

Effect of the Language of the Multi Choice Questions in Organic Chemistry in the Success of the Student

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Abstract: Study mainly deals with the characteristics pertaining to the form and content of multi-choice examination questions, which are taken as the criteria for student success in organic chemistry courses and which also reveal whether the teacher has sufficient experience in terms of preparing questions, the conclusions of which will be guidance for many teachers, as well. Within the scope of this study, factors that are required to be taken into consideration while preparing questions were tried to be identified through the evaluation of the result of an organic chemistry test conducted and some suggestions have been put forward. For such identification, ten multi-choice organic chemistry questions were designed within the framework of possible factors that are thought to affect success. Some of these factors are the questions prepared in accordance with the criteria that were previously drawn out by Cassels and Johnstone [3] for organic chemistry courses and other factors are the questions prepared in accordance with the criteria that were drawn out by the researcher. Researcher's criteria were prepared in the light of experiences of people who have taught organic chemistry for years and people who have worked as chemistry teachers in several high schools as well as university staff whose expertise is in the field of organic chemistry. In the course of this identification, new criteria were defined by taking into account the errors, problems and mistakes observed by the concerned during lessons and exams in addition to the factors which lead to the misunderstanding of learners. Although the criteria identified by Cassels and Johnstone [3] were fundamental to some of the questions, the reflections of these criteria in the organic chemistry exams have turned out to be different.

Key words: Organic chemistry . wording of question . chemistry education . grammar

INTRODUCTION

Effective and long-lasting Science Education is only possible when the individual has an understanding of life, makes sense of life, gets rid of the patterns in his mind to look at the world from a more flexible, objective and larger perspective. At the very point, appropriate chemistry education has an overwhelming importance. Quality of chemistry education in school is directly related to the student success in chemistry courses. In addition, success in chemistry courses cannot be one of the criteria merely for student skill displayed during lessons within the scope of chemical education. With respect to student success in chemistry courses and student's having a good education in chemistry, teacher activity and the environment in classroom will be as much effective as student performance in class. The quality of student success in chemistry courses is directly connected with the respective teachers' teaching and evaluation activities.

In Turkey, evaluation in chemistry courses is carried out through multi-choice or traditional examination questions [1]. Student success in chemistry

course is not only affected by their tendency towards and aptitude for chemistry [2]. It has been found that the wording of multi-choice exam questions also plays a significant role in student success [3]. Thus, appropriation of exam questions to the behavior to be measured and for providing correct perception by the student is the most essential subject to be focused on during the preparation of evaluative questions in chemistry courses by academicians [4]. When the questions both reduce the stages of and facilitate student's thinking, it can be deduced that the student perceives the question in the way required to show the expected behavior. However, when the meaning within the questions causes confusion of thoughts, increases the number of units of thinking and affect the ordering of stages of thinking which is required for solving the problem, it can be judged that the question was prepared in such an unqualified and random way that it cannot measure the expected student behavior [5, 6]. Thus, it is a prerequisite for chemistry education to realistically achieve its aim that teachers prepare exam questions taking into consideration the perceptual situation of students.

Due to the facts that it is a branch of chemistry, has more differences than other branches of chemistry in terms of both theory and terminology and that it includes to various and extensive reactions of analysis and synthesis, organic chemistry, today, is a science that may be perceived as difficult by most students and whose education require some more skills with comparison to other branches of chemistry. It is thought when this course, which becomes a bit more difficult to be understood with reference to the said characteristics, is evaluated through multi-choice exams, a fluent, clear and easy-to-perceive style to be employed in the wording of questions will have positive effects on student success. With this aim, some criteria to be employed in the preparation of multi-choice exam questions, which are used for measuring student success in chemistry courses, were set out to be effective in student success and the study was realized in line with those criteria.

MATERIALS AND METHODS

Measuring instrument: In order to show how effective the wording of questions in the success with respect to multi-choice organic chemistry questions, two tests of 10 questions in two forms each which deal with subjects of organic chemistry were employed as measuring instrument [7-12]. Tests included totally parallel questions. Questions were examined by experts in the field of both chemistry and language, defects were corrected and the final version is prepared after the application of test techniques. As a result of reliability studies of tests, the coefficient cronbach α was found to be 0.92 for type a questions and 0.80 for type b. Before the study, to control if test questions work or not and to make necessary corrections, the measurement instrument was administered to a group of 640 students of the same age; the test with the help of these findings was checked once more.

Sampling: Sampling of the study was consisted of 350 students at the age of 15-17, who continued their high school education. In order to control whether this method of sampling can test student groups at similar levels, control tests with equivalent questions were conducted in two student groups of 175 people each. Control tests were comprised of multi-choice questions, which examine basic organic chemistry knowledge and which were tested in terms of validity and reliability beforehand. The averages of points of success scored in primary tests were checked by independent sample t-test and the inexistence of a statistically significant difference has supported the argument that the groups

in which the study would be conducted were equivalent and the possible difference in success would result from the wording of the question.

