

# An Enrichment Workshop using Argumentation-Based Forensic Chemistry Activities to Improve the Critical Thinking of Gifted Students

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**ABSTRACT** This research aims to evaluate a workshop using argumentation-based forensic chemistry activities to enhance gifted students' critical thinking. A workshop program, consisting of seven argumentation-based forensic chemistry activities, was conducted with 20 students at a gifted school in Turkey. A qualitative experimental design was used. An experiment or drawing activity was first carried out. Following this step, the gifted students reconstructed the activity as an argument after an extensive group discussion. The data collected in the student-constructed arguments and evaluation were analyzed for content. The study's findings show that argumentation-based forensic chemistry activities contributed positively to these gifted students' critical thinking development.

**Keywords** Enrichment workshop, Forensic chemistry education, Argumentation, Critical thinking, Gifted students

## 1. INTRODUCTION

There always have different individuals within the community who have different learning speeds and inspire dazzling products by producing innovative ideas. The primary purpose of gifted education is to identify, develop, and support these individuals' special features (Subotnik, Olszewski-Kubilius, & Worrell, 2011). Renzulli (2012) emphasized two essential characteristics of effective gifted education. First, "the approaches should exhibit a logical relationship between the theory-guided services provided to students and the concept of giftedness that serves as a rationale for the development of that theory." For example, an accelerated theory that suggests the utilization of advanced mathematics lessons should relate to an upper-cognitive understanding of mathematics aimed at students with high abilities. Second, and in particular concerning the enrichment-based theory, "services should be provided for both advanced cognitive development and what are referred to below to as 'intelligence outside the normal curve'" (pp. 150-151). This situation's emergence has been conceived as a guideline for integrating and applying gifted young students to special teaching programs to improve their intelligence levels in the last 30 years.

According to acceleration-based and enrichment-based theories, different programming options for the gifted were searched in the literature. For example, Ng and Nicholas

(2010) conducted a case study regarding the exploration of the nature of interactions in an online learning environment. The investigation sample includes a group of high-ability 14-year-old students who participated in an extended learning project online as an extracurricular activity for approximately six months. The study results indicated that the students interacted differently online depending on the task at hand, and seven of them finished the final task of creating a learning product as A. In another example, Yoon (2009) investigated the effects of self-regulated learning on scientific inquiry performance in a sample of scientifically gifted middle school students. The participants were involved with educating after-school enrichment programs and responded to the self-report. The findings showed that open inquiry learning influenced the use of self-regulatory strategies. Vural (2010) conducted a study based on the learning cycle model as the enrichment for gifted students' education. In the research, gifted students' mental models and pre and post-misconceptions were analyzed. At the end of the study, it was found that the scientifically correct knowledge was constructed instead of gifted students' scientifically incorrect pre-knowledge after the learning cycle model-based

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enrichment. Just as in the previous example, materials based on the standard knowledge construction model were utilized to enrich the education of the gifted that resulted in gifted students' use of the scientific knowledge for daily life (Demircioglu & Vural, 2016). As the last example of the enrichment for gifted education, Cakir's study (2011) could be presented in which materials based on the predict-observe-explain model were applied. At the end of the research, it was determined that gifted students could make proper choices. After backing their decisions with observations, they could form better mental models, resulting in better knowledge construction.

In addition to these studies, it is emphasized in the literature that studies on gifted students should be at a higher level (Ziegler, Stoeger, & Vialle, 2012). The gifted education literature describes several skills in which gifted students perform at higher levels than similar students in the same class or school. These advanced skill differences manifest themselves in various school curriculum levels, particularly in mathematics and reading, in education. This differentiation must extend to the teaching of critical thinking skills as part of the core curriculum. Because developing critical thinking skills is the 21st century main goal for all students (Kettler, 2014).

