

## Popular Science Articles for Chemistry Teaching

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**Abstract:** The presented paper reviews popular science articles (these articles are published in online magazine “The Teacher”) as one of the methods of chemistry teaching. It describes which didactic principles they are in line with and how this type of articles can be used in order to kindle the interest of pupils, students and generally, the readers of other specialties, in chemistry. The articles review the main topics of inorganic/organic chemistry, biochemistry and ecological chemistry in a simple and entertaining manner. A part of the articles is about “household” chemistry. Chemical topics are related to poetry, literature, history of chemistry or simply, to fun news. The paper delineates the structure of popular science articles and the features of engaging students. It also reviews the teachers' and students' interview results about the usage of popular science articles in chemistry teaching process. The aforementioned pedagogical study revealed that the popular science articles contain useful information not only for the students of other specialties, but also for future biologists and ecologists (having chemistry as a mandatory subject at their universities). The articles are effectively used by teachers on chemistry lessons to kindle students' interest in this subject.

**Keywords:** didactic principles; popular-science article; popularization chemistry; teaching chemistry

### 1. INTRODUCTION

The knowledge of chemistry is considered necessary in the modern world, meaning that no country can develop without chemistry. Therefore, a new generation of professional chemists is required. It is also worth noting, that people with other specialties should be more or less aware of this field to easily deal with everyday chemistry.

It is essential to continuously kindle students' interest in chemistry teaching process, considering the regrettable reality that the majority of them do not take interest in this field of science, recognizing it as a difficult, boring and completely useless subject.

Chemistry teaching methods provide plenty of techniques and findings to arouse students interest for chemistry [1,2,3,]. Applying popular science articles is one of these techniques.

This paper reviews the very popular science articles on chemistry, as one of the tools of chemistry popularization and students' (and not only students) engagement in chemistry. The articles should be in line with didactic teaching principles, of course.

The popular science articles, we are going to review, are published with the authorship of Prof. K. Kupatadze in on-line magazine “The Teacher” (<http://mastsavlebeli.ge/?cat=29>) and are targeted at wide range of readers (including those, who have no connection with chemistry) and of course, at teachers and their students as well. The key purpose of these articles is to amuse readers while engaging them into reading.

The articles cover inorganic and organic chemistry, environmental chemistry, biochemistry and household chemistry.

The structure and the style are important in these types of articles. The article should be written in such a way to make the reader want to read despite his/her disinterest in chemistry.

The articles are divided into several categories. In some of them chemistry is associated with poetry and literature, in the rest of them - it is linked with the chemistry history or simply, with amusing news.

By describing each type of article, their essence will be better seen.

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## 2. Description of Articles

The title is of foremost importance when speaking about popular science articles. If the title is of chemical nature, it will only attract the readers interested in chemistry. On the contrary, the title of the article should not have any connection with chemistry, thus drawing potential readers' attention by unexpectedness. As an example, I may name the article "I Will Die without You". Judging from the title, it's difficult to guess what is the article about. It seems to be about love, doesn't it? The reader starts reading and the beginning of the article confirms that the paper is on unconscious love.

"No, I am not kidding, I will definitely die without it. First the sorrow will encompass me; I will frequently get tired and be unable to get asleep. I will slowly become pale, with rapid breathing and weakened muscles. Blood pressure will get lower and I might get cardiac arrhythmia. My immune system will weaken and if I don't take timely care of myself, you can probably guess, how I will end up. However, it may happen to you as well. No, I'm not joking, its deficiency will kill you too".

If one carefully reads the article, surely will notice that it points out all the symptoms of iron-deficiency anemia and that the article is about an element iron. After introduction, it is time to switch the conversation to the iron. "It has been known from ancient times. Egyptian priests, the chemistry followers would compare it to the Planet Mars. Iron is called Ferro in our language, the lack of which will really destroy all of us." The article continues with information on iron in chemical terms, however in a simplified language, to be equally understandable and interesting for general audience. How does iron get into human body, what is it needed for, how is it spread in the nature, etc.? [4,5]. The conclusion of the article echoes the introduction and ends with the verse by great Georgian poet - Galaktion Tabidze. The verse is jocular. The poet jests at one of the ugly buildings (in his opinion) and finally utters: "I will die without you". It's a play of words in Georgian language: "I will die without you" means, that I will be dead without you, the two words "without you" – are pronounced the same as "building", and both can be understood as I can not live without that building. So, the verse has a humorous ending.

