NECESSITY FOR MULTIDISCIPLINARITY IN A GLOBAL WORLD

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Summary

Globalization processes made the world become interdependent, which completely changed the social and economic dynamics of civilization. Hence, we can say that today we live in a VUCA world, which is an acronym for the world which is volatile, uncertain, complex and ambiguous, what can be seen in the current pandemic crisis. In attempts to deal with the challenges it brings, more and more experts incline towards the use of systemic methodologies and multidisciplinary approach. In regular science, we are used to describing the world in terms of individual phenomena, organized according to appropriate research disciplines or areas of life to which they mostly relate. Contemporary world, on the other hand, demands a shift in perspective from focusing on individual phenomena from an aspect of a certain field of science, towards focusing on connections existing between them, which mostly determine the dynamic of the world. In this paper we will discuss this shift as well as methodologies which enable it to happen.

Key words: complexity, multidisciplinarity, interdependence, systemic methodology, dialogical inquiry

1. Introduction

Science is one of two fundamental ways of organizing human experience, second being art. Science and art have the same goal: to make the human experience intelligible in order to make human beings able to adapt to their environment and survive.[1] Therefore, science is not a mere collection of certain facts, concepts and useful ideas about the world and nature and the place of human being within it. It is a process and method of attaining reliable knowledge about the world and the human being, of reaching a valid and reliable description and understanding of the world and the human being, which enables us to make valid and reliable predictions about relevant phenomena emerging in the world, and thus controlling them for the sake of human survival in the world.[2]

In the contemporary world, science encounters a huge problem, because the world today is faced with economic, environmental, social, cultural, and security challenges of unprecedented proportions. On the one hand, we are tied together in complex global networks, but on the other, human interaction within these networks is still fragmented, frequently motivated by self or local interest. In such a situation, it is getting more and more difficult to navigate through information flows that are abundant of information, but do not give us a true picture of what exactly is happening, and many people do not understand how to behave, what rules to follow, and what to expect from the future. In such an uncertain and complex situation, the question of how to go on living is acute both for the society as a whole and for each individual.

Hence, we can say that today we live in a VUCA world, which is an acronym for the world which is *volatile*, demanding our immediate reactions to unpredictable and perpetually changing conditions, which are out of our direct control, and which we must perform under growing level of *uncertainty*.[3] This is a *complex* and dynamic world with increasing interdependencies which create new, *ambiguous* conditions we have never experienced before.

1 Leslie A. White, *The Science of Culture: A Study of Man and Civilization* (New York: Grove Press Inc., 1949), p. 15.

2 Milan Ivanović, *Tri eseja o znanosti* (Osijek: Albert[E], 2008.), p. 18.

3 Oliver Mack, Anshuman Kare, "Perspectives on a VUCA world", in: Oliver Mack, Anshuman Kare, Andreas Krämer, Thomas Burgartz (eds.), *Managing in a VUCA World* (Switzerland: Springer, 2016), pp. 3–19, on pp. 5–6.

