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Use of Art Media in Engineering and Scientific Education

Topic: Art, Science and Technology

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http://www.wcjs.org/cv/groys/groys.html

References:

[1] Alec Groysman, "*Corrosion for Everybody*", Springer, Dordrecht, 2010, 368 p.

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Abstract:

Background: *How many engineers and scientists like art? How many engineers are interested in science and its achievements? Why there is no progress in art, but there is progress in engineering and science? What is the relationship between art and engineering, art and science? How can engineers and scientists use art in their inspiration and creativity? Thus we should explain what art media, engineering and scientific education are. In spite of differences in terms "technology, engineering and industry" we will use one of them "technology" or "engineering". Engineering is the "third culture" in addition to the "two cultures" art and science. There is mutual influence between these "three cultures". What is the general meeting point in them? We speak about interdisciplinary, humanistic and artistic thinking of engineers and scientists.*

Aim: *To show how art media can help in engineering and scientific education. The philosophy of our work is establishing of interrelationships between the "three cultures", studying new inspirations and creativity in engineering, searching and determining common aspects and differences in the "three cultures" in order to show the young generation of engineers, scientists and educators how learning, education and our very existence may be interesting, fascinating, creative, productive, exciting, attractive, rich, and as a result **beautiful**.*

Methodology: *The examples of use of different arts (music, painting, literature, poetry, sculpture) in curricula of materials science, thermodynamics, and corrosion of metals are shown. Analogies, interrelations, metaphors, common aspects and differences between art and engineering disciplines are used in engineering and scientific education for the third and fourth year students.*

Results: *Students and young engineers and scientists who received explanations of engineering and scientific disciplines in comparison with humanistic aspects showed more creativity and satisfaction in their job and life. They have another approach to apprehending of engineering and scientific disciplines and very existence which is now seems **beautiful**.*

Conclusions: *Humanistic aspects should be more and more included in engineering and scientific education, namely we can talk about "beautifying" engineering and scientific learning and education of students and educators using art media results in attractiveness of engineering and scientific disciplines, their "beauty", inspirations and creativity of young generation of engineers and scientists.*

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Abstract

Background: How many engineers and scientists like art? How many engineers are interested in science and its achievements? Why there is no progress in art, but there is progress in engineering and science? What is the relationship between art and engineering, art and science? How can engineers and scientists use art in their inspiration and creativity? Thus we should explain what art media, engineering and scientific education are. In spite of differences in terms "technology, engineering and industry" we will use one of them "technology" or "engineering". Engineering is the "third culture" in addition to the "two cultures" art and science. There is mutual influence between these "three cultures". What is the general meeting point in them? We speak about interdisciplinary, humanistic and artistic thinking of engineers and scientists.
Aim: To show how art media can help in engineering and scientific education. The philosophy of our work is establishing of interrelationships between the "three cultures", studying new inspirations and creativity in engineering, searching and determining common aspects and differences in the "three cultures" in order to show the young generation of engineers, scientists and educators how learning, education and our very existence may be interesting, fascinating, creative, productive, efficient, exciting, attractive, rich, and as a result beautiful.
Methodology: The examples of use of different arts (music, painting, literature, poetry, sculpture) in curricula of materials science, thermodynamics, and corrosion of metals are shown. Analogies, interrelations, metaphors, common aspects and differences between art and engineering disciplines are used in engineering and scientific education for students, young engineers and scientists.
Results: Students and young engineers and scientists who received explanations of engineering and scientific disciplines in comparison with humanistic aspects showed more creativity and satisfaction in their job and life. They have another approach to apprehending of engineering and scientific disciplines and very existence which is now seems beautiful.
Conclusions: Humanistic aspects should be more and more included in engineering and scientific education, namely we can talk about "beautifying" engineering and scientific learning and education of students and educators using art media results in attractiveness of engineering and scientific disciplines, their "beauty", inspirations and creativity of young generation of engineers and scientists. Our experience is summarized in the book "*Corrosion for Everybody*" published by Springer.

