Nomenclature of Cyclic and Aromatic Hydrocarbons by Educational Games: OrgChemGame*

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Abstract

Educational games can be used as an effective means of transferring knowledge in a fun way to complement education and training. The aim of the study was to develop a game and get students' opinions on the game that can be played in Organic Chemistry courses in order to teach the names of commonly used organic compounds with cyclic and aromatic structure. The game, which is called OrgChemGame can be played with at least 3 individuals, one of whom is the referee. The game set includes 48 pcs of 3 cm diameter styrofoam balls with structural formulas of organic compounds identified. OrgChemGame was played by 20 students taking the organic chemistry lecture and studying in the 2nd grade of the Science Education program at a state university in Turkey. The opinions of the students about the game were taken with the opinion form prepared by the researchers. As a result of the research, it was determined that the sizes and colors of the balls and cubes used in the game were appropriate, and the texts used were readable. As a result, OrgChemGame has been designed as an educational game having a purpose and rules. It aims to acquire target behaviors and appropriate to the level of the students, allowing the students to learn with fun, and having sufficient duration and comprehensibility.

Keywords: OrgChemGame; Educational Game; Organic Chemistry, Science Education

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INTRODUCTION

Educational games increase the student's interest in the lesson, ensure the permanence of information, creativity and imagination facilitating the development of skills such as synthesis (Kaptan & Korkmaz, 2001; Kaya & Elgün, 2015; Kayabaşı & Akbaş, 2017; Yıldız, Şimşek & Ağdaş, 2017). These are the activities aiming at learning by doing, living, and where students can participate individually or as a group in certain places, time and rules (Güneş, 2014; Özdenk, 2007). Educational games are also an effective tool to motivate students while learning science (Orlik, 2002) and to increase student motivation (Garris, Ahlers & Driskell, 2002). An educational game designed to be used in the teaching process needs to go through a planning process, be appropriate to the level of the students, be unique, interesting and understandable (Heidemann & Hewitt, 2010; Tok, 2009). Since the students have fun while playing games, adding the game into the education increases their participation in the class while entertaining them (Kukul, 2013). As a matter of fact, Kaya and Elgün (2015) stated that teachers would contribute to student success when they implemented games effectively in the classroom without making much change in the program.

Starting from the preschool period, the use of educational games is included in all levels of education. In this context, there are some games designed on chemistry topics. A crossword puzzle (Erdik, 2003) and a sudoku puzzle containing amino acids and functional groups (Perez & Lamoureux, 2007) were designed to test the ability of undergraduate students to remember organic reactions and reagents. In addition, the following games; “Ion Education Set (IES)” (Yenikalaycı, Çelikler & Aksan, 2017), which aims to teach ions as an educational card game, “CHEMCompete” (Gogal, Heuett & Jaber, 2017) which is used to understand the chemical reactions of alkyl halides and the mechanisms of these reactions, “Retrosynthetic Rummy” (Carney, 2015) to make synthesis applications of functional groups and reaction types more enjoyable for students, have been developed. Card games help students improve their academic performance (Rajashekar & Bellad, 2016). There are also different games developed for teaching chemistry subjects. For example, “ChemOkey” (Kavak, 2012) was designed for teaching the names and symbols of anions and cations, and “The Fastest Fingers” game for teaching naming, isomerism and basic reaction schemes (Eastwood, 2013).

As well as, draw attention to the importance of organic chemistry laboratory in addition to organic chemistry course, found that there are general deficiencies in the students’ knowledge of separation and purification of organic compounds, purity control methods and structure determination of organic compounds by spectroscopic methods (Yılmaz, Uludağ & Morgil, 2001). The reason for this deficiency may be that the theoretical knowledge of organic chemistry is not fully understood. From this point of view, it is thought that the educational games to be developed will help the students to comprehend the basic and applied organic chemistry subjects. The aim of the study was to develop a game and get students' opinions on the game that can be played in Organic Chemistry courses in order to teach the names of commonly used organic compounds with cyclic and aromatic structure.

We developed this game because college students had trouble writing organic compounds. This game is planned to contribute to the naming of cyclic and aromatic hydrocarbons in chemistry. Organic chemistry topics are usually presented in printed form in textbooks, worksheets and exam evaluations offered to students, and are taught and evaluated using paper and pencil. In this study, we aimed to attract students' interest in the subject by using different materials such as balls and cubes. Similarly, Harman and Çelikler (2020) determined that the use of the model-based teaching method is effective in teaching the geometric structures of molecules to science students.

