DOI: 10.53469/jrve.2025.7(11).07

Science Communication as Knowledge Transfer Infrastructure in the Knowledge-Based Economy

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Abstract: ***This paper examines the evolution of science communication as a foundational element of the knowledge - based economy, highlighting its transformation from philosophical dialogues to structured knowledge transfer systems. Emphasizing nuclear and photonic domains, it illustrates how communication practices have mirrored societal and economic needs through historical stages such as natural philosophy, popularization of science, and science PR. The study argues that knowledge transfer represents the most advanced form of science communication, particularly under cognitive and semiotic frameworks. By mapping these changes and analyzing historical examples, the paper offers a compelling narrative of how science communication now plays a central role in national development and public engagement. This paper aims to trace science communication's historical evolution and current role of science communication as a vehicle for knowledge transfer within the Knowledge - based Economy. The article is part of an extensive scientific research focus on Risk Communication in Nuclear and Photonic Fields in the Knowledge - based Economy.***

Keywords: science communication, knowledge transfer, risk communication, cognitive architecture, knowledge - based economy

1. From Philosophical Dialogues to Science Communication

The present paper focuses on the evolution of science communication as a cognitive architecture towards knowledge transfer in the Knowledge - based Economy (KbE).

When speaking about technological and scientific terminology, one of our favorite quotations is from the Romanian philosopher of linguistics, Professor Henri Wald. In an interview with the author of this paper, it was said that words are not only the clouds of our thoughts. They are the core of thoughts! This profound observation is available for science communication. Over the years, the scientific community, journalists, scholars, and professors have used different terms for what seemed to be the same designated activity: presenting the results of the scientific research. Here is a list of the terminology used:

- **Philosophical Dialogues** [1, 2, 3] started in Ancient Greece (6th century BCE) and were used until the 17th Century. The method was used to confront theories elaborated by famous philosophers of that time with the brilliant minds of your generation of thinkers. Another goal was to generate schools of thinkers from different countries. The third goal was to become magnets for the potentates of the times: kings, high - ranking persons from the nobility, bishops, and even the Pope.
- **Natural Philosophy** (**Medieval Period to 18th Century**). It includes the study of nature, which includes what we now name chemistry, biology, physics, etc. The communication channels were, in principle, treatises issued by universities, lectures in universities, and correspondence (so much regretted these days when we use emails).
- **Educational Letters** was a dissemination of science based on correspondence. The most relevant Romanian example is illustrated by an engineer, writer, diplomat, international agent of influence (Ion Ghica), and poet (Vasile Alecsandri). They wrote together in two volumes a package of letters named ***Economic Dialogues*** [4]. These written exchanges of opinion greatly impacted the modernizing process of the Romanian United Principalities after a long Ottoman presence. The author of the present paper is a dedicated reader of Economic Dialogues from the first years at the Economic University of Bucharest until now. In 1990, we started an educational program at the national public radio corporation with the same goal: to modernize Romania after fifty years of the socialist regime.
- **Popularization of Science** (**19th and 20th Centuries)** [5, 6, 7] was completely different in the communist countries, especially in the Soviet Union, and in the capitalist countries. The Soviet Union considered the Popularization of Science a significant part of communist propaganda. The best scientists were involved in propaganda campaigns to stress that the working class from the first socialist country in the world was more creative than the researchers from the "dying" capitalist countries. Lenin was the subject of his propaganda tools. A transmission officer, Lev Theremin, and one of his secretaries, who played piano, convinced Lenin that the electronic device they used incorporated, in fact, Lenin's mind and soul energy. The musical instrument is similar to a radio receiver. The device was named the theremin, and its innovator, the transmission officer, became the icon of soviet electrification. He received permission to travel all over the Soviet Union. The next step was to travel in the USA's communities of technicians and researchers and use the instrument as a spying tool. CIA used the code name "The Thing" for the equipment invented by Leon Theremin. It was a passive listening device hidden in American offices and homes. So, the Soviet propaganda was hand in hand with the espionage and control of the domestic population. The propaganda was the beneficiary of huge budgets. It was a valuable tool for the mind control

of the population. In capitalist countries, popularizing science was more connected with economic growth and a better quality of life.