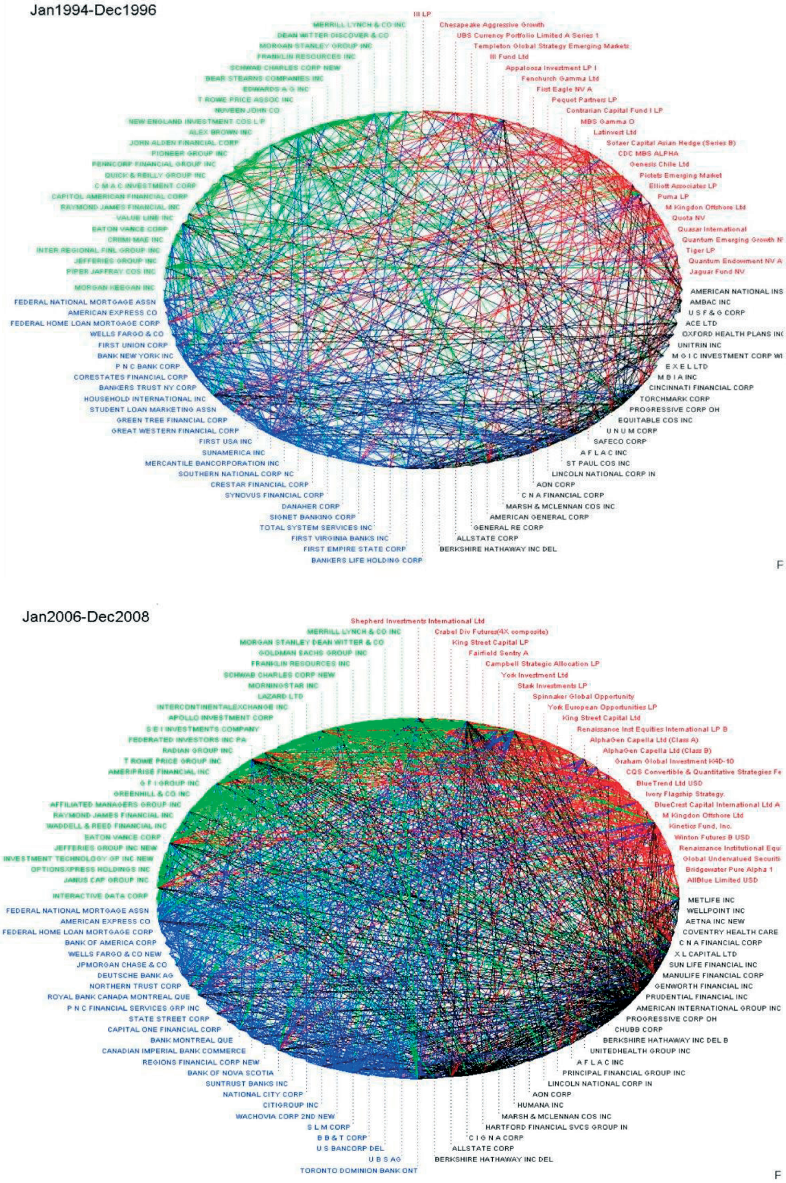
1.1. Interdependence and accelerated growth

If we examine the nature of today's world from the evolutionary perspective, trying to figure out how and why it became such a volatile, uncertain, complex and ambiguous place, we can observe two main "forces" driving the development of the world: 1) constant increase in connectivity between people, institutions, countries and regions, creating ever *growing interdependencies*, which leads to 2) acceleration in the change of the state of the world as a whole, or specific individual phenomena in the world, to the point of *exponential change*, regardless of direction (growth or decline).[4]

For example, researchers at the Ca' Foscari University of Venice investigated development of interdependencies between major world financial institutions, as well as potential systemic risk emerging from those interdependencies.[5] What they found is the existence of constant growth of the network of interdependencies between financial institutions. The upper image in the Picture 1 represents the structure of the network of interdependencies between major financial institutions recorded between January 1994 and December 1996, while the lower image represents the same network recorded 10 years later, from January 2006 until December 2008. What it shows is that the network became significantly denser in that period, making the entire financial system increasingly volatile, sensitive to perturbations in financial flows and thus prone to systemic risk—individual institutions potentially suffering loss and disintegration not as a result of its own activities, but out of systemic factors resulting from the behavior of the entire financial system.

4 Eric J. Chaisson, *Cosmic Evolution: The Rise of Complexity in Nature* (New York: Harvard University Press, 2001), pp. 16–78.

5 Monica Billio, Mila Getmansky, Andrew W. Lo, Loriana Pelizzon, *Econometric Measures of Connectedness and Systemic Risk in the Finance and Insurance Sectors* (Venice: Ca' Foscari University, 2011), pp. 1–15.



Picture 1: Network diagram of interdependencies between financial institutions created over period of 10 years (1996-2006). Type of institution is designated by color: green are broker/dealers, red are hedge funds, black are insurers, and blue are banks.[6]

6 Billio, Getmansky, Lo, Pelizzon, *Econometric Measures of Connectedness and Systemic Risk in the Finance and Insurance Sectors*, pp. 24–25.

What followed was the Global Financial Crisis 2007–2008, the greatest financial crisis since the Great Depression of 1929, which started in USA mainly due to predatory lending to low-income citizens coupled with excessive risk-taking by financial institutions and banking system.[7] Although these practices can be depicted as morally questionable, they are quite common in financial systems, where they are usually described as financial exposure—the amount an investor stands to lose in investment should the investment fail.[8] As a general rule, investors are always seeking to limit their financial exposure, which helps maximize profits, but in systems which operate under high connectivity regime, where there is a constant increase of interdependencies created between elements of the system, certain level of financial exposure which in normal circumstances would be rational, in circumstances of high connectivity becomes overexposure—previously controlled risk becomes uncontrolled.[9]