By being aware of the lack of critical thinking education programs for the gifted, argumentation can be offered as programming options for enhancing gifted students' critical thinking skills (Tuzun, Eyceyurt-Turk, Harmanci, & Ertem, 2017). Critical thinking means making plausible decisions (Freeley & Steinberg, 2005). In other words, critical thinking implies an argumentation process consisted of constructing an argument, presenting evidence and backings to this argument, or building up counter-arguments (Joung, 2003). In contrast, argumentation means coordination of evidence and theory to support or refute a conclusion (Osborne, Erduran, & Simon, 2004). Individuals make decisions about their lives, such as career planning, friendship preferences, and where they will live. Their choices to be well and responsible citizens are based on their ability to think critically. Critical thinking allows them to reduce their argument to their parts to assess their relative validity and strength. Critical thinkers are better informants, as well as better advocates (Freeley & Steinberg, 2005). Hence, critical argumentation is a practical skill that should be developed through the integration into actual or realistic daily life examples of arguments not just for gifted individuals but also for all students from the very beginning of their education levels. Critical argumentation is not only a skill, but it is also related to an attitude within a decision-making process or a solution to a problem. However, they are most often used in both sides' logical thinking processes and balanced issues (Walton, 2006). In terms of a logical, sequential rational argument, Bowell and Kemp (2005) stated that it is necessary to define the controversial subject and determine

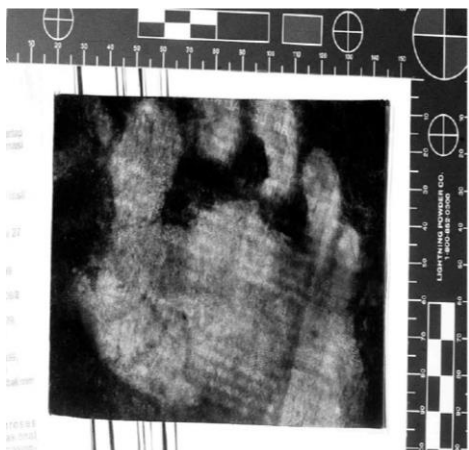
whether the other side of the subject's speaker is trying to persuade. Then, the argument needs to be restructured, and the debate is evaluated at the final stage to determine what is right and what is wrong.

In the literature, Nussbaum and Edwards (2011) explored the concepts of critical questions and argument stratagems as an approach for teaching argumentation and critical thinking. For six months, the study was conducted in social classes, in which 30 seventh-grade students discussed and wrote about current events. Participants were divided into two groups; experimental and control. The study's findings showed that the experimental group made more arguments combining both sides of each topic over time. The experiment group collectively created critical questions, mostly about weight values and the design of practical, creative solutions. West (1994) conducted a study to investigate at a university for determining the effects of argumentation on critical thinking skills. During the implementation, a micro-unit in argumentation theory was tested to impact critical thinking through a quasi-experimental design. The investigation findings showed that there were statistically significant results for both speech core treatment on the 'interpretation of data' subtest and general education public speaking students on the 'argument' subtest. Another research was examined the impact of a unit that integrates the explicit teaching of general reasoning patterns into the teaching of specific science content. It mainly investigated the teaching of argumentation skills in the context of dilemmas in human genetics to seventh-ninth grade students. Experimental group participants' mean was significantly higher than the other group participants for testing of genetic knowledge. There was also an increase in the quality of students' argumentation.

Moreover, students in the experimental group could transfer the reasoning skills taught in genetic to the context of dilemmas given from daily life (Zohar & Nemet, 2002). Kabataş-Memiş and Çakan-Akkaş (2020) researched the efficiency of the argumentation-based inquiry on the critical thinking skills of fifth-grade students. A semi-experimental design was used. Moreover, argumentation-based inquiry activities were utilized for the experimental group. It was seen that argumentation-based inquiry courses made experimental group students' critical skills improved. In another study, Think-Read-Group-Share-Reflect (TRGSR) scientific argumentation strategy was used for determining the efficiency of the Toulmin argument pattern (TAP) on high school students' critical thinking. A semi-experimental design was deployed. The participants were 50 twelfth grade students. The courses in the experimental group were with TAP within TRGSR. Watson-Glaser critical thinking appraisal Form-S was administered as a pre and post-test to both groups for determining critical thinking. Covariance findings showed a significant difference between the groups' critical thinking

after nine weeks (Giri & Paily, 2020). However, in the literature, fewer studies were exploring critical argumentation for the education of the gifted. A study investigating the effect of thought experiments-based argumentation for enhancing critical thinking skills on the education of the gifted suggested the thought experiment - argumentation - critical thinking triangulation as a programming option - enrichment for alignment with the gifted students' acceleration. In the study, single-subject research was used, and interventions were utilized based on single-subject research's theory. At the end of the study, it was found that thought experiment - argumentation - critical thinking triangulation was an effective programming option - enrichment for alignment with the gifted students' acceleration (Tuzun, Eyceyurt-Turk, Harmanci, & Ertem, 2017).