Beyond the ideological aspects, the **Popularization of Science in the 20th Century** played a crucial role in the diffusion of innovation [8]. Evert Rogers, Fritz Machlup [9], and Peter Drucker played a significant role. We shall return to these authors in the chapter dedicated to a knowledge - based economy and knowledge transfer. The popularization of science was the first stage of developing the acceptance of the wave of innovation by workers from both sides of the Atlantic. Andrew Carnegie returned from England in the second part of the 19th Century with a franchise for producing steel [10]. He knew that the American workers were open to innovations and devised new ideas to implement to increase the Pittsburgh companies' competitiveness. This behavior was available even when they knew the results of introducing new technology: losing a part of their jobs. Instead, the European workers, especially the British ones, with strong trade unions and a negative attitude towards inventions and innovation, were ready to destroy the factories and the new machinery, as they had already done. John D. Rockefeller operationalized a group of controllers known as "the men in black. " They enter the employees' houses to check how clean they are, the children go to school daily, and the adults participate in evening popularization of science conferences. The families who tick all these positions received a bonus to their salaries.

Another positive example of the popularization of science in the first part of the 20th Century was the fight against Spanish fever at the end of WW2. Thousands and thousands of people died each day at the end of WW1. Was there any treatment for the pandemic? No. The Research Institute, created and financed by the Rockefeller Family, took the responsibility at the global level to find a vaccine. The American team worked in the labs around the clock. Each version of the vaccine was multiplied and sent to Europe for experiments. John Rockefeller organized a dinner in this mansion in New York. At the approximate hour of the arrival of the ships from Europe, a vast crowd was in front of his house. The people in the street read the results from the European hospitals. The crown knew the names of the patients who accepted the experiments. Each new unhappy result represented a loss for the entire crowd. It was like a vast family generated by advanced research for the first time in human history. Rockefeller's name became synonymous with science and hope. As his contemporaries baptized Rockefeller, the TITAN sat at this table with the gathering of philanthropists and just smiled. A better popularization of science than this is difficult to envision.

- **Science outreach** [11, 12]**.** At the beginning of the 1990s, it was not enough for the young generation to listen to the scientific conferences. The students wanted to touch and participate in easy - to - understand experiments. There was a significant consequence: science and laboratories became democratic. Students and children received permits to visit significant research facilities, even some of the nuclear ones. At the same time, researchers started to set up ad - hoc labs in the street on nights of museums, nights of science, etc. As readers of our paper may observe, this communication phase is not only the beneficiary of a new denomination. It represents a new approach to the relationship between researchers and citizens.
- **Science PR** (20th and 21st Centuries). At the end of the Cold War, more or less, everybody was happy. Democracy was winning in Europe! Today, we know that it was not a correct observation. Russia was waiting for a reborn moment. And it came in 2014 with the war against Ukraine. Consequently, all European countries decided to reduce their budgets for national security. The governments were happy, and the citizens were happy, too. Why? Because larger budgets for consumers were ready to be used. It was easier for the political parties to explain to the voters what positive decisions were adopted to increase the quality of life. Less investment in the defense industry means less investment in advanced research, medicine, and quality of life. There is a smaller amount of money for scientific research. The next consequence is a stronger fight for funds dedicated to research. Each scientific facility and university started public relations campaigns to access governmental and private funds.

Eastern European researchers became competitors with their Western colleagues. The best researchers from new democratic countries received proposals to work in Western laboratories with smaller salaries than their colleagues. Western governments are carefully reducing salaries through European projects for the new entrants. In the middle of the 2000s, things started to change. All researchers in the EU are paid similar salaries for similar competence. For the first time since 1989, the EU decided to finance a large research infrastructure in Central Europe: Extreme Light Infrastructure. This investment has three pillars in three countries: Romania (with the most significant budget), the Czech Republic, and Hungary.

