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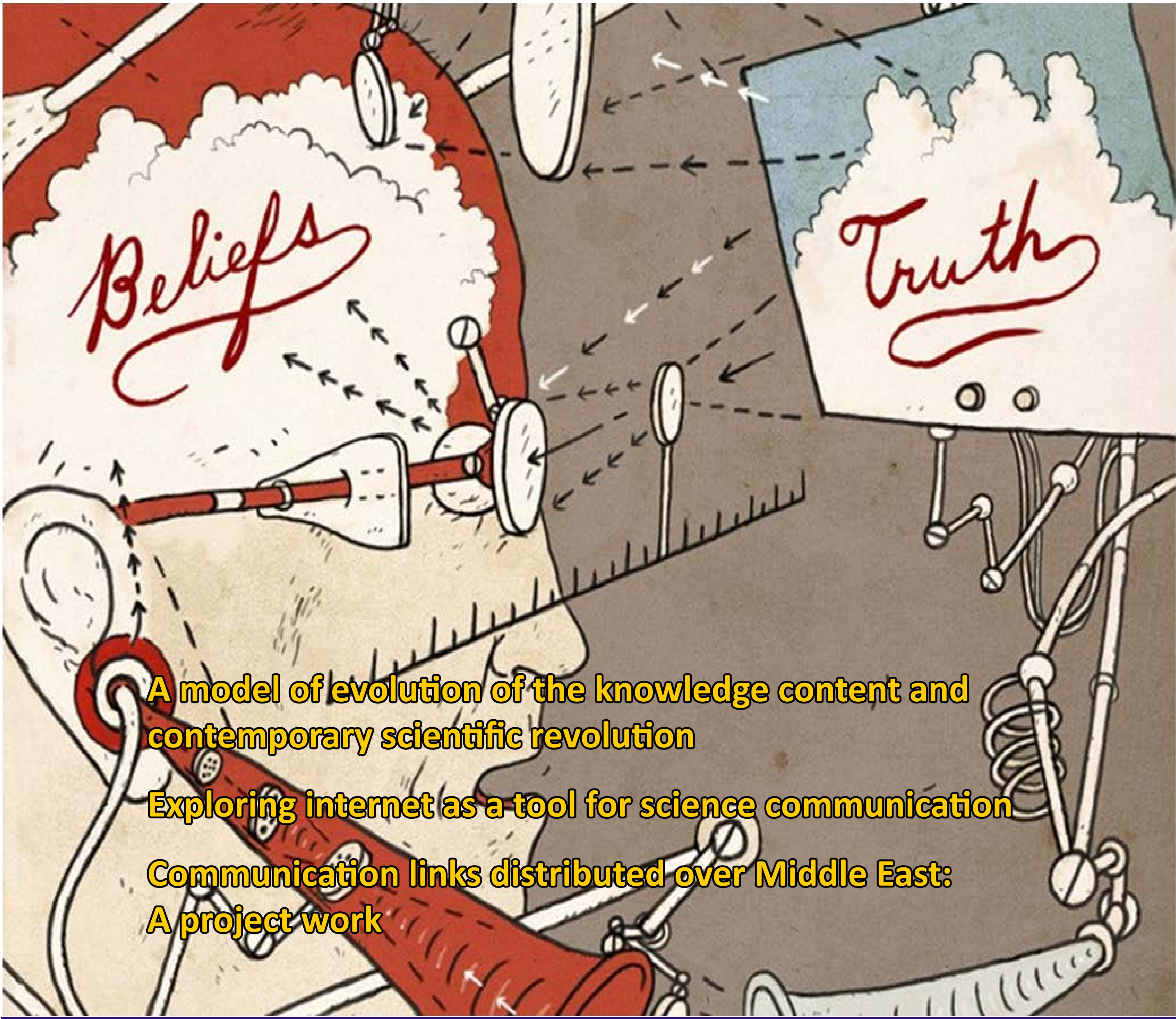

A model of evolution of the knowledge content and contemporary scientific revolution

Exploring internet as a tool for science communication

Communication links distributed over Middle East: A project work

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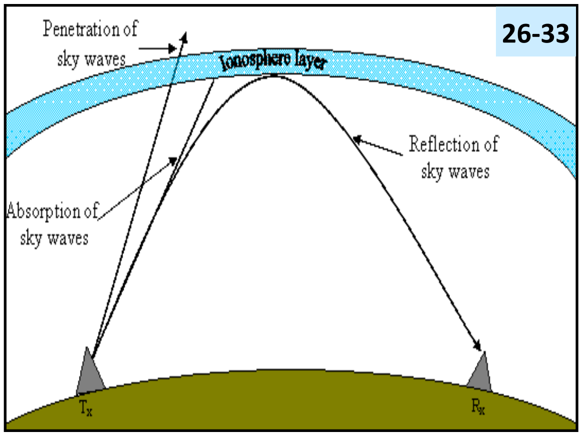
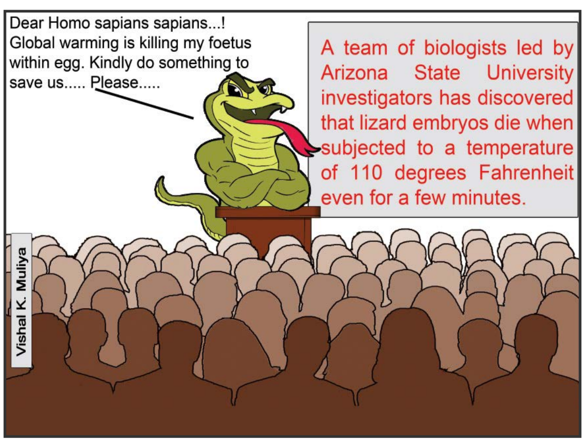
CONTENTS





COVER

Beliefs and Truth

Truth is not that you feel or express; truth is that where argument or counter argument fails; if you bring new evidence based argument, truth will change. Science says there is no absolute truth; theories prevail today are subject to change in view of the new evidence, so our perceptions and beliefs do; that is the essence of the scientific temper. - Editor

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Communication Strategies for Science Governance

We have been discussing science communication largely for the masses in general for a long time. Over the period, the science communication profession has assumed much larger objectives, responsibilities and has expanded its canvas beyond the public communication. The new avenues of science communication have come-up, such as political communication of science, policy framework, institutional or corporate communication, and science advice for governance, etc. A fine blend of scientific knowledge and scientific bent of mind of policymakers would improve the scientific decision making thereby help foster proper socio-economic development.

Much emphasis is given on science policy, science diplomacy and science politics the world over in order to promote socio-economic development and wealth creation through scientific research and technological innovation. All it requires a conceptual and practical framework on communication strategies for science governance at local, national, regional, and global level. At the same time, we must also position ourselves to draw benefits from demographic dividends and fine-tune our strategies so that these are best aligned with the national and global priorities.

The increasing concerns over declining interest in pure sciences amongst students, growing instances of research misconduct, pathetic state of quality of research, and misuse of science and communication for pursuing non-science agenda, etc., call for proper science governance and point towards the need of strong and robust communication strategies to address them with fair, honest, and true science inputs without any bias, prejudice, fear or pressure by so-called interest groups.

This entire concept opens up yet another area of science communication, i.e. "Communication Strategies for Science Governance", which was the focal theme of the 14th Indian Science Communication Congress (ISCC-2014) held in New Delhi during December 25-29, 2014. The deliberations have covered a wide range of issues, such as Science for people; Science for policymakers; Institutional strategies; Policy issues; and Scientists as communicators, etc.

The good governance in science and technology broadly would depend on the way the policies evolved and implemented through active involvement and interaction with stakeholders, including political leadership, technocracy, bureaucracy, diplomacy, scientific fraternity, industry, academics, young researchers and innovators, etc. In order to connect and bring them on a common ground the role of science communication becomes paramount.

It has to mark the confluence of young and experienced, the knowledge and wisdom, the thought and action and a sense of togetherness for the common cause towards serving as a Science, Technology, Innovation (STI) promotion input-output system, especially in a world of cutthroat competition, unavoidable uncertainties, increased public expectations and unrest, and in a place where the essentiality of reaping profit defines the rules of the game! It has come out very clearly and loudly that running the show is important but more important is that how we are able to address these situations probably through our creative faculties and a sense to achieving excellent governance in STI.

The knowledge that we acquire and the attitude that we develop over the period – a best combination of both the elements really holds the key of our overall appearance! Therefore, in other words, the combination of knowledge and attitude and their mutual synchronization plays important role in one's thoughts, more synchronized they are, more excellent they will be! This is how we can achieve the "excellence of thought" influencing our appearance. Similarly, if we are able to align our head and hands together, then we will be able to achieve the "excellence of action" influencing our performance. Now look at the beauty of connecting both the things together – the excellence of thought and the excellence of action – the moment you achieve this point of criticality – you are going to achieve nothing but "Excellence in Governance"!

It was a great coincidence that when the country was celebrating the first "Good Governance Day" on December 25th, 2014 to mark the 90th birthday of the Former Prime Minister of India Atal Bihari Bajpayee, the ISCC-2014 took off with the focal theme "Communication Strategies for Science Governance"; incidentally, Bajpayee extended the popular slogan: "Jai Jawan, Jai Kisan, Jai Vigyan" emphasizing significant role of the governance in promotion of these basic constituents of national development!

Dr. Manoj Kumar Patairiya

A model of evolution of the knowledge content and contemporary scientific revolution

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Assuming that the coincidence of the occurrence of the global science understanding crisis and rapid acceleration of the development of the science is not accidental, we derive the differential equation describing the evolution of knowledge/science. It is shown that it allows one to describe in a simple way basic patterns of development of human knowledge, using a few quite obvious parameters defined primarily by social and biological determinants of the given moment in history.

We do not wish to go deep into the knowledge creation process. The ideas of Nonaka and his coworkers (Nonaka, 1991, 1994; Nonaka et al., 1994; Nonaka & Takeuchi, 1995; Nonaka & Konno, 1998; Nonaka, Toyoma & Byosiere, 2001; Nonaka & Toyoma, 2007), who created a consistent body of theory concerning knowledge creation in organizations can not be directly adopted for the global knowledge of the mankind as a whole, especially when analyzing its temporal variations (Bratianu, 2010). As it is mentioned by Harsh (2009) any conversion or transfer of knowledge consumes time, which does not appear as a variable in the Nonaka's knowledge dynamics model. The temporal features of the knowledge creation can be seen using the NIelssen model, which is the extension of the socialization-externalization-combination-internalization picture (e.g., MacKinnon, Levitt and Nielssen 2006). However, details observed in the human/organization timescale are irrelevant for the global scale.

The metaphorical analysis for knowledge dynamics using the main concepts of energy (Bratianu and Andriessen, 2008), or thermodynamics (Bratianu, 2008), could give the global solution, but as the second law of thermodynamic such treatment is of statistical nature, and works well around the state of equilibrium and by definition is not a right tool for describing in details the process of change, the knowledge evolution, what is our subject of interest. Other metaphors (Andriessen 2007) could help even less.

The space-time conceptual framework for the knowledge as a evolving system the "diffusion" can take place and can be studied within the organization (Davenport and Prusak, 1998), from the organization where it is created to others (Appleyard, 2002; Ciborra and Andreu, 2002)

The Information-Space or I-Space idea of Boisot (1995; 1998) allow one to study the knowledge creation more globally, and it can be, in principle, used for studies on scientific knowledge evolution. The original model is, however, build for relatively small and small scale (in time) systems is rather a kind of the "microscopic model". We are interested in observing the general global, trends, thus quite other treatment of the knowledge/science system is required.

We start our global considerations from the verifications of some of many ideas of the McLuhan "Gutenberg Galaxy" (McLuhan 1962). It contains, among the other aspects, also the analysis of the effects of the medium of the interpersonal communication to the human condition in general. We do not have to share McLuhan's conclusions concerning the causal relation between the evolution of the methods of communication and the ways of human perception and schemes of the knowledge creation and collection, at least some of them, but we use his division of the history of mankind into epochs related to the communication modes:

- oral tribe culture,
- manuscript culture,
- Gutenberg Galaxy, and
- electronic age.

The introduction of the last epoch is of the special interest for us. In the year of 1962, when the "Gutenberg Galaxy" appeared, it could not, of course, take into account today's Internet and the World Wide Web. McLuhan could analyze only the effects of wide expansion of radio and television, and computers (big 'mainframes') are only mentioned marginally. If he could wait a while the Gutenberg Galaxy would comes out quite different.

1.1 Oral culture

The time when the humankind bearing resemblance to the one of our times came into existence, is beyond relevance. The beginning of the oral epoch vanished in the dusk of times which passed, the reason of what is the case of definition rather than reality. So it does not really matter whether the date was 10000 BC or 3000 BC. During that epoch, knowledge perceived as sciences these days, undoubtedly clarified itself. Not going into details, we may presume that it was a set of mythical-religious stories, which were interpreted in face of the reality of everyday life based on analogy and similarities which provided the people of those times with answers to the most important questions. The statement that the point and the nature of the most primary questions did not change much since then, seems to be bold, and what actually changed were obviously the answers. However, it seems that the ancient answers might have been far more satisfying for the people of those times, than the answers the science provides us with nowadays.

Knowledge, back then, was stored in minds of chosen individuals. We may call them 'the wise men', and the whole oral epoch may be called also 'the epoch of the wise men'. Those wise men gained knowledge when they were young, from their predecessor, and were supposed to pass it to their successor in an analogous way. That process could lead to distortions, which, however, may be treated as elements of the knowledge development process, enriching it with new contents, providing the wise men were aware of the process. If they were not, then the random fluctuations which lead to depletion of knowledge may be treated as the result of indiscretion during the copying process (passing and remembering the stories). Obviously, cases of vanishing of some lines might occur, meaning a break in the chain of knowledge, however it seems that the system of the oral epoch dealt with such cases by contacts with geographically divided structures. That kind of a system have evolved for thousands of years before it finally achieved a stable state, where random vanishing of stories was compensated by slowly appearing new ones. Out of necessity, the range of knowledge in the oral epoch covered only as much as a one, let us say particularly gifted and trained mind can accumulate, which all in all is not much. The development of ideas, thoughts, concepts, if it even was to come into existence, then it could not advance much.

1.2 Manuscript epoch

The epoch of manuscripts, which may also be called the epoch of libraries, came into existence after the revolutionary event, meaning when the wise men learnt to write. The invention of writing, is usually dated as fifth century BC, yet there are claims that the first notes were on bones of the upper Pleistocene around 20000 - 30000 BC. Anyway, it is a so distant history, that it is not very relevant nowadays. It does not even matter, how long did it take to introduce the new invention to the knowledge storing system. In some regions of the world, that process did not end until recently. What is important, is that in one moment it was not necessary anymore to remember the contents of a story, as it could be encoded permanently (or less permanently, depending on the need) in use of a set of signs. So important for McLuhan, the distinction between pictographic and alphabetical writing, and according to him the resulting basic differences in quality, will be left to the reader without comment for now, yet maybe in case of a more detailed analysis the issue would have to be reconsidered. One way or another, 'the wise men' are extinct and their stories had been written down and created the basic knowledge for the library system. Manuscripts were stored in libraries, were knowledge was sealed off against distortion and destruction far better than when it was stored in fragile brains of the wise men. The most important feature of the new epoch, however, was that libraries were able to easily receive the newly appearing knowledge. Someone, let us call him 'a scientist', had a chance to make his own input in the system of knowledge. Obviously the system was 'foolproof' and there was no chance of adding something which was not an evaluation of the existing state of knowledge. The scientist was obliged to acquaint himself with the knowledge which was stored in the system and then, and based on that, he broadened the system, most often in form of a comment. As time passed, the amount of information increased and it was necessary both due to the capabilities and resources, to concentrate the libraries in science centers, where scientists who were searching for answers to some relevant questions were able to study, as well as they could add something meaningful to do resources if they wanted to.

The library system required specialization, meaning that a particular group of people had to be taught how to read and write. The group did not only consist of scholars, but also scribes who copied knowledge for the sake of the people who needed it, among whom there were mainly the wealthy people of this world. For some of them, probably deepening knowledge itself was something more important than possessing a collection of neatly ornamented manuscripts. The greatest need for knowledge, however, was obviously manifested by scholars. Their existence was all about letting them near the books and maybe disclosing the contents of those books to them, by the people who read and seen more in their lives. A new parameter for describing the state of resources in the epoch of libraries appears. It is the amount of knowledge gained (or potentially available to be gained) by a scholar during his lifetime. This parameter, as it will prove later, is relevant in terms of a quantitative description of the system.