The game has been developed based on strategy. In real-time strategy games, which is a type of strategy-based games, players compete with their opponents through mutual moves (Korkusuz & Karamete, 2013). Likewise, in this study, students played their games simultaneously.

METHOD

While developing the OrgChemGame, the opinions of experts, whose fields are science education and chemistry education, were taken first. Later, the game developed as a draft was played to the students; this process was observed by the researchers and the students' opinions about the game were taken. Also, it is thought that taking the opinions of the target group that will play a game can provide clues in content arrangements. In this direction, arrangements were made and the game was finalized.

Research Model

The case study design, one of the qualitative research methods, was used in the study. In case studies, one or several situations are analyzed holistically within their own limits (environment, time, etc.) (Yıldırım & Şimşek, 2011).

Research Group

OrgChemGame was played by 20 students taking the organic chemistry lecture and studying in the 2nd grade of the Science Education program at a state university in Turkey. Before starting the game, the students were divided into small groups. During the playing of the game, cooperative learning was carried out in small groups formed. These students, who voluntarily participated in the research, acquired basic information about organic chemistry subjects within the scope of chemistry course during their high school education. At the same time, all of the students were taking the organic chemistry course. It is thought that the students should be taking this course in order to be able to play the game aimed to be developed without forgetting to learn the names of organic compounds in cyclic and aromatic structures and to express their opinions about the game due to their current readiness.

Data Collection Tools

OrgChemGame

OrgChemGame can be played with at least 3 people including a referee of the game. The game set contains 48 pcs of 3 cm diameter styrofoam balls, in which the structural formulas of organic compounds are drawn. In addition, there are 16 cubes with 2.5 cm side length on which the numbers of the compounds, punctuation marks, Latin inserts and alkyl groups to be used are written during the formation of the name of the compounds and 1 checklist containing the names of the compounds. The balls and cubes in the game set are given in Figure 1.

Figure 1. Balls and cubes in the game set

As the rules of the game, in the beginning, a student chooses one of the balls that are given to him/her in the bag containing organic compounds. Then s/he tries to form the name of the organic compound with the structural formula on the balls using the cubes in the game set. S/he sorts the cubes side by side in the same direction so that the generated name is read. The referee then evaluates the accuracy of the answers given according to the checklist and determines the winner according to the number of correct answers at the end of the game. After the referee receives the answers from the

students in each round, when there are incorrect answers, s/he creates the correct answer by lining up the cubes, thus preventing the referee from making bias. For example, a referee can be replaced as a player every 5 rounds. Thus, a learning environment is created by cooperating. The game period is set as one lesson hour (45 minutes) and completed under the control of the referee.

Observation

During the game, the students were observed by the researchers. The environment in which the observation took place was physically a classroom environment. As a result of the observation, it was understood that the game supports the social communication skills among the students and helps in providing scientific language skills. Besides, photographs were taken of how the groups played the game. Examples of some organic compounds written with OrgChemGame are given in Figure 2.

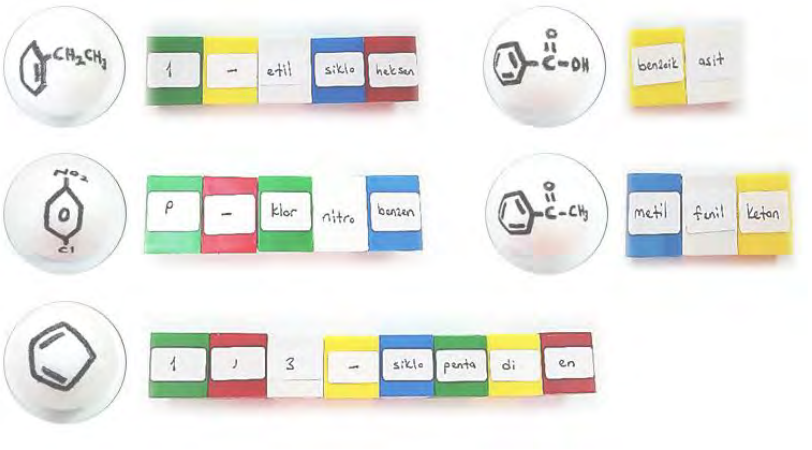

Figure 2. Compound examples written with OrgChemGame

Opinion Form

In the study, students' opinions were also needed in addition to playing the game to learn the subject. The opinions of the students were taken into consideration the pedagogical aspect of the game, that is, in the context of using the existing materials in the teaching of a subject in the best way and managing the process in a good way.