### The Title of the Article – "What Can be Hard"

What can be meant by the word "hard"? It

might mean comma (In Georgian language, "comma" is pronounced the same as the word "hard/heavy/grave"). Yes, you are right. It can have such an importance as to change the whole meaning of the idea if skipped or put in a wrong place. What else can be hard? For instance: the life. It's a common topic of discussion... I could never understand why some people were awarded by hard life while the others enjoyed the easiest one. Furthermore, the one, being indulged with the easiest life, is no better than the one, suffering from hard life. It can be the opposite, but this is the reality and that's all – for some people, life is as easy as a water flow, while for others - it is as hard as staying dry in the rain, but can one really feel others' suffering?

Impression. Yes, it is also possible to be heavily impressed by something, or make heavy impression on others. However, the heaviness is perceived differently by various people. Terenti Graneli (a famous Georgian poet) wrote about heavy fate. Although, in the other verse he wrote that neither the fear of death was easy. Sometimes Galaktion's (Galaktion Tabidze, a well-known Georgian poet) heart was as heavy as the gates of Troy, to open for life. What else can be heavy/hard? Freight, an exam (may be the life test), a mistake...The latter may cause heavy consequences for doctors, teachers and chemists. A doctor does not have the right to play with someone's health and life. A teacher does not have the right to distort someone's spiritual world. Very often a chemist in his/her lab is entrusted with others' health and life besides his/her own. Someone will ask-whether a worker standing on a scaffold has the right of mistake. No, definitely not. Likewise, numerous professions can be listed endlessly. It turns out that each our blunder can be fatal.

However, not all the mistakes are grave. (the word "grave" is pronounced in Georgian the same as words: hard, heavy, severe, comma). For instance, if a housewife mixes sugar with salt in a cake creme, that will not be an error in a big science. Furthermore – baking a cake is not a big deal. And even more, like everything, "heavy/hard" is a conditional concept. The life, which seems hard to me, can be perceived by someone as easy; For instance, snowy weather is hard for me, while for someone it can be amusing.

Therefore, let me write about what's really hard.

Heavy metals: mercury, lead, cadmium, chromium, manganese, nickel, cobalt, vanadium, copper, iron, zinc, antimony, are considered

especially dangerous by the UN Commission". Then article continues describing vanadium [4,5].

The alchemists' topic is used as a "hook" in many of the articles [6].

**The article with the title – "Excuse me, are you a Paracelsus?"** deals with cadmium.

"Now it is warm outside... Smell of spring subtly touches my olfactory senses. Though born in winter, I am not fond of this season of the year and every time it comes, a strange feeling of sadness seizes my soul. Nor I am a worshiper of wintry Tbilisi. Cannot help agreeing with Tato (nickname of the famous Georgian poet Nikoloz Baratashvili) and admitting that in cold weather "Tbilisi is a city of melancholy and grief". Anyway, you can never judge by my appearance what grievance I am bearing, as nobody is actually interested in what you feel, the world requires you only smiling. I paused for a while...It is decided, I will take a walk in such a beautiful weather. I am going home and no reason to hurry up.

Suddenly my attention is caught by a man in front of me. He must be about 70. He is walking too. Having a habit of going fast, I am leaving him behind me in a shortest while, for I want to take him in at a glance. First, I am slightly overtaking him, then turn back and after a while start following him. He has a stocky configuration, not tall, with ruddy cheeks, broad forehead, and back combed hair. He does not even notice that he is being observed. I am burning with desire to approach him and ask:

- Excuse me, are you Paracelsus?

But I do not ask. First of all, he won't understand, second of all, he will refuse by all means, saying that I am mistaken and will start reciting all day long how he was associated with some Para... Wait a minute; let him remember... in short... with some zzel. Or may be celsus? (This is a play of words)... or to an ax (play of words). One can not understand these people...