New ideas infiltrated the system slowly. Whereas in the epoch of the wise men a newly invented story started its life in the moment it was said, the newly written pages had to be read, then copied and distributed among the librarian community, global in a sense, and that process took time. That period covers formation of the idea itself based on stage of getting to know of the existing knowledge, writing down the idea, then reaching the potential readers of the manuscript, including other scientists above all. It is them who finally accept the new idea, or not, and the majority of votes is the factor which defines whether the new idea lands in the set of knowledge of the humankind, or gets forgotten and abandoned somewhere along the way. And that delay, according with the following debate, proves to be a key factor. In the epoch of libraries, the time of distribution of a particular idea may be estimated even as a few hundred years.

1.3 Gutenberg galaxy

The Gutenberg Galaxy, which from our perspective is the epoch of the printed word, does not qualitatively differ from the previous epoch of manuscripts. In that moment, we face with yet another discrepancy in relation to McLuhan's concept. What in our opinion changes most, is only the previously mentioned delay in proliferation of new ideas. There are only as many copies of a book in a printed form made, as needed. The socio-psychological changes do not have to come from the medium, but can be the result of the environmental changes connected to the easiness and the pace of duplication of ideas, for instance, the position of the author himself, who is a modern type scientist. Coming into existence of new ideas is still based on the primary process of getting acquainted with the existing knowledge. It is increasingly being documented as academic degrees, which guarantee the appropriateness of the method used as well as the contents of a scientist's work. The time of distribution of new ideas, nowadays, is a couple of dozens of years. That reduction of time of distribution is mainly the result of the instantly appearing abundance of copies.

That apparently, only quantitative difference has to lead to deep qualitative changes in the society. The knowledge gathered in books is potentially available to everyone. All we have to do is to know how to read. The aspiration of the common knowledge of the art of reading and writing appeared during the industrial revolution, as a result of a late reaction to the development of science, which was brought about by the Gutenberg's invention. After learning how to read (and write), people were finally able to demand to be led through the mazes of the world's libraries. Luckily, knowledge/science was systematized by the „wise man", who knew the rudiments of knowledge, which were designated based on learning on mistakes, experimenting, blind wandering and systematic studies, and its particular branches were named.

That system functioned successfully during XIXth century and until the mid XXth century. The question, if the system could last eternally, is an unreasonable one. One might ask, how much longer it could have functioned. A linear system with the rudiments, canon of knowledge, unfortunately leads to a situation, in which the new appearing elements of science are sooner or later being included in this canon, which is not bad itself because that is what progress is about, but the accumulated knowledge just becomes so vast that there are problems with one of the parameters of the system of knowledge, meaning the time needed by the candidate for a scientist to reach the stage when he becomes one. We reached a dangerously close distance to that border in the end of the XXth century.

1.4 Electronic age

What is even worse, that was the time when the last division in the history of mankind by McLuhan (with modifications) took place: the Internet was invented. That medium, unknown to author of the "Gutenberg Galaxy", changed our reality in just ten plus years. The system of the functioning of the science changed as well. And what really happened? Yet again we deal with a change which is (only apparently) quantitative. By allowing the thoughts to be exchange through the Internet, the time needed for ideas to spread decreased almost to zero. A couple of hundreds of papers on high-energy physics gets to arXiv repository each day. Notification systems automatically send messages about the potentially interesting content to specific scientists. Not all of them, most probably only a negligible minority, check only even the titles of the works concerning their field. The situation is new. Nobody was prepared for that, especially the system of education. We are still cogs in the wheel of a machine which worked just fine, but in the XIXth century. Our actions are mostly based on textbooks from the Gutenberg Galaxy.

The boost in the epoch of information, when connected with the fact that even in the end of the pre-Internet epoch we were close to the border of efficiency of the system of knowledge (and education), makes us assume to believe that maybe we are just crossing that border, or are to cross it very soon.

2. Model of the system of knowledge

In order to analyze the problem of the development of knowledge (science), its definition has to be given first. As E.P. Wigner (Wigner 1950) noticed long time ago, that is not an easy task.

It is quite easy to say that knowledge is the information given meaning and integrated with other contents of understanding (Bates 2005), what is obviously true, but it does not clarify much.

The intuitive idea that knowledge is something more than information has led many authors to make distinctions between information and knowledge (Tuomi 2000). Some models treat knowledge as a higher form of information: the knowledge has to be extracted from the raw materials, and in the process, meaning has to be added to them (e.g., Nonaka and Takeuchi 1995)

On the other hand the external reality we wish to study is available for the experimental studies only as percept and it can not be experienced and recognized as such without the prior knowledge of some kind (e.g., Gibson 1950, Kuhn 1970).

One can measure the amount of knowledge using „knowledge assets" of Boisot, somewhat like Dawkins' "memes" (Dawkins, 1999), which exist in the heads of agents and survive by inhabiting the heads of as many agents as possible. (If they fail to occupy at least one agent's head, they die out.) This idea looks obvious for the oral epoch. Some kind of its generalization is used in the present work.

In the I-Space the new knowledge assets are created by agents (e.g., firms and institutions). This is the „microscopic" point of view. On the largest scale human knowledge is a self-organizing system (Loasby 2002) and the knowledge itself is organization, produced by trial and error, what makes the diffusive character of the I-Space solution so effective.

Leaving this problem for further considerations we would like to briefly introduce the rough, very approximate, but still useful concept.

There are two simple definitions of the actual state of knowledge the humankind possesses: one to vast and the other to narrow, none of which is satisfactory but both are worth to be quoted, because the truth has to lie somewhere in between.

The first is contents of all the volumes of all the libraries in the world. Assuming that an average book may be stored as an about 5MB computer file (100 pages, 50 lines per page, 100 symbols per line), the Library of the Congress containing about 30 million of books, handles about 150TB of information. The British Library with over 13 millions of volumes give us the result of 75TB. Including other libraries all over the world and obvious repetitions (20-50%) gives us more or less 250TB (of uncompressed) text data (The British Library Annual Report and Accounts 2004/2005). While reading one page per minute, it would take a man about a half of billion of years to read it all. A half of billion of years ago, the Proterozoic Eon ended and the oxygen which was newly released to the atmosphere, allowed the life forms we know to appear. There was nobody who could read then, as well as there was nothing to read. It is hard to tell how the world in a half of billion of years will look like. There is no certainty whether there will be anybody knowing how to read, and there is no proof if there will be anything left to read. So the existence of libraries does not mean anything, it does not mean everything at least.

According to the narrow definition, the knowledge of the humankind consists only of those pieces of libraries, which were familiarized with and are known to everybody nowadays. Something can be called ours, when everyone has it. Obviously, in that case our knowledge is extremely limited. That definition is not good.

So maybe it is enough to define knowledge, as all the information discovered and remembered by at least one member of the society. That proposal also has to be rejected, from a very simple reason: two different books often contain contradictory information and different interpretations, so the knowledge of humankind would be full of contradictions, meaning worthless in a big part. We wish it would be the other way round

Wigner finally proposed a rather flexible approach in defining the actual state of knowledge. It covers all the things the members of society might learn, if it came up to their minds, while there is a common belief, even certainty, that all of that forms a coherent image we call reality.

The definition fits the way the knowledge we previously described, is created. That knowledge may be measured in binary units - just as was described based on huge libraries. For other purposes, a more convenient method may be the analysis of the logarithm of that number, called negentropy. Even during the World War II, Erwin Schrödinger (Schrödinger 1944), a lecturer from Dublin Institute for Advanced Studies in Trinity College, noticed importance of that calculation for biological forms in general. Negentropy, calculated based on Wigner's definition of knowledge contents may play a similar role in refer to the civilization development. However, a more detailed analysis of that issue goes beyond this work.

2.1 Oral epoch

We have to start the quantitative analysis, beginning with the epoch of the wise men. Development, which is basically the endurance of knowledge passed orally, may be described by means of a simple differential equation, describing a change in the quantity of knowledge as a competition of two different processes: extinction (let us call it forgetting) and creation. A specific model should be able to provide the stability of knowledge and resistance to temporary deviations. We propose the simplest solution in form of equation

$$\frac{dN}{dt} = -\xi N + \alpha \beta N^{\kappa} \qquad (1)$$

N stands for the amount of knowledge, t is time, dN/dt is a change of the amount knowledge in a particular unit of time, the rate of increase (or decrease, if the value is negative) of knowledge. First of the factors on the right side is negative and stands for forgetting. It is described in use of a one parameter only, ξ, which is defined as the inverse of the average time of extinction of the particular information, in case when there is nothing which can reverse the process of extinction. In the epoch of the wise men, that time is about the lifetime of a wise man. Let us assume that it is one hundred years, just to make it simpler. The second, the positive element, describes the increase of knowledge. Parameter α stands for the number of people who are involved in the knowledge creation process. In the epoch of the wise men, the number was more or less constant. For a particular family, tribe, settlement, there were not many carriers of knowledge, and we may assume that it was a single individual. The second parameter, β, is analogous to the parameter ξ describing forgetting, but is its additive inverse. It is the average rate of creating new stories. It can be both higher than the rate of forgetting, or lower, but it has to be beyond relevance in case of a properly functioning model. We may assume that the input in the resources of knowledge made by each wise man, based on one story, observation or discovery, contributes to β around 0,01.

There is also one more parameter on the right side of the equation – κ. It is essential to ensure the stability of the equation. If it was not there ($\kappa = 1$), then depending on the fact if $\alpha \times \beta > \xi$ or $\alpha \times \beta < \xi$, the rate of increase of knowledge would be rapid and heading for infinity, or it would definitely decrease to zero. Values of $\kappa \neq 1$ ensure that the value of N has to reach stability after some time, which is determined by the solution of the equation

$$\frac{dN}{dt} = -\xi N + \alpha \beta N^{\kappa} = 0 \qquad (2)$$

as

$$N_{stab.} = \left(\frac{\alpha \beta}{\xi}\right)^{\frac{1}{1-\kappa}} \qquad (3)$$

Fig.1 illustrates that situation. It is visible, that in spite of all the variations we deal with, after some time (a few generations for the parameters of the given model) the stability is restored again. As long as the role of the parameter κ, shown in Eq.(3) and illustrated in the Figure, is clear from the mathematical point of view, its interpretation and meaning in the real world requires an additional comment. Understanding why the pace of the knowledge creation is not simply proportional to its resources but 'slightly less' proportional, is not something obvious. The 'snowball model' explains that situation (Fig. 2).

Let us imagine knowledge as a set of points, for instance as a plane figure. If someone is fond of symmetry, let's make it a circle. Each fragment of the circle is a peace of knowledge, and someone who knows it all, meaning a wise man, may try to add some element do the possessed resources. That element is then added to the edge of the possessed knowledge. In the same way a rolling snowball grows. The amount of space on the edge in proportion to the capacity (length) of a two-dimensional circle $\boldsymbol{S = 2 \pi r}$, and, because the amount of space within the circle is $\boldsymbol{V = \pi r^2}$, one get $\boldsymbol{S \sim V^{½}}$, in the case of a three-dimensional sphere it is $\boldsymbol{S = 4\pi r^2 \sim V^{3/2}}$, and so on. In case of knowledge, there is no point to limit the number of dimensions. Yet, if it is finite (***n***), then the proportion of the edge and the inside, which defines the index μ, will always lead to result which is less than 1 ($\boldsymbol{\kappa = (n - 1)/n}$).

2.2 Manuscript epoch

Introduction of the first scientific revolution: invention and application of writing apparently does not require any significant changes in the initial Eq. (1). At first glance it may appear that the only result is a significant increase of 'persistency' of knowledge and all it takes is to decrease the pace of forgetting of knowledge and the model will still be correctly describing the new situation. The endurance of the symbols engraved on walls, horns, bones, imprinted on clay, painted on a wall or a piece of leather, is much longer than in comparison to the fragile brain tissue. If it is at least ten times longer, then the influence of the element of forgetting gets much lower. The closer the value of the index μ gets to 1, the less significant is the factor of forgetting, what results from equation Eq.(3). The limit value is a number certainly greater than 1, to a high power. The solution of simple equation Eq.(1) gives an almost exponential growth, which reaches absurd (meaning infinity) very quickly. Those results are illustrated on Fig. 3.

In the case of our definition of science, the obvious thing is that its volume has to be limited. The level on which we have to stop is not relevant yet, but we certainly have to complement the initial equation with a inhibiting factor, but the factor would have to be found in the real world of the epoch of libraries first.

The previously proposed model of an increase of knowledge, the model of a snowball, beside the fact that it substantiates the existence of an index which is less than 1, it also suggests the correct solution of this limit problem as well. New knowledge appears, as it was already mentioned, and it is added to the regiments of knowledge only if it 'fits' its existing profile. Thereby it is wise to assume that the creation of a new element of knowledge requires getting acquainted with its existing state. So every scholar has to spend some time on studying, before he discovers something new. That model is rather accurate and it would be hard to convince anybody nowadays (maybe except the ambitious pupils from primary schools), that it is possible to achieve something really smart without learning anything previously. On the other hand every scholar has a limited time for learning. If the time of learning approaches the time of living of a scholar, then only the long-lived individuals would be able create new science. It obviously sounds irrational, but unfortunately that process sets the limit for the development of science out of necessity (especially for particular fields of science).

In order to write it down according with our primary considerations, let us assume that the discussed relations are in the simplest, linear form. An additional factor which the rate of creation has to be multiplied by depends linearly on the time left for the scientist after his graduation, for creative activities, and the more knowledge is there to be learnt, the less time he has. The modified equation is now in a form:

$$\frac{dN}{dt} = -\xi N + \alpha\beta \left(1 - \frac{N}{n_0} \frac{\tau_0}{\tau}\right)_{>0} N^{\kappa} \approx (\alpha\beta - \xi) N - \left(\frac{\alpha\beta\tau_0}{n_0 \tau}\right) N^2 \quad (4)$$

There are three parameters describing approaching the saturation point: τ_0 - the time needed to comprehend a one unit of knowledge, n_0 - the measure of that knowledge unit, which is, in fact, only setting the scale on the vertical axis, and τ - the average lifetime of a scholar. Those three parameters are used in equation Eq.(4) combined, so there is no point to qualitatively reflect on each of them separately. In all the calculation below, we assumed that $\tau_0 = 1$ and $\tau = 100$, As one can see, the equation became non-linear (even if we assumeµ $\kappa = 1$) and its solutions for different values of parameters are shown on Fig. 4.

There is a visible change of the increase of N depending on the parameter, which describes forgetting knowledge. There is also a visible relation with the value of the index κ, in case when it is significantly different than 1. What is pretty obvious. The lower index means slower increase of knowledge, however, there are now no contraindications for assuming the limit value of 1.

The dependence on the value of β is also obvious. That parameter describes how active a scholar is, and the higher activity the higher increase of knowledge. The asymptotic value is achieved for big values, just as we wanted it to. It is specified by the parameter n_0 (combined with τ_0 and τ), which describes the amount of knowledge a scholar can comprehend. For most of curves on Fig.4, was assumed to be 1/1000. In case of the epoch of the wise men, β was previously set to 1/100. It seems to be justified, because creativity of 'the scientists' from the epoch of no writing, had to be big enough to ensure the continuity of knowledge. In the moment when knowledge could be written down, meaning more enduring, the importance of creativity decreased. That parameter is not critical for our discussion, because it is always multiplied by α, which describes the number of people who are involved in the process of creation, which is now assumed as a constant, what is not consistent with the growth of population and the development of public system in the epoch of libraries. We will return to that issue later on.

2.3 The Gutenberg galaxy

Analysis of the growth shown on Figs. 3 and 4, we may see that the picture is not satisfying yet. If we assume that the epoch of writing started in 500 BC, (not to mention what the results would be if we agreed to set it as 20000 BC) then close to its end, meaning after 2000 years, we should be able to observe a significant exponential growth of libraries, independently of the date we set (within limits of reason). Maybe there actually was a similar situation in the end of the Middle Ages, but it is highly unlikely for a situation like that to occur much earlier, but curves of increases which represent the solution of Eq.(4) are exponential from the very beginning. The increase of knowledge observed over the centuries, seems to be more linear than exponential. In order to make it so, we have to introduce a one more modification, which is the last one for now.