The opinions of the students about the game were taken with the opinion form prepared by the researchers. In this form, there are 8 open-ended questions about the dimensions and colors of the balls and cubes used in the game, regarding the readability of the texts, the duration of the game, the least number of people to play and the opinions of the students about the requested additions to the game in the form. The research is limited to the readiness of the volunteer students on the subject, the opinion form used in the development of the game and the answers given to the form.

Data Analysis

The students' names were reserved and coded as "S_1, S_2… S_n", and the data obtained from the answers were analyzed by content analysis. Content analysis is carried out in order to reach the concepts and relations to explain the collected data. Content analysis is important in terms of ensuring similar data organized within the framework of certain concepts and themes and facilitates understanding of data by readers (Yıldırım & Şimşek, 2011). "Reliability=[Agreement/(Agreement+Disagreement)x100]" formula given by Miles and Huberman (1994) was used to calculate the consensus and disagreement and the reliability of the research between the coders. Consensus and disagreement of two independent coders were compared and the average reliability of the codes was found 87%.

FINDINGS

The frequency distribution of the students' answers to the question "Are the sizes of the balls used in the game appropriate?" is shown in Table 1.

Table 1. Students' views on the size of the balls used in the game

Code	Student number	Frequency (f)
Appropriate		14
All of the texts can be seen.	S_2, S_5, S_6, S_{11}, S_{12}, S_{13}, S_{15}, S_{16}, S_{20}	9
Easily pulled out of the bag	S_2, S_3, S_{11}, S_{14}, S_{15}	5
Easy to carry	$S_{17,}$ S_{20}	2
Takes up little space	S_7, S_{15}	2
Easily mixed	S_{19}	1
Inappropriate		6
Their sizes are small, should be bigger	S_1, S_9, $S_{10,}$ S_{18}	3
Its mass should be slightly increased	S_1, S_8, S_{18}	3
It's difficult to find when it falls down to the floor	S_4	1

Students generally stated that the size of the balls appropriate. However, some students also recommend increasing the text size to see the entire article more clearly. Direct citations from the answers given by the students are as follows;

"Easy to hold, takes up little space, the texts fit on it" (S_{15})

"Larger balls can be used to make some compound names appear as a whole." (S_{18})

The frequency distribution of the students' answers to the question "Are the colors of the balls used in the game appropriate?" is shown in Table 2.

Table 2. Students' views on the color of the balls used in the game

Code	Student number	Frequency (f)
Appropriate		16
White color makes it easier to see text	S_1, S_2, S_3, S_7, S_8, S_{12}, $S_{15,}$ S_{16}, S_{17}, S_{18}, S_{19}	11
Black font on white base draws attention.	S_2, S_3, S_4, $S_{5,}$ S_9, S_{12}, S_{13}, $S_{14,}$ S_{18}	9
Black font is easy to read on white base	S_{15}	1
Inappropriate		4
There must be different colors to draw attention	$S_{6,}$ $S_{10,}$ $S_{11,}$ S_{20}	4
Different colors should be used for aromatic and cyclic compounds	S_6, $S_{11,}$ S_{20}	3
Should be compatible with the colors of the cubes	S_{11}	1

Students generally stated that the colors of the balls used in the game were remarkable and visible. Some students suggested that different colors could be used to be remarkable and matching the colors of the cubes used. Direct citations from the answers given by the students are as follows;

"Writing names with a black pen on white draws immediate attention." (S_4)

"The balls were one color. Separate colors could be used for aromatic compounds and for cyclic structures." (S_{20})

The frequency distribution of the students' answers to the question "Are the sizes of the cubes used in the game appropriate?" is shown in Table 3.