In order to avoid any accusation or misunderstanding, I will tell you, that Paracelsus was an alchemist. This strange name was taken as a pseudonym, his real name was Philippus Aureolus Theopastus Bombastus von Hohenheim. He tried to compete with an Italian doctor, Avlus Kornelius Cels claiming to be superior to him. That's why he called himself Paracelsus, i.e. superior to Celsus. Although

being an alchemist, he used to practice in medicine as well. Or maybe on the contrary - apart from being a doctor, he also practiced in alchemy. He was searching for a philosophers' stone both for gold-making and medical purposes. That time, two major issues were of concern: life prolongation and rejuvenation. In medicine, Paracelsus believed that blood was the most important thing and he used to call it the main liquid. As for alchemy, he thought that Zink or table salt would act as an accelerator, facilitating sulfide's (which was made of mercury and sulfur powder) transformation into gold". Despite the fact that the reader might be thinking that the next paragraph of the article will deal with zinc, it continues with describing cadmium, as this is the very element, which disperses during zinc extraction from deposits and harms the environment [7].

**The title – "This Rain is So Disturbed because of Me..."** is cited from the verse by famous Georgian poet Otar Chiladze. The article itself refers to acid rains and gases dissolved in water. The introduction gives historical facts about the chemists, who discovered various gases. The second part of the article describes a chemical mechanism of the tragedy occurred on August 21, 1986 at the lake Nyos, in North-west of Cameroon, and reviews several methods of defining pH in rain water [8].

Amusing stories serve as a good "hook" as well. The author of the article "**Smog**" begins with the story how she started learning Turkish language.

"In these latter days I am attending courses in Turkish language. We've got a teacher, named Esra, a long haired and black eyed young woman. She does not know Georgian, but tries her best to learn it. The class is staffed with students; I am the eldest among them. However, it does not make me uncomfortable and I am entirely engaged in the study process. There are only two boys in the class, the rest are the girls and one shouldn't be surprised by such noise, if taken into consideration the number of girls assembled together. Esra Hoja (teacher Esra) knows a couple of Georgian words, that's why sometimes she shouts out with a warning tone: "Gogolar ("gogo" – means a girl in Georgian), this is a mix of Georgian-Turkish. A girl is pronounced in Turkish as "qiz", in plural – "qizlar", however, the word - "gogolar" is somehow different: affectionate and strict at the same time.

You can ask her anything ten times or even more, she won't get tired of explaining with the same

energy and enthusiasm. All was the same that day, when she was teaching us about clock, tirelessly drawing various versions of time on the board, asking the question: - "Saat Qach? (What time is it?)"; One of the girls joked in Georgian: - "Our Hoja is like fire". And as if someone had asked me, I immediately translated the phrase to the teacher: - "You are the woman like fire". At first she couldn't understand, and then we explained that it meant an energetic person and being like fire - was considered to be a compliment in Georgia.

By the way, after the early alchemists, the fire was first looked at by Jan Baptist van Helmond, followed by George Ernst Stahl, and finally by Lavoisier. Each of them saw something different in fire, although all of them unanimously agreed that combustion processes took place during the fire. And what if combustion process is incomplete? Yes, gases release and the very smog is formed from these gases.

Today we are going to talk about smog.

In 1661, John Evelyn described London's atmospheric air in his book "Fumifugium". He wrote about strange smoke and smog sometimes formed in London, which made it difficult to see anything and made an impression of the air full of ash after volcano eruption [8].

After reviewing smog in chemical terms, the article ends with a funny story.

"Once upon a time, a girl and a boy lived in a small borough. They fell in love with each other and met every day. Someone told the girl's father that his daughter was in love with the boy of another man. The girl's father was strict, and he got furious: -"how she could have dared!" He locked up the girl in the house and forbid her to go outside. The girl stopped eating in protest and declared that she didn't want anyone but him. On the third day of hunger, she started thinking about what her lover was doing while she was sacrificing herself and sent him a letter with the help of her sister. (There was no telephone and internet that time). The boy suggested running away from home that night once her sister unlocked the door. And they did so, but the girl's enraged father pursued them, fully armed with lots of bullets.

