biology, common test, validity, reliability*

1. Introduction

Common exams are administered in order to compare the success of students studying in the same grade across all primary and secondary education institutions affiliated to the Ministry of National Education on school level.

In the Article 36 titled 'Exams' in the Regulation on Primary Education Institutions, the following statement is given: "*At least one common exam is administered in each term in order to allow teachers to cooperate and make a common evaluation. The questions and answer keys of these exams are prepared by group teachers and the points to be given for each correct answer are indicated in the answer key.*" In accordance with this provision, common exams are conducted in primary education institutions (MoNE, Regulation for the Primary Education Institutions, 2012). Similarly, the following provision can be found in Article 20 titled 'Common Exams' of the Regulation on Promotion to the Next Grade and Exams in Primary Education Institutions (Repealed): "*In order to allow teachers applying the same program in a school to make a common evaluation, at least one of the written exams are administered together in each term. The common exams are applied after the preparation of the common questions and the answer keys by group teachers on a pre-set date.*" Common exams used to be applied in accordance with this provision. It was repealed and taken within the scope of the Regulation on the Secondary Education Institutions and the statement was changed in the new regulation as follows: "*In order to allow teachers giving the same course to make a common evaluation, common exams are administered in all courses given in more than one classroom, and a common evaluation is made. The questions and answer keys are prepared by group teachers and shared with the students after the exam. Analyses of the exams are made based on the classrooms and grades. The situation of the students that are found to lack of knowledge about some subjects and have a low attainment level are re-evaluated by branch and group teachers. (MoNE, 2013a)*"

Common exams are administered in order to determine and compare the level of students taught in the same education environment or school by different teachers within a specific curriculum in line with the

pre-set targets and aims. Within the scope, the exams are composed of multiple choice questions and prepared by group teachers.

Prepared by group teachers, the common exams facilitate determining the course grade point averages of students besides allowing for a comparison between students' attainment levels. In general, 2 or 3 exams are administered in each course, in each term and one of them is a common exam. The assessment and evaluation system in which the common exams take place demonstrate the school achievement of the students in primary and secondary school and this school achievement makes an additional contribution in the transition to the next grade. The grade point averages make 25% contribution to the secondary education placement score (OYP) in transition to the secondary education. The secondary education grade point averages (OBP) are taken into account in the calculation of the students' scores in transition to the higher education. An additional point of around 60% of these averages is given (Candidate Manual).

Prepared by group teachers and administered across the school, common exams make a significant contribution both to the school achievement and in the transition to a higher grade which demonstrates the importance of their evaluation. It is essential whether the questions encompass the difficulty levels, distinctiveness, reliability and objectives in these exams. Also, in order to answer the question of "What type of an evaluation do these questions make and at which cognitive level are they doing it?", it is aimed in the present study to determine the level of questions according to the cognitive levels used in TIMSS (Trends in International Mathematics and Science Study) exams with the item analyses, reliability coefficients, content validity of the common exam questions applied in the 9th and 11th grades. Thus, a projection and planning will be made regarding whether an appropriate assessment and evaluation were made in the transition to a higher grade by looking after the equity among students regarding the common exam questions.

2. Method

Model
In the research, quantitative and qualitative methods were used together. The determination of the P and D values in the common exams for the 9th and 11th grade students handled within the scope of the research was performed in the quantitative part. On the other hand, evaluation of questions used in common exams within the scope of the objectives determined in the biology curriculum and determination of question levels according to the cognitive scaling used in Trends in International Mathematics and Science Study were studied in the qualitative part.

Study Group
The research was based on the evaluation of the common exam questions applied to the 9th and 11th grade students studying in an Anatolian High School, at the end of the first term of 2012-2013 education year in Ankara. Within this scope, the mentioned common exam questions were re-applied to 256 students in total studying in the 9th and 11th grades in 2 different high schools in Ankara. Achivement tests were applied to 127 students from the 9th grade and 129 students from the 11th grade.

Data Collection Tools
The common biology exam questions for the 9th and 11th grade students were included in the study. Two achievement tests handled within this scope consisted of 25 multiple choice questions each, applied to the students studying in an Anatolian high school in Ankara in 2012-2013 education-year.

Data Analysis
During the data analysis of the research, the item difficulty analyses (P) and item distinctiveness indexes (D) were calculated. Also, KR-20 and Spearman-Brown reliability coefficients were calculated.