Data analysis: Reliability studies of the test employed Cronbach α and percentages of the obtained data were comprised with ztest. The evaluation of questions did not only consist of right and wrong answers marked by the students, but also contained the examination of steps of calculation and methods and ways of thinking pursued in solving the problem, which were obtained from student's drafts on the papers distributed to be used while answering the questions. Thus, factors of wrong or lacking answers could also be identified more clearly and thoughts which caused wrongs were partially determined and taken into consideration in presentation of suggestions and discussions. Since students can never attain the expected level of success if they perceive and interpret something different than what the teacher means to question, the data obtained from such research is going to be illuminating with respect to how students understand and interpret the questions asked in a different way.

CONCLUSIONS AND DISCUSSION

Some of the questions prepared to identify how effective the wording is on success in multi-choice organic chemistry questions were designed with consideration to some factors described in a previous study by cassels and Johnstone [3] and still some questions were designed with a view to the factors developed by the researcher, which were argued to influence students' success. what is stunning for the study, however, is the effect, on student success, of problems in understanding the terms used in the terminology of the organic chemistry. the study is also important in that it emphasizes terminology of each course may lead to differences in students' perceptions. this study has tried to show that such effects occurring from the course itself should be taken into consideration for education while searching for answers to the questions of what and how to teach the student in the best way.

The criteria that are taken into account in wording of questions in organic chemistry: some of these criteria are the factors described by cassels and johnstone [3]. However, inclusion of these criteria within the study is important in that their possibly different reflections in results of organic chemistry exams will contribute to the study in terms of explaining the matters to be paid attention and the

precautions to be taken for organic chemistry exams. Other factors are the ones that are thought to have an effect on success in the research and defined by the researcher.

- Effect on success, of ambiguous structures in the wording of questions for organic chemistry exams,
- Effect on success, of existence of abundant or unnecessary data in the wording of questions for organic chemistry exams,
- Effect on success, of semantically negative and positive structures in the wording of questions for organic chemistry exams,
- Inclusion of expressions that are frequently used in course books in organic chemistry exams,
- Effect on the clarity of the question, of terms of abundance in the questions of organic chemistry exams,
- Effect on success, of the substitution in the wording of questions for organic chemistry exams of the terms that are frequently used in daily life and have the same meaning as in scientific literature,
- Effect on clarity, of semantics in interrogative expressions in the questions of organic chemistry exams,
- Effect on success in solving the problem, of giving the closed or open formula of a molecule in answer choices of the questions for organic chemistry exams,
- The effect of “organic chemistry exam questions prepared indirectly in the form of induction and deduction” on the success of the students.
- The effect on student success of formulated or textual expression of problems in the exams of organic chemistry courses.

It has been determined through statistical evaluations if there is a significant difference between answers for pairs of questions directed. The conclusions obtained from evaluation of question structures and percentages of success for questions reveal the requirement that some conditions should be taken into consideration for a proper perception of the wording of the question. After the questions designed in accordance with certain criteria are conducted, percentages of right answers were calculated and shown in the Table 1.

In both forms of the first question, the “incompletely named” compound is requested to be found. However, when the question is asked in form b, some students initially preferred to first complete the names of the compounds and then separately identify

the uncompleted one out of them. Trying to name the compounds led them to make unnecessary mistakes. The examinations of the papers of the students and interviews with students have been useful, when making the determinations. The students stated that they have directly found the answer of the question a, while they have found out the right answer after answering all the choices of the question b. moreover, some students stated that they could not clearly understand the meaning of “is not named completely” in question b.

When the question is asked in form A, most of the students preferred directly finding the incompletely written choice. The student followed a series of thought from positive to negative while answering the question in form B. However, the question asked in form A, provided that the student more easily perceived the question and directly reached the right answer because it directly questioned the behavior that is wanted to be measured. Here the most important problem in finding the incomplete one was that the place of the-OH group that was not given for propanol, but some students thought that a naming with the said group connected to anywhere would be right while some others thought of connecting it with the second carbon atom.

Very detailed information regarding IUPAC naming of organic compounds, their isomers (if any) and how they are named and additionally how they are named in daily language is given to students during the implementation of syllabus. The way the question is asked necessitates the use of very high level information. When finding the incomplete answer, the student should recognize that it is necessary to write the number of the carbon atom to which the-OH group is bounded in the three carbon compound and find the wrong answer by this way. It is only expected the students to give the answer of the question which necessitates double thought and the evaluation of the answers supports this.

However, there are not as many mistakes in answering this question as the ones observed in the chain of positive to negative thinking. The examination of students' papers contributed a great deal in reaching this conclusion. Another problem encountered in answering this question is that students perceived the question in form B as “which one is not named completely?” This has revealed that not much attention is given concerning whether the question was asked in positive or negative form while answering, since the question itself is already difficult. Because the student is much more concentrated on another matter and neglected the main point of question. The ratio of right answers from the students for the question in form A is 73.14% while the same ratio is 52.57% for the form B (Table 2).