The decision generated a PR campaign inside each country and at the continental level. Germany supported the Czech Republic; France came with Romanian expertise in the nuclear field generated by the cooperation between Marie Curie [13] and Horia Hulubei [14]. This cooperation offered the chance to enter a new field of research: nuclear photonics. The United Kingdom remains without a seat at the table with big money (1 billion Euros). The UK decided to bring in Hungary. The PR campaign is still operational. In his book "The Prince" (1513) [15], Machiavelli shows that institutional changes often face resistance, as established systems protect the status quo. This observation works in scientific life, too.

The Science of Science Communication [15] and Knowledge Transfer [22]. Their coexistence started in the same symbolic year: 1962.

The father of Romanian nuclear research, Academician Horia Hulubei [23], said in 1970 during an interview for the Romanian Public Radio and Television that the evolution of science is so rapid that it is impossible to talk with an economically developed country without keeping the same pace in scientific research.

In 1992, Bruce V. Lewenstein published a seminal article, "The Meaning of 'Public Understanding of Science' in the United States after World War II" [17]. He said, "public appreciation of the benefits that science provides to society".

The main target groups of that period were publishers, professional organizations, science journalists, and ministries. Lewenstein mentioned that the new phase of the evolution in science began in the 1960s.

In the area of Knowledge Transfer, as the actual stage of the science of science communication, the communicators should consider what Susanne Knudsen [18] wrote in 2005 in her article *The Power of Metaphors in Scientific Discourse* is more significant and, from our point of view, is critical in the Knowledge - based Economy. Experts in science communication must develop their discourses, remembering that metaphors have economic, social, and cultural contexts. The massive flux of daily knowledge is a rules changer, more dynamic than ever. For this reason, the author considers semiotics studies essential. We need to refine our studies to capitalize on such advanced scientific research.

Why does the author of the present paper consider the year 1962 as a turning point in the economic, scientific, social, communicational, and cultural evolution? Are there enough consistent facts to support this assumption? The first sign appeared at the end of World War II when Vannevar Bush wrote a report for the president of the USA with a significant title: *Science – The Endless Frontier* [19]. He was the Tsar of Science before, during, and after the Second World War. In his office, the objectives, ways, and means for the nuclear bomb were set up. The report delivered to President Truman in July 1945 was the first such document to develop a national policy for scientific progress. In the letter of transmittal, Bush explains the key role of scientific progress in the USA's life: national security, better medical treatment, more jobs, a better standard of living, and progress in other areas.

Kennedy made his first proposal for an ambitious goal: traveling to the Moon and returning to Earth safely. The reaction was below expectations. The media, activists, and congresspersons were more preoccupied with the costs than the goal itself. It was necessary for the second discourse, on September 12, 1962, at Rice University, to generate a historic vision. Both speeches marked the beginning of the Apollo program as a national priority. In 1962, Fritz Machlup issued his book, *"The Production and Distribution of Knowledge in the United States"*. Machlup is, in fact, the creator of the concept of a knowledge - based economy. Everett M. Rogers published "*Diffusion of Innovation*" in the same year. Peter Drucker [20] initiated debates about the knowledge - based economy and knowledge work. He also raised the importance of knowledge capital. In her *Silent Spring,* Rachel Carson [21] presented a sensitive subject: **climate change**. On May 25, 1961, President Kennedy addressed a joint session of the United States Congress.

The knowledge - based economy nest feeds and develops a national economy with a different structure and a new syntax type. The economic model's two main pillars are advanced research and knowledge, and the new Raw Material. The advanced scientific laboratories created at the end of the 19th Century and reached their peak in the middle of the last Century generated rivers of discoveries and knowledge simultaneously. Was society prepared to absorb and apply this unprecedented volume of knowledge? Did the researchers, investors, professors, and decision - makers know how to mix the unprecedented offer? The researchers in communication observed that it is a chair for them on this table. The host, the nuclear field researchers, accepted communication under two conditions: to develop a new branch of activity named science communication and to study the communication risks in the nuclear field.

