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The Effect of Argumentation-Based Organic Chemistry Teaching on Students' Argument Construction Skills

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Abstract

Some students could not learn organic chemistry because of the difficulty of its submicroscopic nature. In this study, it was aimed to determine the effect of argumentation-based organic chemistry teaching on high school students‟ argument construction skills so on their meaningful concept learning. The study was conducted on 14 high school students at a vocational high school in Turkey on organic chemistry topics through 28 hours period based on the case study. The teaching guide‟s worksheets and students‟ observation notes were used as data collection tools. Through the application process, the students criticized each of the seven submicroscopic nature of organic chemistry concepts‟ paintings in big group discussions, then constructed their own arguments. Then the students evaluated the whole process. Content analysis was employed for the data analysis. Argumentation making students criticize the submicroscopic nature of organic chemistry resulted in a qualified student-constructed argument by making them understand the submicroscopic nature so become critical thinkers. Students‟ process evaluation also underlined that the process made students joyful, motivated, creative, criticizer, and meaningful learners with a differently constructed learning environment. For further studies, different argumentation-based organic chemistry teaching environments could be offered.

Key words: Organic chemistry teaching, Argumentation, Argument construction, Meaningful learning, Critical thinking

Introduction

Why do not some students learn chemistry? The students try hard, but the submicroscopic nature of chemistry makes it difficult (Nakhleh, 1992). We still do not have a change of seeing molecules, atomic or subatomic particles with any of the advanced instruments. We know these particles‟ existence by beams-particles interactions through the advanced analysis; thus, it is equally difficult for teachers to arrange teaching environments for making students understand the submicroscopic nature of chemistry that is still invisible.

Teaching students the submicroscopic nature of chemistry would be meaningful for students if only proper scientific images about the submicroscopic nature of chemistry concepts could be constructed in students‟ mental schemes. Conceptual image can be expressed as holding a conceptual representation of an image as a mental picture in one's mind (Mackenzie & White, 1981). For example, if one keeps an image of the crystal form of sodium chloride in one‟s mind, it means that one can envisage sodium chloride ions, their ionic sizes, and the ions‟ electrostatic interactions, as well as the sodium chloride‟s unit cell structure and the crystal form comprised of these unit cells (Eyceyurt-Türk & Tüzün, 2018). Then, it is essential to employ proper teaching methods for constructing teaching domains in chemistry to make students gain appropriate concept images while learning chemistry concept meaningfully. Argumentation, which is based on inquiring - criticizing concepts, is one of the current teaching methods for making students critical thinkers to construct scientifically correct concept images so learn meaningful. Argumentation is also conducted in effective speech communication to improve critical thinking and construct proper concept images (West, 1994). Argumentation was defined as "a social, intellectual, verbal activity serving to justify or refute an opinion, consisting of statements directed towards obtaining the approbation of an audience" (Van Eemeren, 1985, cf., Driver, Newton

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& Osborne, 2000, p. 292). Argumentation is also "the coordination of evidence and theory to support or refute an explanatory conclusion, model, or prediction" (Suppe, 1998, cf., Osborne, Erduran & Simon, 2004, p. 995).

Argumentation training in the learning environments has two main functions: one is an inquiry process that brings together learners in the coordination of conceptual and epistemic goals, and the other is to allow the trainers to evaluate the progress of the students' scientific thinking and reasoning throughout the training (Osborne, Erduran & Simon, 2004). Argumentation, which is a teaching method, provides some information about the distinction between argument and argumentation. Argument refers to "the substance of claims, data, warrants, and backings that contribute to the content of an argument, whereas argumentation relates to the process of assembling these components, in other words of arguing" (Simon, Erduran, & Osborne, 2006, p. 237).

Engaging students with argumentation processes require the use of argument patterns. The diversity of argument patterns from the literature are like Lawson (2003, p. 1390) argument pattern -hypothesis, planned test, prediction, observed result, conclusion - and Walton and Reed (2003, p. 201) argument pattern - premise, premise, premise, conclusion - whereas the most common is Toulmin (2003, pp. 90-96) argument pattern - claims, data, warrants, qualifiers, backings, rebuttals-. According to Toulmin argument pattern:

> Claims: Assertions about what exists or values that people hold.
> Data: Statements that are used as evidence to support the claim.
> Warrants: Statements that explain the relationship of the data to the claim.
> Qualifiers: Special conditions under which the claim holds true.
> Backings: Underlying assumptions that are often not made explicit.
> Rebuttals: Statements that contradict data, warrant, backing or qualifier of an argument (1958, cf., Simon, Erduran & Osborne, 2006, p. 240).