As we stated earlier, increased interdependencies between elements of a system lead to (often exponentially) accelerated change in the state of the system. In case of a certain disturbance, like a financial collapse, it tends to spread throughout the system like wildfire, both in terms of scope and severity. In the financial sector this phenomenon is called *financial contagion*, the spread of market disturbances from one country to the other presenting a potential risk, especially for countries trying to integrate their financial system with international financial markets and institutions.[10] And this is exactly what happened after the financial crisis first hit USA—in less than a year it spread all over the world, causing European debt crisis of 2009 and worldwide Great Recession.[11]

Although we described interdependency-related phenomena in financial sector, similar phenomena of interconnectedness and contagion can be observed in a wide variety of systems and contexts, such as collective emotions, fashion trends, health related behavior, personal habits, attitudes and opinions, to mention a few,[12] including risks themselves, called system-

7 Mark T. Williams, *Uncontrolled risk* (New York: McGraw Hill, 2010), p. 213.

8 James Chen, s. v. "Financial Exposure", in: *Investopedia*, September 29, 2021. Available at: https://www.investopedia.com/terms/f/financial-exposure.asp (retrieved 14th February 2022).

9 Chen, "Financial Exposure".

10 Hal S. Scott, *Interconnectedness and Contagion* (Cambridge: Committee on Capital Markets Regulation, 2012), pp. 120–137.

11 [s. n.], *World Economic Situation and Prospects 2013* (New York: United Nations, 2013), p. 200.

12 Nicholas A. Christakis, James H. Fowler, *Connected: Surprising Power of Our Social Networks and How They Shape Our Lives* (New York: Little Brown, 2009), pp. 9–12.

ic risks. For example, in 2013 the World Economic Forum issued a Global Risks report identifying 50 most threatening global risks in terms of impact and likelihood, with 529 different connections between them.[13] Therefore, it does not seem surprising that the Global Recession affected unemployment and suicide rates, decrease in institutional an interpersonal trust, and even drop in fertility rates.[14]

1.2. Processes in contemporary science

Contemporary science is also affected by globalization processes. Several features of the development of contemporary science have been identified in almost all countries of the world, including 1) high growth rates of capital investments in development of scientific research activities, 2) constant increase in the number of scientists and researchers, 3) increasing dominance of teamwork among scientists, 4) scientific research is developing according to internationally compatible publicly determined strategic direction, and 5) international scientific projects are being initiated mostly by supra-national scientific assemblies and associations.[15] Nevertheless, there are two distinctive processes happening simultaneously in the course of the development of contemporary science—differentiation (specialization) and integration of knowledge.

On the one hand, accumulation of scientific knowledge in certain scientific field results in specialization and differentiation of the field through development of new scientific disciplines which cover increasingly narrower aspects of reality. In other words, the fate of every scientist is to become dedicated to increasingly narrower field of scientific inquiry and to digest increasingly larger amount of scientific knowledge.[16] Thus, according to several scientific sources, at the end of the 20th century number of scientific disciplines passed 2 000, while several less conservative estimations indicate over 10 000 scientific disciplines existing in the world today.[17] Despite the current

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13 Lee Howell, *Global Risks 2013*, eighth edition (Cologny, Geneva: World Economic Forum, 2013), p. 6.

14 Daniel Schneider, “The Great Recession, Fertility, and Uncertainty: Evidence From the United States”, *Journal of Marriage and Family* 77/5 (2015), pp. 1144–1156.

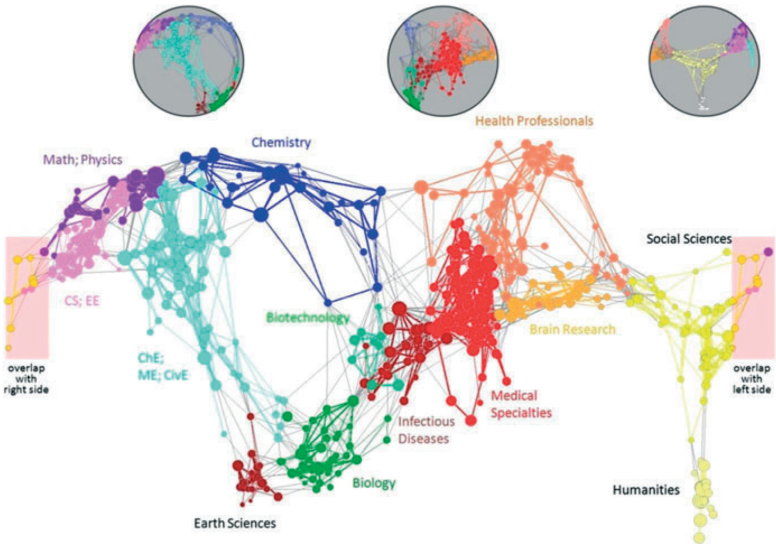
15 Ivanović, *Tri eseja o znanosti*, p. 76.