Table 1: The effect of “the sentence structure of organic chemistry questions in making double thought” on success

Question 1	Right answers (%)
A) Which of the below compounds is incompletely named? a) C ₂ H ₅ -OH-Ethanol b) C ₃ H ₇ -OH-Propanol ○ // c) CH ₃ CCH ₂ CH ₃ -Buthanone d) CH ₃ -O-CH ₃ -Methoxymethane ○ // e) CH ₃ CH ₂ C-OH-propanoic acid	73.14 (N=128)
B) Which of the below compounds is not named completely? a) C ₂ H ₅ -OH-Ethanol b) C ₃ H ₇ -OH-Propanol ○ // c) CH ₃ C-CH ₂ -CH ₃ -Buthanone d) CH ₃ -O-CH ₃ -Methoxymethane ○ // e) CH ₃ CH ₂ C-OH-propanoic acid	52.57 (N=92)

Table 2: The Effect of “the existence of abundant or unnecessary data in the wording of organic chemistry exam questions” on success

Question 2	Right answers (%)
As 0.25 mol of a compound, consisting of 83.3% C and 16.7% H in terms of mass, is 18 grams, which one of the following is the molecular formula? (C: 12, H: 1) a) C ₆ H ₁₄ b) C ₄ H ₁₀ c) C ₅ H ₁₂ d) C ₆ H ₆ e) C ₅ H ₁₀	80.57 (N=141)
In oil refineries, crude oil is decomposed into its main components by fractional distillation method. One of these components consists of 83.3% Carbon and 16.7% Hydrogen in terms of mass. 0.25 mol of this compound is 18 g. This compound boils at 36 ^o C and is used as a solvent in the industry. Which one of the following is the molecular formula of this compound? (C: 12, H: 1) a) C ₆ H ₁₄ b) C ₄ H ₁₀ c) C ₅ H ₁₂ d) C ₆ H ₆ e) C ₅ H ₁₀	38.85 (N=68)

Inclusion of unnecessary long expressions or data and expressions which are not directly related to the solution of the problem in questions both makes it difficult for the students to solve the problem and confuses them. This further increases the difficulty of answering organic chemistry questions. The interviews and the examination of exam papers have revealed that students tried to use the 36^oC temperature value as a data for the solution, tried to find appropriate formulas and, thus, made the question much more complicated and insolvable. Even more, a group of students reported that they had thought for a long time on what kind of a technique was the fractional distillation and pondered whether the fractional distillation had an effect on the solution of the question or not. Therefore, it is of great importance that teachers use the shortest and clearest language when preparing the problems and prepare the questions in a way that the students are not confused with unnecessary data and details [1]. Pentane has three structural isomers; n-pentane, 2-methylbutane and 2, 2-dimethylpropane. Only one of them seems acceptable with these physical data. But although we were concerned that it would be difficult for the students to

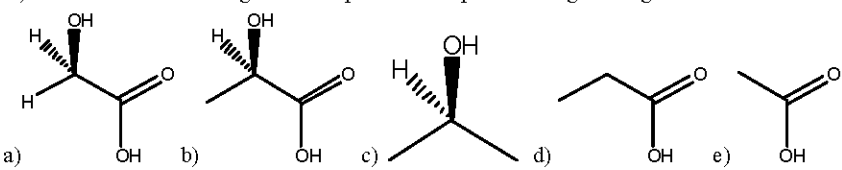
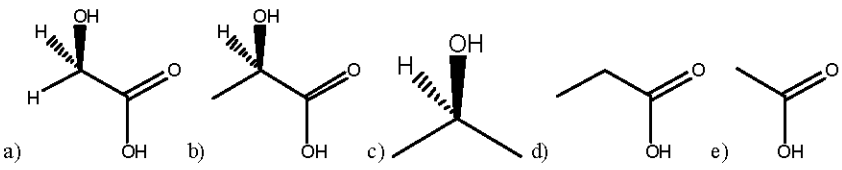
know about the physical properties of these three structural isomers, it was during the interviews with the students revealed that structural isomerism did not take the attention of the students. Furthermore, when the choices are evaluated, it is clearly seen that the question is only about a simple molecular formula calculation and it is not needed to know about the isomerism. Therefore, the expressions used in here just lead the students to get confused and make unnecessary calculations when trying to reach the right answer. There is only one pentane answer in the choices. The students could get confused if the other isomers were also included in the choices, but during the interviews it was defined that they did not have such confusion. But in order to avoid any misunderstandings, it was previously told the students to ignore any structural isomerism.

The high percentage of correct answers to the shorter version of the question, which is arranged to more clearly state what it requires, also points to the fact that students are more successful in questions without unnecessary expressions and data. This study reveals the conclusion that the organic chemistry

Table 3: Effect on success, of semantically negative and positive structures in the wording of questions for organic chemistry exams

Question 3	Right answers (%)
A) Which one or ones of the following assertions is/are true for the compound to result from the addition of one mol Cl ₂ to 1 mol 1-butyn? It shows cis-trans isomer It has a p-bond in its structure It removes the color of bromine containing water a) only I b)only II c) I and II d) II and III e) I, II and III	75.42 (N=132)
B) Which of the following assertions is/are incorrect for the compound to result from addition of one mol Cl ₂ to one mol 1-butyne? It shows cis-trans isomer It has a p-bond in its structure It removes to the color of bromine containing water a) only I b)only II c) I and II d) II and III e) I, II and III	73.14 (N=128)

Table 4: Inclusion of expressions that are frequently used in course books in organic chemistry exams

Question 5	Right answers (%)
A) Which of the following turns the plane of the polarized light to right or left? 	72.57 (N=127)
B) Which one has an enantiomer? 	63.42 (N=111)

questions when asked in a simple language are more easily perceived by students and that students reach the correct answer more easily in questions directed in such way. The percentage of correct answers given by students to the more simplistic version of the question as seen in form A is 80.57. On the other hand, the percentage of correct answers to the version B, which holds more complicated and confusing expressions and is arranged with such expressions that forces students to make different solutions, remains at 38.85.