Keywords: *Art, Science, Technology, Engineering Education, Scientific Education*

1. Overture, or Prologue

"*History is a race between education and catastrophe*"
Herbert George Wells (1866-1944), the English writer, "The Father of Science Fiction"

What do we live for? Here may be different answers. We suggest universal reply on this question – *searching of beauty* in every step of our existence, beings, that is also in *teaching*, *learning*, and *education*. What is the place of *art*, *science*, and *technology* in modern society, in modern culture, in our beings? What are the aims and main functions of *art*, *science* and *technology*? There is no discussion that future of our world depends on *education* of all groups of people, especially young generation of students, engineers, and scientists. Scientific – technological revolution was favourite term of the second part of the 20th century. Progress in science in the Ancient Greece in 6-4 BC resulted in differentiation between *art* and *science* [1]. The same situation took place with *science* and *technology* in the 18-20th centuries. They were separated because of progress in both fields. There was no progress in art [2], and it moved away else from science and technology. We can mention that in the Middle Ages students learned the seven *liberal arts*: the Latin and Greek *grammar*, *rhetoric*, *logic*, *arithmetic*, *geometry*, *astronomy*, and *music*. Even in that time, a person who showed that they knew the arts well enough became a Master of Arts, M.A. Students could choose to study either law, medicine, philosophy, or theology. Those who taught this type of education were known as *doctor of philosophy (Ph. D)*. Today some universities still offer the same degrees as the ones in the Middle Ages.
The British physicist and philosopher Charles Snow differentiated "*two cultures*", *art* and *science*, and we mark out *technology* (*engineering)* as the "*third culture*". It was suggested to use "*split culture*" instead of "two cultures" [3]. This is correct, but real situation shows that the specialization in the last two centuries lead to the splitting of one general culture into many different disciplines, while most problems are complex and require interdisciplinary approaches. What carries out the mission of such bridges for "splitting culture"? First, *computer revolution*. Second, *globalization*. Third, *stresses and loneliness of a person in the world*. Fourth, *education* on different levels. Art can help to overcome many of our problems, and in the first turn improve scientific and engineering education. The use of art-science-engineering connections appear at various levels [3]:

a. Strengthening interdisciplinary thinking in general.
b. "Beautifying" science/engineering and "technologizing/scientifyzing" art education.

All achievements of science and technology have two-Janus faces. Development of computers in the 1990s, the internet, new technologies and new materials changed drastically our world, our beings, and as a result interaction, communication, mutual relations and influences between *"three cultures*" *(art, science and technology)*, and of course, *education* consisting from *teaching* and *learning*. Today *art* is a very complicated phenomenon (field) of our beings included various combinations of traditional *art* (painting, sculpture, music, poetry, literature, theatre, cinema, and ballet), *sciences* and *technologies*. *Digital art* and *multimedia* appeared. *Computer* is the common feature, platform, where our "*cultures*" have cross-sections. Our generation is eye-witness of many scientific and technological achievements describing before only in science fiction.
There is nearly no artist, musician, sculptor, physicist, chemist, biologist, doctor,

engineer in classic term and understanding which were generally accepted even 30-40 years ago. We enter deeper and deeper into small parts. There are specialists in every small thing. On one side we deepened and know more about each thing. On other side, we lose general picture. Today there is no topic in *science* and *technology* where people of only one speciality deal with. Chemists work together with biologists, physicists and mathematicians. Each cannot work without other. With development of computers, we lose something sensual, spiritual, soul, noetic feelings, cultural, and artistic. People speak each other less and less; go to performances, museums and exhibitions less and less. People do not talk each other, but prefer correspondence. The modern world is divided into "lyrics" and "physicists"; "humanitarians" and "naturalists"; *artists, scientists and engineers*. What is the difference between artist, scientist and engineer? The difference is in objects, freedom of their work, creativity, and methods. The task of art and science is similar: "*Science and art have common roots; and they solve general problems of cognition of the universe"* (D.I. Mendeleyev). The aim of engineering is different: engineering is the process of designing and making tools and systems to exploit natural phenomena for practical human means.
There are many examples how *art* helps in understanding and comprehension of our world, work and beings of *scientists* and *engineers*, and what is important, in *scientific and engineering education*. Opposite is also correct: knowledge of science and technology helps in creativity of artists. The world is united (one). We do not speak about the role of art in life and creativity of scientists and engineers. We will discuss how art media is used in achieving purposes of better understanding of scientific and engineering disciplines, such as thermodynamics, materials science and technology, corrosion science and technology.

Thus the aim of this work is to show how art media can help in engineering and scientific education. The philosophy of our work is establishing of interrelationships between the "three cultures", studying new inspirations and creativity in scientific and engineering education, searching and determining common aspects and differences in the "three cultures" in order to show the young generation of engineers, scientists, educators and students how learning, teaching, education and our very existence may be interesting, fascinating, creative, productive, exciting, attractive, rich, noetic and as a result <u>beautiful</u>.
Our experience is summarized in the book "*Corrosion for Everybody*" published by Springer [4].