The achievement tests applied as the common exam were evaluated in terms of the objectives that were aimed to be fulfilled by the students and given place in the curriculum. Within this scope, the distribution of the questions according to subjects, comparison of the information aimed to be measured in the questions and the information indicated in the objectives were performed and the cognitive levels of the questions were determined. With this purpose, it was determined at which level the students were in terms of 'knowing' the answers, 'applying' and 'reasoning' and which level was focused on in this leveling.

3. Findings and Interpretation

The Findings Regarding the Common Exams for the 9th Grade

The item difficulty index (P) and item distinctiveness index (D) of the common exam questions for the 9th grade are given on Table 1.

Table 1: P and D values in the Common Exam for the 9th Grade

Question	P value	D value	Question	P value	D value
1	0,71	0,78	14	0,63	0,57
2	0,72	0,72	15	0,70	0,52
3	0,73	0,70	16	0,71	0,54
4	0,61	0,56	17	0,69	0,74
5	0,67	0,69	18	0,60	0,70
6	0,60	0,73	19	0,66	0,59
7	0,50	0,42	20	0,43	0,46
8	0,59	0,64	21	0,54	0,60
9	0,54	0,55	22	0,31	0,38
10	0,50	0,43	23	0,61	0,53
11	0,63	0,42	24	0,61	0,60
12	0,63	0,55	25	0,57	0,54
13	0,62	0,64	**AVG.**	**0,60**	**0,58**

As a result of the item analysis, the average difficulty of the test was determined to be 0.60. This rate indicates that the test is of medium level difficulty. Only the 22nd question seems to be of a high level difficulty. Besides these, 7 questions were found to be of medium difficulty, while 16 were at easy level. When the item distinctiveness indexes were examined, it was seen that there was not any question below 0.30 and needed to be changed. The distinctiveness of only the 22nd question was below 0.40. The other questions were above this value and their distinctivenesses were fairly high. The difference in the item analysis of the 22nd question is due to a mistake in the arrangement of the choices. As the correct answer was not included among the choices, the teacher corrected this mistake verbally in the classroom. Thus, it is necessary that the choices in this question are re-arranged or the question is omitted from the test.

"Reliability analysis is a method developed in order to evaluate the characteristics and reliabilities of tests, surveys or scales." (Kalaycı, 2006) In the reliability analysis, it is tested whether the statements in the measurement tool are consistent among themselves and, for this purpose, the correlation between them is measured (Ural and Kılıç, 2005). KRE-20 formula is the most common reliability coefficient used to determine the internal consistencies of multiple choice tests (DeVellis, 2003). The internal consistency of the test in a reliability study can be determined with the KR-20 or split-half reliability coefficient (Kaplan and Saccuzzo, 2008). In the common exam questions for the 9th grade, 2 different methods were applied in the reliability analysis: KR-20 and Spearman-Brown reliability coefficients.

While KR-20 reliability coefficient was found to be 0.93, Spearman-Brown was 0.92. Both coefficients demonstrate that the test has a high reliability.

When the reliability coefficients are examined and as a result of the analysis of the test items, it can be seen that the test items were usable. However, they needed to be re-evaluated within the frame of the objectives of the curriculum, in terms of the content validity. Thus, the test questions were evaluated according to the objectives in the biology curriculum for the 9th grade students.

The objectives of the test applied with the common exams for the 9th grade and examined in the present study are as follows:

1. Unit: Cell, Organism And Metabolism
1. With regards to cells, students
1.1. Explain the common characteristics of living organisms based on a cell model,
1.2. Indicate the structure and functions of the inorganic and organic compounds making up a living organism.

It is seen that the items in the test questions are related to two objectives in the curriculum for the 9th grade. However, it would be more appropriate to evaluate the test questions within the framework of the subjects in the unit as the objectives are general. The subject titles within the frame of these two objectives and to which subject the test questions belong are indicated with the numbers on the sides.

Part I : Common Characteristics of Living Organisms   **20**
        A. Cellular Structure
        B. Nutrition
        C. Respiration
        D. Growth and Development
        E. Movement
        F. Excretion
        G. Reproduction
        H. Reactions to Environmental Stimuli
        I. Organisation

Part II : Basic Components of Living Organisms
        A. Inorganic Compounds in Living Organisms   **24**
           1. Water
           2. Acids and Bases
           3. Minerals and Salts   **19**
        B. Organic Compounds in Living Organisms   **7, 12**
           1. Carbohydrates   **4, 8, 9, 21**
              a) Monosaccharides
              b) Disaccharides
              c) Polisaccharides
           2. Lipids   **3,14**
              a) Triglycerides (Neuter Lipids)
              b) Phospholipids
              c) Steroids
           3. Proteins   **5, 11, 22**
           4. Enzymes   **8, 23**
              a) Structure of Enzymes
              b) Characteristics of Enzymes
              c) Factors Affecting the Functioning of Enzymes   **2, 17**
           5. Vitamins   **15, 16**
           6. Nucleic Acids
              a) Structure and Types of Nucleic Acids   **1, 6, 13, 18, 25**
           7. Energy Carrying Nucleotide ATP (Adenosine triphosphate)   **10**