16 John Gribbin, *Almost Everyone’s Guide to Science: The Universe, Life and Everything* (London: Orion Pub Co., 1999), p. 77.

17 Ivanović, *Tri eseja o znanosti*, p. 77.

scientific success, this process of differentiation will eventually reach a point where we will not be able to talk about successful scientific analysis of the world, due to a hyper-production of scientific concepts without the actual accumulation of true knowledge which should accompany such a process.[18] In other words, process of scientific differentiation eventually leads to a point where different researchers will start developing different concepts describing the same phenomena, even in the same field of science.

Luckily, along with the process of scientific differentiation a parallel process of integration of knowledge and sciences is developing, leading to increasing number of interdisciplinary research, connection between different scientific disciplines, and creation of new knowledge. The scientific world becomes increasingly global, with over 35% of articles published in international journals being internationally collaborative (representing a rise in international collaboration by 10% since early 2000s).[19]



Picture 2: The map of science presenting interconnections between different scientific fields and disciplines[20]

[18] Damir Marinić, "Teorije dinamičkih sustava kao metateorijski okvir za istraživanja ličnosti", *Psihologijske teme* 17/1 (2008), pp. 155–183, on pp. 155–156.

[19] Council of the Royal Society, *Knowledge, Networks and Nations: Global scientific collaboration in the 21st century* (London: The Royal Society, 2011), p. 5.

[20] Richard Klavans, Kevin W. Boyack, "Toward a Consensus Map of Science", *Journal of American Society for Information Science and Technology* 60/3 (2009), pp. 455–476, on p. 466.

In order to investigate connectivity between different contemporary scientific fields and disciplines, American scientists Richard Klavans and Kevin Boyack in 2009 analyzed scientific articles from 16 000 worldwide scientific journals with the aim of mapping-out scientific fields and disciplines and their interconnections (Picture 2), which resulted in a model showing significant interconnections between 554 scientific discipline.[21] Nevertheless, the interconnections in this model are represented by cross-referencing and journal/article citations, not by actual collaboration between scientists, or actual interdisciplinary or multidisciplinary research. As we will show in the second part of this paper, there are certain challenges often preventing interdisciplinary collaboration from happening.

Still, abiding to the same systemic laws we explained at the beginning of this paper, existing interconnectedness between scientific fields and researchers creates acceleration in knowledge production or growth of human knowledge, usually expressed as periods of doubling—the amount of time needed for the entire previous amount of knowledge to double. The term *knowledge doubling curve* was coined by system theoretician Richard Buckminster Fuller in his 1981 book *Critical Path*, in which he stated that until 1900 human knowledge doubled approximately every century and by the end of World War II knowledge was doubling every 25 years.[22] Since then several authors provided different, more or less conservative calculations for the knowledge growth rate, some stating that by the time Internet of Things comes to life, human knowledge will double every 12 hours.[23]

Probably the most comprehensive and exact approach to the problem of determining the knowledge growth rate was provided by English scientific blogger Thomas Fuller, who used Compound Annual Growth Rate (CAGR), a composite metric of several growth indicators, such as number of patents, number of publications, peer-reviewed journals, published books, number of graduate and post-graduate students, which are then combined with economic growth rates and GDP structure. The question was whether human knowledge doubles every 5 years, and analysis showed that among 25 fastest growing fields of knowledge, only 10 of them have knowledge doubling

21 Klavans, Boyack, "Towards a Consensus Map of Science", pp. 472–474.

22 Richard Buckminster Fuller, *Critical Path* (New York: St. Martin's Press, 1981), p. 349.

23 David R. Schilling, "Knowledge Doubling Every 12 Months, Soon to be Every 12 Hours", *IndustryTap into news* (2013). Available at: https://www.industrytap.com/knowledge-doubling-every-12-months-soon-to-be-every-12-hours/3950 (retrieved February 14th 2022).

rates less than 5 years, with fastest growing rates in fields of nanotechnology, ICT, stem-cell research, global warming and epidemiology (Table 1).[24] These fields of knowledge also receive greatest funding, due to their public and business importance, the higher certain field of knowledge is on the list of public or business priorities, greater is the funding, and shorter is the knowledge doubling period (for top priorities it is less than 2 years).