An example of an argument according to Toulmin argument pattern can be seen at Figure 1.

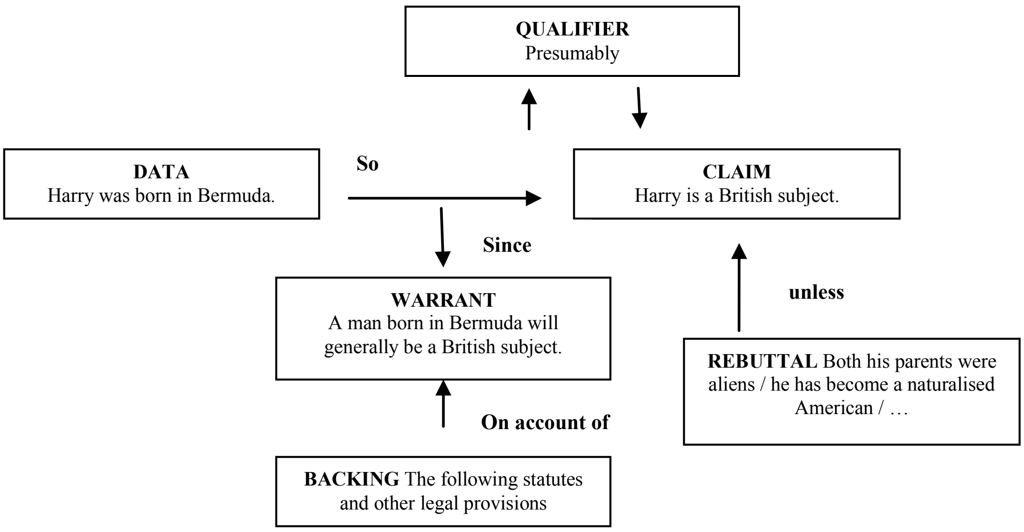


Figure 1. An example of an argument according to Toulmin argument pattern components (2003, p. 97)

Many strategies are being used in argumentation such as table of statements, concept maps, experiment reports, competing theories, and predict-observe-explain processes in literature (Erduran, 2007). Being different from the literature in the current study, drawings were offered as an argumentation strategy for making meaningful the submicroscopic nature of chemistry for students through images.

On the other hand, along with the changes and developments of the 21st century, countries are organizing science curricula to develop critical thinking of individuals to adapt to innovations. However, this situation cannot be appropriately integrated into the classes since teachers do not have enough knowledge about critical thinking or that the meaning attributed to critical thinking is not clear (Vieira, Tenreiro-Vieira & Martins, 2011). Thus, "What do we mean by the term „critical thinking‟?" Although there is no consensus on the definition of critical thinking for researchers, Norris and Ennis (1989, cf., West, 1994, p. 3) define critical thinking as "reasonable and reflective thinking that is focused upon deciding what to believe or do". In other words, Scriven and Paul (2003) stated that "critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (cf., Cook, 2008, p. 13). Critical thinking can be stated in argumentation as the process of the argumentation, which would also give a chance to students to construct much more properly scientific images in their mental schemes as a product of criticizing their own and others‟ thinking strategies in depth.

There are studies on argumentation-based teaching environments, argument construction skills, meaningful learning, and critical thinking in literature. In a research, a general chemistry laboratory course was constructed on the basis of argument driven inquiry as an instructional model. Making students criticize their own and each other thinking strategies, making students construct arguments through inquiry would make students critical thinkers. This study modelled how to design an argument driven inquiry chemistry lab session for making student critical thinkers through arguing (Kadayifci & Yalcin-Celik, 2016). West (1994) conducted an argumentation education with 74 students by using an experimental design with pre and post-test control group for improving students‟ critical thinking. At the end of the study, it was found that the experimental group‟s students were successful than the control group‟ students based on „data interpretation‟ and „argument‟ subtests. In another study, argument structures and critical thinking questions were examined. There had been an application process for six months. Experimental design with pre and post-test control groups were employed in this study too. The study showed that experimental group‟s students could not only construct critical thinking questions successfully but also could construct arguments containing arguments and counter-arguments at the same (Nussbaum & Edwards, 2011). Kabataş-Memiş and Çakan-Akkaş (2020) investigated the effect of argumentation supported by inquiry on fifth-grade students‟ critical thinking skills. Experimental design was employed. The lessons in the experimental group were constructed on argumentation supported by inquiry. It was underlined that argumentation supported by inquiry made experimental group students‟ critical skills enhanced. In a different study, Think-Read-Group-Share-Reflect (TRGSR) argumentation strategy was utilized for improving high school students‟ critical thinking based on Toulmin argument pattern (TAP). Experimental design was used. 50 twelfth-grade students participated in the research. Experimental group lessons were with TRGSR based on TAP. Watson-Glaser critical thinking appraisal Form–S was employed for evaluating the critical thinking of both groups as pre and post-test. After a nine-week period, a significant difference among the groups were found in means of critical thinking (Giri & Paily, 2020).