When the subject distribution of the test items are examined, it is seen that 24 questions were about Basic Components of Living Organisms (2nd part) though there was only 1 question from Common Characteristics of Living Organisms which is the first part. It is seen that the enzymes and nucleic acides subjects were given more place in these 24 questions. That the teachers who prepared the test focused more on these two subjects may be because they are difficult to understand. Also, these two subjects are very suitable for writing test items. Özatlı (2006) named the first 3 subjects as genetic engineering, biotechnology and gamet, gen and allergens in the study that he carried out in order to determine the subjects that students had difficulty in understanding in biology lessons. The prior knowledge regarding these 3 subjects identified by Özatlı are given within the nucleic acides subject in the 9th grade. Thus, the teachers focused on the nucleic acides subject that students found hard to understand. Although the subject distribution was good and there was no subject that was not included, it would be better to ensure a more equal distribution among the subjects rather than focusing on one or two subjects.

When the content of the test items for the 9th grade is examined, the questions based on calculation draw the attention. 3 questions in the test are based on calculating the base numbers of the nucleotides within the DNA and the purine and pyrimidine. Similarly, one question requires a calculation of aminoacides and peptide bond, while another is about the glucose number. This demonstrates that 20% of the questions are based on mathematical calculations. Though basic information on biology subjects are given in these questions, they are considerably easy. That the test is evaluating whether students have this basic information with 3-5 questions requiring mathematical calculations is a significant situation. Here, the basic mathematical calculation skills of the students are measured rather than a basic knowledge of some biology subjects. For this reason, a limitation has been introduced regarding mathematical calculations about the structure and functioning of nucleic acides in the new curriculum (MoNE, 2013b) Thus, it will be more appropriate that teachers use the questions based on reasoning rather than such mathematical calculations.

The cognitive leveling applied in TIMSS 2 exams is knowing, applying and reasoning. Knowing means "*the knowledge of the students based on the knowledge level, scientific facts, information, concepts, tools and methods;* applying means *"the direct use of knowledge"* and reasoning "*involves such complex intellectual activities as making scientific conclusions / solving problems based on reasoning, making explanations, decision-making and adapting knowledge to new situations*" (Yıldırım et al., 2013).

The questions in the test were subject to a triple classification according to the cognitive levels used in TIMSS exam: knowing, applying and reasoning. The opinion of the subject-matter experts were taken in this classification. In conclusion, 9 of the test items used for the 9th grade students were at "knowing" (3, 10, 11, 13, 14, 15, 18, 19, 21); 13 were at "applying" (2, 4, 5, 6, 7, 9, 12, 16, 17, 20, 22, 24, 25) and 3 were at reasoning (1, 8, 23) levels.

Upon the examination of the TIMSS 2011 exam questions, it is seen that 35% of the science questions for the 8th grade are from biology. The cognitive distribution of these science questions is as follows: 35% knowing, 35% applying, 30% reasoning (Oral and McGivney, 2013). In the common exam for the 9th grade, this distribution is as 36% knowing, 52% applying and 3% reasoning. The rate of the questions in the test is nearly equal to the rate of TIMSS questions. In this case, the difference in the number of reasoning questions is very striking. Thus, it would be appropriate to change some questions in the 'applying' level to reasoning questions.

According to the results of TIMSS 2011, 8% of the 8th grade students had an advanced level, while 18% had upper-intermediate, 28% intermediate, 25% low and 21% of the students remained below the low level (Oral and McGivney, 2013). It is necessary to give place applying and reasoning questions in schools rather than knowing level in order to ensure the promotion of the students remaining below the

low level and those having a low level to the intermediate level and the promotion of the students in the intermediate level to an advanced level. Thus, it is essential that teachers prepare questions at the applying and reasoning level both in the primary education and the secondary education. Within this scope, the exams for the 9th grade have included very important questions at the applying level. Increasing the rate of reasoning questions will also increase the quality of the test.

The Findings Regarding the Common Exams for the 11th Grade

The item difficulty index (P) and item distinctiveness index (D) of the common exam questions for the 11th grade are given on Table 2.