Table 1: Speed of knowledge doubling in the world[25]

Field of knowledge	CAGR (%)	Doubling (years)
Nanotechnology patents	44,91	1,87
Nanotechnology journals	42,03	1,98
Global warming patents	38,62	2,12
Prions patents	33,76	2,38
Programming patents	33,53	2,4
Stem Cells patents	26,47	2,95
Prions journals	25,57	3,04
Global warming journals	24,71	3,14
Epidemiology patents	17,37	4,33
Stem Cells journals	16,63	4,51
Programming journals	12,55	5,86
Alzheimers Disease patents	11,26	6,5
Oncology patents	10,02	7,26
Alzheimers Disease journals	9,65	7,52
Oncology journals	9,23	7,85
DeSolla Price estimate (world literature)	7	10,24
Epidemiology journals	6,22	11,49
Mars journals	5,78	12,34
Shale oil journals	5,53	12,88
US patent grants	5,21	13,65
University enrollment worldwide	4,85	14,64
US patent applications	3,88	18,21
U.S. Book publishing	3,65	19,33
Shale oil patents	2,58	27,21
Abt publications in astrophysics since 1970	4,01	17,67

24 Thomas Fuller, *Does Human Knowledge Double Every 5 Years?* (2007). Available at: https://newsfan.typepad.co.uk/does_human_knowledge_doub/ (retrieved February 14th 2022).

25 Fuller, *Does Human Knowledge Double Every 5 Years?*.

Although different types of knowledge have different rates of growth but it is generally accepted that human knowledge is increasing exponentially at an extraordinary rate. Arguably we may have reached a point where relevant knowledge is increasing faster and in greater quantities than we can absorb especially within a certain field of knowledge. Moreover, while knowledge is increasing, its useful lifespan is decreasing, prompting scientists to constantly replace outdated knowledge with new. This puts a demand on scientific community to organize accordingly a continuous process of such "digesting" of knowledge in a more systematic way, which might be more challenging than it seems, as we will show in the next section of the paper.

2. Leaning towards systems science approach

To summarize the above, on the one hand, the world with its growing complexity and volatility keeps pressuring humanity with emerging crises and similar phenomena. At the same time, on the other hand, scientific knowledge of the world also becomes increasingly complex, bringing scientific community to a place where, challenged by complex world phenomena, it starts recognizing the need for re-orientation of scientific focus towards more comprehensive scientific worldview and methodology.

In attempts to deal with these challenges, more and more experts incline toward use of systems methodologies and multidisciplinary approach, because the goal of systems science is to reveal and define systemic laws which operate in the world and which emerge from the dynamics of complex phenomena—systems—and to apply them in approach to solving scientific and practical phenomena. In other words, the fundamental rationale of systems science approach is that in every aspect of human activity exist phenomena which can be described as systems ruled by specific systemic laws, which enable us to understand the nature of phenomena, its function and behavior.[26] In that sense, systems science approach is inherently multidisciplinary.

Besides that, in science we are used to describing the world in terms of individual phenomena organized according to appropriate research disciplines or areas of life which they mostly relate to. Contemporary world, on

[26] Dušan Radošević, *Osnove teorije sustava* (Zagreb: Matica Hrvatska, 2001), p. 1.

the other hand, demands a shift in perspective from focusing on individual phenomena from an aspect of a certain field of science, towards focusing on connections existing between observed phenomena, which mostly determine the dynamic of today's world.[27]