As it was previously mentioned, the knowledge distribution process in the epoch of wise man, was in fact rapid. An invented story, which was then told to people (meaning the whole social group: family, clan, tribe), almost instantly became well known. A scientific discovery, or whatever we call it, 'came into effect' without any unnecessary delay. The situation changed drastically when the civilization came to a point when the knowledge needed to be reprocessed to symbols, then encoded and preserved. That encoded knowledge went around in the form of copies, but it did not reach far because of its high value, so that scholars had to travel in order to gain that knowledge, and that process took time because the interested people had to visit many places in order to learn this or that. The duration of the knowledge re-distribution process may be variously assessed. The good example is how the 'world' familiarized with the works by Aristotle, starting with XI[th] century and than after its rediscovery in the World of Latin or the Copernican Revolution which took place in 1543 (however from our perspective, maybe the date of the beginning of writing would have to be set even 40 years back). It was not a short time, in the second case Galileo, one hundred years after Copernicus, still could not feel safe at the Tribunal of the Inquisition, and Newton wrote "Principia..." which gave some sort of an explanation of the forces which applied in the planetary system, and that was another one hundred years later. It has to be remembered that the fate of other discoveries with less spectacular consequences, as in less important, might have evolved even slower.

The effect of delay in distribution of the new knowledge may be included by introduction of a new parameter δ. It is defined as the time from the very introduction of a new discovery, until the first effects it may cause in the system of knowledge.

$$\frac{d\,N(t)}{dt} = -\xi\,N(t)+\alpha\beta\left(1-\frac{N(t-\delta)}{n_0}\;\frac{\tau_0}{\tau}\right)\left(N(t-\delta)\right)^K \quad (5)$$

The solution of that equation is illustrated on Fig. 5. Both graphs present the same relations, but with a different scale in refer to the axis of time. The family of continuous curves shows results that differ by time of delay δ. The asymptotic dashed line stands for the increase of knowledge in case of infinite delay. In such case, the newly invented ideas do not influence the rate of increase of knowledge. The remaining cases show, that the delay not only influences the point at which that particular curves leave the asymptotic line, but also influence their slope, which stands for the rate of increase.

The value of the knowledge obtained over a very long period of time is constant, however the value is no longer defined by equation Eq.(2), but

$$(\alpha\beta-\xi) - \left(\frac{\alpha\beta\tau_0}{n_0\tau}\right)N = 0 \qquad (6)$$

3. The present situation

Having what seems to be a complete equation describing the development of knowledge, we may attempt to apply it in a particular case of humankind as such. The values of parameters which were described for all of the four mentioned epochs are presented in Table I.

Table 1: The values of parameters of the model in particular epochs

Epoch	Period	α	β	δ	K	ξ
Oral	- 500BC	1	0.01	1	0.9	0.01
Manuscript	500BC - 1500	1	0.01	300	0.9	0.001
Gutenberg Galaxy	1500 - 2000	1	0.01	30	0.9	0.000001
Electronic	2000 -	1	0.01	0	0.9	0.0000001

The introduction of printed books increased the circulation of information ten times and at the same time caused that once a book was printed, then it stayed in the circulation forever, or at least lasted in it as long as anybody wanted to read it. The current epoch, the epoch of the Internet caused that the time of proliferation of knowledge decreased almost to zero. Those changes were discussed in details in Sect. I. The values proposed in Table I are not adjusted precisely, but they are rather the values which seem to be reasonably close to the truth. They are close enough to make the solution comparable with the observations of the actual development of science over the centuries. The value of the parameter α will be discussed in the following. For now, its value was set equal to 1 for all of the epochs, so the presented result may be interpreted as the amount of knowledge per a single individual. The results of Eq.(5) for the given parameters are shown in Fig.6.

The horizontal axis on Fig. 6 was matched to the usual time convention. As it is presented on the left picture, the invention of writing did not trigger any sort of a revolution, the Gutenberg's invention resulted in both scientific and technical-scientific revolution, visible as a fast but more or less linear increase in the XVII[th] century, expressed clearly in the right picture.

What is the most interesting from our point of view, is the beginning of the current (and future) epoch, originating at the turn of centuries and caused by a sudden increase of the flow of information.

3.1 Population growth

There is a one more modification of the model left, meaning a more appropriate match for the value of the parameter α, to be more specific. As it was previously mentioned, it is related to the number of the people involved in all the intellectual activities of a given social group, which is more or less the number of the people in the 'world', and by world we mean the world which was available to an average individual, a scientist particularly. We can estimate the increase of the population over the centuries rather precisely. It is presented on Fig. 7. By introducing value of the parameter α being proportional to the population of Europe, we get the conclusive image of the evolution of science from the very ancient times, with extrapolation for the future. It is presented on Fig. 8.

It shows the boom of the epoch of the Internet, in total. Reaching the point of saturation occurs more or less after 30 years. The properly adjusted values of parameters may obviously alter that period, nonetheless the fact is that whatever our approach to that issue may be, probably now is the time when we are inevitably nearing that sad moment, however it is also probable that it has already skipped our attention.

It may apparently seem that reaching the state of stagnation, stabilization of the value N, should have been noticed and lead to countermeasures, or at least astonishment. However, it is not so. Let us remember that, for the whole time, we examine knowledge concerning one field only, meaning theses, statements and theories that are related and form a coherent unity. The upper limit originates from the fact that in order to reach further, one would have to comprehend so much information, that it would exceed his life time to do so. In such a situation, and obviously before that, there must some concepts appear, based on a partial familiarity with the state of knowledge of a particular field. If these are not full of nonsense, obviously incorrect, missed, banal etc., then they are independent from some parts of knowledge gathered up to now. If over time there would other ideas based on that new concept appear, and the construction of a system of knowledge around them starts, a one which would only partially be consisted with the previous rudiments of knowledge, then a new field of knowledge would appear. It would start to develop and spread just as same as was in case of the parent field until then. Primarily less wealthy and more humble, it allows the scientists to prove themselves in the new field, as they did not have opportunity to do it in case of the old one. The increase of the new field is according with Eq.(5) and the parameters which are proper for a given epoch. At the same time nothing limits the old the fully grown systems, and new fields and specialties may emerge from them. All of which develop more or less with the same pace. The possible differences may come from differences concerning the parameter α, which describes the social attractiveness and the fact of a particular field being 'scientifically' fashionable. The more fashionable fields develop faster.

The quantitative analysis of that process leads to an identical equation, in terms of the general idea, as Eq.(5), where the value of N would no longer stand for the amount of information, meaning available knowledge, but the number of existing fields of science. The interpretation of parameters of such a model will obviously be different. However, the solutions will be similar to those presented above. The number of fields will be snowballing, the result of what quite likely is not to be good.

The process of division of the system of knowledge to fields which are significantly independent is not a new phenomenon. The study of inanimate nature, the changes within it as well as meaning of those changes, which basically is all that we call sciences, was all included in ancient physics. Nobody wonders that nowadays we have astronomy, chemistry, meteorology and biology. That division, which is obvious and results from the described way of creation of new fields, leads to new specialties. Nowadays, it is hard for a botanist to communicate efficiently with a nuclear astrophysicist. Those two fields have so little in common, that the newest inventions in both fields are totally independent and have nothing in common. The process of division of science goes so far that for instance within physics that the specialist of quantum optics is not able to discuss much about his work with a cosmologist, if he wants to go into details. People like Boyle and Smith, the winners of the Noble Price in Physics in 2009, might be able to understand the importance of the works of this year's laureates Geim and Novoselov, but there are probably not many people in the world who could actually explain what exactly all of them were awarded for. Disciplines, fields and specialties of modern physics have little in common, and the examples are numerous. All of that implicates that the process of snowballing of specialties has already started.

Discussing the expected final state of that process, if there even is one, is out of the scope of this paper. We would like to ask a question though, whether the state that was described above and the perspective of its evolution would influence the system of education or not, and because of the fact that the answer to that one is pretty obvious, we need to rephrase the question to the form: what is the influence and how to deal with it?

4. The particular application: the crisis of the (science) education system

The system of education is to prepare the youth to move around the world efficiently, and without collisions. We may also ambitiously assume, that we would like the world to become more and more friendly. In order for it to be so, it would be good to know it first, and then to make it better as much as it is possible. The history taught us that the attempts without understanding the world, or even against that, led to some unpleasant consequences. Assuming that those postulates are true, we come to the conclusion that the knowledge we possess now, needs to be passed to the youth, as knowledge meaning wits lets us to understand those things which are around us in use of imprecise terminology. The times when it was possible to teach someone everything, before he gets too old to use that knowledge, are definitely long gone. It was probably figured out back then, that the knowledge of a particular field needs to be put in order. During those times, there were only a few fields of sciences, and by saying a few we mean about one, so there is no difference if we talk about teaching physics or science in general. Science need to be systematized first and then their basic rules have to be systematically and holistically compiled in form of books, in which each chapter would describe a particular field from the very basics and go into details, whereas the limit of those details would depend on the purpose of the book. Next, those books would have to be extended until they reach the wanted extension. The volume we spoke of, was measured by the amount of time of teaching, including the age and predispositions of the student. Those kinds of books were adjusted to the general teaching scheme and met the criteria of equality and universality. A student could stop the process of education at specific moments and then he was left with the knowledge he acquired up to this point. The most determined students would acquire the status of scholars and specialists of a given field, academic degrees and titles. By design, they would know a particular field of science. That design worked well a hundred years ago, but nowadays the statement could be confirmed only by some radical optimists.

According to the analysis of the process of increase of the knowledge resources, as a great number of new fields and specialties arises right in front of us, the system crashes. The reason is simple: the scheme which was designed in the beginning is not sufficient enough. It cannot cover everything that was invented and is important from the point of view of knowledge of the humankind. Among other reasons, the most important is that nobody knows everything. Nobody knows the whole knowledge concerning all the fields of physics, and if such person still exists nowadays, he will cease to exist very soon. Collegial bodies may be appointed, the attempts of what are being undertaken. They may create some sort of a scheme, but it would be a compilation and a comprise, so it would basically be something different than it should be. The canon of knowledge compiled in that way become some vast, that after the previously described process of simplification, it no longer includes anything but the unimportant set of the arbitrary basic terms and rules, the true meaning of which may only be discovered on some advanced stages of education, after getting acquainted with multiple terms and rules.

The only solution of this situation is the rejection of basic principles of common, general need of teaching of physics/science.

The rejection of the old pattern causes that the systematized set of beliefs in general, becomes irrelevant. There is no need for everybody to know something in all the fields. It is better when everybody knows something on some particular fields. The problem is with the choice of the contents, which are to be taught. What is important from the objective point of view, is that it is not possible to teach everything, despite the fact that in most cases that is not even necessary (in a narrow, utilitarian sense), nevertheless a sensible decision is to individualize the choice to the maximum. It is not true, that the youth of different regions are all interested in the same thing. Even if it does not concern fashion or music, the diversity of interests is obvious. In order to meet the social demands in this case, the teacher has to be accordingly prepared. The role of a teacher undoubtedly increases in case of the proposed model. First of all, he has to possess a broad knowledge, strongly regulated, processed, and prepared to be passed to the needing. Secondly, he has to possess the meta-knowledge about what is important and how to wisely select the contents, in order to maintain a coherent image of the physical reality. Neither of the aspects is present in the current system of education, according to the XIXth century scheme. The reason for what is that there simply was not enough room. Creating teachers who are ready to work in the new reality is a hard process, which requires some basic changes in the model of teaching, however it seems that after the method is mastered, then the teaching itself, as well as mastering the possessed skills, would not be painful and time consuming anymore. In fact it would be the opposite, meaning it might make the job of a teacher (of physics) much more interesting, and if not - then much more creative for sure.

The rejection of the present commonality of education and replacing the old system with the one will result, particularly during the transitional period, in lack of the so called 'specialists', who are those people who by choosing a particular profession would want to, or even are obliged to, possess the knowledge of physics which was defined according to the present standards. The need of those professions will decrease in the long run, however there will probably always have to be a group of people like the one mentioned, who after receiving the general education, would educate themselves in exact sciences as well, according to the pattern above. They will choose the career path which requires particular skills, meaning the use knowledge of exact natural sciences. They will be required to get through the physics course, similar to the one at the advanced GCSE level. Obviously the contents which are to be taught should be narrowed, in order for the knowledge to present some sort of a standard. There has to be a possibility of elimination, or inclusion to the program of the whole themes, if needed. Leaving those kinds of choices to the teacher at this level, drastically increases the meaning and the prestige of a teacher. Due to the fact that this way of education is the most similar to the current one, it will be the easier to introduce it. It will only require to reconstruct the system of base of the program, and involve some changes in contents of particular themes.

The third way of education concerns those people who intend to become 'the wise man' in the future, meaning those people described in the beginning of this work. Nowadays, they would have to be called scientists. The people in the future will try to increase the knowledge resources of the humankind, they will attempt to know the unknown and undiscovered. In order to do so, a clear image of the whole is needed, different for everyone, but it has to be significantly deepened. The knowledge passed should be as deep as possible, however one has to bear in mind not to overstep with the formal perception of the taught contents. It is not always possible, but the attempts should be undertaken. This way and the previous one, are divided by the way which was designed for the specialists of applied sciences. A future scientist might solve the problems which are included in the typical book of problems nowadays, but does not necessarily have to know how. Obviously it is not true that he does not have to learn how to solve problems, but the main point is that the nature of the problems would be different. Methodology of physics, as a science seeking for answers but also questions that nobody can answer to, is something qualitatively different than searching for solutions of standard problems. Someone who chose that way, should acquaintance himself with that methodology. Modern schools do not provide that. The best student can solve complicated problems which were maliciously compiled by the professionals whose job is to compile those problems, whereas the problems with face in the real life rarely are malicious, but they often are hard and do not have to be typical. The system of education specifically designed for that group of the young people, practically does not exist nowadays. All of the actions concerning the so-called gifted youth, are rare. As a course of time, we may expect the increase of pressure concerning that issue and even now it is high time to start wondering how to pass the knowledge needed by the youth to create new values (scientific). The easiest way is to stall, meaning stuff the hungry minds with useless skills, some abstract mathematical calculations, which may appear to be useful one day, and to wait until they graduate. After that they get caught in the web of higher education, which tends to operate more and more similarly to the previously described system. Making the institutions of higher education responsible for teaching the gifted youth results in losses, from which in many cases they cannot recover from. The more absorbent and flexible minds undergo the process of conformism, which is when their potential growth of hidden capabilities and creativity suffers. On the other hand it is hard to organize classes in the way it would fit the most ambitious individuals, considering only school and its little capabilities.

The third way has to be conducted together with universities, colleges and academies, or other institutions where there is even a potential possibility of encountering science in its form *in statu nascend*i. In order to learn how to create new values and methods of using the current, not only intellectual, tools but also the instrumentation which is close to the current one, the youth has to leave the school buildings, because it is not possible to create modern laboratories of various fields there (even physics lab). Moreover, it is futile. Another possibility is to visit university labs. In this way, the postulate of modernity and direct access will come true, but it will automatically introduce the unwanted element of selection based on the distance from the place one lives to the leading science centers. Those limitations are hard to be overcame, so basically it is not possible to base the third way of education on that. The only option seems to be to create some small educational laboratories with on-line access, in the vicinity of the big science labs at university compounds. In use of those modern technologies, the young people could conduct classes from anywhere and essentially study and search for solutions of the problems of particular interest to them, not limited by local resources, using both the base and the help of the academic scientists.

There are even more demanding challenges which a teacher on the third way of teaching has to face with. He has to be the guide for the youth in their search, he has to play the role of a medium between them and the facilities which share their on-line labs, but he also has to know how to solve problems. On the other hand, he is not required to possess some specific knowledge of physics, because that may always be asked for, providing one knows how and who to ask. As a course of time the students themselves have to learn how to ask proper questions, however it is the teacher who should show them how to do it first. The teacher should coordinate the work of his students at that stage, propose some directions of enquiry. How active he is needs to obviously depend on the group he works with. Those groups will not be large, because they cannot be. Irrespective of the way we define 'particularly gifted students' in physics, we cannot expect that it exceeds 1 per mille of the population. Organizing a lesson for such a small group is a problem, however for the same reason those groups will be cared for by the teachers with particular predispositions, skills and training required for that kind of a work with the youth.

The involvement of universities, colleges and academies in the teaching process at the preacademic level, seems to be particularly valuable for, at least, a couple of reasons. First of all, the institutions of higher education may share, on-line, a part of their unique equipment, they have a capable staff at their disposal and potentially are ready to provide the substantial help in solving complex problems which may occur during classes, and finally, help in staff training. On the other hand those institutions should have interest in finding individuals who are interested in science, potentially gifted, who may constitute to the development of those institutions in the future.