Esra Hoja paused here ....

- Then? What happened then?

- How should I know what happened? You have to think yourself! I told the story for I wanted to put the verbs in the past tense

and to make you get used to it. Now we are going to learn how to use verbs in the past tense.

Past tense is necessary of course; however, the story should be finalized. We can not allow the father to kill the fleeing kids through the double-barreled shotgun, can we? Look, I've got an idea...

The boy and the girl entered the town before the chasing father. There was smog everywhere in the town...So, the father could not see anything, he had never heard about fog either. Finally, he gave up and came back to his village. At our next discussion when explaining the future tense, we are going to talk about the family and the number of children the couple will have".

Through this type of articles, we refer to such fields as environmental chemistry. The articles on metals and above-mentioned acid rains serve the same purpose, using the history of chemistry and poetry as a "hook". However amusing stories are applied again when talking on silver.

The article "**Let's Take a Selfie**" reads about silver.

"Time will pass and we will say - Do you know, what time we lived in?"

It was the time, when taking at least one selfie a day was vitally important. Taking a selfie was possible everywhere, on earth and in the sky, in water and under it. One just had to point a camera directly at face, or at the shop window, or at the mirror. It was available to use mirror in any place. As for the look, conventionally, it was divided into three categories: serious or sad, smiling and with the so called "pouty lips". I liked to view the third category most, however tastes differ. One pouty photo decorated every third page of social network. No, my article is not against "Selfie". On the contrary, take it everywhere and anytime you wish. I just want to write a history of photography in a way to somehow link it to chemistry.

In 1839 Robert Cornelius took the first selfie. If translated from Greek, photography means painting with light. Such painting is possible by means of a chemical element, silver..." [6]

Another article is dedicated to silver as well, titled, "Aluminibus et Salibus.... do not disclose". The title is taken from alchemical doctrine. The alchemists had a motto not to disclose the rule of gold-making to anyone. However, this article describes chemical and

physical features of silver, and the article “Let’s Take a Selfie” refers to silver distribution in environment.

Several articles refer to water and its pollution: “**Water –the Origin of life**”; “**Once Again on Water**”; “**Kocaeli, Izmit, Nicomedia**”. The first two articles deal with water properties and its distribution, while the third one refers to water pollution and its natural treatment systems.

- “Welcome to Turkey, wish you a happy day!
- a customs officer is handing over my passport with an artificial smile, opening the entrance door of the country. – Thanks, likewise” – I am replying with the same smile.

What a happy day! - It is raining cats and dogs. I am looking for a person holding a big paper with my name on it, to drive me from Istanbul to Kocaeli. Kocaeli is near Izmit. This is old Nicomedia, located next to Constantinople (now Istanbul) with the shores flaunting in the Sea of Marmara. The city was founded in 712 B.C. and was called Astacos. After being destroyed, it was first rebuilt by King Nicodemus; Therefore, the city was named after him. Plinius Junior wrote about the landmarks of Nicodemia in his letters, commenting how great it would be to install water pipes and lay the channel between the inner lakes and the gulf of Nicomedia.

So, if we drive along this Gulf, we will get to Kocaeli. It takes half an hour to drive there from Izmit, and about an hour and a half - from Istanbul.

Kocaeli inhabitants are proud of having potable water running directly from taps. Drinking water is taken from the Mount of Chenesuyu (Çenesuyu), famous for its quality and purity. They take pride in the whole network of natural treatment systems and take special care of the cleanliness of water.

Today I am going to talk about water for the third time, however, now, our discussion will refer to its pollution and treatment” [9].

In this style of popular science articles, almost all important didactic principles are followed. Most of the emphasis is made on the principle of comprehensibility and the principle of interdisciplinary links. That is why it's fun and easy to read. In addition to chemistry, readers get information from other fields as well.

### 3. RESULTS AND DISCUSSION

The questionnaire on popular science articles were elaborated for students and secondary school teachers (Table 1-6).