For all these reasons, this study examines the effect of argumentation-based organic chemistry teaching on high school students‟ argument construction skills so on meaningful learning and critical thinking. Being aware of the missing studies in literature about argumentation-based organic chemistry teaching and the need of it, the current investigation would exemplify a detailed educational application process for further studies (Eyceyurt-Türk, Tüysüz & Tüzün, 2018). Hence the study‟s research question is: What is the contribution of argumentation-based organic chemistry teaching to students‟ submicroscopic nature of organic chemistry perceptions via their argument construction skills?

Method

Theoretical Framework: The Case Study

This study employed the case study as the theoretical framework. The cases of interest in education are people and programs. It is interested in them for both their uniqueness and commonality. It was sought to understand them in depth (Stake, 1995, p. 1). This framework is especially suited for this study since the case of interest is argumentation-based organic chemistry teaching as the program and its effect on students‟ argument construction skills so on their submicroscopic concept understanding and critical thinking as the people. Through the study, students‟ evaluation about the whole process was taken, but the study was not a phenomenological one since students‟ argument construction skills; thus, their concept understanding, and critical thinking were examined too.

Setting and Participants

This study was conducted at a vocational high school in Turkey. The first semester of the organic chemistry course was the focus of the investigation. It was met a class of 14 students for four hours per week for seven weeks which was a total 28 hours period for this study. Reachable sampling was employed for this study since the participants were one of the researchers‟ backyard. All the participants were willing. The participants were female because of the vocational high school‟s type. The participants were being educated on arts at this occupational high school.

Instruments

For enhancing high school students‟ critical thinking by making them argue the submicroscopic nature of organic chemistry concepts via argument construction, first, seven paintings were created by a professional artist parallel with Ministry of National Education‟s 12th-grade organic chemistry teaching targets. The paintings illustrated the submicroscopic nature of organic chemistry concepts successfully. Three different science educators checked the paintings‟ content validity. The science educators‟ suggestions were reflected in the teaching process, such as “Atoms do not have colors, using color in paintings is only for presentation to help to recognize the different atoms.”

In the second step, an argumentation-based organic chemistry teaching guide for enhancing students‟ critical thinking skills by criticizing the submicroscopic nature of organic chemistry concepts and constructing their own arguments was constructed. The teaching guide consisted of seven activities, making students create their own arguments after analyzing, arguing and criticizing the submicroscopic nature of concepts in the paintings. The first painting was about an organic compound (methane), the second one was about carbon allotropes (fullerene), and the third was about Lewis‟s formulas about organic compounds (methane‟s Lewis‟s formula). The fourth was about hybrid orbitals of organic compounds (ethylene‟s hybrid orbitals), fifth about molecule geometries of organic compounds (tetrahedral geometry of methane), sixth about functional groups of organic compounds (ethyl alcohol and diethyl ether), and the last one about isomers in organic compounds (three isomers of pentane). Hence, the first instrument was determined as the teaching guide. Three different science educators checked the teaching guide‟s content validity. In Figure 2, examples from the teaching guide were given.


Painted by Başak, 2016

After analyzing, arguing and critizing the painting in a big group discussion, construct your claim about the painting (allotropy concept).

....

Find statements (data), that could be used as evidence to support your claim.

....

Construct warrants to explain the relationship of your data with your claim.

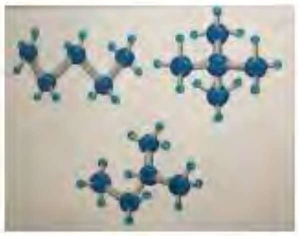
....