Summary

The 'three-way system' which was describe above, may introduce the society of the XXIst century to the world of modern science. It provides an image of a rational reality to everybody, what gives basics for the scientific view of the physical world and understanding the laws of nature. It allows the development of the technical fields, as well as the relative ones, allowing to show the path of education for the people who want to become the trained staff in sophisticated fields, new technologies, with skills which require specific knowledge. It also gives the opportunity of development for potential creators of science, allowing them to possibly early try to face with the challenges of science.

In comparison to the XIXth century system, the role of a teacher in the educational process increases. The teacher becomes the creator of the teaching program. He implements, so he needs to be prepared for that, what means that the process of education for teachers has to be altered. The teacher cannot be a student of physics no more, meaning a one who wrote his master thesis concerning "the study of dynamics of particles in the reaction chambers of zeolite in use of the methods of nuclear magnetic resonance relaxation of deuterons", or "the neutron-excess nuclei structures of double magic ^{208}Pb" (the real titles proposed for the academic year of

2010/11 in one of Polish Institutes of Physics), and attended some pedagogical courses.

When leading students the first way of education prepared for general, wide audience, it is not relevant for the teacher to possess deep knowledge in one and a very specific fragment of the knowledge of physics. The teacher needs a broad general knowledge and he should acquire it during his higher education on the specialty of teaching physics, both in theory and in practice. This kind of studies is at least of the same, but probably bigger importance for the society as sophisticated theoretical, optics, solids state or high energies physics which could lead to the Noble Price, in principle.

The program of university studies for teachers must also contain the training concerning the teachers, who are to work with the young people interested in knowledge, and particularly interested in physics concerning the second and the third way of the proposed education system. The narrow specialization is irrelevant, or even harmful here. The efficient capturing of basics of physics is necessary for a proper training of the future specialists, for instance at the technical universities, for specialists in chemistry, physics, or even in teaching.

The education for teachers concerning the third way is the most debatable, as on one hand the narrow specialization would result in easier management of the students, once they were to follow the same direction. However it has to be assumed that, as a general rule, it will not happen that way. The specialists on the third way may be a part of the university staff, and there job is to deliver the necessary knowledge concerning the topic they offer, to the teacher. Instead of that, the teacher should master the art of preparation and conducting experiments, making observations, analyze the results and then conclude. Those skills are extremely important not only for physics, the lack them sometimes leads to unpleasant misunderstandings, particularly if it is about the statistical analysis and general knowledge of statistics.

The requirements of the proposed system, in refer to teachers, are high and complex, but it seems that it is possible to include them in a system of education, what would make

it coherent. The task is not easy, but necessary to be completed because only the trained teachers are able to painlessly lead physics and sciences education out of the crisis, in which they undoubtedly are, as it was proven.

We have shown that it is possible to find one simple equation describing the development of the knowledge/science on a global scale. We have used it to estimate few parameters determining the evolution of the humankind knowledge as a whole and predict the near future. This can be useful in searching for remedies to the observed worldwide science education crisis.

In principle the method can be used to establish the model for microscale, the kind of the I-Space picture, to have a detail insight into the mechanisms of knowledge creation of distribution in time.

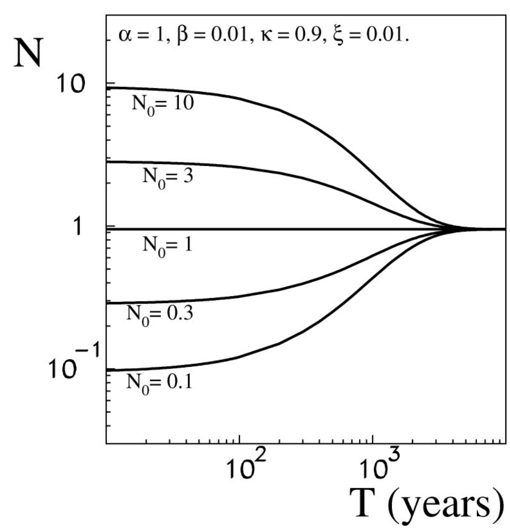


Figure 1: Evolution of knowledge (N) in the oral epoch for the typical parameters with various initial states. As may be observed, in spite of the variations, the state of knowledge stabilizes in the long run.

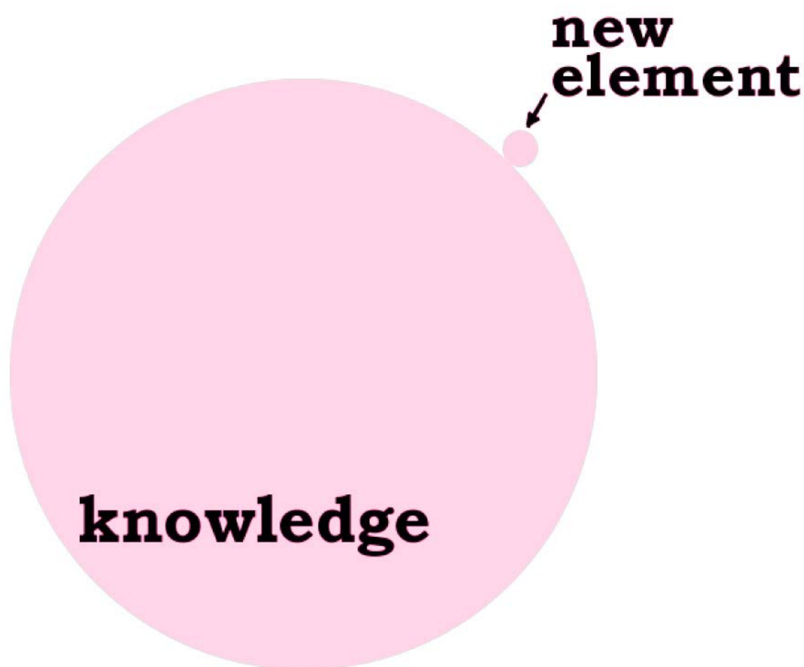


Figure 2: The scheme of increase of knowledge in a model of a snowball

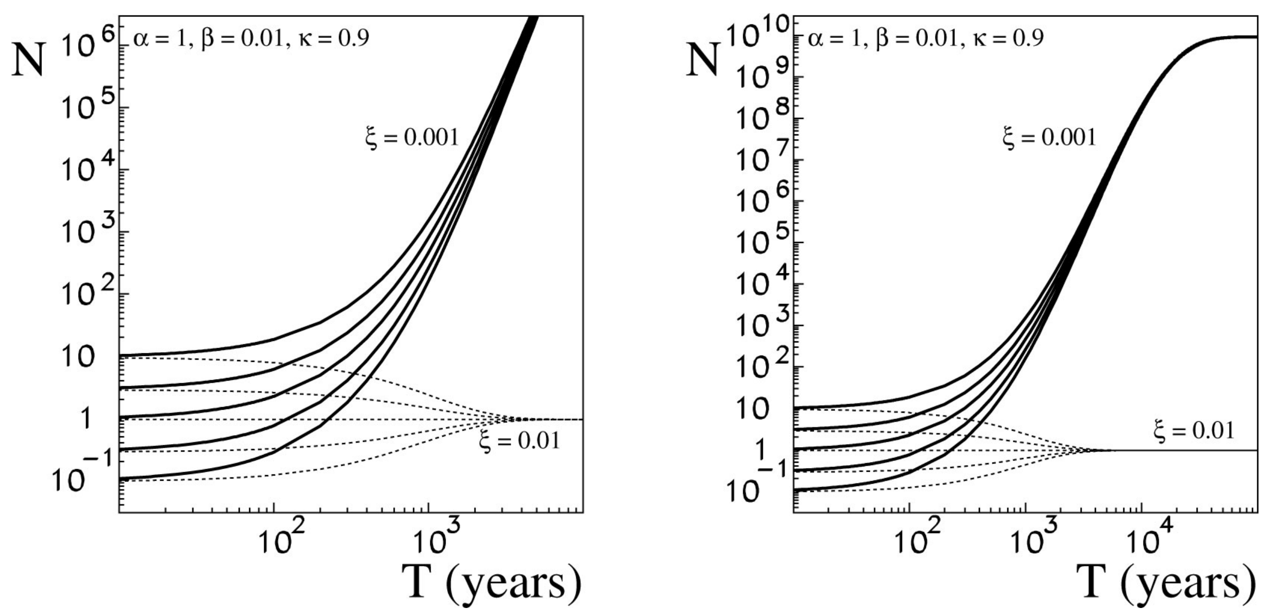


Figure 3: Almost exponential growth of the value of knowledge, when the parameter of forgetting is increased by 10 (left picture), and it reaches asymptotic value 10,000,000 times bigger than for $\xi = 1/100$ (right picture). Curves from Fig.1 are presented for comparison.

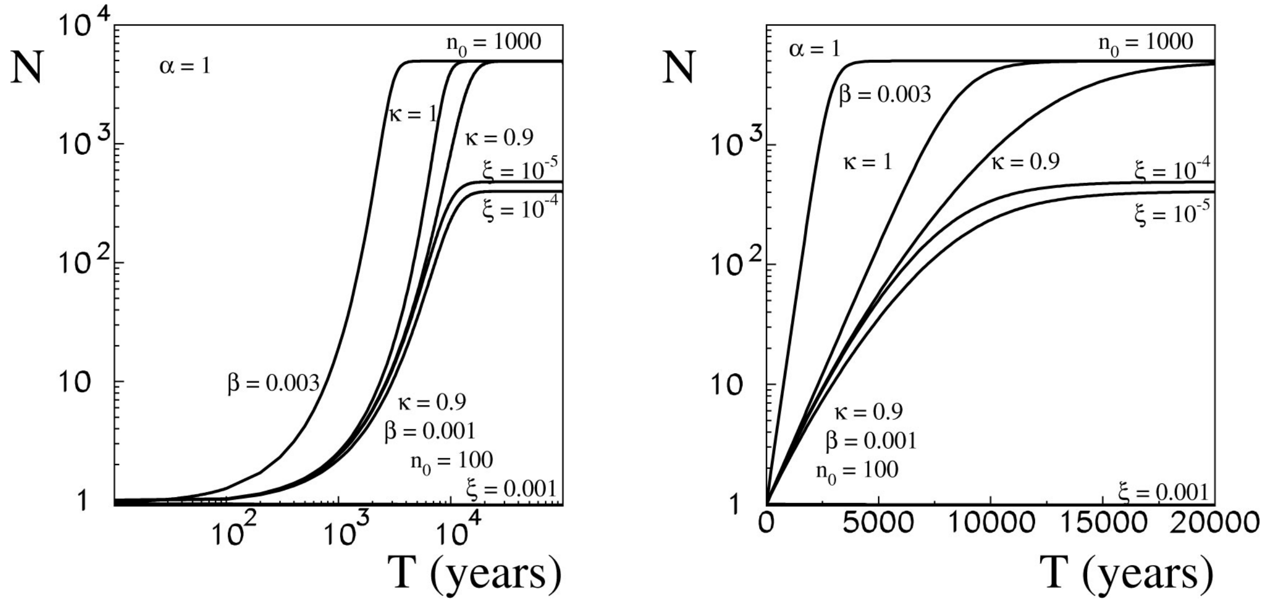


Figure 4: Knowledge development in the epoch of the written word (in both logarithmic and linear scale)

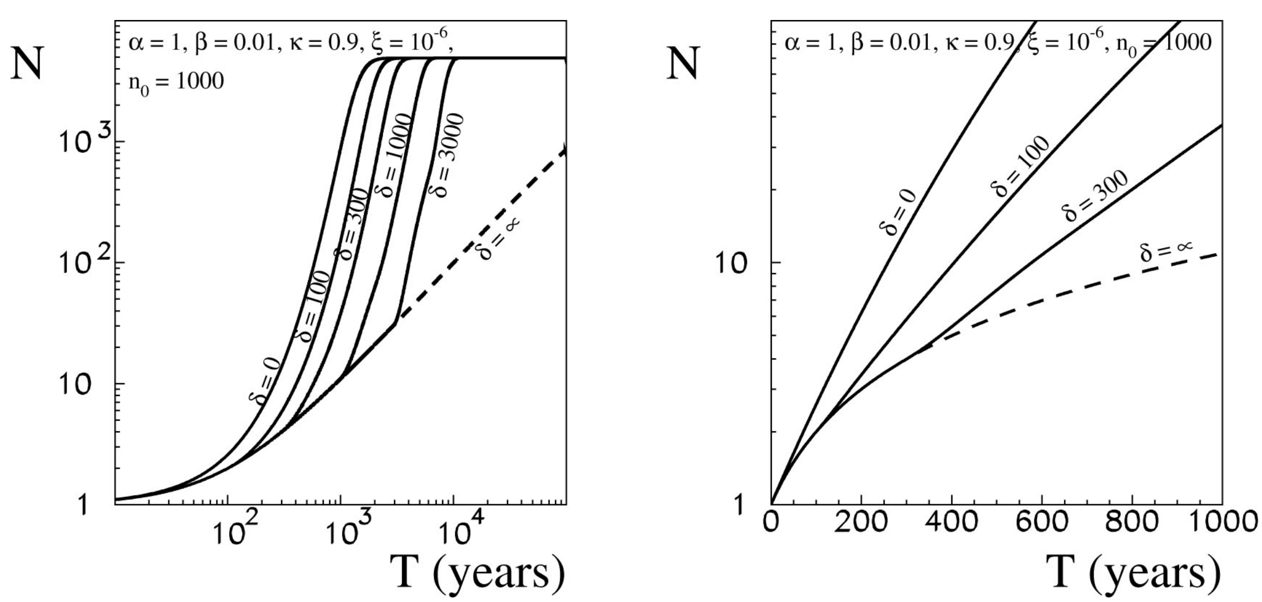


Figure 5: Development of knowledge in the epoch of the written word, depending on the rate of proliferation (time of delay) of new ideas. Dashed asymptotic line stands for the constant increase of knowledge. The remaining curves present the acceleration caused by the increase of knowledge assimilated after time δ.

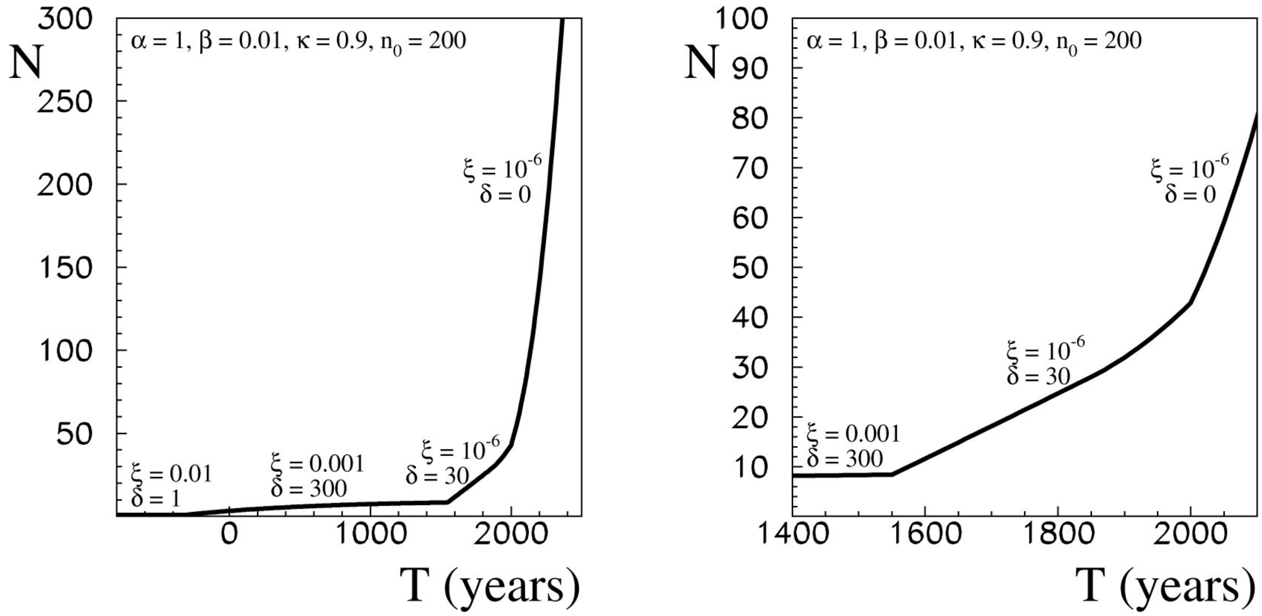


Figure 6: The history of knowledge of humankind in all of the four epochs, with reasonably adjusted values of the parameters. The picture on the right is the magnification of the fragment concerning the ages XV-XXI.