Enrichment offers gifted students a deeper interaction with a particular subject than they could do in a regular class to align with their acceleration, their more rapid cognitive processing (Subotnik, Olszewski-Kubilius, & Worrell, 2011). For example, specific forensic chemistry activities could be constructed as a subject since the gifted students do not encounter such a subject in their regular classes. There is only research about forensic chemistry activities for the gifted in the literature (Tuysuz & Tuzun, 2019). The determined subject 'forensic chemistry' is the chemistry that conducts the chemical analysis for proof to be used in the legal system (Gercek, 2012). Moreover, the development of the sensitivity and selectivity for detection of analytical methods in recent years has made progress in the forensic analysis for various evidence, including narcotics and explosives, and material conveyed to the victim or crime scene (Almirall, 2005). An example of the forensic analysis from the literature could be seen in Figure 1. Forensic chemistry education is needed since the students choose it as a career (Gercek, 2012). Thus, training programs should provide better-prepared graduates and future leaders in the forensic chemistry profession (Almirall, 2005).



**Figure 1** The footprint in the aluminum dust (Royds, Lewis & Taylor, 2005, p. 267)

This research aims to evaluate the programming options (enrichment) for the workshop of gifted students. Forensic chemistry activities based on argumentation were applied for improving gifted students' critical thinking. In light of the preceding, the research's importance is to fill the literature gap about specific forensic chemistry education enrichment studies on gifted education. The main question (problem) of the research was determined as "How could the gifted students' critical thinking skills be improved by the programming options, the enriched workshop based on argumentation activities on the topic of forensic chemistry?"

## 2. METHOD

### 2.1. Research design

The current investigation was employed case study methodology as a type of qualitative research. The cases of interest in education are the people and the programs. The researchers are interested in both of them for their uniqueness and commonality. They seek to understand the factors and variables that impact them. They would like to hear their stories and their feelings, emotions, and affective states (Stake, 1995). For this research, the case of interest for a more in-depth understanding is the enrichments - programming options - for the gifted education.

### 2.2. Sample of the Study

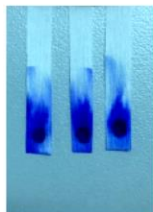
Being different from the quantitative methods, qualitative methods it was enough to work with a smaller participant number since the qualitative findings would provide much more knowledge in depth (Yildirim & Simsek, 2008). Thus, this research was conducted on 20 gifted students at a school for gifted in Turkey in the 2017-2018 academic year. Furthermore, there was no need to generalize the findings to a population in qualitative methods (Yildirim & Simsek, 2008). Programming options for the workshop for gifted students were the focus of this research. The sample selection method was a purposive sample. According to the purposive sample's criteria, the sample's students had to be intended as gifted, educated at a science and art center, and willing. The gifted students' age average was nine. 13 of the participants were female, and the others were male.

### 2.3. Research Instruments

Firstly, as being the research instrument, the worksheets were used. Argumentation focused forensic chemistry activities teaching guide worksheets for the alignment with gifted students' acceleration and improving their critical thinking were constructed.

The teaching guide consisted of seven forensic chemistry activities that made students construct their arguments, according to Walton (2006) argument pattern components after arguing the experiment/drawing part of the activity. Walton's (2006) argument pattern components were a conclusion (a constructive claim) based on three premises (warrants of the conclusion). Two different

## THE MYSTERY AT THE NOTE



**Target:** Making forensic chemistry applications

**Learning strategy:** Argumentation

**Materials:** Two different blue colour pens, alcohol solution, adsorbent layers, beaker, stick, ruler, scissors, sticker

**Doing the experiment:** Suppose you found a note written by a blue colour pen at a crime scene. You had two suspects and you found two different blue colour pens at their homes. Find whose pen was used for writing the note. Use chromatography.