2.1. Cybernetics of science and necessity for multidisciplinarity

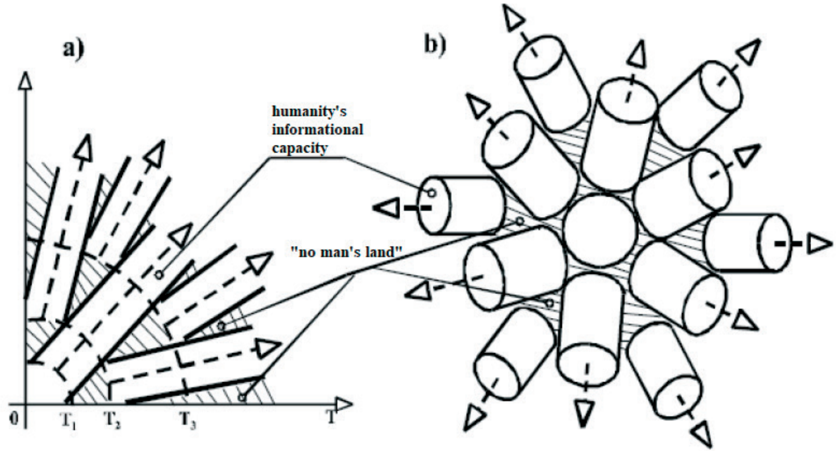
Probably the most comprehensive description of the development of both pre-scientific and scientific knowledge, which at the same time clearly shows that at certain point in its development science will have to become integrated in a certain way, and that the optimal place for that integration (at least from the current perspective) lies in systems science, comes from the 'father' of the branch of systems science, cybernetics, Norbert Wiener. In the introduction to his book *Cybernetics or Control and Communication in the Animal and the Machine* he described that cybernetics originated from his experiences of scientific meetings on MIT, which he was a part of.[28] Those meetings were a kind of scientific colloquia, where each participant could put his ideas and scientific results to test, in a dialogical but scientifically rigorous atmosphere. Although the meetings were almost ideal environment for discovery and development of new scientific insights and approaches, unexpected insights started to emerge that between traditional scientific disciplines, especially at the borderline between disciplines, exist 'uncharted fields' of knowledge which cannot be investigated using traditional scientific approach and methodology of either of bordering scientific disciplines. Wiener called those areas 'no man's land' and considered them to be the most fruitful areas for the future development of science.[29]

We can explain this idea in the context of scientific development and development of multidisciplinarity using a simple diagram (Picture 3):

[27] Donella H. Meadows, *Thinking in Systems: A Primer* (White River Junction: Chelsea Green Publishing, 2008), p. 13.

[28] Norbert Wiener, *Cybernetics or Control and Communication in the Animal and the Machine* (Cambridge: MIT Press, 1962), p. 1.

[29] Wiener, *Cybernetics or Control and Communication in the Animal and the Machine*, p. 4.



Picture 3: The process of science development[30]

In the diagram 3a (diagram 3b is only a 3D representation of diagram 3a) the time of scientific development of humanity is placed on X-axis, while the area between X-axis and Y-axis represents the amount of knowledge which humanity had in certain historical period (T_1, T_2, T_3, etc).

If we take point 0 in the diagram as the beginning of scientific development of humanity, e.g. discovery of written language, we can say that until the point T_1 in the history of humanity the entire knowledge of humanity could fit in the informational capacity of a single human brain. We know from history that this period is a period of *l'uomo universale*, gifted individuals which were universalists in a scientific sense, successful in nearly every scientific discipline or expertise. Those individuals did not only use existing knowledge, but started creating new knowledge, which over a certain period of time became too large for individual human's informational capacity. This led to the creation of new scientific disciplines and specialization (differentiation) in science, since individuals could now manipulate only with a limited amount of knowledge they were mostly attracted to or felt could improve in the future (period between T_1 and T_2).

However, specialization of science in the period between T_1 and T_2 created areas of human knowledge which existing sciences could not cover in their approach to reality— 'no man's land' (delineated areas in the diagram)—which turn into new scientific disciplines only after they accumu-

30 Radošević, *Osnove teorije sustava*, p. 278.

late enough newly discovered knowledge by which it can be clearly differentiated from existing scientific disciplines, but which can also be coherent enough to come under the umbrella of a new scientific discipline. In the observed period it happens at point T_2 (in the point T_1 this area is still too small to create a new scientific discipline) and this process continues (point T_3 and onward) until today, and will keep on continuing until the entire knowledge potential of humanity becomes discovered and absorbed.

2.2. Challenges to scientific integration

As we previously stated, the challenge placed before the scientific community in this process is that over time these periods will become shorter while scientific disciplines, as well as 'no man's lands', will become more diversified and complex. Nevertheless, problems of humanity stemming from 'no man's lands' have to be solved, regardless of the fact that these fields of knowledge are not sufficiently developed for scientists to truly understand these phenomena. In other words, these problems cannot wait for 'no man's lands' to ripen enough to become established as new scientific fields or disciplines, and this is especially so in today's global world, as we explained at the beginning of this paper. These problems can be solved only through collaboration and communication at least between scientists coming from the bordering disciplines of 'no man's lands'.