2. Science, technology, engineering, and art

"Scientists study the world as it is;
engineers create the world that has never been."
Theodore von Kármán (1881-1963), the Jewish- Hungarian-American aerospace engineer and physicist

History of human society shows that *art* was at the dawn of its existence and development. Primitive man had to show to his relatives and friends by means of pictures, motions of his body and sounds what happened during the hunt or other events. Thus the first representations in the form of pictures in caves, sounds and motion imitations of animals and his friends appeared. Pristine people were the first *artists*. *Education* in the form of *teaching* and *learning* appeared in that period. Then *technology* appeared as a requirement to survive and improve life of people. Only then people began to think how one thing worked with other, what were the causes of phenomena around him. People began research, endeavour, compare, analyze, synthesize and thus “primitive” *science* appeared. Thus we should differentiate between *technology*, *science* and *engineering*.

The Great Pyramid of Cheops predates the Parthenon by two thousand years, and the Egyptians were certainly far in advance of the Greeks in terms of their development of weighing scales, cosmetics, inks, wooden looks, candles, and many other inventions. These, however, are examples of *technology*, not *science* [5]. The same concerns *technological and engineering activity* in Rome Empire. *Technological* inventions promoted different *arts* in the ancient world and today they play probably leading role. *Technology is a practical activity*, as demonstrated by the Egyptians and Rome examples already given, which helped to facilitate life: trading, beautification, conquests and protection, writing, death rituals, etc. In short, *technology is all about making life more comfortable, while science is simply an effort to understand the world* [5]. *Scientists are driven by curiosity, rather than comfort or utility*. *Science is investigation or study of phenomena.*

Egyptians could be successful technologists without having any grasp of science. When they brewed beer, they were interested in the technological methods and results, but not why and how one material was being transformed into another [5]. Probably, the Greeks were the first real scientists, and the French mathematician, engineer and philosopher Jules Henri Poincaré (1854-1912) described this difference two thousand years later: “The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is *beautiful*. If nature were not *beautiful*, it would not be worth knowing, and if nature were not worse knowing, life would not be worth living. Of course, I do not here speak of that *beauty* that strikes the senses, the *beauty* of qualities and appearances; not that I undervalue such *beauty*, far from it, but it has nothing to do with science; I mean that profounder *beauty* which comes from the harmonious order of the parts, and which a purr intelligence can grasp”. The Greek scientists began to build scientific logics – the main scientific principle. *The scientist was like a creative artist, working not with paint or marble but with the unorganized sensations from a chaotic world* [6].

Engineering is the discipline, art and profession of acquiring and applying scientific, mathematical, economic, social, and practical knowledge to design and build structures, machines, devices, systems, materials and processes that safely realize solutions to the needs of society. The *concept of engineering* has existed since ancient times as humans devised fundamental inventions such as the pulley, lever, and wheel. Historically, the first was military engineering and then civil engineering.

The differences in scientific and engineering education exist in titles of modern disciplines: materials science and engineering, corrosion science and engineering.

We also should take into consideration different meanings and definitions of word *art*. *The Encyclopaedia Britannica* defines art as “*the use of skill and imagination in the creation of aesthetic objects, environments, or experiences that can be shared with others*” [7]. *Art* is something that stimulates the individual’s thoughts, emotions, beliefs, or ideas through senses. Generally*, art* is made with the intention of stimulating thoughts and emotions. Similar situation occurs in *engineering* and *science*.

Usually people think that *science* predates *technology* and *engineering*. Let me give two examples where technology and engineering appeared long before scientific understanding of these phenomena. The first example concerns the invention of