Guarantee your warrants with backings to underline your assumptions that are not explicit.

....

Describe the rebuttals, statements that contradict either your data, warrant or backing of your argument.

....


Painted by Başak, 2016

After analyzing, arguing and critizing the painting in a big group discussion, construct your claim about the painting (isomery concept).

....

Find statements (data), that could be used as evidence to support your claim.

....

Construct warrants to explain the relationship of your data with your claim.

....

Guarantee your warrants with backings to underline your assumptions that are not explicit.

....

Describe the rebuttals, statements that contradict either your data, warrant or backing of your argument.

....

Figure 2. Examples from the teaching guide‟s worksheets

Students‟ observation notes were used for evaluating the whole process. Thus, the second instrument was determined as observation notes. The observation notes‟ content validity was also checked by three different science educators. Three independent science educators checked the instruments‟ reliability, 95 percentages were calculated as the researchers‟ coding and categorizing consistency. For coding, categorizing, and cross-content analysis Erickson‟s (2004) research was used.

Data Collection and Analysis

Before the application session, argumentation strategy and critical thinking‟s meaning were introduced to the students. During the application session, the students analyzed, argued, and criticized each of the seven paintings in big group discussions, criticized their own and others‟ thinking strategies, and then constructed their own arguments individually based on Toulmin (2003, pp. 90-96) argument pattern components (claims, data, warrants, backings, and rebuttals) throughout four hours per each of the paintings. In a traditional learning session, the students only listen to the teacher; however, a constructivist social context was constructed for students - they were able to access interactive board, organic chemistry presentations, organic chemistry simulations, questions about organic chemistry, Ministry of National Education‟s 12th grade online chemistry book, and each other and teacher so to criticize the submicroscopic nature of chemistry in this study. At the end of the application session, students evaluated the whole process. The content analysis was employed. First codes were constructed, then the codes categorized on the philosophical logic of which argument contained what codes as a whole category, and then frequencies-percentages calculations were made. Cross-content analysis (Erickson, 2004) – making sure that each of the codes is under a category - was made for data reliability. For the content analysis process, it would be beneficial to underline how argumentation, making students criticize the submicroscopic nature of chemistry, and argument construction would enhance students‟ critical thinking. Based on Cambridge International Thinking Skills Syllabus (2020-2022), being able to construct scientifically true arguments would mean the students gained critical thinking skills.

Results and Discussion

After analyzing the data, the results were given in two subtitles: students‟ argument construction skills and students‟ process evaluation.

Students' Argument Construction Skills

Toulmin‟s argument pattern components (claims, data, warrants, backings, rebuttals) were used as codes, the student constructed arguments were analyzed according to these codes, then these codes‟ combinations made the categories. For each of the categories, frequencies and percentages were calculated. The analysis could be seen in Table 1.

Table 1. Student constructed arguments' analysis for each of the seven paintings*

	f - %										
Painting about	**CD**	**CDW**	**CDB**	**CDR**	**CDWR**	**CDBR**	**DWBR**	**CWBR**	**CDWBR**	**CDD WBR**	**total**
1.Identifying organic compounds				1 7% S3	2 14% S8, 11				11 79% S1, 2, 4, 5, 6, 7, 9, 10, 12, 13, 14		14 100%
2.Carbon allotropes	1 7% S13	2 14% S8, 10	2 14% S4, 5	1 7% S9					8 57% S1, 2, 3, 6, 7, 11, 12, 14		14 100%
3.Lewis formulas of organic compounds						1 7% S3			13 93% S1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14		14 100%
4.The hybrid orbitals of organic compounds					1 7% S5	1 7% S13			11 79% S1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12	1 7% S14	14 100%

5.The molecule geometries of organic compounds		1 7% S5	1 7% S14	1 7% S8			1 7% S10	10 71% S1, 2, 3, 4, 6, 7, 9, 11, 12, 13	14 100%
6.The functional groups of organic compounds								14 100% all	14 100%
7.Isomery in organic compounds	1 7% S5					1 7% S14		12 86% S1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13	14 100%

*It would be beneficial to underline that only the third painting is about the symbolic nature of chemistry. Except that all other paintings are about the submicroscopic nature of chemistry. In Table 1, claim was shown by C, data by D, warrant by W, backing by B, rebuttal by R, frequency by f, percentage by %, and student by S.