Table 2: P and D values in the Common Exam for the 11th grade

Question	P value	D value	Question	P value	D value
1	0,67	0,01	14	0,63	0,29
2	0,84	0,24	15	0,60	0,30
3	0,74	0,23	16	0,77	0,51
4	0,88	0,19	17	0,65	0,30
5	0,50	0,10	18	0,87	0,29
6	0,62	0,38	19	0,60	0,30
7	0,61	0,29	20	0,81	0,11
8	0,85	0,16	21	0,90	0,17
9	0,87	0,29	22	0,82	0,34
10	0,60	0,38	23	0,86	0,34
11	0,89	0,37	24	0,82	0,31
12	0,50	0,29	25	0,50	0,25
13	0,66	0,45	AVG.	0,72	0.28

When the item analysis results are examined, it is seen that the 11th grade test is found very easy by the students. In this test, 11 questions were quite easy, 11 questions were easy and 3 questions were of medium difficulty. As for the distinctiveness of the items, 13 of them need to be rearranged as they remained below the level 0.30. There are only 2 items, the distinctivenesses of which were above 0.40. This shows that the application of the test without any change was not recommendable as it was both very easy and its distinctiveness was not sufficient.

KR-20 and Spearman-Brown reliability coefficients of the common exam questions for the 11th grade students were calculated separately. KR-20 reliability coefficient was found to be 0.74 while Spearman-Brown reliability co-efficient was 0.74. Both coefficients demonstrate that the test was reliable.

That the reliability coefficient of the test was high does not demonstrate that it can be used as it is. Considering the item difficulty levels and distinctiveness levels, it is obvious that the test needs some changes.

When the objectives of the curriculum are evaluated in terms of the content validity of the items of the test for the 11th grade, the curriculum objectives and the distribution of the questions according to the subjects shaped within the framework of these objectives are as follows:

Unit 1 : Plant Biology
1. With regards to the structure of a flowering plant, students
1.1. Show the main parts of a flowering plant on a diagram.
1.2. Explain the plant tissues with examples. **9, 11, 21, 23**
1.3. Tell the functions of the root and give examples to hairy root and taproot.

1.4. Design an experiment in which they can observe the growth of the root and carry out the experiment.

1.5. Show the tissues in the transverse and longitudinal section of the root, on a diagram. **5, 13**

1.6. Tell the functions of the stem and give examples to woody and non-woody stems.

1.7. Show the tissues in the transverse and longitudinal section of the woody and non-woody stem, on diagram. **4**

1.8. Explain primary and secondary growth in plants.

1.9. Show the tissues in the transversal section of a leaf by drawing.

1.10. Indicate the structure and functions of a leaf and give examples to leaf types. **2**

2. With regards to transport in plants, students;

2.1. Explain the mechanisms ensuring the conveyance of the water from the soil and its transport to the stem, in plants. **6, 15, 17, 20, 25**

2.2. Explain the process of the transport of photosynthesis products in plants. **10, 14**

3. With regards to nutrition in plants, students;

3.1. Explain the conditions necessary for the nutrition of a plant.

3.2. Explain the importance of nutrients salts in plants. **12, 18**

4. With regards to growth and movement in plants, students;

4.1. Indicate the environmental factors which have an impact in the growth of a plant.

4.2. Explain the effect of hormones in growth. **3, 22**

4.3. Explain photoperiodism, nastic and tropism movements with examples. **16**

5. With regards to sexual reproduction in plants, students;

5.1. Indicate the structure and functions of the parts of a flower **1, 7, 8, 24**

5.2. Explain pollination on a flower model.

5.3. Explain fertilization in flowering plants.

When the distribution of the test questions according to the objectives is examined, it is seen that the focus was on transport in plants and the functions of the flowering parts. Here, it should also be questioned whether there was a consistency between the knowledge that the questions aimed to measure and the objectives. When the objectives are handled, it is seen that a direct reference was made to and an explanation was given about the knowledge that was aimed to be taught. When it was necessary to prepare questions according to the objectives, this need was highlighted in the objective. For example, the objective of "Students show the tissues in the transversal and longitudinal section of the root on a diagram." requires students to show the tissues on a diagram, in the related question. However, there is no diagram given in the related question. Thus, there are different reasons why the questions were not given according to the pre-set objectives. The first of these is that the questions were not prepared according to the objectives but the subjects; secondly, the test items were composed of multiple choice questions. Some of the multiple choice questions were selected from test preparation books.

As a result of the classification of the common test questions for the 11th grade according to the cognitive levels used in TIMSS exam, 11 of the test items were at "knowing" (2, 4, 7, 10, 11, 12, 14, 19, 21, 23, 24); 8 of them were at 'applying' (1, 5, 8, 9, 13, 17, 20, 22) and 6 of them were at 'reasoning' levels (3, 6, 15, 16, 18, 25).