But, as we learned from previous attempts to come to such collaboration, the road towards it is paved with many challenges. These challenges are, first of all, organizational challenges because it is very unlikely that these scientific collaborations would happen spontaneously, since scientific community, like any other organization, finds it difficult to accept innovations. In this sense, we can highlight the common challenges faced by organizations in the process of growth and development, which were summarized in a pictorial way by organizational expert Peter Senge in his book *Fifth Discipline: Principles and Practice of Learning Organization*, and show how they might be applied in the context of scientific collaboration:

- *"Full cup of tea"* is a metaphor taken from the famous Zen koan. It indicates the attitude of an individual who believes that he has acquired all the necessary knowledge and skills during his life so far, which is the attitude we can often see in longtime scientists. As long as an individual embraces such an attitude, he is not ready to collaborate, because the necessary prerequisite for collaboration is the awareness that we do not have the answers to all questions, and that innovation of scientific perspective can come only through collaboration, both within the same field of science and between sciences.

- *Focusing on events* implies the habit of 'linear' thinking, where reality is viewed from the aspect of individual events, not the whole, like it is considered in systemic thinking. It is often seen in attempts to fix certain problem or to implement a certain reform, where those involved in the process become fixed only to the problem they are trying to resolve, without taking the wider context in which the problem is happening into consideration. For example, educational system often responds to individual challenges as separate phenomena, such as bullying, poor grades, or high absences from school, with specific seemingly appropriate interventions—anti-bullying programs, additional classes for students with poor grades, or pedagogical measures for those who are skipping school often—without considering the common, deeper root cause of these problems (e.g. lack of emotional culture in school). This is especially problematic in today's world in which practically all societal problems are systemic in nature, and thus interconnected—if you attempt to fix one problem, you could end up having additional problems emerging, which you did not even take into picture.
- *"The enemy is out there"* represents a widespread phenomenon of attributing responsibility for a particular situation (as well as possible change) to external circumstances or 'force majeure', due to the inability to systematically think and reflect. For example, scientists are often not able to see their role in addressing societal problems of today's world, or to start certain initiatives, because they "don't see a point in doing so", because there is lack of financial or political support, lack of interest in making such initiatives, etc. What scientists need to realize is that every change starts locally, from implementing it in their own immediate environment. They might not be able to change certain state policies which are preventing them to act in a certain way on a more global scale and they certainly cannot be held responsible for it—only for implementing change in their immediate environment (with that respect Centre for Interdisciplinary Research of the Faculty of Humanities and Social Sciences in Osijek is a nice example of good practice).

- *"My position – it is me"* represents the common occurrence that a person's position in an organization determines the perspective from which he or she perceives and interprets organizational challenges. In the realm of scientific work, it reflects inability of certain scientist to adopt perspectives from other scientific fields, because he became immersed in his own scientific perspective to the extent that he is unable to view his own perspective as one of many other (equally legitimate) perspectives. The reason why it happens is because every scientific discipline in the course of its development develops its own point of view, approach to research problems, and its own scientific terminology, which every apprentice to a certain scientific field adopts in the course of his education. Although this scientific specialization undoubtedly has its good points, it causes communication barriers not only between scientists and non-scientists, but also between scientists belonging to different fields of science.

From this we can see that the actual first and foremost challenge we are facing in attempts facilitating integration and multidisciplinarity in science is to start educating future experts in that direction, so that they adopt the appropriate frame of values, principles and skills necessary for knowledge transfer and adoption of systemic outlook on reality which is appropriate to conditions of today's society and state of the world. Without this, it is not possible to raise a generation of scientists and experts who are able to adequately cope with extremely complex and dynamic challenges, such as the coronavirus pandemic, which in the future may only be more difficult and more comprehensive. In simpler terms, the reason why problems we are facing today seem so complex and unsolvable is that we were not properly educated to solve them.

3. Conclusion

Although the goal of this paper—to demonstrate the necessity for multidisciplinarity in today's global world—would have been accomplished even without this conclusion, we felt the need to, at least to a small extent, try to provide possible solutions which could facilitate interdisciplinarity and multidisciplinarity in science.

