



Digital Trends in Science Communication: Global Scenario

^{1*}Rayies Altaf, ²Deepika Bhaskar

¹Centre for Studies in Science Policy, Jawaharlal Nehru University, New Delhi

²Centre for Science Education and Communication, University of Delhi, Delhi
raiesaltaf@gmail.com

ABSTRACT

The article is a review of global perspective of digital trends in Science Communication. This is an interesting time for Science Communication the world over with new and emerging trends of communicating scientific findings making their impact. Digital media has revolutionized the way we share information and interact with each other, as well as with the society around us. It has empowered communities by giving them easy and equitable access to knowledge resources, surpassing all kinds of barriers and impediments both physical and otherwise. Communicating Science to the knowledge community and to society was always a challenge for scientific community as well as science communicators. With digital media and social media, scientific information and knowledge now reaches more people than ever before in a short span of time. World is increasingly going digital, so are the modes of communication. With a variety of media tools available, communication has now become holistic, precise and engaging. Social media makes it possible for messages to reach the right audience in no time. The study focuses on various recent digital trends in communication scientific information like social media platforms, Blogs, video streaming, google trends, virtual or augmented reality, visual storytelling, gamification, smart phone applications etc. The study also involves a screening of online resources available for effective reporting of scientific information.

INTRODUCTION

Digital media is the new buzz word of the post-modern world, which has surpassed the traditional media both in capacity, as well as capability. Techno-scientific innovations have not only revolutionized the human lives but also the way they communicate with each other. Thanks to the unprecedented progress in communication technology, the whole world has shrunk to a 'global village' and the contemporary society is now a 'networked society'. Digital technologies have surpassed both sociocultural and geographical boundaries. All this has brought us closer to each other, than ever before in the history of mankind. Communication is now easy, fast, reliable and precise. World is increasingly going digital

and people now spend more time on digital media platforms for fulfilment of their needs, which range from getting news about day-to-day happenings to entertainment. A survey study done by World Economic Forum in collaboration with Willis Towers Watson in 2015 about digital media use in the world¹, gave an overall positive picture. In this survey which included 5000 digital media users across five countries, half of the respondents agreed that their digital media use improved their overall quality of life both socially and professionally. Only one in seven respondents disagreed. For two-thirds of respondents in this survey, digital media use had improved their ability to carry out their work, collaborate with colleagues and build relationships. According to a recent survey conducted by Globalwebindex on the use of digital and traditional media², consumers in 29 countries out of total 34 spend more time on digital forms of media than on traditional media. Further, across 29 countries, average time spent on linear TV (traditional TV set-up) has declined, broadcast radio is down in 24 countries and physical printing press has dipped in 15 of them. At the same time online TV has recorded increase in 28 of 31 countries and online press has risen in 26 places. Thus digital and online media seems to be slowly replacing the traditional media in almost all formats including visual (eg. TV), sound (eg. Radio) and print (eg. print media). The latest statistics from International Telecommunications Union say that about 70% of the world's youth, aged between 15 and 24, are now online.³ About 94% of the youth (aged between 15 and 24) from developed countries and 67% youth of the same age group, from developing countries are now using internet. Thus internet and digital media provides a huge potential as well as opportunities for engaging with people especially the youth.

Communicating Science to society was always a challenge before the scientific community as well as science communicators. The landscape in which science communication is taking place is changing. Information is spreading faster. Communicators, scientists and scientific organizations are making use of social and digital media tools. Social media being inherently interactive in nature, sharing any content initiates public discussion and debate. Thus two-way communication takes place via digital platforms. Scientists may get criticisms or queries via social media. They may find bloggers they have never interacted with or spoken to, writing about their work. People are increasingly turning to online sources for news about science and technology. According to the National Science Board of USA, in 2014 alone, approximately 47% Americans turned to digital sources for news about science and technology.⁴

MAIN CONTENT

Science Communication through digital media

Digital media has emerged as a popular platform for communicating science as well as science's active engagement with the society. Through its wide reach, it has not only provided us with ample ways for enhancing public understanding of science but also public participation in science through online citizen science initiatives. Science, reaches the grass-root level simultaneously in most regions of the globe through multiple digital media channels; and thus has become an integral part of people's lives all over the world. The advent of internet has given the common man living in any part of the world, access to scientific knowledge, produced and practiced anywhere in the world. Thus it has empowered the new generation with knowledge and tools of modern science. Through online science

journals, peer-to-peer communication of scientific knowledge is now quick, easy and more interactive. Thus, in many ways, online and offline digital ways and means of communication have made science more interactive, all pervasive and at the same time, also real-time. At a certain time, a scientific event or experiment done in any part of the world is watched and commented, simultaneously by millions around the world, thereby expanding reach across space and time.