**After doing and arguing the experiment:**

Your conclusion:

.....

.....

Premise:

.....

.....

**Figure 2** An example from the worksheets

science educators checked the content validity of the teaching guide. An example from the teaching guide's worksheets could be seen in Figure 2.

Secondly, participant observation notes were employed as research instruments. In other words, the whole process' evaluation was made by using gifted students' observation notes. The same two science educators checked the observation notes' content validity. The instruments' reliability was checked by two independent science educators' coding and categorizing consistency, which was determined as 95 percentages. The correlation to the formula was given as

The coding/categorizing consistency percentage = (parallel codes / all codes) x100.

The independent researchers reached a consensus when there was incompatible coding and categorizing them by redefining codes and categorizes them for these pieces of knowledge.

Data triangulation, investigator triangulation, theory triangulation, methodological triangulation, and environmental triangulation were offered in the literature (Guion, Diehl, & McDonald, 2002). In this research, to establish the study's validity, data triangulation was made using two different data collecting tools, and investigator triangulation was done using two different researchers in the analysis process.

## 2.4. Procedure

Before the workshop, forensic chemistry, argumentation, argument, and critical thinking were introduced to the gifted students. During the workshop, firstly, the experiment/drawing part of the activity was conducted, and then the gifted students reconstructed the

activity as an argument according to Walton's (2006) argument pattern components (conclusion, premise, premise, premise) after extensive group discussions. After carrying out the workshop, the gifted students evaluated the whole process.

## 2.5. Data Analysis

The content analysis was utilized for the collected data. The codes and categories were constructed, and then frequencies and percentages were calculated. The cross-content analysis was utilized for data reliability to ascertain that each of the codes was under a category (Erickson, 2004). Thus, there would be no codes that eluded observation during categorizing. In other words, each code belonged to a category. The content analysis would be beneficial to denote how gifted students' critical thinking was measured. Based on Cambridge Assessment International Education, the gifted students were thought to improve their critical thinking skills if they could construct scientifically correct arguments while reconstructing an activity as an argument. Also, the arguments must contain Walton's (2006) argument pattern components. On the other hand, the students' argument construction skills were evaluated as sufficient if only their scientifically accurate constructed and all Walton argument pattern components consisted arguments percentages were higher than %33 of all the participants for each of the forensic chemistry experiments/drawings.

## 3. RESULT AND DISCUSSION

After utilizing the content analysis to gathered data, the results accessed were given in two subtitles: students'

**Table 1** Student constructed arguments' analysis\*

Forensic chemistry experiments/ drawings	f - %									
	PP	PPP	PPPP	PPPPP	CP	CPP	CPPP	CPP PP	CPP PPP	Total
1.Taking fingerprint	1	2	1	1	1	2	7	2	3	20
	%	%	%	%	%	%	%	%	%	%
	5	10	5	5	5	10	35	10	15	100
2.Isolation of DNA					3	4	8	5		20
					%	%	%	%		%
					15	20	40	25		100
3.Taking footprint and calculation of height from footprint		1			4	6	7	1	1	20
		%			%	%	%	%	%	%
		5			20	30	35	5	5	100
4.Taking teeth print					1	1	16	1	1	20
					%	%	%	%	%	%
					5	5	80	5	5	100
5.The mystery at the note					2	6	12			20
					%	%	%			%
					10	30	60			100
6.Forensic chemistry paintings						1	15	3	1	20
						%	%	%	%	%
						5	75	15	5	100
7.Soil analysis					2	4	14			20
					%	%	%			%
					10	20	70			100

\*In Table 1, conclusion was shown by C, premise by P, frequency by f, and percentage by (%).

argument constructing skills and students' process evaluation.