steam engine. Steam engine was invented in 1698 by an English military engineer Thomas Savery (1650-1715), improved by an English blacksmith Thomas Newcomen (1663-1729) in 1712 and by a Scottish mechanical engineer James Watt (1736-1819) in 1769 and worked long before the explanation by a French engineer Nicolas Léonard Sadi Carnot (1796-1832) in 1824 why and how it worked. With remarkable insight, Carnot made an abstract model of the essential features of the heat engine, and analyzed its operation with cool and faultless logic [6]. This was the work of a scientist-engineer-artist which resulted in formulation of the 2nd law of thermodynamics (the most important and probably leading law in nature!) by a German scientist Rudolf Julius Emanuel Clausius (1822-1888) and a Scottish scientist and engineer William Thomson (Kelvin) (1824-1907) in 1850s. Let me mention the phrase of an American scientist Lawrence Joseph Henderson (1878-1942) that "*Science owes more to the steam engine than the steam engine owes to Science*" (1917). Another example is the invention of the *daguerreotype process of photography* in 1839 by a French artist and physicist Louis-Jacques-Mandé-Daguerre (1787-1851) long before scientific explanation how it works. Both inventions resulted in drastic changes in our life, in science, in technology, in engineering, in industry and, of course, in art. First, many works of art about the 2nd law of thermodynamics were appeared. Second, photography became an important part of modern art and our very existence.
Some people think that many engineering and scientific disciplines are dull, especially when they are provided with mathematics. We would like to show that these disciplines are attractive if we use art media in their learning.

3. Use of art media in scientific and engineering education

"Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught."
Oscar Wilde (1854-1900), an Irish writer and poet

Art can help in understanding and remembering of different processes and phenomena studying by scientific and engineering disciplines. There were given examples of comparing of corrosion phenomena with pictures and statues of famous artists and sculptors such as Alberto Giacometti ("Tall Figure" was compared with general corrosion), Philip Guston ("Pit" was compared with pitting corrosion), Hieronymus Bosch ("The Garden of Early Delights" was compared with three periods of car's life: new car, beginning of corrosion, and destruction), and Umberto Boccioni ("Unique Forms of Continuity Space" was compared with erosion) [4]. Examples of descriptions of behavior of materials were given in literature by writers Lyman Frank Baum, Alexander Volkov, Brothers Grimm, and Hans Christian Andersen [4].
There is mutual influence of art, science and technology. Advances in science and technology (especially in computers) always influenced art. For instance, existence of computer music, computer poetry, computer painting, computer graphics, etc. *Industrial design* and *architecture* cannot exist without achievements of technology. Probably, architecture is art plus science multiplied technology and engineering. We don't mean this side of interaction.
Our aim is to show how art can be used in scientific and engineering education, show <u>beauty</u> of engineering and scientific disciplines, arouse (excite) creativity in engineers and scientists to discover, invent and compose new technologies, new decisions, new vision and explanations of the world around us.

3.1. *Beauty* as a general denominator of use of arts in scientific and engineering education

"*Everything has its beauty, but not everyone sees it*"
Confucius (551-479 BC), a Chinese thinker and philosopher

What is the general denominator in our approach? *BEAUTY*. *Beauty* belongs to philosophical aesthetic category and many its definitions exist. Many philosophers, people of art and scientists discussed what *beauty* is. There are many researches regarding *beauty* in art and science and its place in life of people. But … we did not find researches about *beauty* in engineering and industry, *beauty* of soul or character of a person. We will try to discuss what beauty in engineering is. People perceive and feel *beaut*y through their organs of sense, including intuition. *Beauty* is a quality which is impossible to measure and give a quantitative estimation. The variety of the objects of beauty has been used as an argument for beauty's subjectivity [8]. Elaine Scarry wrote manifesto for revival of *beauty* in our intellectual work, as well as our classrooms [9]. Which neuro-pshycological processes occur in the brain of people, when they say "beautiful tree, beautiful picture, beautiful sculpture or beautiful music"? We are far from deciphering of biochemical processes occurring in our organisms during *perception of beauty*.

Beauty and *symmetry* play important role in our lives. Symmetry is an important element and phenomenon in assessing *beauty*. Symmetry is considered as main bridge between art and science. Based on general concept of symmetry, beauty and harmony, it was shown that theoretical physics can be borderland between science and art [10]. This is correct for any discipline. For instance, mathematics was the basis of searching *symmetry, harmony and beauty* [11]. Then the same principles of symmetry, harmony and beauty were found in physics, chemistry, physical chemistry, and biology. Then similar things were found in corrosion science [4]. We consider *beauty* as main bridge between art, science and technology, especially in education.

Physicists and mathematicians are often motivated in their theorizing by a desire for *beauty*. There is the consensus that the laws of physics and mathematics should be elegant, simple and harmonious, and these factors often act as excellent guides for pointing physicists and mathematics towards laws that might be valid and away from those that are false [5]. *Beauty* in any context is hard to define, but we all know it when we see or hear it. The mathematicians in the Ancient Greek were probably the first who connect different principles in mathematics with aesthetic philosophical principle of *beauty*. Then physicists contributed in understanding of *beauty* of physical laws, and now chemists with elegant, harmonious and *beautiful* chemical reactions, chemical forms and structures including different smells.