Digital media enables decentralization of information by both access to and collection of it. It enables dialogue among the diversity of actors. Trends in the digital means of communication are contributing towards integrating science and the society, thus bridging the gap. Some of the popular digital media platforms for communicating science include Blogs, live video streaming, augmented or virtual reality, online citizen science initiatives, social media platforms, gamification, smartphone apps and the like.

I) Social Media as a popular channel for communication of science:

Social media has brought a revolution in communication and information sharing. The world is communicating and networking through the social media platforms. Term ‘Social media’ refers to a variety of internet based platforms, applications and technologies that enable people to interact.⁵ These are meant to be community based through which users create online communities to interact, collaborate and share information, content, ideas etc. Social media is becoming very important as far as communication is concerned. Social media platforms are not only becoming one of the fastest growing categories of media⁶ but are also now effective tools for communication.⁷ Examples of social media are blogs, facebook, Instagram, LinkedIn, Pinterest. They have created a boom in the availability of scientific information in the society. Through social media platforms information on and about science & technology is now available in variety of forms and formats and access to such information is easy.

Blog and Blogosphere:

With the internet becoming more social, blogs are emerging as a popular way of communicating ideas and thoughts to the public. A blog, also known as weblog, is a website consisting of entries or posts, which appear in reverse chronological order with the very recent one appearing first. Blogs generally include features like comments, write-ups, ideas and even links to increase user connectivity. The process of writing a post for a blog is known as Blogging and anybody who writes content for a blog is known as Blogger. The whole ecosystem of blogs and bloggers in the internet is known as Blogosphere. The earliest blogs started as online diaries in 1990s. Blogging has become an important part of online world with popular bloggers impacting the world of business, politics and society, through their blogs.

Blogs are making their impact in the world of science, equally. Many leading scientists and communicators around the world have their own blogs which provide regular updates on their work or general science, with millions of people following them. Blogs are becoming an easy way to communicate scientific developments to audience and explain to them various scientific phenomenon. Some of the popular science blogs are listed below:

<http://scienceblogs.com>: This blog is a fascinating compilation from the world of science writing and has separate sections dedicated to life-sciences, physical sciences, medicine, brain and behavior, technology, and environment. It features more than 60 bloggers which have been selected on the basis of their originality, insight, talent and dedication to provide up-to-date coverage of their respective scientific fields. For example, Greg Laden, a biological anthropologist and science communicator writes regularly through this blog.

<http://physicsbuzz.physicscentral.com>: This blog gives regular updates on various research initiatives and phenomena in the physics world. It covers fields like light and optics, sun, quantum mechanics, particle physics, space etc.

<http://askamathematician.com>: It is a question and answer website where questions received by email are answered and turned into posts. Questions related to mathematics and physics are answered. Readers and audience can put their comments and responses, after the answers get published on the blog. There is provision of getting directly connected with a scientist and discuss questions related to physics, geophysics, biology and neuroscience on the blog.

<http://planetary.org>: This website works towards empowering people all over the world with the knowledge of advance space science and space exploration. It hosts a blog which is dedicated to cosmos, where guest bloggers put popular and recent space stories (& news), accompanied by images released by various space agencies.

<http://dailygalaxy.com>: This weblog keeps the readers and subscribers updated with the most recent news and happenings in space science and space exploration.

<http://science.howstuffworks.com>: This blog is dedicated to answering some of the interesting and curious questions occurring in our minds on day to day basis. It covers a wide range of areas like animals, health, lifestyle, science, technology etc. Queries are answered in easy simple language,

<http://iflscience.com>: This blog provides the readers with latest research carried out by scientists around the world. The research findings are categorized under the broad themes of environment, technology, space, health and medicine, brain, plants and animals, physics and chemistry.