As can be seen in Table 1, student-constructed scientifically correct arguments based on all Toulmin‟s argument pattern components were 79, 57, 93, 86, 71, 100, and 86 percentages through the paintings. The students‟ conceptual understanding in other words submicroscopic thinking skills via constructing arguments would be adopted adequate by the three science educators if only scientifically correct arguments based on all Toulmin argument pattern components would be 33% for each of the paintings. It can be seen in Table 1, all the percentages are over 33%; thus, it can be said that students‟ concept understanding, in other words submicroscopic thinking skills via constructing arguments are adequate so their critical thinking skills‟ improvement is too since scientifically proper argument construction means the improvement of critical thinking too according to Cambridge International Thinking Skills Syllabus (2020-2022).

Student constructed arguments from worksheets were given below for strengthening the findings.

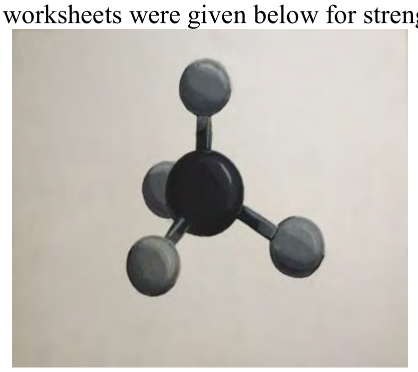


Figure 3. Painting about identifying organic compounds *(Painted by Başak, 2016.)*

The argument of student 2 (S2): CH_4 is an organic compound (claim). It consists of C and H (data). If a compound consists of C, H, O, N and S atoms, then it is an organic compound (warrant). For forming this organic compound, C makes four bonds with H (backing). A compound could have C atoms that does not mean it has to be an organic compound always (rebuttal).

The argument of S5: CH_4 is an organic compound (claim). It is combustible (data). Organic compounds are combustible (warrant). C_2H_6 is an organic compound, and it is combustible too (backing). If a compound is combustible that does not mean it has to be an organic compound (rebuttal).

Figure 4. Painting about carbon allotropes *(Painted by Başak, 2016.)*

The argument of S1: Fullerene is an allotrope of carbon (claim) because of its‟ shape in space (data). The other carbon allotropes differ from fullerene because of their shapes in space (warrant). For example, graphite‟s layer formation differs from other carbon allotropes (backing). If we could find a chemical in space like fullerene formation, then the warrant would be invalid (rebuttal).

The argument of S4: Fullerene can be used in nanotechnology (claim). When K is vaccinated to fullerene, its‟ conductivity increases (data). Nanotube can be used in nanotechnology like fullerene (backing).

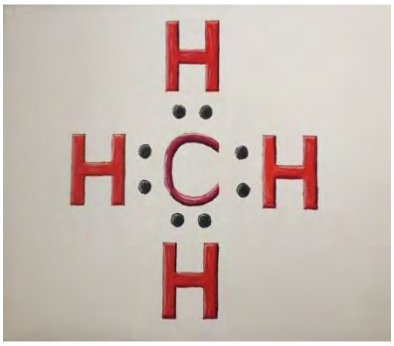
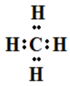
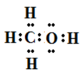
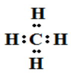
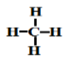


Figure 5. Painting about Lewis formulas of organic compounds *(Painted by Başak, 2016.)*

The argument of S12: Lewis‟ formula of methane is  (claim). Electron dot structure is the basis for this (data). Dots showed the electrons of C and H‟s orbitals with the highest energy in Lewis‟ formula (warrant). Lewis‟ formula of methanol is  (backing). If the concept of Lewis‟ formula loses its‟ scientific value, then the warrant would be invalid (rebuttal).

The argument of S13: Lewis‟ formula of methane is  (claim). C and H use two electrons per bond (data). C makes four bonds with H atoms (warrant). The structural formula of methane is  (backing). If Lewis‟ formula loses its scientific value, then the claim would be invalid (rebuttal).

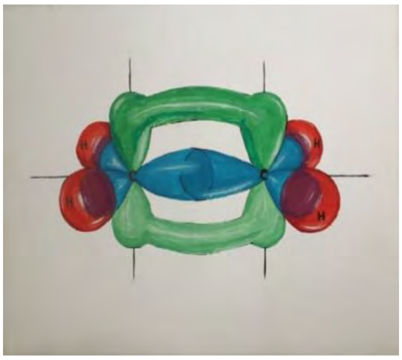
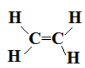
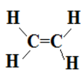


Figure 6. Painting about the hybrid orbitals of organic compounds *(Painted by Başak, 2016.)*

The argument of S6: C makes the hybrid of sp^2 (claim).  (data).  (warrant). The molecule geometry is triangular (backing). If the concept of hybridization loses its‟ scientific value, then the claim would be invalid (rebuttal).