When they are compared to the questions for the 9th grade, it is striking that the number of knowing and reasoning questions was higher. Though the increase in the number of reasoning questions demonstrates an improvement, the decrease in the number of knowing questions is an undesired situation. It is also considered that it would be better to have more number of questions at the 'applying' level.

4. Conclusion and Discussion

When the items in the common biology exam questions for the 9th and 11th grades are examined, the following can be said regarding the text applied to the 9th grade:

1. The test is of medium difficulty and has a distinctive feature, but the 22nd question should be reviewed.
2. The test is reliable.
3. The items in the test cover the objectives and thus the content of subjects,
4. Mathematical calculations in the test articles are more than needed.
5. There are too many application-oriented questions in the test and it has been determined that some of these questions should be at "reasoning" level.

Regarding the test for the 11th grade;
1. The test is quite easy,
2. Although the reliability coefficient is sufficient even if not high, half of the test items are far away from being distinctive and can not be used as they are.
3. The test items cover objectives and subjects, but the distribution of the questions should be organised better.
4. The questions are focused more on applying level rather than knowing.

The Ministry of National Education made a change in the system of transition from basic education to secondary education in 2013-2014 school year and began to apply the common exams indicated in the curriculum to the 8th grade students centrally across the country. A calculation will be made based on the points that students get in the other exams applied in their schools in addition to the points they get in 6 branches in each of both terms, thus, they will be placed into a secondary education institution. The Ministry of National Education has indicated the calculation of points in this practice as follows (TEOG [Transition from Primary to Secondary Education] Introduction Presentation):

The grade point average means the average grades obtained as a result of multiplying the cumulative grade points of all courses that are evaluated with marks with the number of weekly course hours and dividing this value to the total weekly course hours of that class. The grading is made based on a 100-point system.
Within the scope of the Common Exams, the points obtained from the courses, the exam of which was applied will be multiplied with their own weight coefficients. The weighted common exam point will be calculated by dividing the values obtained from the sum of their multiplication into the sum of weight coefficients. The grading will be made based on a 700-point system.
The grade point averages of the students from the 6th, 7th, 8th and 9th grades will be added up with the weighted common exam points in the 8th grade. The resulting sum will be divided in two and the point that will be considered for the placement is obtained. The grading is made based on a 500-point system.

The exams applied to the 6th, 7th and 8th grade students by their teachers are as important as the central common exams for placement to secondary education institutions. Thus, the validity and reliability of the exams applied in schools have gained importance. It is planned to introduce a system in the transition from secondary education to higher education similar to the one applied in the transition from basic education to secondary education and this plan increases the importance of the exams applied by teachers at schools, even more. Such aspects as the questions found in the distinctiveness of the test items in the exams for the 11th grade, within the scope of this study, the fact that the content validity of the test was not sufficient and the distribution of the cognitive levels of the questions require more attention. It is striking that the questions at the 'applying' level are focused on more in the tests. Similarly, the following finding is given place in the "TIMSS 2011 Results from Turkey's Perspective" prepared regarding the TIMSS 2011 exam: "W*hile application-oriented questions are used predominantly both in science and maths exams, the questions that need reasoning and explanation are rarely used.*" (Yıldırım et al. 2003) Also, the number of correct answers given to 'knowing' questions both in the 4th and 8th grade levels in TIMSS 2011 is fairly low in comparison to those in 'applying' and

'reasoning' questions. Researchers have interpreted this situation with the following sentences: "*...students adapt scientific concepts and principles to a given situation, thus, find solutions and answer the questions where they need to produce explanations, without having sufficient information about scientific facts, concepts, tools and methods*" (Yıldırım et al. 2013)

Yıldırım et al. also indicated that "this situation can be evaluated as an indication that it was focused generally on answering questions or on advanced cognitive activities without giving sufficient attention to scientific concepts, principles and facts." This shows us that students began high school with a lack of basic information and it is necessary to focus on the 'knowing' questions intensively, at the basic level here. As a result of an assessment and evaluation carried out with the questions prepared as mentioned, it should be discussed whether the transition models, either from basic education to secondary education or from secondary education to higher education, are equitable.

It is a very crucial deficiency that the exams prepared and applied by teachers at schools and having an effect on the results of the placement exams which will shape the future of students are not scrutinized sufficiently despite being very important. Thus, it may be possible to make the exam system more equitable and fair by ensuring the continuous analysis of such questions asked to students and by increasing the capabilities of our teachers regarding assessment and evaluation.

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