<http://iopblog.org>: This weblog (also known as iop blog) is the blog of the Institute of Physics, which is a leading scientific membership society working for the advancement of physics for the benefit of all. It gives the latest news about the world of physics and also updates about the recent developments occurring for the advancement of the discipline.

<http://mindhacks.com>: This is a blog dedicated to knowledge dissemination in the areas of neuroscience and psychology. It provides the reader with the latest news and views in these two areas.

<http://itsokaytobesmart.com>: It is a blog created by Joe Hanson, a biologist and a science writer. The aim of the blog according to Joe is to talk about science and how it would shape and impact our future. This blog puts videos and write-ups explaining various interesting phenomenon around us. For example, what happens to a video after it gets uploaded to youtube, Why do more species live near the equator etc.

<http://nanoscale.blogspot.in>: This blog provides general information, news and updates about condensed matter and nanoparticle physics.

<http://profmattstrassler.com>: This blog has been started by famous theoretical physicist Matt Strassler. It aims to inform and teach the general public with no background knowledge of physics about various aspects of science including particle physics. The blog provides content which is easy to understand and mostly jargon free.

<http://blog.tanyakhovanova.com>: This blog is run by a mathematician. It describes mathematics as a subject of study and tells us about her life as a mathematician. The blogger also writes on applications of mathematics in our lives in general.

Facebook:

Facebook is the most popular social media platform. As of June 2017, on an average the number of daily active users on Facebook was 1.32 billion⁸ and by June 30, the number of monthly active users were around 2.01 billion. Thousands of scientists and communicators across the globe are constantly interacting with people through their facebook pages and thus putting large amounts of scientific information in the public domain. Similarly, it is now important for every research institute in the world to have a Facebook Page and upload its programmes, as well as other information on it and also get feedback from the online community. For example, National Aeronautics Space Agency (NASA), USA has around 20 million followers on its Facebook page.

Table 1. A list of World's renowned science research institutes/organizations including those, referred by Nature Index 2015, which is compiled by Nature Research Journal and which dominate the world of science, with their facebook followers

S.No	Name of the Institute	No of Facebook followers
1	Chinese Academy of Sciences	313
2	Harvard University	5,030,784
3	French National Centre for Scientific Research (CNRS), France	128,475
4	Max Planck Society, Germany	156,822
5	Stanford University, USA	1,205,957
6	University of Tokyo, Japan	70,218
7	Massachusetts Institute of Technology (MIT), USA	1,007,596
8	University of Oxford, UK	3,331,714
9	University of Cambridge, UK	1,857,032
10	Indian Institute of Science (IISc)-Bangalore, India	70,432

Twitter:

Twitter is one among the most influential social media platforms where almost all influential people from politicians to Heads of State, from academics to celebrities express themselves either as personal opinions or even their official stands. Science is no more separate from this very popular media platform and almost all popular scientists and science writers are on twTtter. Similarly, all the top notch research organizations of the world have their official Twitter handle through which they connect to masses. Twitter allows unlimited 140 character posts, which can be embedded with pictures, videos, live streams etc. It sorts the tweets into threads so that it becomes easy to follow conversations. The commonly perceived benefits of Twitter are the size and diversity of the audience, and also the ability to engage with the public.⁹

Some of the twitter accounts which are popular among the audience are:

NASA: National Aeronautics Space Agency, a Space Research organization of USA, which tweets through @NASA. You can also tweet back to NASA on its official Twitter account. Such is its impact and popularity that on Twitter alone, NASA has more than 25 million followers.

European Space Agency: This leading space agency has multiple tweet accounts related to various aspects of space science and exploration as well as astronauts who work there. Its main Twitter handle is @ESA. Like NASA one can tweet back to ESA and get connected. ESA has 0.755 million followers on twitter.

Indian Space Research Organization (ISRO): ISRO tweets @ISRO and has more than one million followers.

The science personalities (scientists and science writers) all have made their presence felt on twitter and talk to netizens through their regular updates or tweets. Usually scientists have a reputation of being anti-social. Social media has given them the opportunity to connect to the laymen and other scientists alike. Most of the scientific community around the world are taking full advantage of the social media and are on twitter now. Twitter is full of opportunities to hear what these scientists have to say, start a conversation with them and even follow their work. For example, @realscientists, which is a titter account, a different scientist tweets about his/her research every week. One week the focus is on astrophysics, the next week it would be on, say gene editing. This particular twitter handle has around 54,000 followers. In 2014, the online issue of science magazine an initiative of American Association for Advancement of Science (AAAS) listed 50 most followed scientists on twitter (the popular tweeters in the world of science).