Table 3. Students' views on the sizes of the cubes used in the game

Code	Student number	Frequency (f)
Appropriate		17
Writable space is enough	S_1, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{13}, S_{14}, S_{16}, S_{18}, S_{19}	12
Easy to handle	S_2, S_3, S_5, S_{14}	4
Easy to carry	S_9, S_{20}	2
Compatible with the size of the ball	S_{10}, S_{17}	2
Inappropriate		3
Should be smaller	S_{12}, S_{15}	2
Should be larger	S_4	1

Students generally stated that the writable spaces of the cubes were sufficient. Direct citations from the answers given by the students are as follows;

"Compatible with the size of the ball. The cubes are of suitable size in which the names of the long compounds can also be written." (S_{10})

"The cubes are unnecessarily big. Could have been a little bit smaller." (S_{12})

The frequency distribution of the students' answers to the question "Are the colors of the cubes used in the game appropriate?" is shown in Table 4.

Table 4. Students' opinions about the colors of the cubes used in the game

Code	Student number	Frequency (f)
Appropriate		17
Making the game remarkable	S_1, S_2, S_3, S_5, S_6, S_7, S_8, S_{12}, S_{13}, S_{14}, S_{15}, S_{17}, S_{18}	13
Increases desire to play	S_6, S_{14}, S_{17}, S_{18}	4
Does not distract because it is not bright	S_1, S_3, S_{11},	3
Prevents confusion	S_{10}	1
It makes easy to read the texts	S_{12}	1
It makes students focus on the writing	S_{11}	1
Inappropriate		3
Should be more different colors	S_4, S_{16}	2
Should be single color	S_{16}, S_{20}	2
Color should be used for each number, substituent, punctuation and compound name	S_{20}	1

Students generally stated that the use of colorful cubes in the game makes the game remarkable and increases the desire to play. It is noteworthy that a student offers to use of a color for each of the numbers, substitutes, and punctuation and compound names used in nomenclature. Direct citations from the answers given by the students are as follows;

"The color of the cubes makes the game more interesting and fun." (S2)

"A separate color could be used for numbers, for the main structures, for the substituents, and for the line." (S_{20})

The frequency distribution of the students' answers to the question "Are the readability of the texts used in the game appropriate?" is shown in Table 5.

Table 5. Students' opinions on the readability of the texts used in the game

Code	Student number	Frequency (f)
Appropriate		15
Text sizes is easily readable.	S_1, S_2, S_3, S_6, S_7, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17}, S_{18}, S_{20}	15
Black font on white base on balls is easily readable.	S_1, S_{15}	2
Inappropriate		5
Text sizes should be large.	S_4, S_5	2
Text sizes should be small.	S_8, S_{19}	2
Texts should be printed or computer printout.	S_5, S_9	2

Students generally stated that the text sizes on the balls and cubes used in the game were readable. Direct citations from the answers given by the students are as follows;

"Texts on balls are clear and understandable" (S_{17})

"Texts can be computer printout" (S_9)

The frequency distribution of the students' answers to the question "Should a period be given for the game?" is shown in Table 6.

Table 6. Students' opinions about the period of the game

Code	Student number	Frequency (f)
Yes		17
Will be boring if indefinite	S_3, S_4, S_5, S_6, S_7, S_8, S_{10}, S_{11}, S_{14}, S_{16}, S_{20}	11
Periodical game will be more fun	S_2, S_3, S_8, S_{14}, S_{20}	5
The period provides competition	S_3, S_{16}, S_{18}	3
It should be periodical but the individual should determine it.	S_{19}	1
If it is periodical, the game will be taken seriously	S_{16}	1
Duration makes the student fast	S_{11}	1
Should be periodical and period can be extended for reinforcement	S_{12}	1
45 minutes	S_2, S_4, S_5, S_6, S_7, S_{14}, S_{20}	7
30 minutes	S_{11}, S_{16}	2
1 hour	S_{13}, S_{15}	2
2 hours	S_{12}	1
No		3
There should be no time limit	S_1, S_9	2
Teaching should not be limited to a period of time	S_1	1
Duration reduces attention	S_{17}	1
Hurrying prevents learning	S_{17}	1
Each individual should determine themselves.	S_9	1

Students generally suggest that the game should be periodical and it should take 45 minutes or more. Direct citations from the answers given by the students are as follows;

"It can be boring if indefinite. " (S_4)

"Students are constantly competing over time and the game should not be restricted." (S_1)

The frequency distribution of the students' answers to the question "How many people at least should play the game?" is shown in Table 7.