### 3.1. Students' Argument Construction Skills

Students constructed arguments for each of the seven forensic chemistry experiments/drawings of the workshop. The indicators to measure the ability to argue were first scientifically correct constructed arguments and second Walton (2006) argument patterns consisted of arguments. Therefore, student-constructed arguments were analyzed if only they were scientifically correct constructed. Students' scientifically accurate constructed arguments were then coded according to Walton's (2006) argument pattern components, and then categories were formed. In the end, frequencies and percentages were computed for each of the categories. The cross-content analysis was utilized, too. The participant constructed arguments' codes, categories, frequencies, and percentages could be seen in Table 1. In Table 1, the conclusion was shown by C, premise by P, frequency by f, and the percentage by (%). For example, a 'PP' category means a scientifically valid constructed argument consisting of the Walton argument pattern premise and premise components as codes without a conclusion component code. A 'CPPP' category means a scientifically valid constructed argument consisted of all Walton argument pattern components, conclusion, premise, premise, premise as codes. Another example could be the 'CPPPPP' category, which means a scientifically correct constructed argument consisted of all Walton argument pattern

components, with an extra two premises components as codes.

As seen in Table 1, students' scientifically accurate constructed arguments total frequencies for each of the forensic chemistry experiments/drawings were equal to the total number of participants. Students' scientifically correct constructed arguments consisting of all Walton (2006) argument pattern components were 60% for the first experiment, 65% for the second experiment, 45% for the third experiment, 90% for the fourth experiment, 60% for the fifth experiment, 95% for the sixth drawing, and 70% for the last experiment. The total percentages of conclusion-premise-premise-premise 'CPPP' category, conclusion-premise-premise-premise-premise 'CPPPPP' category, and conclusion-premise-premise-premise-premise-premise 'CPPPPP' category were taken as categories consisting of all Walton argument pattern components for each of the forensic chemistry experiments/drawings.

The students' argument construction skills were evaluated as sufficient by the two science educators if only their scientifically correct constructed and all Walton argument pattern components consisted arguments percentages were higher than 33% of all the participants for each of the forensic chemistry experiments/drawings. In other words, the students' ability to argue was thought enough if only they constructed scientifically valid arguments based on Walton's (2006) argument pattern components. It could be seen in Table 1 that all the percentages are over 33% for each of the forensic

**Table 2** Students' process evaluation

Categories	Codes	f - %
Learning outputs	Learning new information	20 - 100%
	Enjoyable learning	7 - 35%
	Learning through experiment	8 - 40%
	Learning through drawing	3 - 15%
Critical thinking outputs	Criticizing their own thinking strategies	11 - 55%
	Criticizing others' thinking strategies	11 - 55%
Total	Total	20 - 100%

chemistry experiments/drawings; therefore, it could be stated that students' argument construction skills were sufficient, so their critical thinking skills were too. In other words, the gifted students' argument construction ability was enhanced since students' percentages were increased throughout the argument construction processes. According to literature, it could be stated that scientifically accurate argument construction means being able to think critically (Cambridge Assessment International Education, 2017). Thus, it could be said that the gifted students' argument construction skills were sufficient and that this contributed positively to their critical thinking skills.

To strengthen these qualitative findings, student-constructed arguments from the teaching guide's worksheets were given below. G showed 'Gifted student'. As seen in Figure 3, (1) *Taking fingerprint: Take your fingerprint by using a graphite pen, a sheet of white paper, adhesive tape. Compare your fingerprints with your peers. (Students' fingerprints were used by only themselves according to ethics.)*

The argument constructed by G7 (G for gifted): We took our fingerprints by using graphite (conclusion). We can take fingerprints by using iodine (premise). We can take fingerprints by using silver nitrate, too (premise). If one's finger was bloody, then we could take fingerprint by spraying luminol (premise). As seen in Figure 4, (2) *Isolation of DNA: Isolate your DNA from your saliva by using saturated salty water solution, detergent, and alcohol and examine the macroscopic shape of your DNA. (Only the teacher's bio-matrix was used because of ethics.)*

The argument constructed by G3: We isolated DNA from saliva by using saturated saline water solution, detergent, and alcohol (conclusion). One could isolate DNA from hair also (premise). One could also isolate DNA from blood (premise). We can find relations with the help of DNA (premise). As seen in Figure 5, *Take the footprint and calculation of height from the footprint. Moreover, take your teacher's footprint by using starch and a glass-sheet. Calculate your teacher's height by using her footprint. You can also calculate her average-weight by using her footprint too.*