It is much more easier to find the right answer of a question asked in a positive way [3]. This conclusion was investigated to find out whether it had some similarities in organic chemistry questions or not and the following results were revealed (Table 3):

In the study it was determined that the inclusion of positive or negative expressions in the wording of question do not affect the percentages of correct answers given by students, i. e. Success, in the light of statistical estimations. This conclusion is also supported by interviews with students and the drafting papers used in the exam. Student statements during the interviews point to the fact that a directly asked question, either positive or negative, is perceived by students in such a way to yield the expected student behavior. In such case, the student directly looks for the answer to what is asked. An important and hindering matter here that is

identified from students' statements is that students resort to the solution of the problem either they re looking for the right or the wrong. They cannot directly mark the right or wrong answer by just looking at the question. This can be interpreted as an intrinsic difficulty of organic chemistry, which is different from the study of Cassels and Johnstone [3]. The student cannot easily find the correct or incorrect answer by directly looking at the question or through a few simple calculations and writes down the solution as if she was solving a traditional exam question. This situation inevitably causes a substantial waste of time. Here it is crucial that the question is worded in such a way to explicitly express what it means rather than it is asked either positively or negatively. While 75.42% of students provided correct answer to the first version of the question, which is arranged as "which one is correct?", 73.14% gave correct answers in its negative version. It would be beneficial to examine this question in order to define its difference from the question 1, which entails double thinking. Because, in question 1 while asking not complete named, infact in this question incomplete named is asked; and the student at this point follows the mental chain that entails double thinking by naming correctly at first and then naming incorrectly. This increases the possibility of mistakes also seen in conclusions of question 1 (Table 4).

It is a known fact that, with reference to the wording of the question, the selection of the words which attract attention and facilitate perception among the words of the question is effective in promoting success in perception by the student of the clarity of what is the student behavior that is wanted to be measured [13]. Furthermore, attention should be paid concerning that the terms used in questions are not different from their forms seen in course books or auxiliary sources the student interacts with. Although both terms question the same thing in this case, the usage in form A is more common. Therefore, questions should be carefully worded in such a way that the student perceives it fully and properly. In the Turkish education system, when "Turning the plane of the polarized light to right and left" is said, the molecules of which their mirror images do not overlap directly occur in mind. When the question asked tries to find out the right information regarding the "turning the plane of the polarized light to right and left" directly, the question is much easier understood by the students and the right answer is much easier reached. When the same information is asked as "which one has an enantiomer?" according to the feedback from the students; the student first relates the concept to the subjects in organic chemistry, if the right relation is made in here, the student thinks about the place of enantiomers in stereoisomerism. Because here, many concepts those might be confused with the enantiomer concept might occur in mind (eg. diastereomerism, racemic mixture, etc). When the students are configuring the enantiomer concept in their minds, they need to define many concepts concomitantly and have to separate the enantiomer concept from these concepts. Because, after the information regarding the substances turning the plane of the polarized light to right and left is given to students, it is taught to students that these are called enantiomers and this is never highlighted again. The students therefore prefer to learn this foreign word namely "enantiomer" as "substances turning the plane of the polarized light to right and left". This conclusion is achieved from the interviews made with the students and teachers. Thus, the student

is forced to go through a chain of thoughts consisting of some steps in order to reach the right answer. Therefore, she follows a long way to interpret and give the right answer to the question. The possibility of errors increases on the way to the right answer and the question becomes much more difficult. For the reason, the question should be carefully worded to be fully and properly perceived by the student in addition to the care for using terms of common usage or, more appropriately, consideration should be given concerning that the expressions corresponding to the same meaning are used at the same frequency. To this aim, wording of questions requires care in using the terms used in course books or the concepts with the same meaning should be used with same frequency in course books so that the student could be familiar with them. Because a full understanding of what the question requires will both spare time for the student and be effective in the promotion of the percentage of right answers. The wording of multi-choice organic chemistry questions should not be of such nature that adversely affects the skill of understanding the question no matter how extensive and wide-ranging the subjects are.

Conclusions also support this argument. The percentage of right answers to the version of question directed in form A is 72.57 while the corresponding percentage for the version B is 63.42 (Table 5).

In the form A of question 5, which shows the wording of the question with positive terms of quantity the percentage of right answers from students is 82.28 while in form B, which shows the wording of the question with negative terms of quantity, the percentage of right answers from students is 77.14.

Respective statistical studies have revealed that terms of quantity in questions asked to students did not affect the perception of the question. In these questions, stability is a concept with a positive meaning. When it is expressed as "the most stable", positive meaning is strengthened. when the question is asked in form B, the word "least" inserted before "stable", which has a positive meaning, negates the semantically positive expression; however, this difference do not yield a significant difference in student success (Table 6).