We can illustrate how historical evolution of science and technology influence philosophy and art, and as a result *conception of beauty* as a philosophical category. The ancient Greece (~ 4th century BC) was famous by science of mathematics which was in the centre of its philosophical scheme [12, 13]. Art and all life in the ancient Greece was a reflection of this "mathematical philosophy". This approach is seen in any work of art (sculptures, architecture, music, theatre): proportions and harmony (symmetry, golden section, Fibonacci numbers). Accordingly, *beauty* was based on the same conceptions, namely, physical beauty of body was considered as harmony and correct (*beautiful*!) mathematical proportions. Sport in the ancient Greece was

organized on service for reaching such *beauty*. We can even say that art was on the service of such "philosophy of mathematics".
The term *beauty* was specific in every civilization. Jews did not create works of art because it was forbidden depicting people and animals. The only achievement of *beauty* in Jewish architecture was the Temple built/enlarged by Herod the Great in Jerusalem in the 1st BC: "One who has not seen Herod's Temple, has never seen a *beautiful* building" [14]. The concept of *beauty* among Jews was concentrated on morality, thinking, soul, philosophy, on spiritual state of a person.
The Middle Ages in Europe (12th-16th centuries) were marked by development of theology, and this relationships between God and human being was reflected in art and philosophy. Most work of art (painting, music, sculpture, architecture) in this period were created on Biblical motives or were devoted to God. Accordingly concept of *beauty* was shifted in the direction of God and Bible motives.
In the 16th-19th centuries natural sciences began flourishing in Europe, presentations and ideas about the world and the place of a man began changing. Accordingly philosophical thinking, art and *concept of beauty* were changed. We can see beginning of strong mutual influence and reciprocal penetration of science, art, and technology in this period.
The 20th century was marked by intensive development of science and technology, and at the end of the 20th - beginning of the 21st century our civilization came to *computerized society*. This *computer revolution* immediately influenced *art* and philosophy. In spite of these drastic changes in our beings, we did not find objective definition of *beauty* till now. Therefore our findings of use of *conception of beauty* in art, science and engineering are subjective. We searched also how *beauty* relates to *engineering* (*technology*). We revealed new realm named *art engineering* where principles of *art* penetrated into *engineering*. Here are some examples: coating of industrial structures from aesthetic point of view, use of music for productive work of employers, spreading of good smell in toilets and offices, flowers and sculptures outside and inside offices and factories. We are eyewitnesses how *beauty* enters and catches important place in engineering (technology). Elegant decision of engineering task may be beautiful, simple and harmonious, similar to mathematical and physical laws, rules and equations.
We will show how poetry is used in scientific and engineering education.

3.2. Poetry in scientific and engineering education

Poetry is probably one of the most philosophical branches of art, and *poets are obliged to supply proof as scientists*. We will give two examples of use of poetry in scientific and engineering education. When you teach *entropy* you can talk about Anglo-American poet Wystan Hugh Auden (1907-1973) who has been admired by physical laws and wrote brilliant poem "*Entropy*" which is well studied by students and perceived with great pleasure. Here is a part of this poem.

I'm not being negligent
Nor plain, messy no!
But somebody intelligent
Once made up a law:

This is not a simple verse,

It's a scholar rhyme –
Entropy in the universe
Increases all the time.

From Big Bang to Bigger Boom
One thing just we may assume:
Universe-roulette-wheel spins –
Order loses! Chaos wins!

The Canadian engineer Tom Watson created brilliant poem "*Rust's a Must*":

Mighty ships upon the oceans
Suffer from sever corrosion;
Even those that stay at dockside
Are rapidly becoming oxide.
Alas, that piling in the sea
Is mostly Fe_2O_3
And when the ocean meets the shore,
You'll find there's Fe_3O_4.
Cause when the wind is salt and gusty
Things are getting awful rusty.
We can measure it, we can test it;
We can halt it or arrest it;
We can gather it and weigh it;
We can coat it, we can spray it;
We examine and dissect it;
We cathodically protect it.
We can pick it up and drop it,
But heaven knows, we'll never stop it.
So here's to rust: Not doubt about it,
Most of us would starve without it.