The argument of S8: C makes the hybrid of sp^2 (claim).  (data). The sp^2 hybrid orbitals‟ energies are equal (warrant). The molecule geometry is triangular (backing). If the concept of hybridization loses its‟ scientific value, then the claim would be invalid (rebuttal).

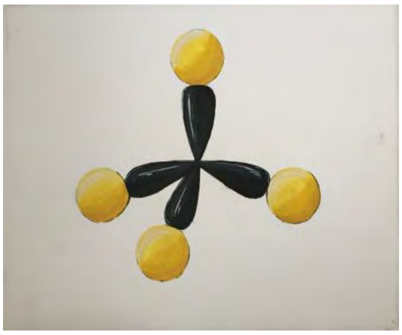
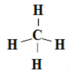


Figure 7. Painting about the molecule geometries of organic compounds *(Painted by Başak, 2016.)*

The argument of S5: The molecule geometry of CH_4 is tetrahedral (claim).  (data).  (backing).

The argument of S11: The molecule geometry is tetrahedral (claim). The hybridization of the central atom is sp^3 (data). The molecule geometry is tetrahedral because of the hybridization of the central atom (warrant). Just like C_2H_6 molecule‟s central atom (backing). If the concept of hybridization loses its scientific value, so does the concept of molecule geometry its scientific value (rebuttal).

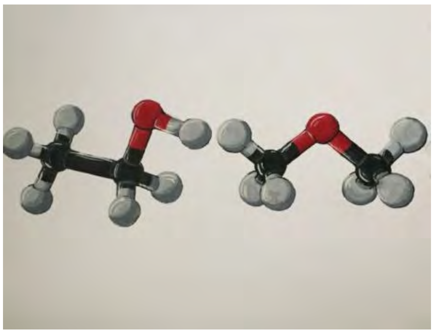
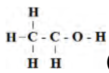
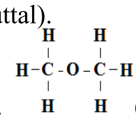


Figure 8. Painting about the functional groups of organic compounds *(Painted by Başak, 2016.)*

The argument of S7: The functional group of ethanol is -OH (claim).  (data). Because its‟ structural formula involves –OH, I classified this compound as alcohol (warrant). C_2H_5 - OH (backing). If the concept of functional group loses its‟ scientific value, then the claim would be invalid (rebuttal).

The argument of S11: The functional group of dimethyl ether is -O- (claim).  (data). Because its‟ structural formula involves -O-, I classify this compound as ether (warrant). CH_3 - O - CH_3 (backing). If the concept of functional group loses its‟ scientific value, then the claim would be invalid (rebuttal).

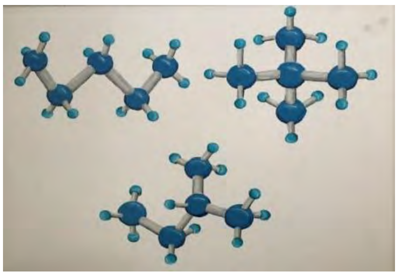
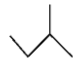


Figure 9. Painting about isomers in organic compounds *(Painted by Başak, 2016.)*

The argument of S3: n-pentane and isopentane are chain isomers (claim).  and  (data). The molecular formulas are the same, but structural formulas are different (warrant). CH_3-CH_2-CH_2-CH_2-CH_3 and CH_3-$CH(CH_3)$-CH_2-CH_3 (backing). If we did not argue, the arguments and counter arguments would not be formed (rebuttal).

The argument of S4: isopentane and neopentane are chain isomers (claim).  and  (data). The molecular formulas are same but structural formulas are different (warrant). CH_3-$CH(CH_3)$-CH_2-$CH_3$and (CH_3)-$C(CH_3)_2$-CH_3(backing). If we did not argue, the arguments and counter arguments would not be formed (rebuttal).

Students' Process Evaluation

Observation notes were coded, then categories were constructed, and then frequencies-percentages were calculated for codes. The results could be seen in Table 2.