Table 5: Effect on the clarity of the question, of terms of abundance in the questions of organic chemistry exams

Question 5	Right answers (%)
Which compound is the most stable in an equilibrium mixture resulting from the addition of 1 mol water into 1 mol acetylene in an acidic environment? a) Vinyl alcohol b) Acetaldehyde c) Formaldehyde d) Ethyl alcohol e) dimethyl ether	82.28 (N=144)
Which compound is one is the least stable in an equilibrium mixture resulting from the addition of 1 mol water into 1 mol acetylene in an acidic environment? a) Vinyl alcohol b) Acetaldehyde c) Formaldehyde d) Ethyl alcohol e) Dimethyl ether	77.14 (N=135)

Table 6: Effect on success, of the substitution in the wording of questions for organic chemistry exams of the terms that are frequently used in daily life and have the same meaning as in scientific literature

Question 6	Right answers (%)
Which of the following reacts by both addition* and substitution*? a) Ethylene b) 1,3-butadiene c) Acetylene d) Cyclopentan e) Propane	70.28 (N=123)
Which one of the following compounds results in both addition and substitution reactions? a) Ethylene b) 1,3-butadien c) Acetylene d) Cyclopentan e) Propane	50.28 (N=88)

*In the original Turkish version of the question, A holds the Turkish correspondents of “addition” and “substitution”, which are “katilma” and “yer degistirme” respectively, while in B phonetic transcription of these words (i. e. “addition” and “substitution”) are used as specific terms

Table 7: Effect on success, of semantics in interrogative expressions in the questions of organic chemistry exams

Question 7	Right answers (%)
How many liters of gas O ₂ should be used under normal conditions in order to burn the acetylene, resulting from an initial CaCO ₃ of 20 g.? a) 2.24 b) 4.48 c) 6.72 d) 11.2 e) 22.4	71.43 (N=125)
How many liters of gas O ₂ should be used under normal conditions in order to burn the acetylene, resulting from an initial CaCO ₃ , of 20 g.? a) 2.24 b) 4.48 c) 6.72 d) 11.2 e) 43.07	51.42 (N=90)

In the wording of interrogative sentences for organic chemistry exams, usage of most common meaning of terms that are used in daily life and to have the same meaning as in the scientific language facilities student' perception and brings about high percentages of right answers to the question. Moreover, it was also seen during interviews, examination of exam papers and as a result of statistical (estimations) that usage of more specific academic terms could confuse the student. To attain this goal, terms of “katilma (ing. addition)” and “yer degistirme (substitution)” were selected since they have correspondences in both academic language and daily life with the same meanings. When the question is conducted in form A with these words in the group of 175, 70.28 percent of the students provided the right answer. These Turkish version of terms are widely used in both scientific field and daily life. They also thoroughly undertake the function and sense of “katilma (ing.: addition)” and “yer degistirme (ing.: substitution)”. That's why they are very easy to perceive and understand. when the question is presented in form b with the words “addition and “substitution”, the percentage of right answers falls to 50.28. Presentation of questions to students stated in sentences which are composed of words that are employed in both science and daily life with the same meaning and that are quite easy to perceive facilitates finding of the right answer more easily and increases the percentage of right answers. Because students think of only the actions when they are faced with the original Turkish version of these terms and they reach the answer more easily. However,

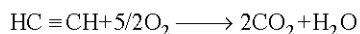
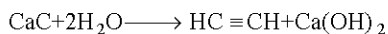
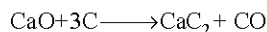
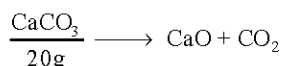
with respect to “addition” and “substitution”, students think about which one corresponds to addition and which to substitution at first and then they try to find the right answer and might sometimes confuse the concepts while trying to find their way. In addition to the fact that these conclusions are derived from interviews and discussions with the students, another fact that of organic chemistry teachers often experience such difficulty was stated by the teachers with whom we had the opportunity to exchange views in the identification of our criteria. Statistical studies also support this view.

In Turkish short intervals in the speech which are used to semantic units are called PAUSES [14]. Pauses are usually indicated with commas (,) in the written language. When pauses are not correctly used in the written language, some important ambiguities may occur. Below is an example pair of questions worded in such way (Table 7).

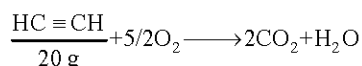
In form A of the question, it is quiet clearly stated that we have 20 grams CaCO₃ and we will produce a certain amount of acetylene out of it to burn with an unknown amount of oxygen; thus, success in answering the question increases.

However, the student has two perceptions of the question when asked in form B.

In form B of the question, CaCO₃ is given just for extra information and is emphasized as an input in production of acetylene. However, students perceive the question in form B as in form A and solve the problem with this perception. A number of students used the following equation steps when solving the problem:



These students have solved the problem by taking CaCO_3 as 20g. Another group of students solved the problem by using the equation below:



The amount of 20 grams is truly perceived to qualify the CaCO_3 in the question in form A, but with the insertion of a comma used as a pause before 20 g (in form B) it was perceived by some students as a value that belonged to acetylene while it was perceived by some students as a value that belonged to CaCO_3 and different solutions resulted. Although such punctuation should not actually cause problems, incorrect reading may cause incorrect perceptions. Proper use of "comma" both for punctuation and pause in the wording of organic chemistry questions and its proper understanding in Turkish is of great importance.