Similarly top international science journals, like Nature, have hundreds of thousands of followers on Twitter, who not only get to know about recent happenings in the world of science but also can interact with them through tweets. Nature which is present as '@nature' has 985,000 followers.

Table 2: A comparison of the followers of official Twitter accounts, owned by some renowned scientists and science-communicators

S.No	Name of Scientist/Field of Specialization	Twitter name	No of followers in 2014 ¹	No of followers in 2017 ²
1	Neil deGrasse Tyson/Astrophysicist	@neiltyson/2009	2.4 M	8.36 M
2	Brian Cox/ Physicist	@ProfBrianCox	1.44 M	2.69 M
3	Richard Dawkins/Biologist	@RichardDawkins	1.02 M	2.29 M
4	Ben Goldacre/Physician	@bengoldacre	341,000	488,000
5	Phil Plait/Astronomer	@BadAstronomer	320,000	594,000
6	Michio Kaku/Theoretical Physicist	@michiokaku	310,000	595,000
7	Sam Harris/Neuroscientist	@SamHarrisOrg	224,000	902,000
8	Late Hans Rosling/Global Health Scientist	@HansRosling	180,000	369,000
9	Tim Berners Lee/Computer Scientist	@timberners_lee	179,000	261,000
10	P.Z. Myers / Biologist	@pzmyers	155,000	178,000
11	Steven Pinker/Cognitive Scientist	@sapinker	142,000	329,000
12	Richard Wiseman/Psychologist	@RichardWiseman	134,000	143,000
13	Lawrence M. Krauss/Theoretical Physicist	@LKrauss1	99,700	348,000
14	Atul Gawande/Public Health scientist & surgeon	@Atul_Gawande	96,800	213,000
15	Oliver Sacks/Neurologist	@OliverSacks	76,300	118,000
16	Dan Ariely/Psychologist & Behavioural economist	@danariely	73,000	138,000
17	Eric Topol / Geneticist	@EricTopol	44,800	110,000
18	Brian Greene/Theoretical Physicist	@bgreene	38,700	693,000

¹ <http://www.sciencemag.org/news/2014/09/top-50-science-stars-twitter>. Retrieved on: 08-08-2017 at 6:14 pm.

² No of followers as on 08-08-2017. Source: twittter.com

19	Marcus du Sautoy/Mathematics	@MarcusduSautoy	34,200	460,600
20	Sean Carroll/ Theoretical physicist	@seanmcarroll	33,200	113,000

Live video streaming:

Live streaming is becoming the core focus of various social media platforms. Live Video evolves as a true connection with the audience. The development can partly be attributed to using power of ‘videos’ to capture more attention. Live news videos have captured the attention of everybody with the start of Facebook Live feature. Similarly, Instagram also introduced the live streaming feature in 2016 while as Twitter introduced 360 degree live video feature. Snapchat also succeeded in introducing 24 hour Live Stories. Video feature is becoming a popular tool even in traditional media outlets like BBC, The Economist and the New York Times with all of them introducing video features in the websites as well as apps and also dynamic video.

Videos are a vital tool to communicate even the most complex concepts of science & technology. Through live streaming many scientific phenomena and events are broadcasted live on the internet. For example, Solar Eclipse of 2017 was streamed live by many websites around the world including NASA and Twitter. Similarly, videos related to complex concepts like Plasma Science are broadcasted live on internet.

Google Trends:

Google Trends is a public web based feature which is based on Google Search. It shows trending news stories of the day across various regions of the world. It helps to see the latest trends, data and visualizations from Google. The data is collected on the basis of total search volume globally. Google trends has categorized the search themes into various categories. One such important category is Science and Technology (Sci/Tech). You can see which news/topic in the field of S&T is most searched by netizens and is thus trending on a particular day. This search can be performed country wise, for example, the top 10 news items/topics of Sci/Tech which have been searched in India, specifically. One can also find top charts or trending news of any previous year country-wise.