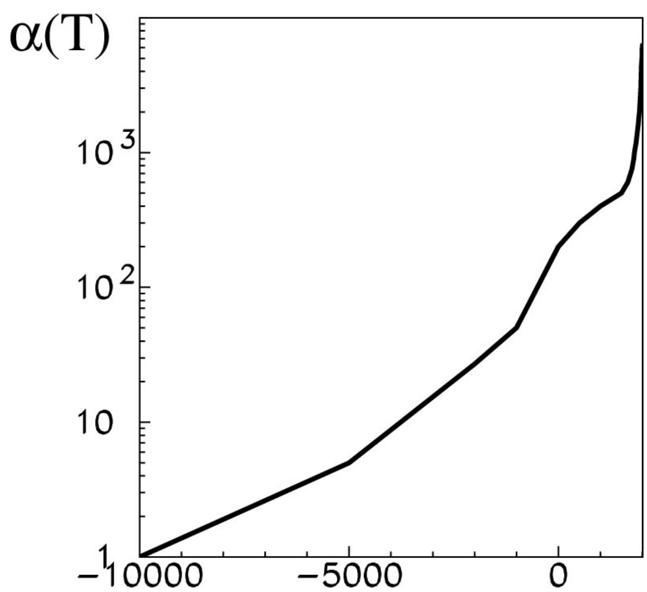
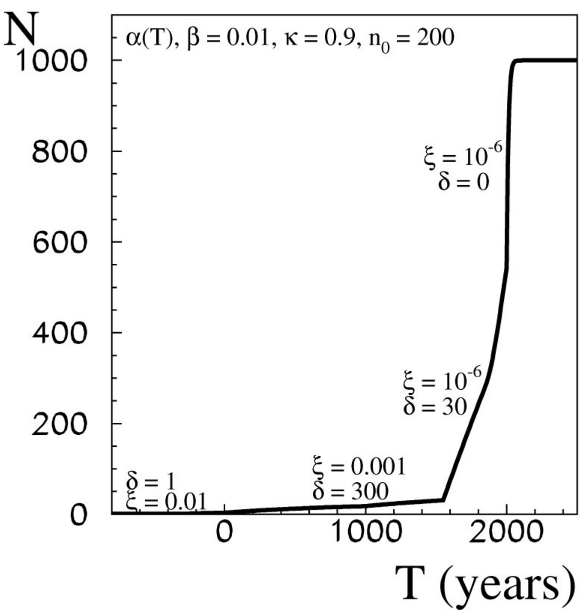


Figure 7: The population of Europe (in millions) over the centuries (Aubuchon 2004).



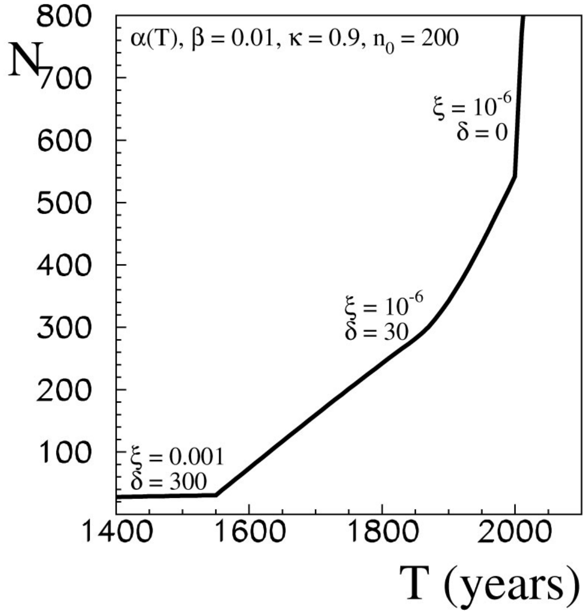


Figure 8: The history of knowledge of the humankind in all of the four epochs, including the demographic growth from Fig. 7. The picture on the right is the magnification of the fragment concerning the ages XV-XXI.

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Exploring internet as a tool for science communication

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This article describes the need and requirement of science communication by scientists and others. The use of internet as a tool for using science communication has been explored in many ways. The channels of science communication are mentioned. The other methods like use of multimedia, television are discussed with the journalism and the use of Internet. The mechanism of web and opportunities and challenges given by it are discussed for communicating science in the new e-environment. The domains of knowledge, skill, habits of mind and the literacy skills are discussed. Collaboration between researchers has become more effective due to science communication via internet. Changes occurring in the practical and economic realities for distributing knowledge have been explained. Future trends in science communication are emphasized at the end of the article.

The various means of communication, even nonverbal ones such as pictures, video clips and music, can become manifest in one way or the other and serve as an object of content analysis (Merten 1995).

The effective communication of science and technology is becoming an essential component of all aspects of social and economic development. In the last few decades, science has delivered dramatic changes globally in human services say, health, survival and life styles. Communicating science to people through mass media is significant challenge in the new millennium. Science communication (SC) has been conceived as popularization to the main business of science. As Hilgartner (1990) describes it, the globally dominant and ascendant view of SC during the last century implied a two-stage model firmly distinguishing the work of producing new knowledge from that of disseminating it: first scientists develop genuine new knowledge; subsequently, communicators carry suitably simplified accounts of it into the public domain. SC has been taken to be a field mostly occupied by neither scientists, nor communicators, or scientists in retirement or scientists who do not fit in their own domain or niche area. Unfortunately, a specialized breed of 'scientists-communicators' (science communicators) that has come up over the period and has to take a lead role to steer SC, which has emerged as a specialized field of knowledge, is ignored in many countries and India is no exception. In Sweden, public communication is still conventionally described as the 'third undertaking' of scientific institutions, an undertaking clearly ancillary to the first two of research and education.

Scientific research is heavily dependent on communication and collaboration. Research does not exist in a bubble; scientific work must be communicated in order to add it to the body of knowledge within a scientific community, so that its members may 'stand on the shoulders of giants' and benefit from all that has come before. The effectiveness of SC is crucial to the pace of scientific progress: in all its forms it enables ideas to be formulated, results to be compared, and replications and improvements to be made. The sharing of science is a foundational aspect of the scientific method. The Internet is likely to become one of the most important means of communication. Science does and has to promote itself, especially in the extremely competitive situation where one has to attract the attention of a public overfed with multimedia content. But if science wants to retain its credibility, it also has to thoroughly redefine its relations with other parts of society (Kalb and Rosenstrauch 1999). Content analysis has established itself as an independent method of empirical social studies. The various means of communication, even nonverbal ones such as pictures, video clips and music, can become manifest in one way or the other and serve as an object of content analysis (Merten 1995). Consequently, content analysis can also be used as a method to systematically examine home pages or sites on the Internet.

One characteristic of the documents is their scientific style. The authors give bibliographical information, and the structure of the text resembles typical scientific texts: abstracts in the introduction, with footnotes and annotations frequently used. Today, the public communication of science and technology is a vibrant field of political invention, in relation to what are now commonly advertised as the 'ethical, legal and social aspects' (ELSA).

Science communication

This article explores the use of web and internet as a tool for SC. SC is the interpretation and presentation of scientific knowledge and scientific results in language accessible to lay audience. Scientific production is "aimed at the advancement of knowledge" and SC is "aimed at bridging the distance between science and the public" (Bensaude-Vincent, 2001). The impetus for bridging this gap is the "political duty in democratic societies to inform citizens". According to Bensaude-Vincent, critics of SC view the gap as an "ideological entity created by science popularizers in order to position themselves as mediators." Burns, Connor and Stocklmayer (2003) defined SC as the use of appropriate skills, media, activities and dialogue to produce one or more of the following personal responses to science:

- Awareness, including familiarity with new aspects of science
- Enjoyment or other affective responses, e.g. appreciating science as entertainment or art
- Interest, as evidenced by voluntary involvement with science or its communication
- Opinions, the forming, reforming, or confirming of science related attitudes
- Understanding of science, its content, processes, and social factors

SC has been defined as an effective source of moulding public opinion for positive change. In Indian context, SC must be in the process of simplification which is described by Bharatmuni as 'sadharanikaran' - process of simplification. Gautam Buddh described it as 'Bahujan Hitaya' and 'Bahujan Sukhaya' which means it must be in tune with the welfare of masses (Dharurkar 2009). SC channels include scientific journals, print and online media, public presentations, lectures, video, interactive centers, public museums and places of interest, Internet, world wide web and others.

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Multimedia

For the vast majority of adults, the media constitute their main source of information about science and, significantly, about science-related matters, which impact upon society (Brossard and Shanahan 2006). Science education reform movements, worldwide, are stressing the need for science programmes, among their other aims, to prepare students to engage with science in the contexts they will encounter in later life. Typically, this is taken to include equipping, and thereby empowering, young people to engage critically with the reporting of science in the media (Council of Ministers of Education, 1997).

Television

Almost every household in developed countries and every village in every developing country today has a TV set. Programmes that are oriented to those with a strong interest in SC, for example *Horizon* in the UK, can do an excellent job in presenting the natures of science and technology because of their capacity to present experts and their ready use and juxtaposition of actual phenomena, models, and animations.

Science journalism and the internet

Web began in 1989 as a collaborative project designed to make communication easier among scientific researchers around the world (Marlow 1996). E-mail also was used early and frequently in the scientific community to facilitate communication (Aborn 1988). This early use of the web and e-mail among the scientific community makes the science "beat" an interesting one to explore. Today, e-mail use is pervasive, with users ranging from major corporations to academic institutions (Hunter and Allen 1992). Journalists are making the web part of their daily routines and in so doing are reshaping the profession. Garrison's (2000) most recent study examined journalists' use of the world wide web for news gathering and discovered a significant growth in the use of the web.

> *People who are digitally literate know how to use "specialized tools [and skills] for finding digital information" (e.g., Internet search engines and Boolean commands) and know "how digital information is different from print information"*

Internet

The internet is a powerful disruptive force and acting as a medium. There are plenty of excellent web sites in which scientific information is being archived, discussed and explained, and which are used by scientists as research tools or by researchers, students, policymakers, medical doctors, insurers, designers and others. The popularity of the Internet has challenged many core assumptions about relationships between sources, mass media, and audiences in many areas of communications but perhaps most dramatically in the area of SC (Treise and Weigold 2002).

Because of the ease and cost effectiveness with which information can be posted on the web, the number of sites has exploded over the past ten years. For consumers of science information, the web presents both opportunities and challenges. By entering terms into a search engine, consumers may quickly discover that there are hundreds or even thousands of sites that offer science information with the click of a mouse. Flanagin and Metzger (2000) found that their survey respondents viewed online information to be as credible as that found in television, radio, and magazines but less credible than information found in newspapers. Sundar (1999) investigated the criteria respondents use in rating print and online news stories by having college students read print or online stories and then rate them using twenty-one adjectives, including accurate, believable, interesting, relevant, sensationalistic, well written and others.

The Association of College and Research Libraries (ACRL, 2000) has recognized information literacy as a six stage process. First, an adult has to determine the nature and extent of information that is needed. Second, he or she should be able to access the information effectively and efficiently; third, evaluate the information and its sources critically; and fourth, incorporate selected information into his or her knowledge base and personal value system. At the fifth stage, the person should know how to use the information effectively to accomplish a specific purpose; and by the sixth, understand the economic, legal, ethical, and social issues surrounding information access and use. Digital literacy - a type of information literacy - demands a certain degree of fluency in a digital information environment. People who are digitally literate know how to use "specialized tools (and skills) for finding digital information" (e.g., Internet search engines and Boolean commands) and know "how digital information is different from print information"

Scientists are socialized into a world in which communication via the internet is 'natural'. Communication is the engine of science, accounting for an increasing amount of scientists' time and increasingly taking place over the internet. From posting calls for research proposals on the web, through conferring with partners on a proposal by email, to the joint production, online submission and online review of the proposal via email and attachments, and on to the confirmation of the decision on the proposal, research projects or programmes can be / and are established over the internet, without a face-to-face meeting or any paper changing hands. Very many of the routine activities of scientists are facilitated over the internet: calls for papers, editing of journals, hosting of conferences, sharing of data, authoring of papers, publication of conference proceedings and journals, and many more informal exchanges and encounters.

Research and academic libraries have also driven the development of the institutional repository model of networked publishing of papers generated from within their communities; these papers are now shared in a manner that attenuates the journals' control of the material generated from within those institutions. Some of the sites maintained by scientific institutions or funders also present the source material on which the news item is based, or link their news reports to the relevant journal papers. Even where the links are not made directly, the more experienced web user can trace news media reports back to their proximate sources (press releases) and more remote sources (journal papers), thus laying bare the interpretation and reinterpretation in the processes of public dissemination.

One can use Google and other search engines to discover information about anything on the internet, but our search skills probably do not match our lack of patience and need to know things fast.

Collaboration

The internet facilitates collaboration between researchers on an effectively global scale across cultural, geographical and disciplinary boundaries; the internet also brings with it accelerated specialization or 'balkanisation' within the sciences (Van Alstyne and Brynjolfsson 1996), as a sub-specialist who may be one of a kind in her own face-to-face community can interact with someone else in the same sub-specialism in any other part of the world. The internet operates as a means of collaboration, but also to facilitate and foster intensified competition, between institutions presenting their achievements over the web, between discipline niches networking by email, and between individuals arguing in online discussion groups. 'Access to the web has opened up many aspects of scientific research previously hidden from the general public,' it has been claimed (Peterson 2001).

The internet has fundamentally changed the practical and economic realities of distributing scientific knowledge and cultural heritage. For the first time ever, the internet now offers the chance to constitute a global and interactive representation of human knowledge, including cultural heritage and the guarantee of worldwide access (Berlin Declaration 2003). The Declaration aims 'to promote the internet as a functional instrument for a global scientific knowledgebase'. Internet users, whether scientists, scholars, students or others, can find resources through direct access to publishers' sites, or through portal services such as Stanford University's High Wire, Lund University's Directory of Open Access Journals, and PubMed Central, an open archive of literature from the biomedical and life sciences. Some of the sites maintained by scientific institutions or funders also present the source material on which the news item is based, or link their news reports to the relevant journal papers. Even where the links are not made directly, the more experienced web user can trace news media reports back to their proximate sources (press releases) and more remote sources (journal papers), thus laying bare the interpretation and reinterpretation in the processes of public dissemination.

Current trends

Scientific research papers are many and some are freely available also, through excellent scientific news websites and blogs which report and analyze peer-reviewed research, some of which use a tool called Research Blogging (e.g. www.researchblogging.org). Many of these sites are interactive, so that users can ask questions and otherwise comment. There are good online reference sources, though free ones such as Wikipedia (www.wikipedia.org) are more attractive to most people than subscription reference sources, which may be more accurate. One can use Google and other search engines to discover information about anything on the internet, but our search skills probably do not match our lack of patience and need to know things fast.

Conclusion

Science communication as a professional field of communication receives more and more attention in various countries throughout the world. SC professionals try to get the lay audience and other stake - or shareholders, like industry and government, involved or engaged in the early developments of science and technology via dialogue programs, debates, science centers, educational processes, and media exposure. SC is important from a democratic, economical, and cultural perspective. Scientific websites still do not seem to appeal to a clearly defined target group. The majority of the web sites still cater to the interests of their own scientific community. This sort of communication is important indeed, but from the point of view of public relations trying to appeal to a general audience, science must not stop at this point. Institutional policies are more or less restrictive on their individual members and more or less responsive to public contributions. The internet facilitates personal communication as well as formal, institutional communication, and this too is extensively represented in science through the use of newer internet technologies such as weblogs (blogs) to present individual views and facilitate open discussion. The internet facilitates multimedia, effective communication as well as text or numbers based dissemination of technical information, and this is represented by the use of podcasts on some science sites. Professionals should explore the ways and means to utilize the e-resources available by using the internet.

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Communication links distributed over Middle East: A project work

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In this project, the behavior and correlation between High Possible Frequency (HPF) and Optimum Maximum Usable Frequency (OPMUF) parameters for communication links distributed over Middle East region were studied. A mutual correlation equation between the two parameters has been suggested. The analytical tests of the monthly and annual variation of the (HPF) and (OPMUF) parameters have been conducted for gathered theoretical dataset which were calculated using VOACAP and REC533 international HF models for the solar activity year 2000. According to the results of this test, the correlation between the two parameters is simple and can be expressed by a linear regression formula. The predicted values using the suggested equation gave a good fitting with the theoretical values generated from the international HF communication models.

The ionosphere is the region of the Earth's atmosphere extended from 60 to 1000 km. In this region free electrons and ions can exist for a considerable period of time, resulting charged particles. The ionosphere layer is depending on the electron density, so this layer is subdivided into four layers: D-layer (60 to 90 km.), E and E_s layers (90 to 140 km.), F1 and F2 layers (140 to 420 km.) and topside layer (420 to 1000km.) [1].