600 students were interviewed, either first year students (students of introductory courses), not having chosen chemistry as a specialty, or the students with the specialty of a biologist and an ecologist, for whom chemistry was a compulsory subject. Introductory course is lectured at Ilia State University during the first year and this subject is taught rather generally. These students are expected to choose the specialty on the second course and it is more likely that they will never study chemistry as a subject. However, they will always have to do with chemistry in their lives and therefore introductory courses are specifically planned in a way to clearly demonstrate this connection with chemistry.

100 secondary school teachers were from different public or private schools. The questionnaire provided the following questions for chemistry teachers and students (tables 1-6).

**Table 1.** Anonymous inquiry questions and answers: Question #1

How often do you read popular-science articles?	Students	Teachers
Always	35%	70%
Very often	20%	10%
Often	30%	10%
Rarely	10%	10%
Never	5%	-
Other	-	-

**Table 2.** Anonymous inquiry questions and answers: Question #2.

If you do, why?	Students	Teachers
It is readable	35%	40%
Interesting information about chemistry is conveyed simply	15%	50%
it contains other interesting information besides chemistry	20%	5%
In the learning process, I just enjoy reading it	30%	5%
Other	-	-

**Table 3.** Anonymous inquiry questions and answers: Question #3.

If you don't do, why?	Students	Teachers
I am not interested in articles of this type	2%	----
I am not interested in any form of chemistry	2%	----
It is written uninterestingly	3%	----
It is boring	2%	----
It is written unclearly	1%	----
Other	5% (cannot find time for it)	10% (cannot find time for it)

The interview showed that the majority of teachers and students often read popular-science articles. They read because it is interesting and chemical information is conveyed simply and clearly. It is also significant that except chemistry, it provides other valued information too. However, the interview revealed those students as well, who don't read such articles, naming the lack of time as an excuse. But the smallest part of them considers such articles to be unexciting. The majority of students believe that

reading such articles will be very useful for students of other specialties, as many articles refer to environmental and the so called "household chemistry".

**Table 4.** Anonymous inquiry questions and answers: Question #4.

Will it be useful for the student of other specialty to read such articles	Students (Question only for students)
Very useful	80%
Useful	10%
Most useless	10%
Useless	--
It does not provide any information	--
Other	--

**Table 5.** Anonymous inquiry questions and answers: Question #5.

Which field is more important to link with chemistry in articles like this to make them interesting?	Students	Teachers
Poetry	5%	10%
Literature	5%	5%
Art	1%	--
History	19%	70%
Amusing stories	70%	5%
Other	--	--

**Table 6.** Anonymous inquiry questions and answers: Question #6.

Will it be useful for a student (school students) to read such an article	Students	Teachers
Very useful	60%	10%
Useful	10%	10%
Most useless	5%	--
Useless	5%	--
Does not provide any information	----	--
Other	20% (Household chemistry, Environmental chemistry)	80% will help them in learning the chemistry

Most of the teachers believe that such articles will be interesting for school students and will help them in learning the chemistry.

The majority of students consider that chemistry should be related to amusing stories in this type of articles. Teachers prefer to connect chemistry with history and poetry.

#### 4. CONCLUSION

The use of popular science articles in teaching

can be linked with the following didactic principles such as:

**Pedagogical creativity** - to present any chemical subject matters in an original and interesting way;

**Cognitive principle** – each article gives the reader information in several directions;

**The principle of connecting the theory to practice** – to review each discussed topic with repeat to practice;

**The principle of new knowledge** – let the reader be motivated to seek new knowledge.

**The principle of interdisciplinary links** - linking the subject of discussion to other sciences – history, literature, etc.

**Principle of comprehensibility** - the material should be conveyed in a scientific language simply and clearly at the same time.

**Principles of using examples**-The material should be enriched with live, amusing examples and experiments; such an approach raises students' motivation in learning process (for instance, conducting chemical experiments which are humorously described almost in every article).

**Principle of transfer of knowledge**-The information should be linked with everyday life;

Articles on environmental chemistry enable the future generation (the citizens and decision-makers of tomorrow) to get at least ecologically educated and be aware of the importance of ecological safety, if not being chemists.

The articles related to biochemical issues allow students to easily understand chemical processes ongoing in their body.

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