Virtual Reality or Augmented Reality:

It is a novel medium for brand new storytelling. Through VR, animated stories have been produced (biomedical stories related to cancer and epigenetics at Garvan Institute of Medical Research.) The animations show how biological molecules behave inside our cells and how things go wrong in disease. Through VR one can view the scenes of a process in three dimensions, providing a window into molecular or even subatomic world. VR helps one to tell science stories that are complex and highly abstract, in a way that is more meaningful and easy to understand. For example, Molecular VR³ is a virtual tour into a cell showing the finest details of cell communication system and the highly complex world of protein machinery. With a Google Cardboard one can explore the microworld of cell, which is the

³ <https://unimersiv.com/review/molecule-vr/>

basic unit of life on this planet. Videos based on virtual reality applications in medicine, physics, life-sciences and science & technology museums.

Instagram:

Instagram is becoming a new avenue for Science Communication. Through Instagram, scientists are uploading on Instagram and creating visual stories about them and their research. It is helping scientists to socialize with the rest of the society straight from their laboratories. Science stories which are in the form of creative visuals which depict scientists and their work, as well as their workplace. Instagram accounts are easy to access and have the potential to attract attention to and comprehend complex scientific information, while making the story interesting and engaging.¹⁰ Science Instagram posts that attract most likes and comments are the ones which are rich in fascinating visuals and curious videos. They also create a sense of awe among the young viewers who may themselves be inspired to become scientists. ‘*Scientists Selfies*’ is one such project on Instagram, through which scientists are trying to enhance their public image by socializing and interacting with their followers. Instagram is also changing the way we see or imagine scientists. It is breaking the various gender stereotypes related to scientists. Now increasing number of female scientists are registering themselves on Instagram to break the age old stereotype of scientists being white and male. Some of such communities of female scientists on Instagram are @science.sam, @phd_fashionista, @stylish_streaking and @biologistimogene.

II) Smart Phone Applications:

Mobile technology has made possible a much greater reach of internet, increasing the number of internet users everywhere. Smartphone is one such innovation which has brought internet and information in the hands of the public. Smartphone are not behind when it comes to Communicating Science to the society. They possess immense potential in facilitating access and opportunities to connect science and technology with society. There are hundreds of apps both in android as well as iTunes (of iPhone) which are dedicated to provide science news or scientific information to mobile users.

Some popular science communication apps in android system are listed below:

Science Review Feed: This app collects science news and updates from various other sources like NYTimes.com, ScienceMAG.org, Yahoo, Nature.com, Reuters.com, Wired.com etc and puts them on a single platform.

News fusion: Apps like Science Review Feed is a science news collecting app.

General Science: This particular App helps to understand daily life problems, explaining them in the light of modern scientific theories.

III) Digital practices of Citizen Science as a way to communicate and understand science:

Citizen Sciences is an exciting platform that enables one to learn science, technology, engineering and maths outside the classroom setting, through experiments, games etc. Earlier Citizen Science was involved in simple data collection tasks like bird counting in Ornithology, tracking changes in ecosystem like pollution, entomology (BeeSpotter). Similarly, in tracking various ocean related data like coral reef study or tracking other

geophysical phenomenon or even observing astronomical phenomenon (Asteroid Zoo). This was all done offline and manually, with little or no access to related knowledge resources. There is a considerable shift now in how citizen science projects are carried out. Developments in information technology have increased the range and scope of Citizen Science. With internet now at the helm of affairs and availability of various digital tools including social media channels, Citizen Science is becoming more communicative, participatory and engaging. Digital citizen science platforms and websites not only facilitate the involvement of public in scientific endeavors, exploration or experimentation but they also act as huge repositories of knowledge which enhances the capability of the participants to take an active part, thereby enhancing public understanding of science. Citizen Science initiatives have not only created a separate niche in the Science Communication ecosystem but also have been successful in forging a deeper involvement of citizen volunteers and amateurs, which results not only in understanding of the previously existing knowledge but also in the production of new data. Some of the citizen science projects involve complex problems like exploring and understanding the structure of complex proteins. Some of the best citizen science practices on digital media platforms are listed below.