The Highest Possible Frequency (HPF) and Optimum Maximum Usable Frequency (OPMUF) are two of the ionospheric parameters. The (HPF) is defined as "the highest possible frequency can be reflected from the ionosphere layer". It is working the upper usable limit exceeded 3 days per month. The (OPMUF) is defined as "the effective optimum maximum usable frequency can be reflected from the ionospheric layer".

As these parameters strongly depend on the ionization level of the F-layer, so the values of these parameters increase at strong solar activity and conversely occur during a week of solar activity and the ionospheric parameters' values decrease [2]. The HPF & OPMUF are important to determine the best highest frequency that maintains the link between two locations.

Radio communications

Radio waves are electromagnetic waves of frequency range from 3 Hz to 300 GHz. The propagation of radio waves through the ionosphere is relevant in all modern forms of communication. The earliest form of radio communication used High Frequency (HF) of the type experimented upon by Hertz and Marconi-waves having frequency range (3-30 MHz) [3]. Ionosphere layer is very important for high frequency communications which are reflected from the ionosphere layer to the surface of the earth. The most useful way to perform systematic measurements in the ionosphere is to use HF waves. The use of HF radio spectrum continues to grow for both civil and military purposes as for HF signals which use ionospheric refraction from point to point is known as sky wave propagation.

The sky waves are of great importance for very long distance radio communication. These waves are affected by characteristics of ionized layer at least three ways [4]. Firstly under suitable conditions, charge particles can remove energy from sky waves and thus lead to attenuation for these waves. Secondly the sky waves traveling from one place to another in which the electron density is different will undergo a change in its direction of propagation, due to the effect of electron density. Thirdly the ionization layer has no ability to reflect the sky waves because these waves have enough energy to penetrate ionosphere layer, as shown in figure (1).

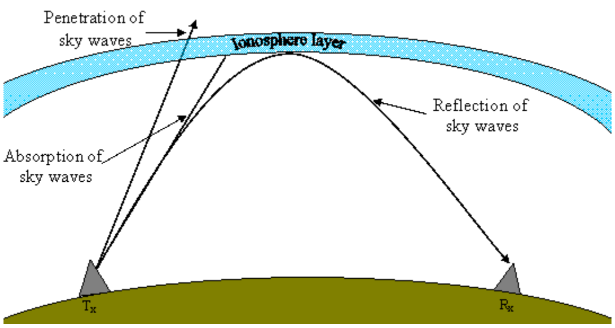


Figure 1: Propagation of sky waves

The International Telecommunications Union (ITU) has therefore played the lead role in establishing international standard models for ionospheric characteristics. On advice from its International Radio Consultative Committee (CCIR) and, more recently, its Radio Communication Sector (ITU-R), ITU has issued a standard set of models [CCIR, 1966, 1991; ITU-R, 1997]. These CCIR models and related software are available from ITU [5]. Most communication models intended for direct reception by the general public. There exists a large number of broadcasting stations in HF band which are also known as "world band radio". Until recently, analog modulation techniques have been employed for broadcasting in HF band.

HF communication models

In this project the "VOACAP" and "REC533" international HF communication models have been adopted to predict the expected performance of high frequency band. Most of broadcasting stations in the world (British Broadcasting Corporation (BBC), United States International Broadcasting (USIB) and others) use VOACAP and REC533 models because they represent last and best models to analyse HF band.

In 1985, the Voice of America (VOA) adopted the Ionospheric Communications Analysis and Prediction Programme. The name was changed to the Voice of America Coverage Analysis Programme (VOACAP) to distinguish it from the official "National Telecommunications and Information Administration" (NTIA) "IONCAP" programme. The development of VOACAP was accomplished for VOA by the Naval Research Laboratory and the Institute for Telecommunication Sciences (Department of Commerce, NTIA) [6]. This recommendation 533 model was made available to the ITU in July 1993 by Working Party 6A (WP6A). It was developed and was maintained by the United States Department of Commerce, National Telecommunications and Information Administration, Institute for Telecommunication Sciences (NTIA/ITS) [7]. VOACAP and REC533 models provide a global status of the ionosphere and the range of usable HF for a specified path between transmitter and receiver stations.

Tests and results

The aim of this project work is to study the behavior and correlation between High Possible Frequency (HPF) and Optimum Maximum Usable Frequency (OPMUF) parameters for the communication links between the transmitting and receiving stations over Middle East region. The year of 2000 has been taken as a year of study, because the selected year represents a maximum active cycle of the solar cycle 23. The monthly sunspot numbers of the selected year are shown in table (1):

Table 1: Monthly sunspot number of the solar year 2000.

Month	Sunspot Numbers (SSNs)
Jan	90.1
Feb	112.9
Mar	138.5
Apr	125.5
May	121.6
Jun	124.9
July	170.1
Aug	130.1
Sep	109.7
Oct	99.4
Nov	106.8
Dec	104.4

The Middle East region has been adopted as a region of study, and the capital Baghdad was considered as a transmitting station while other 35 different locations which are spread around Baghdad have been considered as receiving stations. The geographical locations (latitude and longitude) and distance of the selected receiving stations were listed. In this project the international communication model "VOACAP" has been used to calculate the dataset of the HPF parameter, while the dataset of the OPMUF parameter has been determined using the "REC533" international communication model. Table (2), shows samples of the output dataset of the (OPMUF) & (HPF) parameters from the execution of the picked international models for the link.

Table 2: Samples of the dataset of the (OPMUF) & (HPF) parameters.

OPMUF (REC533) (Baghdad – Van)												
Time	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.
0	6.7	8.4	11.3	12.9	12.8	12.7	13.1	11.3	10.3	9	8.3	7.3
1	7	8.4	11	12.5	12.4	12.2	12.6	11.1	10	9	8.5	7.5
2	7.4	8.6	10.6	11.9	11.9	11.5	12.1	10.7	9.7	8.9	8.7	7.7
3	7.2	8.4	9.9	11.1	11.4	10.9	11.4	10.1	9.2	8.4	8.2	7.3
4	6.3	7.4	9	10.5	11.1	9.8	10.1	9.8	8.6	7.7	7.3	6.3
5	5.6	6.7	8.8	10	10.6	10.2	10.5	9.4	9.1	8	7.2	5.9
6	5.8	7.2	9.6	11.5	11.6	11.2	11.6	10.7	10.2	9.4	9	7.2
7	8.1	10.2	12.6	13.6	12.8	12.1	12.5	12	12.6	12.4	11.7	9.5
8	11.5	14	15.9	15.5	13.5	12.4	12.6	12.7	14.2	15	15.2	12.9
9	14.6	16.9	18.1	16.6	13.8	12.4	12.4	12.7	14.8	16.4	17.6	15.6
10	16.3	18.1	18.9	17.3	14	12.5	12.6	13	15	16.9	18	17
11	16.4	18.3	19.2	18.1	14.7	13	13.3	13.7	15.3	16.9	18.3	17.2
12	15.8	18	19.3	18.8	15.5	13.6	14	14.4	15.5	16.7	17.9	16.4
13	15.4	17.8	19.1	19	15.9	13.9	14.5	14.6	15.5	16.6	17.6	15.5
14	15.2	17.6	18.6	18.6	15.7	13.7	14.5	14.4	15.4	16.6	17.4	15.1
15	14.9	17.6	18.2	18.1	15.3	13.3	14.1	14.1	15.3	16.6	17.3	14.9
16	14.2	17.4	17.9	17.7	14.9	12.9	13.6	13.8	15	16.3	16.6	14.5
17	12.9	16.6	17.3	17.3	14.5	12.9	13.4	13.5	14.5	15.3	15.2	13.2
18	12.1	14	15.9	16.3	14.1	12.7	13.3	13.1	13.6	13.7	13.1	11.5
19	10.1	13.5	15.5	15	13.4	12.4	13	12.7	12.5	13	12	10.7
20	8.3	11.2	13.9	14.9	12.6	11.9	12.5	13.2	12.3	11.3	10.4	9.4
21	7.3	9.7	12.9	14.1	13.3	12.7	13.4	12.5	11.5	10.1	9.5	8.5
22	6.9	9	12.1	13.6	13.1	12.8	13.5	11.9	10.9	9.5	8.9	7.9
23	6.7	8.6	11.6	13.3	13	12.9	13.4	11.6	10.6	9.2	8.5	7.5

HPF (VOACAP) (Baghdad – Van)												
Time	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.
0	6.41	7.16	9.92	11.4	11.7	11.5	12.5	10.3	9.08	8.5	7.12	6.32
1	6.73	7.22	9.67	11	11.35	11	12.1	10	8.9	8.48	7.28	6.47
2	6.54	7.34	9.43	10.5	10.97	10.4	11.6	9.67	8.71	7.99	7.5	6.58
3	6.35	7.12	8.79	9.83	10.48	9.86	11	9.2	8.18	7.52	7.13	6.25
4	5.56	6.33	8.02	9.35	10.21	9.6	10.6	8.9	7.73	6.92	6.36	5.44
5	4.94	5.75	7.84	9.62	10.54	9.98	10.9	9.27	8.15	7.2	6.24	5.08
6	5.27	6.54	9.24	11.1	11.62	12.4	13.6	11.9	9.9	9.08	7.85	6.08
7	7.29	9.13	12.1	13	12.74	13.3	14.5	13.3	12.1	11.9	10.9	8.57
8	10.2	12.5	15.2	14.7	13.34	13.6	14.5	13.9	13.6	14.4	14.1	11.6
9	12.9	15	17.1	15.6	13.5	13.4	14.2	14	14.1	15.6	16.2	14
10	14.6	15.4	17.7	16	13.51	13.1	14.1	13.8	14.1	16.2	16.7	14.6
11	14.6	15.6	17.9	16.6	14.08	13.7	14.8	14.5	14.2	16.2	16.5	14.6
12	14.1	15.3	17.8	17.2	14.81	14.3	15.6	15.2	14.4	16	16.2	14
13	13.7	15.1	17.8	17.6	15.32	14.7	16.2	15.5	14.5	15.8	15.8	13.2
14	13.6	14.9	16.8	16.8	14.72	13.6	15.3	14.4	13.9	15	15.2	12.8
15	13.3	14.9	16.4	16.3	14.35	13.3	14.9	14.1	13.8	15.1	15.1	12.8
16	12.7	14.8	16.2	16	13.97	13	14.4	13.8	13.6	14.9	14.6	12.4
17	11.7	14.3	15.7	15.6	13.72	12.9	14.1	13.5	13.2	14	13.4	11.5
18	11.5	13.5	14.8	15.1	13.59	12.5	13.7	12.9	12.7	13.3	11.9	10.6
19	9.63	11.4	13.4	14	12.98	12.2	13.4	12.6	11.7	11.7	10.1	9.13
20	7.96	9.51	12.1	12.9	12.34	11.8	13	12.1	10.8	10.2	8.84	8.01
21	6.99	8.27	11.2	12.2	11.95	11.7	12.8	11.5	10.1	9.14	8.06	7.24
22	6.56	7.72	10.7	11.9	11.94	11.6	12.8	10.8	9.68	8.95	7.64	6.8
23	6.4	7.37	10.2	11.6	11.89	11.6	12.8	10.5	9.35	8.66	7.26	6.45

In this project an analytical study for the gathered theoretical dataset of the two parameters has been conducted to examine the probability of getting a mutual correlation between the HPF & OPMUF parameters. In order to investigate the correlation between the selected parameters, the study has been made in two parts (periods). The first one was made for the monthly median values of the HPF and OPMUF parameters for the 24 hours of 12 months. Fig. (2) shows a sample of the scatter plot between the HPF & OPMUF values for the link.

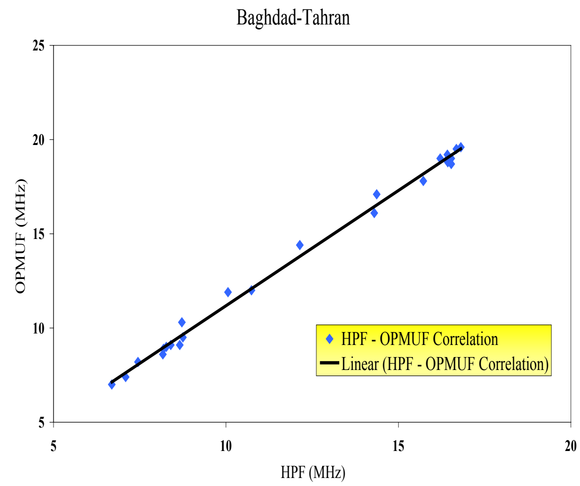


Figure 2: Sample of monthly correlation between HPF& OPMUF

The second part was made to investigate the correlation between the two parameters between Baghdad and other receiving stations for the **annual** variation of all months of the year 2000. Fig. (3) presents sample of the annual correlation for the link.

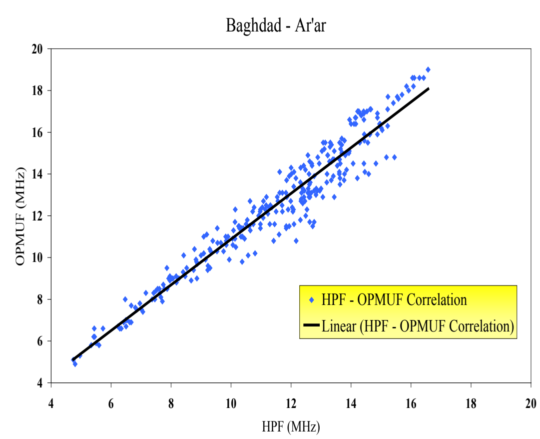


Figure 3: Sample of the annual correlation between HPF and OPMUF

It's clear from the scatter plot of the monthly and annual behavior tests between (HPF and OPMUF) parameters that shown in figures (3) and (4), the correlation is simple and can be expressed as a linear regression correlation, so the suggested mutual correlation equation between the studied parameters can be presented by the following simple equation:

$$OPMUF = \sum_{n=0}^{n=1} a_n (HPF)^n$$

Table (3) show samples of the coefficient values (a_o and a_1) that resulted from the analytical test of the monthly variation between the HPF and OPMUF parameters for 12 months and different links.

Table 3: Correlation coefficients for the monthly analytical test.