The argument constructed by G11: We took footprint by using starch (conclusion). We can calculate the adult's height from her footprint length. (24.5 centimeters / the adult's height) x 100 = 15) (premise). We can compute the adult's average weight from her footprint. (After calculating the adult's height from her footprint length, the average weight would be on the minus five - plus five scales of the

adult's height's last two numbers.) (premise). We can analyze the footprint by ultraviolet radiation, too (premise). As seen in Figure 6, (4) *Taking teeth print: Take your teeth to print using a plaque made from a candle and use a heater and forceps. Heat the plaque by using forceps; fold it at the shape of a horseshoe by using forceps. And then bite it but be sure the plaque is not so hot for your mouth's safety. Wash your mouth with water after biting the*



(1) *Taking fingerprint; Take your fingerprint by using a graphite pen, a sheet of white paper, adhesive tape. Compare your fingerprints with your peers. (Students' fingerprints were used by only themselves according to ethics.)*

**Figure 3** A fingerprint (bbc.com)



(2) *Isolation of DNA: Isolate your DNA from your saliva by using saturated salty water solution, detergent, and alcohol and examine the macroscopic shape of your DNA. (Only teacher's bio-matrix was used because of ethics.)*

**Figure 4** Isolated DNA(Photo taken through workshop)



(3) *Take the footprint and calculation of height from the footprint Take your teacher's footprint by using starch and a glass-sheet. Calculate your teacher's height by using her footprint. You can also calculate her average-weight by using her footprint too.*

**Figure 5** A footprint (Photo taken through workshop)

plaque. Compare your print with your peers'. (Students' teeth prints were used by only themselves according to ethics.)

The argument constructed by G8: We took teeth print by using candle plaque (conclusion). We calculated age with the help of teeth print. (As an example, if the candle plaque contained a lack of two/three teeth prints and the other existing ones were under average size, it would back up that the teeth print was eight/nine years old.) (premise). Teeth print could be made observable by using carbon paper (too). (Two sheets of carbon papers standing back to back must be put in the two layers of white paper then the paper must be bitten.) (premise). Footprint could be taken from the feet (by using warm candle plaque. It could give hints the person's weight with the pressure made.) (premise). As seen in Figure 7, (5) *The mystery at the note: Suppose you found a note written with a blue color pen at a crime scene. Also, suppose you had two suspects, and you found two different blue color pens at their homes. Find whose pen was used for writing the note. Use chromatography.*

The argument constructed by G1: We found which of the pens was used for writing the note by using chromatography (conclusion). We used adsorbent layers and alcohol solution (premise). The link found at the representative crime scene and one of the typical pens' ink walked simultaneously, and the other pen's ink walked much more rapidly on the adsorbent layer (premise). We could do the same experiment by using paper-towel as the adsorbent layer and water as adsorbent (premise). As seen in Figure 8, (6) *Forensic chemistry paintings: Draw a painting about forensic chemistry. Compare your drawing with your peers'.*

The argument constructed by G14: I drew a forensic chemistry painting (conclusion). I drew luminol's chemical structure (premise). I drew DNA's chemical structure (premise). I drew my handprint (premise). Hence, I made science and art integration (premise). (The painting could be seen in Figure 9.)

The argument constructed by G19: We drew forensic chemistry paintings (conclusion). I drew DNA's chemical structure (premise). I drew luminol's chemical structure (premise). I drew graphite is one layer's structure (premise). (The painting could be seen in Figure 10.). (7) *Soil analysis: Suppose you found soil at the crime scene. Find where the soil came from. Consider alkali concentration for representative soil samples, which means pH would be specific for soils from different regions.*

The argument constructed by G19: We analyzed the representative soil samples by determining their pH (conclusion). Thus, the representative crime scene's soil and the representative soil samples obtained from the suspects could be compared (premise). Because pH is specific for soil from different regions (premise). And there are other instrumental techniques for advanced soil analysis (premise).