eBird: Launched in 2002 by the Cornell Lab of Ornithology and National Audubon Society, eBird is an online platform and a real-time checklist program for bird observations. Citizens, bird-lovers and scientists get real time information about bird abundance and distribution across the globe. A checklist in the field of biodiversity monitoring is a list of species and their respective abundance recorded at a particular location. eBird has revolutionized the way the birding community accesses and reports information about the birds. The project initially was aimed to cover the Western Hemisphere but then it was broadened to include the whole globe in 2010. eBird is an excellent example of crowdsourcing in science, where citizens and scientists can equally contribute to the creation of data, which they can access anytime. eBird's aim is to utilize the large number of bird observations made every year by ornithologists and recreational bird watchers. An interactive web-interface engages thousands of bird enthusiasts to submit their observations or submit their queries into the eBird database. The observations of each individual are then added to the data submitted by other participants. Thus a large network of observers creates a huge database of their observation about birds. It documents the presence or absence of a species thus contributing to our knowledge of biodiversity around us. This data is then made available through internet via various formats.

eButterfly: eButterfly was launched by Max Larrivee and Jeremy Kerr at University of Ottawa in 2012, with two simple ideas in mind.² One, people are passionate about observing butterflies and two, each butterfly observation has potential research value for fundamental and conservation research. This citizen science project facilitates an easy and accessible way for butterfly observation data to be compiled, organized, verified and shared. eButterfly involves diverse participants like butterfly enthusiasts, conservationists, policy makers, ecologists, scientists and educators, who gather various kinds of data related to butterflies in North America. This data sharing platform provides exclusive data about the butterflies like species occurrence, migration timings, community structures and the relative abundance at various geophysical regions in US, Canada and Mexico. eButterfly is being used as a conservation tool by monitoring butterflies and providing data about their distribution, phenology and relative abundance.² It is also used by scientific community and

conservationists in ecological and conservation research, as butterfly abundance and distribution are an indicator of local changes in climate. So far, this project has gathered over 2,30,000 observations including 682 species of butterflies from more than 39,000 checklists by more than 5500 unique registered participants. E-butterfly.org

eOceans: eOcean consists of various citizen-science initiatives (eSharks) related to marine ecosystem and is a way for anybody to get involved with ocean science. To keep a track of marine ecology, marine debris, and climate change. It is a global project, launched in 2014 with the aim of building a comprehensive ecological baseline data using observations of local citizens, marine life enthusiasts and scientists. eOcean is open to anybody and any participant can report their observations.

iNaturalist: iNaturalist is an online platform for recording and sharing the observations related to nature. It is also a place where nature lovers can interact with each other and learn about the natural world ecology. The project was initiated at UC Berkeley's School of Information in 2008 and was created to record and share the living life on this planet. The observations may range from information about the presence of beautiful wildflowers to bird spotting. The creators of this online platform want to build a living record of life on earth and through which scientific community and ecologists could keep track of changes in biodiversity.

iSpot: This project is run by The Open University and was originally developed by the Open Air Laboratories (OPAL). iSpot is a platform which encourages citizens to engage and explore the nature around them and thus acquire relevant knowledge. The aim is to identify wildlife and share nature. According to the official website of iSpot, about 3000 species have been identified by citizen participants. A participant has to simply enter the website and add his/her observations related to any living species with photographs and other relevant details.

Zooniverse: Zooniverse is among the largest online platforms for participatory research or citizen science projects. It is actually a collection of various citizen science driven research initiatives. It allows common people to be volunteers and participate in such research projects. The goal is to accomplish the research by citizen participation which is not otherwise practically possible. The research projects on Zooniverse include those from Biology, Climate, Medicine, Space, Environment and Languages etc.

IV) Gamification as a novel way of communicating and doing science:

Introduction:

Games are becoming popular tools to communicate and understand science and scientific phenomena. A new generation of online games not only provide entertainment, they are also helping scientists solve puzzles involving a very broad range of themes from genes and conservation to the universe. They offer excellent ways and means to understand complex scientific processes and offer solutions to them. Some research problems in science possess high levels of computational complexity and solving them requires producing huge amounts of data sets and probabilities. Gamification is an effective tool to provide solutions to such research problems by presenting such problems to non-experts, in the form of computer games. 'Gamification' is the addition of game-like features to something that isn't traditionally a game. Gamification has been applied to the very complex scientific phenomenon which are otherwise too tedious and difficult for non-professionals to

understand and to participate in. Computer based games thus play an inevitable role to bring non-scientists on board, to solve world's complex scientific problems and thus unravel and understand the mysteries of nature. The good thing about these games is that they are global, which means anybody from anywhere in the world who has access to internet can play them. Most importantly, games are becoming the means through which many scientific problems are understood and subsequently solved. Thus an effective tool of communicating, understanding and engaging with science.