Baghdad-Van				
Month	a_o	a_1	R^2	MSE
Jan	- 0.3962	1.1417	0.9949	0.2
Feb	- 0.0471	1.1624	0.9907	
Mar	0.8349	1.0357	0.9879	
Apr	0.6696	1.0498	0.9766	
May	1.0017	0.9746	0.9305	
Jun	5.2328	0.5796	0.6365	
Jul	5.0213	0.5805	0.6142	
Aug	4.0047	0.6797	0.8395	
Sep	0.9789	1.0057	0.9826	
Oct	0.4478	1.0336	0.9907	
Nov	0.7379	1.0616	0.9944	
Dec	0.0142	1.1553	0.9954	

Baghdad- Aleppo				
Month	a_o	a_1	R^2	MSE
Jan	- 1.0692	1.1437	0.9978	0.19
Feb	-1.1176	1.2217	0.9939	
Mar	-1.2348	1.1833	0.9898	
Apr	-2.1006	1.2383	0.9752	
May	-1.9623	1.1894	0.903	
Jun	2.9811	0.789	0.7638	
Jul	2.4007	0.7952	0.7588	
Aug	2.8833	0.7998	0.8851	
Sep	-1.4627	1.2061	0.9782	
Oct	-0.1433	1.0603	0.9901	
Nov	-0.7895	1.1991	0.9967	
Dec	-0.9311	1.2114	0.9938	

Baghdad- Tehran				
Month	a_o	a_1	R^2	MSE
Jan	0.8092	0.8815	0.9971	0.17
Feb	0.9131	0.8136	0.9949	
Mar	1.0532	0.8437	0.9881	
Apr	1.5192	0.8156	0.9776	
May	2.5331	0.7754	0.9245	
Jun	-0.9997	1.0619	0.7988	
Jul	-0.0973	1.0421	0.7726	
Aug	-2.0522	1.1405	0.9194	
Sep	1.2731	0.8235	0.9838	
Oct	0.3031	0.93	0.9953	
Nov	0.6852	0.8328	0.9358	
Dec	0.9709	0.808	0.9947	

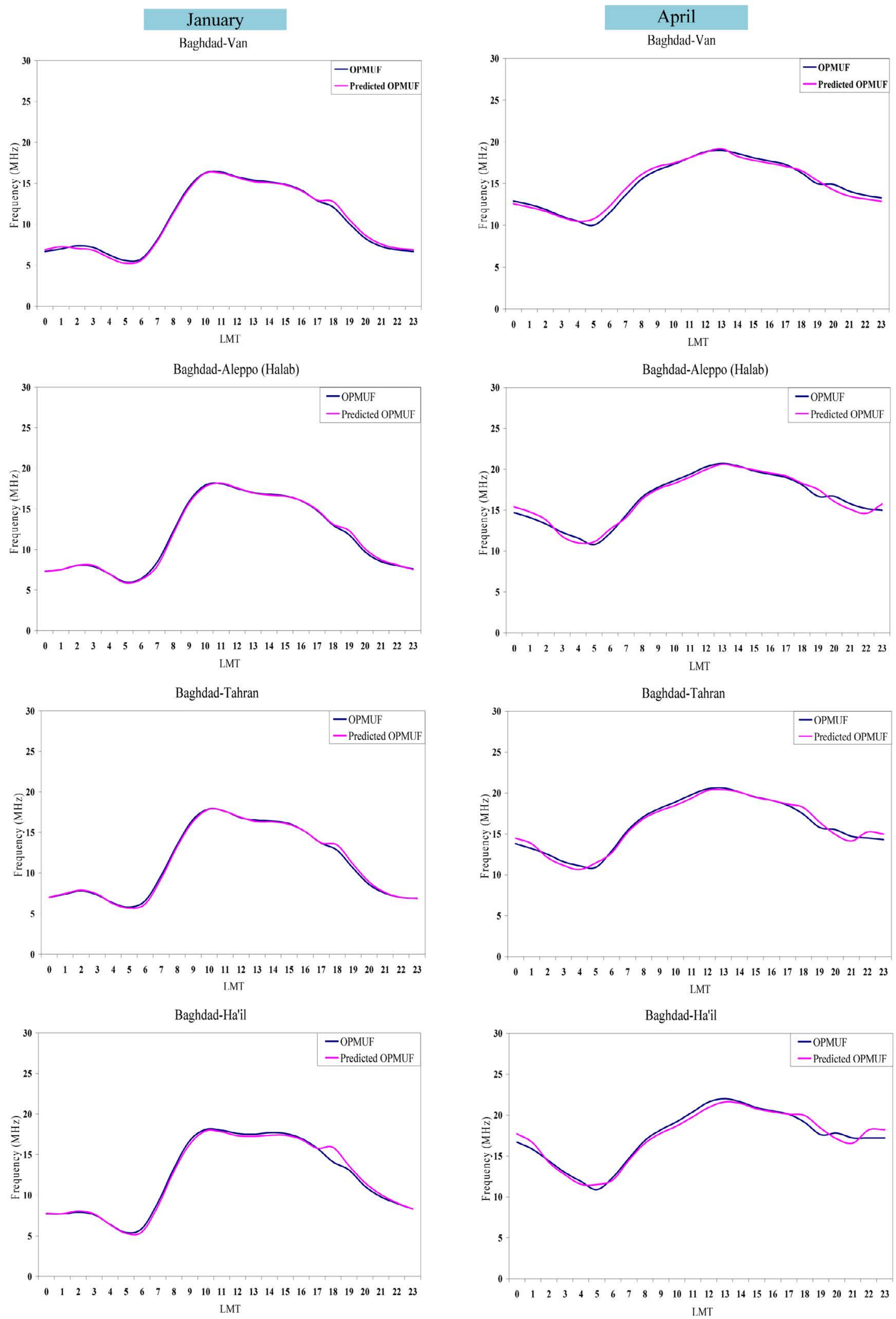
Samples of the predicted monthly values of the OPMUF parameter that have been calculated using the suggested formula (Predicted OPMUF) and the theoretical monthly values obtained from the execution of the international model (REC533) are presented in Fig. (4) for different months and different sites.

Table (4) shows the annual correlation coefficients for the mean value of the annual variation between the HPF & OPMUF parameters for the thirty five selected sites (receiving stations).

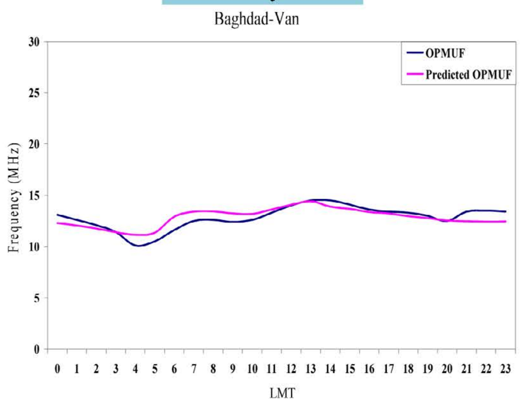
Table 4: Annual correlated equations for selected receiving locations.

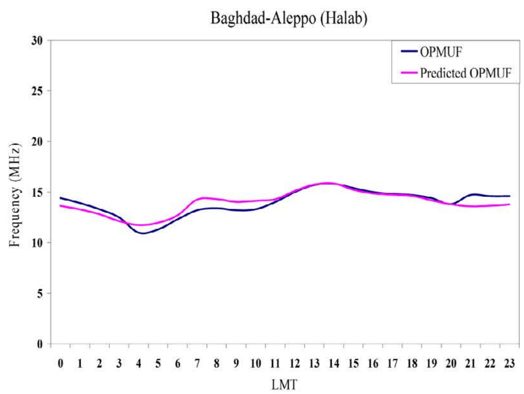
Station Name	a_o	a_1	R^2
Al-Abilah	- 0.6865	1.1053	0.937
Al-Aqabah	- 0.8511	1.1106	0.9327
Aleppo (Halab)	- 0.5208	1.1058	0.9349
Al-Hazakah	- 0.1409	1.0946	0.933
Al-Jawf	- 0.2558	1.0976	0.9338
Al-Jufur	- 0.2793	1.1003	0.9295
Al-Qatif	- 0.7364	1.105	0.9373
Al-Raqqah	- 0.3329	1.1054	0.9339
Amman	- 0.6441	1.1083	0.9337
Ar'ar	- 0.0686	1.0948	0.9348
Ba'ar	- 0.6458	1.1114	0.9344
Buraydah	- 0.5496	1.1046	0.9389
Dayr Alzawr	- 0.0787	1.0927	0.9334
Demascuse	- 0.5647	1.107	0.9341
Diyarbakir	0.833	1.002	0.9195
Erzurum	0.7473	1.0033	0.9225
Ha'il	- 0.4437	1.1038	0.9377
Hamadan	- 0.061	1.0938	0.9349
Hamah	-0.5432	1.1077	0.9353

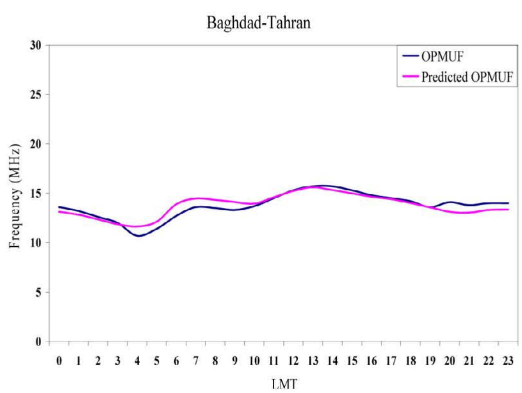
Figure 4: Samples of monthly theoretical and predicted OPMUF

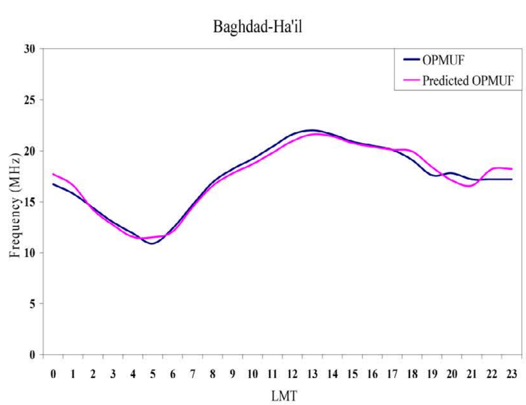


July

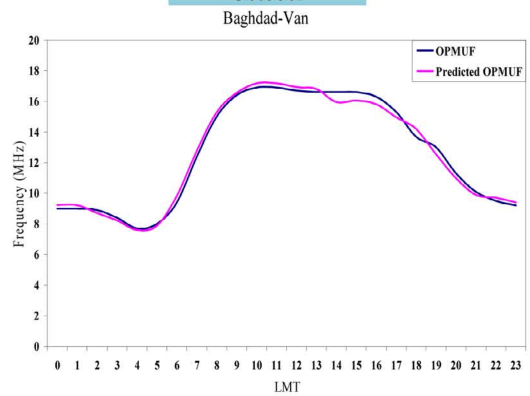


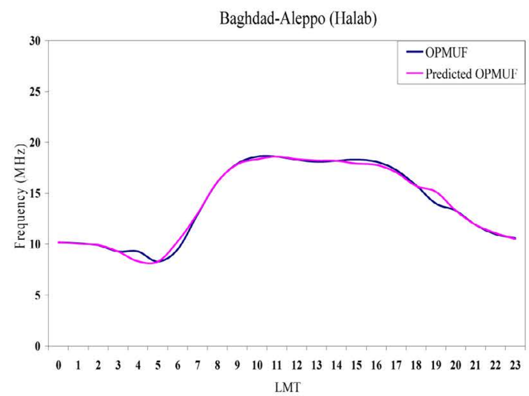


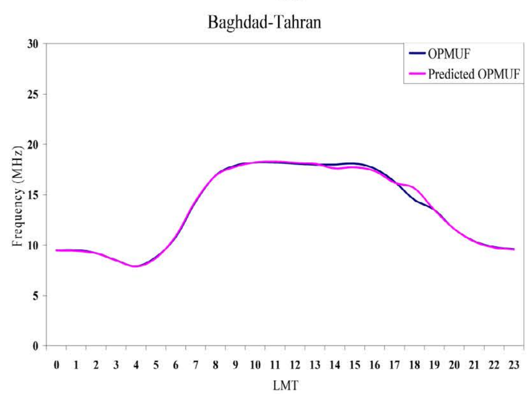


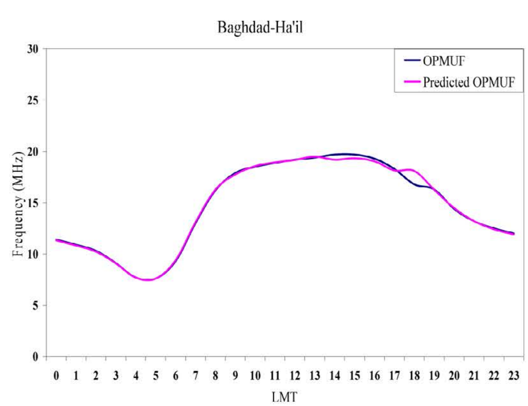


October









Isfahan	- 0.4176	1.1019	0.9402
Izmir	0.3301	1.0248	0.917
Karmanshah	0.1157	1.0803	0.9329
Kharma	- 0.6889	1.105	0.9361
Kuwait	- 0.3546	1.1044	0.94
Macca	- 1.6073	1.1295	0.934
Mahabad	1.0749	0.973	0.915
Malatya	0.8571	0.9956	0.9204
Masjed Sul.	- 0.1688	1.0973	0.9369
Riyadh	- 0.8865	1.1105	0.9402
Shiraz	- 0.6563	1.1051	0.9419
Tabriz	0.8955	0.9976	0.9218
Tabuk	- 0.8896	1.1164	0.9346
Tadmur	- 0.3625	1.1064	0.9337
Tehran	-0.4619	1.103	0.9412
Tayma'a	- 0.7875	1.1159	0.9364
Van	0.8903	0.9976	0.9217
Zanjan	0.9443	0.995	0.9221

Fig. (5), show samples of the variation (fitting) between the calculated values of the annual predicted OPMUF that have been determined using the suggested formula and the annual theoretical OPMUF values that have been calculated using the REC533 international model.

Conclusions

It's obvious from the analytical study that has been made for the dataset of the HPF and OPMUF parameters that the two parameters have the same behavior and consequently the correlation relationship can be conducted between them. The monthly and annual tests of the correlation between the two parameters show that the mutual correlation is simple and can be represented by a simple linear regression equation. The correlation coefficients show that the suggested equation can give a good fitting between the two parameters standing on the values of the (R^2) and the MSE which were within the accepted range. A monthly variation of the correlation between the theoretical and predicted OPMUF values for the months (January, April, July, and October) for the link (Baghdad-Van) was recorded. The shapes show a good fitting between the two curves for the months (January, April, and October) and a little variant in (July) that may due to the high solar activity during

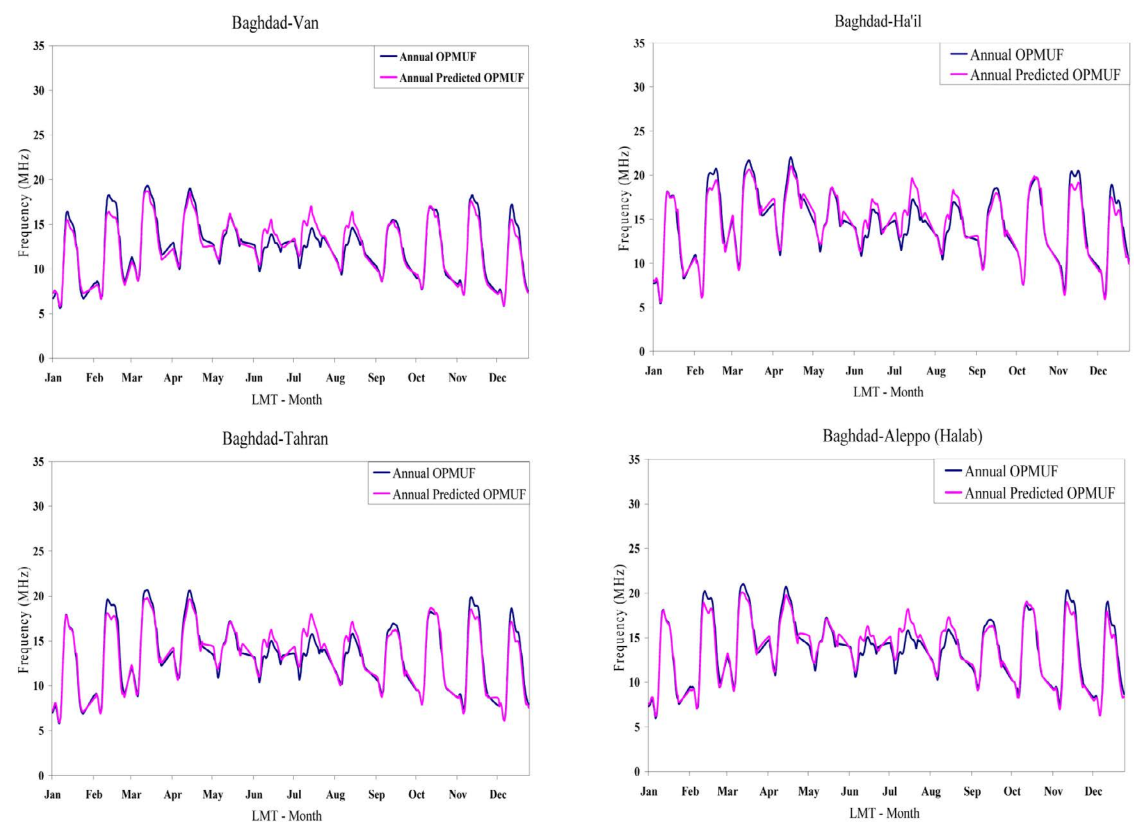


Figure 5: Sample of annual theoretical and predicted OPMUF

the summer time. An annual variation of the correlation between the theoretical was observed and predicted OPMUF. The presented figures show that the correlation between the two parameters is good, so it gives generally mean square error (MSE) equal to (0.9102). According to the above, the following conclusions can be drawn:

1. The behavior of the two parameters is same, so the relationship is simple and the mutual correlation can be conducted.
2. The analytical study has been made for monthly and annual tests, in order to investigate the accurate correlation between the two parameters for different months and different directions to cover the studied region.
3. The suggested equation was simple (simple regression equation) gave good results as compared to the theoretical data obtained from execution of two latest modern HF international communication models.