In the form A of question 7, it is stated that 20 grams of CaCO_3 was used in order to obtain acetylene, while the required amount of O_2 was asked. The amount of O_2 to be used for burning the acetylene is asked and the input for that acetylene is 20 grams CaCO_3 . However, in form B of the question, by the insertion of a comma before the quantity puts the question in a position totally different than the former one. Here the amount of oxygen required to burn 20 grams acetylene is asked. Due to the use of comma in the problem students who put the stress on the wrong place or who did not pay attention to the comma perceived the question in different ways and followed different solutions. This finding is reached by both the evaluation of exam papers and one-to-one interviews. Students developed two different ways of thinking in the form B of question 7:

In the first one, they thought that 20g amount belonged to CaCO_3 , while in the second one they thought that 20 g amount belonged to the acetylene.

It was also proven by the examination of exam papers. Students usually have difficulty in making sense of such emphasis and this difficulty is also reflected in

the results obtained. The question in form A was answered correctly by 71.43% of students while in form B the ratio of right answers was 51.42. Insertion of the comma in the question inclined students to different perceptions and solutions. Although this way of questioning is not specific to only organic chemistry questions but included in the above-said criteria since they can also be seen in organic chemistry questions. In fact it results from incorrect use of language and difficulty in understanding by students. There wouldn't be this much misunderstanding if form B of the question was asked as "How many liters of O_2 gas is required to burn 20 gram acetylene?" or if the students had paid necessary attention to the punctuation. The main issue here is, punctuation is important no matter what the languages of the countries are and the students should be careful about this. As in many languages, such problems are faced in Turkish language, too and this shows the necessity to take one more point into consideration when using question languages. The use more brief and clear wordings that lead the student to understand the question in a right way, is of great importance. But it is very well known that many teachers do not give importance to that (Table 8).

Understanding of formulas in organic chemistry can sometimes be difficult. Especially, the compounds given in systematic names are difficult to recognize for students. The possibility of the same systematic name having more than one alternative indicates that the said problem may also turn to be a problem of perception in wording of the question. In the 8th question, which prepared by taking this criteria into consideration, students recognized the compounds given in structural formulas more easily than the compounds given in systematic names.

In form A of the 8th question, choices are given to students with their structural formulas and a 70.86% average of success was retained. This is a considerably high level of success. Open statement of formulas, which means giving the structural formulas in organic chemistry, facilitated the perception of the compound by students, as the choices are also visually additor. Especially, expression of compounds having "confusing characteristics, isomers and different functional groups" with structural formulas made it easier to recognize and understand the molecules. During the interviews with the students and after the examination of the papers, it was found that in choices with systematic names, students first wrote down the structural formulas in order to find the right answer. However, their problem was not only writing down the structural formulas of the molecule but also the obligation to know about the primary, secondary, tertiary concepts and the difference between them. Its difficulty from the perspective of the

Table 8: Effect on success in solving the problem, of giving the closed or open formula of a molecule in answer choices of the questions for organic chemistry exams

Question 5	Right answers (%)
Which of the following is a tertiary alcohol?	70.86 (N=124)
CH ₃ b) H CH ₃ -C-CH ₃ CH ₃ -C-CH ₂ -CH ₃ OH OH	
c) CH ₂ -CH ₂ d) CH ₂ -CH-CH ₂ OH OH OH OH OH	
e) CH ₂ -CH-CH ₂ -CH ₃ OH OH	
Which of the following is a tertiary alcohol?	41.71 (N=73)
a) 2-methyl-2-propanol b) 2-butanol c) 1,2-dihydroxyethan d) 1,2,3-trihydroxypropan e) 2-methyl-1-butanol	

Table 9: The effect of "Organic chemistry exam questions prepared indirectly in the form of Induction and Deduction" on the success of the students

Question 9	Right answers (%)
A) Which of the following form when Ethanol and 2-propanol mixture is oxidised in an acidic environment? I) Ethanoic acid II) Propanon III) Propanoic acid IV) Ethylpropylether a) Only I b) Only II c) I and III d) I and II e) II, III and IV	58.28 (N=102)
B) Which of the following alcohol mixture form ethanoic acid and propanon when reacted with MnO ₄ in an acidic environment? a) Ethanol / 2-propanol b) Methanol / 1-propanol c) Ethanol / 1-propanol d) 1-propanol / 2-propanol e) Ethanol / propanol	45.14 (N=79)

student is obvious. They go through more calculations for the solution, which increases the risk of errors. Thus, the percentage of rights answers provided for this question remained at 41.71. The main issue that is wanted to be reflected here is, especially for the students in the evaluated age group, giving the structural formulas instead of systematic names would play a big role in the success. By giving the structural formulas, the errors that might be made while trying to write down the structural formulas could be neglected (Table 9).

Primary alcohols are oxidized to aldehydes and carboxylic acids and secondary alcohols are oxidized to ketons with strong oxidizers in acidic environments. In question B which prepared by the help of this knowledge, students are confused with "which alcohol mixture" and "KMnO₄" expressions. When the answer sheets are evaluated, it is seen that the students have tried to find alcohol mixtures by testing all the choices. In question A, the student understands that s/he is going to start from one primary and one secondary alcohol.