The idea of crowdsourcing science games is to utilize the immense amount of energy and time invested by people into computer games, and use their efforts for serious purposes like solving real life problems.

Following are some of the popular online science-games:

Foldit: Foldit is an experimental game related to protein folding, developed as a collaboration between the University of Washington's department of Computer Science and Engineering and Biochemistry. It helps in predicting and designing the structure of proteins. It was developed by University of Washington D.C. in 2008 and players from anywhere in the world can play this game. Every living thing including plants, bacteria and viruses are made up of proteins. The main building block of our body is proteins and proteins themselves are made of Amino Acids. There are hundreds of types of proteins which differ from each other in shape and structure. The shape and structure of a protein plays a key role in deciding its main function that is, what this protein can do. Besides proteins being reasons of so many diseases like HIV/AIDS, Alzheimer's, Cancer, they can also play important role in curing them.

In this game the players predict the structure of proteins. Knowing the structure of proteins gives us an idea about what function it performs and thus it can become easy to target it with drugs, in case of any illness. Players can not only predict the structure of proteins in this game but they can also design brand new proteins that could be used to prevent or treat any specific diseases.

Eyewire: Eyewire is citizen science initiative in the field of neurosciences. It was launched in 2012 from MIT in collaboration with Seung Lab of Princeton University. It is a 3D puzzle game, to map the human brain and anyone can play it. Each time a player untangles a puzzle, discovers a new neuron. The participant is given a colored piece of neuron and the challenge is to connect it to other neurons so that the neuron loop is complete. The aim is to map the 3D structure of neurons and to helping scientists discover how neurons connect and network to process the information, thus helping them to understand the working of the brain. So far participants from 55 countries have taken part in this game. Initiative of MaxPlank Society, MIT, NIH and Gatsby Charitable Foundation. The worldwide initiative was started in 2012.

Fraxinus: This crowdsourcing game was originally developed to save ash forests of Great Britain from the fungal disease called *ash die back* disease, caused due to fungus *Chalara fraxinea*. In the game, players have to align and match on-screen patterns which correlate with genetic data collected by scientists from the field. The results are then used in identifying the breeding varieties, which are resistant to the disease. This game was developed by Sainsbury Laboratory at University of Cambridge *Genetics*.

Higgs Hunters: This game was jointly developed at CERN by ATLAS, University of Oxford and New York University in 2014. There is a very huge data which is produced daily in Large Hadron Collider (LHC) which is based in European Centre for Nuclear Research (CERN). LHC is the world's largest particle collider or accelerator and most sophisticated machine built ever on earth. The LHC accelerates the particles to very high speeds equivalent to the speed of light and makes them collide each other. As a result of this high speed collision, particles break or decay into new types of particles. In doing so, the LHC can recreate the conditions that were present in the billionth of a second after the Big bang. The data about particle collisions runs in millions and it is almost impossible for the scientists working over there to exactly pin point those strange collisions (particle which fall part or decay in unexpected ways). This knowledge about particles decaying or breaking off in abnormal or unexpected ways would help in a completely new understanding of the particle physics, thus giving us better sense about the building blocks of the universe and its origin.

Quantum Moves: This game, that is a part of the scienceathome.org, is a step towards achieving perfection and speed in the execution of quantum operations in the realm of Quantum Physics. This game was born out of the dilemmas and questions physics researchers confronted with, when they took the challenge of building a quantum computer in the basement lab of Aarhus University, Denmark. Quantum Physics it is believed could lead us to more technological advances in the fields of computing and simulations.¹¹

This simulated video game gives everybody a chance to play and an opportunity to do front-line quantum physics research. The idea behind the game is simple: every time a player plays, his mouse movements are simulating the laser beams used in the real quantum lab to move the atoms onto the right pathways. In this game players have to move the atoms and the challenge is to move them with the maximum speed but in a controlled way. It is difficult to maintain the maximum speed as atoms become excited and the atomic wave function delocalizes. Gaining the presumed quantum speed limit is thus a challenge which players are asked to tackle. The whole game is based on the idea of storing single atoms in a very specific trap, where each atom sits in a well like an egg in an egg tray. With this trap, scientists can store around 300 atoms in a neat configuration. With such configurations physicists are getting close to building a superpower quantum computer. Prototypes of quantum computers are currently developed in physics labs all around the world.