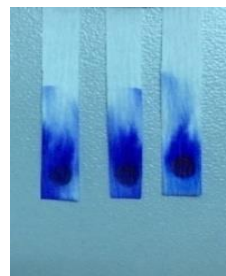
### 3.2. Students' Process Evaluation

Participant observation notes were used as a research instrument in this section. There were not any questions



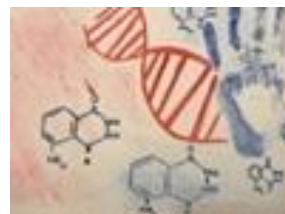
(4) *Taking teeth print: Take your teeth print by using a plaque made from candle, also use heater and forceps. Heat the plaque by using forceps; fold it at the shape of a horseshoe by using forceps. And then bite it but be sure the plaque is not so hot for your mouth's safety. Wash your mouth with water after biting the plaque. Compare your print with your peers'. (Students' teeth prints were used by only themselves according to ethics.)*

**Figure 6** Teeth print (Photo taken through workshop)



(5) *The mystery at the note: Suppose you found a note written by a blue color pen at a crime scene. Also suppose you had two suspects and you found two different blue color pens at their homes. Find whose pen was used for writing the note. Use chromatography.*

**Figure 7** Chromatograms (Photo taken through workshop)

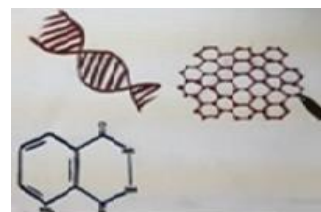


(6) *Forensic chemistry paintings: Draw a painting about forensic chemistry. Compare your drawing with your peers'.*

**Figure 8** A painting (Photo taken through workshop)



**Figure 9** A forensic chemistry painting (by G14)



**Figure 10** A forensic chemistry painting (by G19)

asked to participants; instead, they took some notes evaluating the process as learning and critical thinking outputs. Data gathered from students' observation notes for the whole process evaluation was coded and categorized. Then frequencies and percentages were calculated. The cross-content analysis was utilized too. Codes, categories, frequencies, and percentages for students' process evaluation could be seen in Table 2. In Table 2, the frequency was shown by *f* and percentage by %.

The two science educators considered the percentages if only the percentages were over 33% of all the participants. It could be seen in Table 2 that students' process evaluation was about new information learning (100%), enjoyable learning (35%), learning through experiment (40%), criticizing their thinking strategies (55%), and criticizing others' thinking strategies (55%).

To strengthen these qualitative findings, students' process evaluation from the students' observation notes were given below:

G1: ... *I took my fingerprint. We took teeth prints. Then, we solved the mystery at the note. I analyzed the saliva and soil. I calculated the person's height from her footprint ... (learning new information code).*

G3: ... *I took my fingerprint. I solved the mystery at the note. I analyzed the saliva. I took a footprint. I analyzed soil. All was so amusing ... (learning new information code, enjoyable learning code).*

G9: ... *We did so many experiments about forensic chemistry. All was so amusing. I liked forensic chemistry so much (enjoyable learning code). We took footprint. We took fingerprint (learning new information code). Everybody's thinking differed from each other (criticizing others' thinking strategies code). My thought became different through the experiments (learning through experiment code, criticizing my own thinking strategies code).*

G20: ... *I did experiments (and got the information). If I could use advanced instrumental analysis techniques, I could get much more information (learning new information code, criticizing my own thinking strategies code)*

### 3.3 Discussion

The main goal of gifted education is to help gifted students develop their talents. Gifted researchers and educators have designed specific services (e.g., programs, interventions, curricula) based on the gifted learners' characteristics to effectively address their learning needs (Jen, Moon, & Samarapungavan 2015). In this research, firstly, it could be said that gifted students' critical thinking skills improved by making them construct forensic chemistry activities as arguments during the workshop. According to the literature, scientifically proper constructed arguments based on an argument pattern could improve students' critical thinking skills (Cambridge Assessment International Education, 2017). As a reason for this improvement, gifted students encountered a differentiated-enriched learning environment that they have never encountered before. This result may have led