This solely will lead the student to remember some information. Thus, when solving the problem, the student will be conscious of that there is one point that s/he should pay attention. But in question B, there is no such clue and the students therefore tried to find the answer by testing all choices. Furthermore, they should also know that KMnO₄ has an oxidizing characteristic (it is not stated in the question), carboxylic acids are formed by the oxidation of primary alcohols and Ketons are formed by oxidation of secondary alcohols. In question B, the students tested all of the choices in this endeavor. They are also required to know the oxidizing characteristic of KMnO₄ and that acids are produced through oxidization of alcohols. A clear answer could only be reached through a complicated and successive mechanism of thinking. Moreover, students reported that they could make sense of the question B after reading it a few times. However, wording of the same question as in question A provided that students perceived the expected answer more easily and directly and the ratio of right answers to this question was

Table 10: The effect on student success of formulated or textual expression of problems in the exams of organic chemistry courses

Question 10	Right answers (%)
$\begin{array}{ccccccc} & \text{H}_2\text{SO}_4 & \text{Cl}_2/\text{light} & \text{NH}_3 & \text{Sn/HCl} & & \\ & \text{A} & \text{B} & \text{C} & \text{D} & & \\ \longrightarrow & \longrightarrow & \longrightarrow & \longrightarrow & \longrightarrow & & \end{array}$	
A) Toluene + HNO ₃ What is the output indicated with D That resulted from a series of reactions starting with Toluene?	69.71 (N=122)
o-amidobenzylamine b) p-aminobenzylamine c) nitrotoluene d) Benzendiazoniumchloride e) benzylalcohol	
B) Toluene and nitric acid yield a compound X in an environment with sulphuric acid, then the compound X yields the compound Y in a lighted environment with Cl ₂ and the compound Y yields Z together with NH ₃ and Z with T in yield the output D in a Hydrochloric acidic environment. Which of the following is the output D?	44.57 (N=78)
o-aminobenzylamine b) p-aminobenzylamine c) p-nitrotoluene d) Benzendiazoniumchloride e) benzylalcohol	

Table 11: Overall statistical results for answers according to the specified criteria

Question											
Wording of the question	1	2	3	4	5	6	7	8	9	10	
% of Correct	A	128	141	132	127	142	123	125	124	102	122
Answers	B	92	68	128	111	135	88	90	73	79	78
z		4.88*	10.81*	0.68	2.30*	1.52	4.58*	4.64*	6.64*	2.75*	5.67*

higher than that of the second version. In question A, some students had difficulties, because KMnO₄ and K₂Cr₂O₇ were not stated as oxidants in the question. But other students having this theoretical information did not have any difficulties. The conclusion is that it is much easier for the students to understand the question and to reach the right answer, when the question is asked in the form of deduction.

The ratio of student success in question A is 58.28% while the same ratio for question B is 45.14%. Briefly, students perceived the question A more easily and could reach the solution more easily in this form (Table 10).

In organic chemistry, formulization or schematization of some problems instead of asking them in a plain wording form facilitates the perception of students, since the visual additor increases the clarity of problem. Interviews with students revealed that wording of reactions in the form of plain statements distracted and confused the students and prevented the perception of what is asked. Thus, the semantic integrity of the question is destroyed. Presentation of the question in a brief and formulized way in form A added to the clarity of the problem and the student could relate the question in this form to his/her previous studies and could reach the right answer more easily. Because, in the organic chemistry books and the teachers of organic chemistry prefer such shorter indications in teaching. Such kind of brief and clear statements are frequently seen especially in subjects of

synthesis. Examination of students in the same way they are taught during lessons has yielded more efficient results. Therefore, a brief, clear and formulized wording of questions of chemistry and especially organic chemistry, plays a promoting role in student success.

69.71% of students provided correct answers to form A while 44.57% gave correct answers in form B. But here, various reaction series might produce more than one product. In this step it is not expected that the students are aware of that, but they are previously warned about eliminating the minor products.

SUGGESTIONS

Table 11 shows the results of z-test applied in the comparison of percentages estimated with the scores of success obtained from the questions prepared with consideration to the previously specified criteria.

With a view to Table 11, it is seen that there is a difference between averages of pairs of questions in each question (forms A and B). However, further research is required to find out whether such difference is actually significant in terms of statistics. Z-test is applied to the percentages obtained from A and B forms of these questions [15]. The results of statistical evaluation are displayed in Table 11. When Table 11 is examined, it is detected that there are statistically significant differences between the averages of pairs of questions for questions 1, 2, 4, 6, 7, 8, 9 and 10. Only

the average differences between pairs of question 3 and 5 are not statistically significant. In other words, the existence of negative or positive structures in the wording of organic chemistry questions does not make a significant difference between percentages of student success. Similarly, the existence of terms of quantity (scarcity or abundance) in the interrogative sentence does not make a significant difference between ratios of student success. These findings conflict with the study by Cassels and Johnstone [3]. It is thought to result from the facts that the course itself is already difficult, students intensively concentrate on the question while solving it and slight nuances in questions do not stand as quite confusing elements.