Solving the puzzles and challenges posed in Quantum Moves will help the team of physicists at Aarhus University to build a large-scale quantum computer. Quantum computers would be totally different from ordinary computers. They would not only be smaller in size but also very powerful that can do all types of complex calculations.

This game has become very popular and so far more than 2 hundred thousand players have played it for more than 8 million times.

Turbulence: This is also an initiative of 'Scienceathome.org'. Turbulence is a concept in fluid dynamics, which was described by renowned physicist Richard Feynman as 'the most important unsolved problems of classical physics.' It is characterized by chaotic changes in speed & direction (or velocity) and pressure. Scientists study turbulence because it has implications as well as applications in real life situations. For example, understanding the dynamics of the turbulent air behind an aeroplane is vital in maintaining the safety of airspace

around an airport. Also understanding turbulent mixing can be helpful for designing more efficient systems for introducing medicine into the bloodstream.

Turbulence game is a collaborative project of mathematicians, physicists, computer scientists and game designers. In the Turbulence game, a player competes with other players to explore shapes that are formed in chaotic regions of turbulent flow. These shapes are known as RIVs (Regions of Intense Vorticity). To understand and knowing about these RIVs helps scientists to understand the phenomenon of turbulence. This is where players come in. In the game players have to find the 'biggest' regions of intense vorticity in each snapshot of the simulation. By the word 'biggest' is meant that region which can hold largest spheres. The sphere size determines a very important length scale in turbulence. This scale is thought to be closely linked to the dissipation scale, which gives us information about the process in which turbulence begins to calm down and dissipate.

Cropland Capture: This special game helps in ensuring global food security by developing world's first crop map of the earth. In this game participants have to search through satellite images of earth and look for arable land to help develop the first-ever global crop map, which would help in identifying yield gaps and monitor crops affected by drought and thus plan for global food security. The more land a player identifies, the more he scores.

Some Success Stories:

In 2011, some people while playing this game *Foldit* resolved the structure of an enzyme that causes an AIDS like disease in monkeys. Researchers had been working on this particular problem for 13 years. The gamers solved it in three weeks.

In 2012, people playing an astronomy game known as *Planet Hunters* found a curious planet with four stars in its system, and to date they have discovered more than 40 such planets that could potentially support life. All of these planets had been previously missed by professional astronomers.

CONCLUSION

As more and more public is seeking information about science and technology online, science communication through online and offline digital platforms becomes ever more important to bridge the deficit and at the same time facilitate a dialogue between science and society. The major advantage digital and online platforms offer is that they facilitate real time discussion of issues related to science and technology, while contributing to the diffusion of the knowledge. The future of science communication is increasingly becoming digital in nature as more and more people are gaining access to internet.

Online citizen science initiatives are coming up in big way with universities and laboratories around the world, designing and developing citizen science projects in various scientific disciplines like biology, ecology, physics, chemistry etc. and with such a scope of citizens' participation, as never seen before in the history of research. Digital media is democratizing as well as decentralizing scientific knowledge, while increasing the base of target audience for science.

Games are becoming a popular and favourite way to engage citizens in problem solving in science. Through carefully designed computer games, citizens and scientists are collaborating

in innovating new possible approaches and methods for solving specific problems and overcoming challenges in research. Games are becoming a popular way of public understanding of science as well as public participation in science. They are helping in large scale data collection and data analysis. The most important feature of online citizen science initiatives is that they are global in scope, meaning participants from all over the world can participate in them and thus become *citizen-scientists*.

Although there are many studies on the use of digital media in the developed countries of Europe and US but there is dearth of such data from the developing world. There are hardly any comprehensive studies on the use of social and digital media for communicating science in the developing world. Hence, there is a need to carry out studies on the use and implications of digital media in communicating science in developing countries.

The future of science-communication would largely depend on how policies and practices related to the field are shaped by emerging trends of online ecosystem.

Endnotes:

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