them to increase their interest and to think more deeply about the situations they face. Moreover, the exchange of views in the process might have contributed to their ideas regarding the situations they face. Like this research's findings, the literature offers accelerated and enriched programming options for gifted education (Stott & Hobden, 2016). In other words, carefully planned acceleration offers educational benefits to high-ability learners (Dare & Nowicki, 2015). It was also suggested to look for ways to further the sequence of critical thinking skills in specific learning domains (Kettler, 2014). Hence, in this research, specific programming options were studied to further gifted students' critical thinking strategies in a particular argumentation-based forensic chemistry learning domain with the awareness of the gifted students' acceleration. There is only one research about forensic chemistry activities for the gifted (Tuysuz & Tuzun, 2019). This research illustrated an argumentation-based forensic chemistry activities application in detail for workshop enrichments for the gifted education. Thus, it was thought that this study might contribute to the gap in the literature about specific enrichment studies. Moreover, the teachers of the gifted could conduct a similar application process in their workshops.

Secondly, the students evaluating the process showed that the process made them able to learn new information and made them able to criticize their own and others' thinking strategies. Kaya and Kilic (2008) said that students educating in argumentation-based lessons could learn the scientific concepts in detail, and through criticizing their own and others' thinking strategies, they could also know the nature of science and how science works. Another study from the literature underlined the importance of small-group discussions for high-ability students (Jen, Gentry, & Moon, 2017). A microanalysis of student initiations in gifted classes and their effect on the emergence of dialogic discourse showed that student initiations trigger teacher responses and student responses that often lead to additional student initiations. All these options give rise to a more balanced classroom setting, in which both teacher and student create meaning, amounting to dialogic discourse as defined by Lotman (cf., Netz, 2014). In this research, students' evaluation of the usefulness of criticizing their own and others' thinking strategies justifies the previous research.

In the literature, forensic chemistry applications were not so familiar. Hence, the education of forensic chemistry applications, in other words, the teaching of chemical analysis of evidence was crucial for gifted students and all students for training future leaders in the forensic chemistry profession (Almirall, 2005; Gercek, 2012). This research's application process, its forensic chemistry experiments, and its argument evaluation process were modeled on how to make forensic chemistry education by



a basic logic for educators who would want to make such an instruction.

The limitations of this research were theory triangulation (use of outside professionals' views) and methodological triangulation (use of different methods), and environmental triangulation (various settings), which could not be utilized. For further studies, different programming options to align with gifted students' acceleration and improve their critical thinking skills could be constructed on specific subjects based on more triangulations.

Another limitation of this research was its multidisciplinary was limited by only arts integration to forensic chemistry. Future giftedness research needs more multidisciplinary for several reasons. First, to prove the credentials of gifted education, researchers specializing in the economics of education are required. Additionally, many other sciences might be valuable allies, such as political sciences, arts, sports science, etc. Second, when we adopt an ecological or a systemic approach, a single disciplinary approach will rarely suffice (Ziegler, Stoeger, & Vialle, 2012).

As students evaluated the process, one of the gifted students said that "... I did experiments and got information. If I could use advanced instrumental analysis techniques, I could get much more information ...". The participants' age was nine in this study. It could be against the ethics of performing advanced forensic chemistry experiments with these students because, in this research, basic experiments that would not make students apprehensive were constructed. However, if the participants were gifted students from high school level or were university students, advanced crime scene scenarios and advanced instrumental analysis techniques could be used for further studies.

#### 4. CONCLUSION

The findings of the study showed that argumentation-based forensic chemistry activities contributed positively to the participants' critical thinking development as getting 60% success for the first activity, 65% for the second, 45% for the third, 90% for the fourth, 60% for the fifth, 95% for the sixth, and 70% for the last. In light of these findings, it might be stated that this study contributed to developing the argumentation structuring levels of gifted students since students' percentages were enhanced throughout the argument construction processes.

According to literature, it could be stated that scientifically accurate argument construction means being able to think critically (Cambridge Assessment International Education, 2017). Therefore, it could be said that the gifted students' argument construction skills were sufficient, and this situation contributed positively to the development of their critical thinking skills. Moreover, when the students' evaluation of the process was examined, they stated that the process made positive contributions for them, such as new information learning, enjoyable learning,

learning through experiments, criticizing their thinking strategies, and criticizing others' thinking strategies.

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