Choice or multi-choice exam is a kind of examination where a question is asked to student and its answer is given with three or four other statements which are not the answer of the question. In such kind of exams, students are expected to read the question directed them, to ponder and find the answer and to select and mark their answer among other statements. Since answering is nothing but a single marking, quite a short time will be enough for this process. Thus, a test consisting of multi-choice questions may contain as many questions to be read and thought about its answer. Therefore, some formal characteristics have an overwhelming importance just as the wording of the question for students is plain and avoids subjective concepts [1].

Designed with the aim of determining how effective the wording is on success in multi-choice chemistry questions, the questions were formed in the light of the criteria specified in a previous study [3] as well as some other criteria defined by the researcher. In the determination of those criteria, the aim was to define the difficulties stemming from the language of a course like organic chemistry, in particular, which differs from the study by Cassels and Johnstone. Under Conclusions, percentages of success in questions are statistically evaluated and it has been concluded that some criteria are required to be taken into consideration for the proper perception of the wording of an organic chemistry question by students. Following the identification that the wording of organic chemistry questions plays a great role in student success, the importance of appropriate wording of exam questions in line with the behaviors to be measured has revealed itself [16]. It is a prerequisite for success that teachers arrange exam questions with consideration to the environments of lessons. Due to the characteristics of human nerves system, the individual think much faster than she listens and is easily distracted while listening. The instructor who is aware of this fact should arrange their mode of lecture in accordance with

this characteristic. The method of dictating in lessons will provide that student more easily understands the lecture and as a student who is familiar with wording of the teacher, they can adapt themselves to the exam questions more easily. A previous study argues that 20% of what is read, 40% of what is read and 60% of what is firstly read and listened and then written are remembered [17, 18].

Thus, the method of teaching should be taken into consideration while preparing exam questions and the wording of questions should be in accordance with the wording of lectures. In this study which questions student skills in terms of the knowledge of basic concepts in organic chemistry, but the major aim of which is to measure the effect of wording of exam questions on student' perception, it has been concluded that teachers should follow a set of rules during the preparation of multi-choice questions so that students can correctly perceive the question and give the expected answer in a short time. Accordingly, the following should be taken into account in the wording of organic chemistry exam questions:

- In the wording of organic chemistry question, questions should be in such way that it tests directly the student behavior which is aimed to be measured. The wording of question should be sufficient to prevent the student from wasting time in the stage of thinking and to help find the right answer. In short, the student should properly perceive the question.
- Inclusion of excessive and unnecessary statements or data other than the ones needed for solution distracts the student and prevents their right thinking. Also the student tries to use these extra data.
- When the wording of organic chemistry question is semantically positive, the ratio of correct student answers increases. Because questions with a negative sense prevent the student from direct thinking, so the student answers at two stages, which causes waste of time and distraction.
- The percentage of correct answers to the questions containing different terms other than the expressions the student knows or is familiar with is low. The wording of questions should avoid different forms. Because multi-choice questions are such questions that measure student's knowledge with a single choice, a clear and easy-to-understand wording shall help directing the student to perceive and mark that choice.
- It is seen in the study that organic chemistry questions which hold negative terms of quantity are

less perceived with comparison to the questions including positive terms of quantity. However, the statistical evaluation has revealed that this difference is not statistically significant.

- Use of synonyms in the wording of organic chemistry questions yields less successful results when compared to the use of terms students are familiar with. Students look for the most common term that they are familiar with and, if not, they cannot properly match synonyms of these terms with their thoughts and existing knowledge. Furthermore, the terms should be presented to students in the form they are included in course books and curricula, which is going to raise the percentage of correct answers by students. Existence of substitute terms and concepts in chemistry do not entail their exact inclusion in the wording of chemistry courses and questions. It would be more beneficial that students learn synonyms of terms and concepts at further stages of chemical education, when they will have to.
- Open statement of molecule formulas in organic chemistry is more clearly understood and learned than closed formulas. Finding the correct answer of a question designed with open molecule formulas also is higher than with closed formulas.
- Questions do not always include a clear statement. Indirect and obscure questions are seen to be difficult to answer and students have to take into account some points although unnecessary in such case, which causes waste of time. Thus, performance of students becomes less successful.
- The comma, which is called "PAUSE" in Turkish, should be carefully used in the wording of question so that it will not destroy semantic integrity.
- In the wording of a question about an organic reaction concerning a number of reactive and experimental conditions, these environments should be stated not in a long way but briefly and systematically, which will play a promoting role in students correct answers.

In short, teacher should be careful in wording of exam questions so that the questions will be easily perceived by students. The requisite of correct and efficient perception of questions is that the wording of question is brief, clear, direct and grammatical and has a positive sense and properly employed punctuation. This is an application to be carried out by teachers who are good at details of written and spoken language and competent in their native language. Teachers who are

far away from expressing his thoughts and speeches [19]. In this study, ideal characteristics of wording of questions are identified on the basis of multi-choice exams. As for traditional exams, the wording of exam questions and most of the above discussed characteristics might be not as important as they are in multi-choice exams. The multi-choice examination system, which aims efficient use of time and completion of many questions in a limited time with the highest efficiency and performance but which implies the evaluation of a number of subjects at the same time, is also very common in the world today. Thus, a thorough care and attention in its preparation is important in terms of teachers' sufficiency and the ratio of correct answers given by students to their questions is taken as criteria in terms of student success, as well.

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