Historical aspects may be beautiful and enjoyable in learning scientific and engineering discoveries.

3.3. Chemist Johann Döbereiner, poet Johann Goethe, discovery of catalysis and Russia

The German chemist Johann Wolfgang Döbereiner (1780-1849) is known through his theory of triads (as a pioneer of the periodic system for classifying elements in 1817, that is 52 years before Dmitri Mendeleyev), great teacher on chemistry, and discoverer of catalysis [15]. He was a chemical assistant, friend and protégé of famous poet Johann Wolfgang von Goethe (1749-1832) who was also a Minister of State Saxe-Weimar at the Grand Duke Karl August in Germany in that period. Döbereiner showed in 1823 that if platinum sponge is spread out on a watch-glass and a stream of hydrogen is directed on to it in such a way that it mixes with air before touching it, the gas bursts into flame at once. This discovery was developed into the Döbereiner lamp in which a jet of hydrogen, generated from zinc and sulfuric acid, is ignited by a small amount of finely divided platinum. This lamp replaced the tinder box as a means of lighting domestic lamps and candles and functioned until it was replaced by the phosphorous match. The Swedish chemist Jöns Jacob Berzelius (1779-1848), the master of chemical nomenclature, gave the name “catalysis” in 1835 to the process of acceleration of oxidation of hydrogen on the surface of platinum discovered by Döbereiner. This story is related to Russia, because Döbereiner got platinum from the Grand Duchess Maria Pavlovna from Russia. She was a daughter of the Czar Paul I and was married Karl August’s son; two of her brothers became the Czars Alexander I and Nicholas I. Deposits of platinum were discovered in Ural in 1820s. Platinum was already in demand in Western Europe for both decorative and scientific purposes. The Minister of Finance in the government of Nicholas I the Count Egor Kankrin decided to use the platinum for coinage. Neither Kankrin nor the Russian chemist Sobolevsky were satisfied with the chemical methods of manufacture of platinum in Russia. Maria Pavlovna was interested in chemistry and, through her brother Czar Nicholas I, she was well acquainted with work and problem with platinum. Similarly at Weimar, through her father-in-law Karl August, she was aware that Döbereiner had some experience in this field. Maria Pavlovna obtained some amount of platinum from Russia to help his work. Döbereiner helped in refining of Russian platinum, discovered catalysis and reported about his work to Goethe. We can only suspect that both (chemist Döbereiner and poet Goethe) discussed this, that Döbereiner read the tragedy “Faust” and the novella “Elective Affinities” written by his elder friend Goethe. The latter work of art gave impulse to new scientific field named *human chemistry*.

3.4. Human Chemistry

In *exact sciences* there are quantitative measures of estimation of each value: mass, length, force, energy. In *humanistic disciplines* (history, philosophy, psychology) as well as in *art* there are no quantitative criteria. This is similar to question *how to measure beauty, love, friendship, democracy*? If there is no quantitative estimation of some category or phenomenon, any definition becomes undefined, ambiguous and abstract. We know that in chemistry there is the function named *Gibbs energy* which defines the “*love*” between substances. Why there is no such function for estimation of love between people? Thus people tried to estimate this and *human chemistry* appeared [16, 17]. *Human chemistry* is the study of bond-forming and bond-breaking reactions between people and the structures they form. Historically, *human chemistry* appeared in 1809 with the publication of the novella “*Elective Affinities*” by Goethe, a chemical treatise on the origin of love [18]. In this stage today *human chemistry* is similar to alchemy in the middle ages, it borders with art, but further investigation on the molecular level in human brains will help to discover what happens in our organisms, and intimacy will end. Probably, such discovery will cause us to be unhappy, because mystery and wonder of love and relationships between people will be finished.

3.5. Music in scientific and engineering education

“*Life without music would be a mistake*”
Friedrich Nietzsche (1844-1900), a German philosopher

Music has always been among the leading arts, and therefore has been used for different studies. Plato (428-348 BC), the founder of Western philosophy, declared in the “*Republic*”: “*Education through music is extraordinary important because rhythm and harmony penetrate to the depths of the soul, seize and ennoble it*” [19, 20].