Table 2. Students‟ process evaluation

Categories	Codes	f - %
Learning outputs	Meaningful learning	12 - 86% S1,2,3,4,5,6,8,9,10,12,13,14
	Different learning environments	6 - 43% S1,2,3,5,6,13
Behavioral outputs	Enjoyable learning	7 - 58% S1,2,3,4,6,11,13
	Being motivated	5 - 36% S1,3,7,11,14
Critical thinking outputs	Criticizing own and others‟ thinking strategies	6 - 43% S1,4,9,10,11,12
	Being creative	5 - 36% S1,3,7,11,14
		total 14 - 100%

The codes would be considered by the three science educators if only the percentages of the codes would be over 34%. It can be seen in Table 2 that students‟ evaluation was about meaningful learning (86%), different learning environments (43%), enjoyable learning (58%), being motivated (36%), criticizing own and others‟ thinking strategies (43%) and being creative (36%).

Examples from the students‟ observation notes were given below for strengthening the findings.
S11: ……. Throughout the argumentation process, criticizing others‟ thinking strategies made the lesson meaningful (criticizing own and others‟ thinking strategies code).
S14: ……. Student constructed arguments stated our creativity (being creative code).

Conclusion

This study examined the effect of argumentation-based organic chemistry teaching on high school students‟ argument construction skills so on their meaningful learning and critical thinking skills. It was found that argumentation making students criticize their own and others thinking strategies resulted in scientifically correct and qualified arguments, which showed they understood the submicroscopic nature of organic chemistry. According to Cambridge International Thinking Skills Syllabus‟ (2020-2022) targets, constructing a scientifically valid argument showed that students‟ critical thinking skills were also improved.

On the other hand, group discussions may have caused students to think much more deeply about the submicroscopic nature of concepts they faced and look at them with a more critical eye (Çelik & Kılıç, 2014; Çelik & Kılıç, 2017). Moreover, besides learning content, it is necessary to educate the students regarding how we know (Driver, Leach, Millar & Scott, 1996; Millar & Osborne, 1998, cf. Osborne, Erduran & Simon, 2004). More specifically, the construction of an argument, and its critical evaluation is a core discursive science activity especially making students enhance their mental images about concepts (Osborne, Erduran & Simon, 2004, p. 995).

It is necessary to create social context to support dialogic discourse (Osborne, Erduran & Simon, 2004). In this study, a constructivist social context was constructed for students - they were able to access interactive board, organic chemistry presentations, organic chemistry simulations, questions about organic chemistry, Ministry of National Education‟s 12th grade online chemistry book, and also each other and teacher because only in constructivist classrooms, students can be viewed as thinkers with emerging theories about the world (Grennon-Brooks & Brooks, 1999, p. 17). After arguing in a dialogic discourse, the students constructed their own arguments individually based on Toulmin‟s argument pattern components which gave them a chance to judge a claim based on data, warrant, backing, and rebuttals to make them understand the submicroscopic concepts much more appropriately by criticizing and critical thinking.

Students" process evaluation uncovered that argumentation made students criticize their own and others thinking strategies and learn meaningfully. Tümay and Köseoğlu (2011, pp. 105-106) explained the same case in their research as "Once the students are educated in argumentation-based classes, they are able to construct the chemical concepts properly in their minds, to think about daily life problems by inquiring alternative explanations, and to make plausible decisions by criticizing claims and warrants that came through an argumentation process".

Students" process evaluation also underlined that argumentation-based organic chemistry education made students joyful, motivated, creative, criticizer, and meaningful learners with the help of a differently constructed learning environment.

Recommendations

There was a gap in the literature about argumentation-based organic chemistry teaching to high school students for meaningful learning and for making them become critical thinkers via enhancing their argument construction skills (Eyceyurt-Türk, Tüysüz & Tüzün, 2018). For this reason, in this study it was investigated the impact of argumentation-based organic chemistry teaching on high school students" argument construction skills which meant by properly constructed arguments meaningful learning and criticizing could be done too, so this study exemplified a detailed educational application process not only about argumentation for making high school students criticize the submicroscopic nature of chemistry in organic chemistry education but also argumentation, argument construction, and critical thinking for further studies. Deliberative discussions are typically only included in 2% of all high school science classes (Lemke, 1990; Wells, 1990; cf., Osborne, Erduran & Simon, 2004). The way to increase this rate is to convince teachers that argumentation is an important component in science teaching (Osborne, Erduran & Simon, 2004). This study"s detailed description may help this purpose too.

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