Table 7. Students' opinions about the least number of people to play the game

Code	Student number	Frequency (f)
Two people		17
Prevents the player to be active if it's more than two.	S_2, S_3, S_4, S_5, S_6, S_9, S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{17}, S_{18}, S_{20}	14
Prevents learning if it's more than two.	S_3, S_6, S_8, S_9, S_{16}	5
It will be confusion if it's more than two.	S_3, S_4, S_{10}, S_{15}	4
Individual takes too much time	S_{17}	1
Single person	S_1, S_7, S_{19}	3

Students generally stated that it should be played with two people. Direct citations from the answers given by the students are as follows;

"Two people because not everyone is active in the game when there are too many." (S_5)

"I think there will be confusion if there are more than two people." (S_{15})

The frequency distribution of the students' answers to the questions "Do you think the name of the game is appropriate? Do you have any suggestions to include?" is shown in Table 8.

Table 8. Students' opinions about the name and the additions to be made in the game

Code	Student number	Frequency (f)
The name of the game is appropriate as it reflects the content	All students	20
Sufficient for teaching the subject	All students	20
Inorganic compounds can be added	S_{12}, S_{16}, S_{20}	3

All of the students stated that they found the name of the game appropriate and the content sufficient. Some students suggested that inorganic compounds could also be added. Direct citations from the answers given by the students are as follows;

"In my opinion the game is sufficient for the organic lecture at the university."(S_8)

"I wouldn't make any addition." (S_{13})

"I would add the nomenclature of inorganic compounds to this game" (S_{20})

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

In this study, it was aimed to develop a game that can be played in Organic Chemistry courses in order to teach the names of commonly used organic compounds with cyclic and aromatic structures. Summarizing the opinions obtained at the end of the game students generally stated that the size of the balls appropriate, the colors of the balls used in the game were remarkable and visible, the writable spaces of the cubes were sufficient, the use of colorful cubes in the game makes the game remarkable and increases the desire to play, the text sizes on the balls and cubes used in the game were readable, the game should be periodical, and it should take 45 minutes or more, it should be played with two people. And, all of the students stated that they found the name of the game appropriate and the content sufficient. As a result of all these positive opinions, OrgChemGame has been designed as an educational game having a purpose and rules. It aims to acquire target behaviors and appropriate to the level of the students, allowing the students to learn with fun, and having sufficient duration and comprehensibility.

While the educational activities carried out with fun affects the students' learning and teaching process positively, they enrich the process not only for entertainment but also to support academic

content learning (Barab & Dede, 2007; Miller, Chang, Wang, Beier & Klisch, 2011). In this context, OrgChemGame is a game that can be used in teaching and reinforcing the nomenclature of cyclic and aromatic compounds commonly used within the scope of organic lesson and it is thought that it can make the students participate actively in the course. The games should be given a name and that the chosen name should be kept in their mind and make them feel excited (Özbal, 2009). The name OrgChemGame given to this game was liked by the students and called their attention.

When designing an educational game, how much information the students will learn in which environment, their interactions with other learners, the role of the teacher and the students in the learning process, the materials required for the game, the time needed for the game, the content levels of the students, their interests, age and whether they are appropriate for the subject to be taught in the classroom should be considered. Educational games should complete the work done in the classroom (Özbal, 2009; Ocak, 2013). When these properties were taken into consideration, it was determined that the dimensions and colors of the ball and cube materials used in OrgChemGame were appropriate and the texts used were readable. The duration of the game was set as 45 minutes. As a matter of fact, it was seen that most of the students who participated in the research stated that the indefinite game would be boring but it would be more fun by providing competition when it was within a limited time. The game is played with at least 2 players, and one referee determines the winner of the game. The students stated that if the number of players is more than 2, the players will not be active and this will cause confusion in the game and thus, it will prevent learning. Students stated that OrgChemGame is sufficient in terms of content and some students suggested that inorganic structured compounds can be added.

In line with the findings obtained from the research, it is suggested that similarly, educational games that include organic chemistry subjects that students have difficulty can be developed. In addition, it is recommended to include the students who are ready on the subject in the educational games to be developed in accordance with the relevant subject area, and to include their opinions. It can be stated that this will contribute to the students' pedagogical content knowledge.

Since the playing of the game is limited to the tables in the classroom environment, some balls rolled off the table and fell on the floor during the game. In future research, to prevent this, a platform on which the selected balls can be fixed or game boards on which balls and cubes can be easily sorted can be used.

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