Children learn the alphabet "*ABC*" to the tune of "*Twinkle, Twinkle, Little Star*", and the states of the USA in the alphabetical order from a song "*Fifty Nifty United States*"; students learn some chemical reactions to the tune of "*Oh, my darling Clementine*", or the tune of "*America the Beautiful*". Thus, music can be useful in learning and remembering the basics of language, social disciplines and science.
In order to understand the role of music in scientific and engineering education, we should mention that music is the most abstract form of art, but word is a real and concrete form of expression of our thoughts. We use mostly visual and hearing perception in education. Thus, we can connect music, word and picture or writing and use them in education. Such education by means of humanistic topics turns any dull discipline in aesthetic form of scientific and engineering education. Here are some examples.

a. When you explain what happens with crude oil in distillation column during rectification, how different organic substances containing in crude oil move and boil, are separated according to their boiling temperature, and gasoline, kerosene, gasoil, fuel oil are obtained you can imagine and compare with the music composition "*Rhapsody in Blue*" (1924) by a Jewish-American composer George Gershwin (1898-1937). In other words, distillation of crude oil and moving of fuels in heat exchangers can be associated with music of George Gershwin.
b. Thermodynamic reversible processes (a quasi-static process that happens infinitely slowly) can be associated with the eternal motion, namely, with the "*Flight of the Bumblebee*" (1899-1900) by a Russian composer Nikolai Rimsky-Korsakov (1844-1908), or the "Perpetual Motion" by an American composer Edward MacDowell (1861-1908). When we are listening to these music compositions we feel that this music is eternal as well as there is no end both for it and for any thermodynamic reversible process.
c. The 2nd law of thermodynamics (the entropy of the universe tends to a maximum) is associated with the "*Bolero*" by a French composer Moris Ravel (1875-1937) or "*In the Hall of the Mountain King*" (suite "Peer Gynt") by a Norwegian composer Edvard Grieg (1843-1907) or "*Polovetzkian dances*" (opera "Prince Igor") by a Russian composer Alexander Borodin (1833-1887). The analogy is in the "expansion" of music during its development. The same occurs with the universe.

3.5.1. "Music" in Corrosion Phenomena [21]

Many corrosion phenomena are accompanied by "musical sounds and shouts" which are used in acoustic emission and electrochemical noise measurements for determining localized corrosion. Pitting corrosion is a local anodic dissolution of metallic atoms, when they, in the form of cations exit the lattice. The number of cations leaving the lattice area in a unit of time is the electric corrosion current which occurs with a definite frequency. What is a sound in music? A sound in music is a physical phenomenon and this is the spread of waves with a definite frequency. We can transform the electric corrosion current into the "language" of music waves in this way and "listen" to any destruction of passive film and pit formation. This "music" is stochastic and the waves probably are not analysed for harmony, so we can name it by "corrosion dissonance", or "corrosion dodecaphony". We can listen to such "stochastic" sounds in music compositions of the Jewish-Austrian composer Arnold Schönberg (1874–1951) and the Russian composer Alfred Schnittke (1934–1998).

When cavitation occurs in the centrifugal pumps, we listen to the specific "music of cavitation" like the flow and blows of stones. Tin is a malleable, ductile, highly crystalline silvery-white metal. When a bar of tin is bent, a strange crackling sound known as the "*tin cry*" can be heard due to the breaking of the crystals. Any cracks in metals can be "heard". Interesting analogy, comparison and association between stress corrosion cracking (SCC) and music by Alfred Schnittke can be done, and even each stage in SCC can be "described" or accompanied by some of his music compositions, for example, "*Quasi Una Sonata*".
Certainly such music examples can connect *beauty* of scientific and engineering disciplines with the harmony – disharmony of our world, namely, better understanding and remembering of scientific and engineering disciplines.

4. Humor in Scientific and Engineering Education

"The more you know humor;
The more you become demanding in fineness."
Georg Christoph Lichtenberg (1742-1799), a German scientist and satirist

Humor, smile, laughing occupy not the last place in our life and help to overcome many difficulties and misunderstandings. *Humor* is the tendency of particular cognitive experiences to provoke laughter and provide amusement. In other words, *humor* is the ability to perceive, enjoy, or express what is amusing, comical, incongruous, or absurd. The term *humor* derives from the *humoral medicine* of the ancient Greeks, which taught that the balance of fluids in human body, known as *humors* (in the Latin, *humor is body fluid*), control human health and emotion. *Humor* is very fine and clever *art* in the area of *human creativity* (art, science and engineering being the varieties). *Humor* occurs when the brain recognizes the pattern that surprises it. *Humor* in education can help take away the tension, tiredness, "sleepness", even misunderstanding, and relax. Anecdotes, jokes, jests, and quotes of famous scientists, engineers and artists may also help in understanding and accepting of the complexity and *beauty* of scientific and engineering disciplines. Here are several examples [22].