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- Editor

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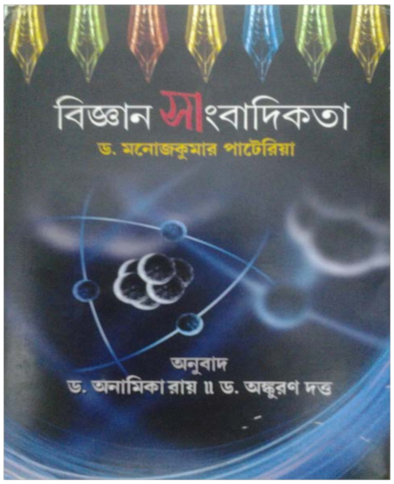
Science journalism in Bengali *'Vijnan Sangbadikata'*



Vijnan Sangbadikata by
Dr. Manoj Kumar Patairiya
Bengali Versioning:
Dr. Anamika Ray and Dr. Ankuran Dutta
Published in 2013 by Vicky Publishers, Guwahati

Science journalism in Bengali is well developed may be because of the fact that Kolkata remained the centre for science and its propagation for a long time in modern India. The urge for scientific explorations as well as sharing its excitement with the public has been very common throughout. Similarly, a number of literary works sprung over the period from this part of land. A combination of creativity driven science and literature has been able to lay down the foundation of rich science communication culture. It is for that reason, not only science popularization movements became very active, but mass media and literati also found the way for overwhelming progress in science fiction as well.

The book Hindi Vigyan Patrakarita by Dr. Manoj Kumar Patairiya was first published in 1990 incorporating a chapter on science journalism in Indian languages including a major portion in Bengali. Since then, a number of activities have taken place and varieties of publications have been brought out. Science communication and science journalism have also seen a number of new trends and have been evolved tremendously to cater to various cross sections of the society. However, always remains scope for creativity and progress to achieve accomplishment in any area so as in science journalism.

The present Bengali version of the book is an attempt to spread the understanding of science journalism in general and trick of the trade in particular, especially those who are in search of such material and want to shape their career or profession in science journalism or science communication. Dr. Saroj Ghose, a well-known celebrity in science communicator and architect of the concept of modern science centres and science cities in India has written the foreword of the book. Dr. Ghose is known for his monumental contribution to the field of science museums not only in India but also across the world. Dr. Anamika Dutta, Assistant Professor, Guwahati University and Dr. Ankuran Dutta, Associate Professor, K.K. Handique Open University, Guwahati have translated and transformed the original book written by Dr. Manoj Kumar Patairiya, into its present form for the benefit of Bengali readers.

It is hoped, that like earlier versions of the book in Hindi and Tamil languages, the Bengali version of the book would be welcomed by one and all, especially the science and journalism enthusiasts. The book is going to come in major Indian languages in near future and will be serving as a potential resource on the subject to serve the science journalist fraternity and will help bring about positive changes the way science is reported and finds space and time in mass media. The present Bengali version will be useful for science communication teachers and students as its other languages' versions and editions were largely found valuable by them. Collectively, we should be able to bring about a new wave of qualitative science journalism in the country, and this humble effort in the form of this book is going to form a firm base for it.

[Mr. Tarun Banerjee, Oasis, N Block, Sector 12, Noida, U.P.]

14th Indian Science Communication Congress (ISCC-2014): A Report

Prof. B.K. Kuthiala, Vice Chancellor, MCU at a technical session

The 14th Indian Science Communication Congress (ISCC-2014) on the focal theme 'Communication Strategies for Science Governance' was held at Indian National Science Academy (INSA), New Delhi during 25-29 December 2014. The conference was organized by Indian Science Writers' Association (ISWA). It was catalyzed and supported by the National Council for Science and Technology Communication (NCSTC), DST, New Delhi.

Several topics were discussed and deliberations made during the conference on varied aspects of "Communication Strategies for Science Governance", which was the focal theme of ISCC-2014. The deliberations covered a wide range of sub themes, such as Science for people, Science for policymakers, Institutional strategies, Policy issues, Scientists as communicators, and a special session for young scholars' et al.

The conference began with lighting of ceremonial lamp. The prominent speakers amongst other included Prof. B.K. Kuthiala, Vice Chancellor, Makhanlal Chaturvedi National University of Journalism & Communication, Prof. Pramod K. Verma, Director General, M.P. Council of Science & Technology, and Scientific Adviser to the Govt. of Madhya Pradesh, Mr. Anil Saumitra from Media Chaupal, Dr. V.K. Srivastava, Senior Deputy Director General, Indian Council of Medical Research, Dr Manoj Kumar Patairiya, Additional Director General, Prasar Bharati (Ministry of Information & Broadcasting, Govt. of India), and Dr. M.C. Tiwari, Head International Boundaries, Ministry of External Affairs, Govt. of India. The overall conference was coordinated by Mr. Tariq Badar from CSIR-National Physical Laboratory, New Delhi, and Dr. A.K. Singh, Head, Mass Communication, Sahuji Maharaj Kanpur University.

One of the most important points emphasized by Prof. Kuthiala is that instead of talking about nature we should initiate dialogue with nature to understand and appreciate the nature – a way forward for sustainable development. Prof. Pramod K. Verma, Director General, M.P. Council of Science & Technology, and Scientific Adviser to the Govt. of Madhya Pradesh said that there should be different levels of science communication. He also stressed the need to conserve and popularize tribal wisdom. He talked about the science communication initiatives like 'Kaarigar Vigyan' and Media Chaupal, Senior Scientists' Forum, etc., undertaken at the MPCST. In his address Dr Patairiya elaborated on the theme and objectives of the congress. Dr. Patairiya said science governance which is also termed as part of soft science encompasses the management aspects of sci-

Mr. Chander Mohan, NRDC, speaks on science exhibitions

Mr. Anil Saumitra, Spandan, leads a group discussion

ence as well. It prepares us for future and guides us towards excellence in science. Dr Patairiya pointed out that it is a pleasant coincidence that the conference on 'Science Governance' is virtually begun on the 'Good Governance Day' designated by the Govt. of India, i., December 25, 2014. Mr. Anil Saumitra emphasized on the role of science communication in development. Mr. VP Singh, Secretary ISWA elaborated on the role of ISWA and ISCC on accelerating the science communication movement in India. Dr. V.K. Srivastava, emphasized on various aspects of Clean-up Campaign and Health Awareness. Over 200 scientists, science writers, academicians, science correspondents and students participated in the congress.

The first one was an exhibition session chaired by Dr. Lal Singh from NCERT, New Delhi. The delegates got an opportunity to see various publications including Indian journal of Science Communication. Mr. Chandra Mohan from NRDC interacted on an environment friendly fruit wash technology which is cost effective and increases the shelf life of fruits and vegetables. The main highlight of the session was a demonstration on Braille edition of a popular science magazine in Hindi (Braille) for visually impaired. The magazine is edited by Mr. Chandra Mohan. The outcome of the session was summarized by Dr. R.S. Yadav from AIR and a well known science communicator.

The first scientific session on the theme 'Science for people' began with a presentation by Bharti Bhojak on the challenges and opportunities in science communication through regional languages with a special emphasis on Hindi newspapers and magazines. The presentation by Mr. VK Muliya was an innovative method of communicating science

A scientific session in progress

Dr. Manoj Patairiya (left) facilitates open session

Dr. Ankuran Dutta, CEMCA, participates in interaction

A scientific session in progress

through science cartoons. Dr Rita malik highlighted the history of science communication down the ages. Mr CB Devgun elaborated the efforts of SPACE an NGO on taking science to the people through Citizen Science concept. The summary of the session was presented by rapporteur Dr. Anshu Arora from Punjab University.

The evening session of the first day was chaired by Dr. Prabha Sharma a researcher and science communicator from Delhi University. The session began with a presentation on green technologies with a futuristic approach of dissemination among common masses. The next presentation was on MOOCS- a new frontier in science communication by Dr. Umesh Arya from Guru Jambheshwar University, Hisar. The other presentation was on Role of Community media on health issues with special emphasis on mental health by Dr. Anukaran Dutta from CEMCA.

The activities of the second day started with a scientific session on the theme `Institutional Strategies'. The first speaker Dr. N. Bajpai emphasized the importance and means of science communication for humanities' students. It was followed by a talk by Dr. S.P. Mahendra, who presented a study on science content in the print media, based on research conducted in Dausa district in Rajasthan. Ms. Kalpana Sangwan commented on the changing role of teachers and need for developing scientific attitude in students. Dr. Seemin Rubab from J&K talked about the INSPIRE science camps and described the students' response in three camps. She emphasized that these camps offer a unique opportunity to practicing scientists for communicating their area of research and work in simple language understandable to higher secondary students. The last talk of

A visually challenged participant reads science publication in braille

Prof. P.K. Verma, DG, MPCST, chairs a scientific session

Delegates from all over India attend ISCC-2014

Dr. C.S. Raghav, NBPGR, chairs a split group interaction

the session was by Ms. Nisha Sharma, a science communication student from Lucknow University, who presented a survey based study on the scientific temper at a village in UP. Dr. Smita Mishra from Delhi University systematically summarized the talks presented in the session.

The second session on `Policy issues' began with a talk by Dr. Mahendra Kumar Pandey, on conceptualizing an effective public communication policy, for development- sustainability in the Indian context. The second presentation was by Mr. J. Ashok Kumar, who discussed on the scope of attracting young talent to science. Dr. A.S.D. Rajput from Pune threw light on importance of science communication in good governance. A talk highlighting the role of regional languages in science communication was given by Dr. Gopal Singh from BBAU, Lucknow. Sri Birat Raja Pradhan presented a study analyzing role of science communication in health sector. The last talk of the session was by Dr. I. K. Mishra on e-governance and the impact of new media technologies on society. The session was chaired by Dr. Ankuran Dutta and Mr. S. R. Dixit acted as rapporteur.

The post lunch session on 'Scientists as communicators' was chaired by Prof. B.K. Kuthiala, Vice Chancellor of MLC National University of Journalism & Communication. The first talk was by Dr. Puneet Kumar from Lucknow University, who threw light on the concept of weblog. He explained as to how a scientist can communicate in an easy way by creating a blog and initiating a dialogue. Dr. A.S.D Rajput discussed on the scope of interaction of scientists with the masses. The concluding talk of the session was by Dr. Anamika Ray from Guwahati University, who talked on the consequences

A physically challenged participant at the conference

A display of science publications at the venue

Prof. P.K. Verma gives Best Paper Award to Dr. Anamika Ray

ISCC-2014 concludes

of open education resources in scientific research. The session ended with a summary of talks by the rapporteur Dr. Seemin Rubab and in depth analysis by the chair.

Another session of the day was specially designated for the young researchers and scholars. The first talk was by Shalini Singh on hygiene awareness among housemaids in Lucknow. The second talk was from Kanishka Singh on role of science communication in control of river pollution. The analysis was done for water pollution in Gomti River. It was followed by a presentation by Alakh Sharma who presented a study of causes behind poor response to gadgets using solar energy. The concluding talk was from Ms. Aparna Singh on dissemination of scientific researches carried out at Lucknow University. It was followed by a talk from Manisha Pandit on comparative analysis of two English dailies: *The Hindu* and *Indian Express* on coverage of Mars Orbiter Mission (MOM).

A puppet show on science communication was presented by Gaurav Sharma, Khushboo Sharma, Ankit Awasthi, Anjali Sharma, Surya Teja and Shahshank on `A Night of the Scorpion'. The session's outcome was highlighted by rapporteur Sri Anoop Chaturvedi from *The Pioneer*. The session Chair, Prof K.K. Kapoor from the University of Jammu emphasized the importance of the session as an incubator of future science communicators. The third day of the conference started with a Poster Session under the chairmanship of Dr. Gopal Singh. The main attraction of the third day's proceedings was the split group discussion under the chairmanship of Dr. Subhan Khan from CSIR-NISTADS. All the participants were divided into five groups under the guidance of group leaders to discuss ways and means to make science communication widespread and effective in India with regard to science governance. After brainstorming, the group leaders presented their recommendations. The recommendations were summarized by Dr. AK Singh, the rappoerteur of the session.

Post lunch session of final day was a Panel Discussion, chaired by Dr. VK Srivastava of ICMR. Dr. RS Yadav, AIR presented the ISCC-2014 report. During valedictory session several science communicators like Mr. Kesar Singh from Water Portal, Mr. RD Rikahri, Former Editor, *Invention Intelligence*, Mr. Sripal Sangwan, Senior Agriculture Journalist, Mr. Mohd. Khalil Former Editor, *Science Ki Duniya,* an Urdu quarterly, were felicitated. Best papers from all the five sessions were also awarded during the valedictory session. Dr. PK Verma, Director General, MPCST, Bhopal addressed the gathering as the Chief Guest. Dr. MC Tiwari, Head, International Boundaries, Ministry of External Affairs, Govt. of India was the Guest of Honour. He stressed on targeting children for better science communication efforts. Dr. VK Srivastava in his presidential address deliberated on the need for science communication in regional languages in a multilingual country like India. The ISCC-2014 concluded with ISWA-AGM and networking of various stakeholders.

[Dr. Seemin Rubab and Dr. R.S. Yadav, Programme Officer, Science Cell, All India Radio, New Delhi-110001]

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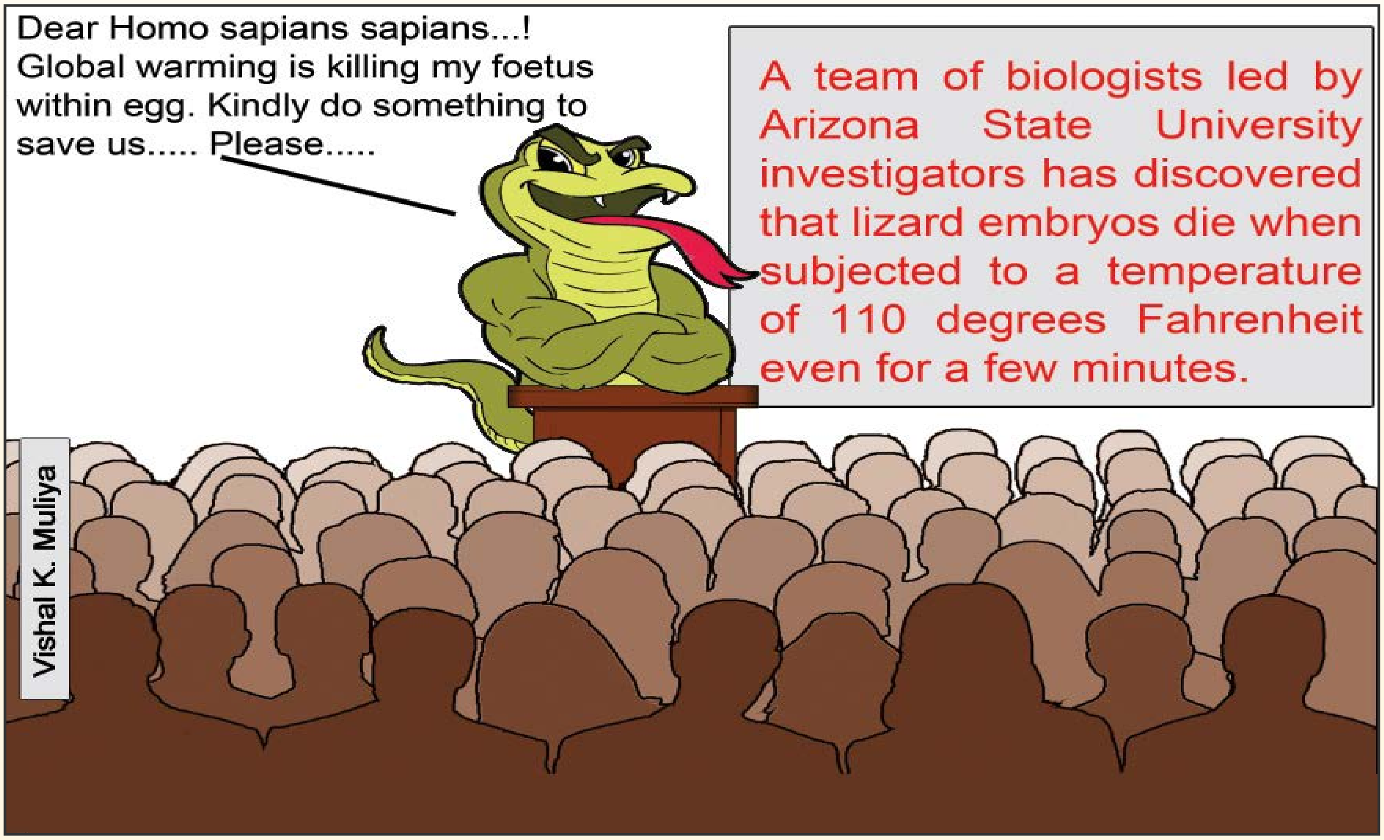

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