The evolution of the academic journal "Knowledge: Creation, Diffusion, Utilization" was crucial in formally recognizing scientific communication. Founded in 1979, this journal, with Robert F. Rich as its founding editor, aimed to unite scholars, policymakers, administrators, and corporate researchers working independently in the interconnected fields of knowledge creation, dissemination, and application. In 1994, the journal underwent a significant name change, becoming "Science Communication: Linking Theory and Practice". This renaming signifies a consolidation and a growing recognition of "science communication" as a distinct and evolving field of academic inquiry. Although the journal's initial scope was broader than an exclusive focus on science, the central themes of knowledge dissemination and utilization are essential to science communication.

This conceptual construction suggests that the relationship between scientists and public opinion reveals significant gaps in knowledge. Because of this context, offering scientific information to the general public can help develop an open dialogue with researchers. We are suggesting leaving aside the ancient philosophers (2300 years ago), the Renaissance (1300 years ago), the Enlightenment (18th Century), and the 19th Century. The middle of the 20th Century was the real moment when space goals generated a new branch in communication efforts: science communication. The entire timeline of communication in the science field is marked by visible signs that communication is a support tool, a complex and delicate toolbox for economic development. Our research is coming up with arguments that **Knowledge Transfer** is the latest version of science communication.

The first example is trivial. Scott Kelly [24], a decorated colonel of the USA Air Force, spent 340 days at the International Space Station and was commander for six months. One Friday night, one of his crew members was woken up by one and asked to repair the toilet. He was nervous and answered: "I am a colonel of the USA Air Force. " The crewmate said: "Yes, but your job description is written that you are in charge of repairing the toilet". There was a leak involving contaminated water, requiring immediate technical response! He asked the mission commander from Houston to come up with a solution. There was no time for science popularization or science understanding. It was knowledge and technology transfer. A few weeks later, similar trouble occurred during a similar Friday night. Again, knowledge and technology transfer were the solution. Then, the direction of the communication process changed, and he delivered his discoveries to the technical team from Earth. The new toilets are more resilient now.

The second example is from the Defense Industry. A few months after Russia initiated the war against Ukraine, David started to produce and use UAVs. It was a brilliant idea for the Ukrainian officers, and they received full support from the teenagers and the rest of the population. SMEs started to

produce drones at low prices. The Russian forces were surprised. The Russian industry was not ready to produce similar drones. Mr. Putin's government bought UAVs from Turkey, China, and Iran at a very high price. The managers of the SMEs did not become experts in the physics of liquids. They are only producers. The young pilots of drones did not receive high - level training in avionics as the American pilots did. They are just pilots for drones. Knowledge and technology transfer is the new stage of science communication for this level of economic development. Thirty to fifty years ago, achieving this level of professional performance was impossible.

A strong theoretical support was necessary. Both sides of the communication process were the beneficiaries of this evolution. In 1979, an academic journal, " Knowledge: Creation, Diffusion, Utilization, " was initiated. Robert F. Rich was the founding editor. In 1994, the journal became "Science Communication: Linking Theory and Practice". The new title reveals the changing point of understanding the relationship between science and society.

2. Research Methodology

We generated a timeline of science communication as a general scheme and a particular timeline for science communication. The article adopts a qualitative - historical approach, presenting timelines and real - world illustrations. While no empirical methods are used, the narrative is contextually rich and logically structured for a theoretical framework.

A clear example is the PhD topic: Risk Communication in the Nuclear and Photonic Fields. The topic became a subject in communication research and public communication when nuclear research and nuclear energy became relevant for the scientific and energy markets.

3. Conclusions

Science communication has undergone a significant transformation, aligning itself with socio - economic needs at every stage of development. From philosophical dialogues to strategic public relations, each phase reflects a shift in public understanding and economic imperatives. This paper reinforces the idea that knowledge transfer is not just a continuation but a culmination of science communication efforts, tailored for the modern knowledge - based economy. Future discourse must focus on refining semiotic strategies and fostering public engagement to sustain innovative ecosystems.

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