a. What is the difference between thermodynamics and stick? Stick has two ends and no one beginning. Thermodynamics has two "beginnings" (the 1st and 2nd laws) and no one end.
b. When we use several times the name of some scientist, for example, Gibbs phase rule, Gibbs function or Gibbs energy, Gibbs-Helmholtz equation, chemical potential suggested by Gibbs, we may tell about the movie "The Angel's Ash". A pupil of twelve years old in small town in Ireland was asked to write a composition about Jesus. That was in 1930s. The weather was rainy all time (Ireland's weather!), there was no job for parents, no good flat, no enough food, and many little children died in Ireland. A little pupil of 12 wrote in the composition: "Jesus lived in the South in warm country (Israel) with much sun, there were no rains, and he had not to wear shoes. If he wanted to eat he went to fig or pomegranate trees and ate much fruit. If Jesus was born and lived in Ireland, he was ill and has died in the little age, and I had not to write this composition". This is the place to joke that "because of Gibbs we should learn more and more thermodynamics".
c. The German physico-chemist Walther Hermann Nernst (1864-1941), who received the Noble Prize in 1920 "in recognition of his work in thermochemistry"

and was a founder of the 3rd law of thermodynamics, commented in 1937, that it had taken three scientists (Mayer, Joule, and Helmholtz) to formulate the 1st law of thermodynamics, two scientists (Clausius and Thomson-Kelvin) to formulate the 2nd law, but that he (Nernst) had been obliged to do the 3rd law all by himself. He added that it followed by extrapolation that there could never be the 4th law of thermodynamics [23]. This is fine joke, as in the same 1930s scientists understood the importance of the law of thermal equilibrium, and they called it the "*Zero Law*". Not the fourth one!

d. The British cosmologist Stephen Hawking said that we get pleasure from sex and science (and engineering), but from the latter much more time … You may mention to your students that cognitive process in science and engineering is the permanent discovers, and we can enjoy every new ascertain in knowledge.

5. Conclusion

"The aim of life is self-development.
To realize one's nature perfectly—that is what each of us is here for."
Oscar Wilde (1854-1900), an Irish Writer and poet

We use five organs of sense (*sight, hearing, smell, taste, and touch*) plus *intuition* in *art, science and engineering*. People use their organs of sense not in similar manner in life, especially in education. Only *sight* and *hearing* are mostly used in education. We know also that all people are different in use of these organs of sense. Is there any quantitative measure for them? No, we can use only qualitative estimation. Such situation causes trouble in use of art media in scientific and engineering education (comprising teaching and learning). Educators should show that meaning of life is *searching beauty* and enjoy by every step of education. But how to enjoy? To learn seeing *beauty* in every day life: in engineering, in science, in their teaching and learning. This depends on point of view. Use of art media in scientific and engineering education helps in this searching. Thus we can make the *scientific* and *engineering* education productive, attractive, fascinating and then to make the job of a scientist and an engineer also creative and interesting. The students which acquire *engineering education* will remember some things, but many of them will not use and forget what they were taught. But … if to teach students the same things combining with art, they will remember probably forever. This is main philosophical approach to *engineering/scientific teaching* and *engineering/scientific learning*.

6. Epilogue, or Instead the End

"I am not young enough to know everything."
Oscar Wilde (1854-1900), an Irish writer and poet

Arts and *science* are similar in that they are expressions of what it is to be human in this world. Both are driven by curiosity, discovery, searching, and the aspiration for knowledge of the world or oneself. The British physicist Brian Cox reveals in the TV series "Wonders of the Universe" on the BBC how the most fundamental scientific principles and laws explain not only the story of the universe, but the story of us all. This is art/science movement, sometimes called "*sciart*" [24]. But *technology/engineering/industry* also takes part in this convergent process of interaction. Therefore I would like to spread this and call "*sciartech*" or "*sciarteng*".

This is another step in uniting of “*three cultures*”. We should popularize art which promotes formation aesthetic and high moral (spiritual) principles mobilizing aspiration for self-knowledge and self-realization [25]. We should continue our approach of use of art media in scientific and engineering education, investigate *creativity* and where it comes from, as it is one of the last human frontiers, and one over which we have little control. In order to develop and use *creativity* and our *imagination* in teaching, learning and work we should unite “three cultures”.

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