First of all, in order to facilitate communication and mutual understanding between representatives of different scientific fields, we need to *adopt a common paradigmatic frame of reference*, which would give us a mutual ground, language and concepts. Cyberneticians claimed that such a common, universal scientific language could be found in mathematics.[31] Unfortunately, this never happened, nor was such a universal language ever found.[32] However, language of systems theories might serve that exact purpose; as we stated earlier, concept of system is universal, applicable to any phenomena which can be described in terms of its content, structure and function, and which abides by the same systemic laws.[33] For example, atom can be seen as a system, but so can a molecule, cell, tissue, organ, organism, society, universe, etc.

Secondly, once there is a common scientific language, it is important to facilitate free flow of knowledge and adoption of different scientific perspectives through *development of group (collective) intelligence*, or what is sometimes called *shared* or *interconnected thinking*, which has been shown as the most promising way to create innovation in almost any field of human experience.[34] There are many different methods and techniques to build or enhance group intelligence, and we will not delve into each of them, because it exceeds the scope of this paper. Nevertheless, there is one common thing they share—the dialogical stance of participants of the process.[35] It requires every individual involved in the process of building mutual perspective and knowledge on certain scientific problem to adopt an emotional attitude of acceptance and suspense, empathy and perspective sharing, which are not skills included in curricula of scientific training, although they should be.

Lastly, in order to preserve and enhance the development of inclination toward multidisciplinarity in the long run, we will need to invest efforts to remove, or at least *lower transaction costs in flow of talent, knowledge, technology and finance* with regards to multidisciplinary scientific projects. Meaning we could preserve collaboration for short periods of time, but in the long run human nature would definitely get in the way. Our brains are instinc-

31 Wiener, *Cybernetics or Control and Communication in the Animal and the Machine*, p. 9.

32 Radošević, *Osnove teorije sustava*, p. 277.

33 Ibid., pp. 17–20.

34 Frederic Vester, *The art of interconnected thinking: Tools and concepts for a new approach to tackling complexity* (Munich: MCB Publishing house, 2012), pp. 67–73.

35 David Bohm, *On dialogue* (London: Routledge, 1996), pp. 6–60.

tively tribal, designed to trust people who we feel are similar or closer to us and to distrust those who are further from us, which creates enormous transaction cost in society. Ironically, the greatest innovation potential exists between people who are the most different from one another. Here we need to learn from examples of good practice, innovation ecosystems like Silicon Valley which were able to overcome these transaction costs through a distinct set of social behaviors, building a culture of innovation not from top-down instructions, but through actual practice, role modeling, peer-to-peer interaction with diverse individuals, to name a few.[36] Individuals who can bridge between social networks of different scientific fields to bind greater communities together for common action or projects are essential to building and maintaining scientific innovation ecosystems. Public attempts to foster innovation in science that do not focus on changing human behavior are doomed to fail. When particular social behaviors allow the free flow of talent, ideas and capital, we find that human networks can generate extraordinary patterns of innovation.

To build scientific innovation ecosystems, first of all we must transform the culture.

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36 Victor W. Hwang, Greg Horowitt, *The Rainforest: The Secret to Building the Next Silicon Valley* (Los Altos Hills: Regenwald, 2012), pp. 10–11.

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Nužnost multidisciplinarnosti u globalnom svijetu

Sažetak

Procesi globalizacije učinili su svijet međuovisnim, što je posve promijenilo društvenu i ekonomsku dinamiku civilizacije. Tako možemo reći da danas živimo u VUCA svijetu, što je engleski akronim za svijet koji je nestalan (*volatile*), neizvjestan (*uncertain*), kompleksan (*complex*) i neodređen (*ambiguous*), čemu možemo svjedočiti i prolazeći kroz trenutnu pandemijsku krizu. U pokušajima suočavanja s izazovima takva svijeta, stručnjaci sve više pribjegavaju sistemskim metodologijama i multidisciplinarnosti. U znanosti smo naučeni sagledavati svijet u pogledu pojedinačnih fenomena u strogo određenim područjima, organiziranim prema disciplinama koje ih proučavaju ili područjima života na koja se najviše odnose. Današnji svijet, naprotiv, zahtijeva pomak u perspektivi, s usmjeravanja na pojedinačne fenomene u pojedinačnim područjima znanosti na veze koje postoje među njima, a koje u najvećoj određuju dinamiku današnjeg svijeta. U radu će biti govora upravo o tom pomaku, kao i o metodologiji koja ga omogućuje.

Ključne riječi: kompleksnost, multidisciplinarnost, međuovisnost, sistemska metodologija, dijaloško razmatranje