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Research 2.0: Placing Academic Research in the Pasteur's Quadrant

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Abstract—*Academic research has undergone a major shift by emphasizing more on applied research rather than basic research. Pasteur's Quadrant is a perfect aid to visualize the present scenario as it bridges the gap between applied research and research focusing on theoretical enhancement. 'Open Science' aims at unraveling the academic research process by employing collective intelligence to break down the barriers that currently exists among researchers and also among the research community and the society. This domain of research is argued to be more productive in nature and it is also claimed to reduce the 'time to discovery' factor due to the conjoined efforts of scholars, professionals, students and other members of the society. Since the characteristics of open science are homogeneous to that of web 2.0 (which emphasis on user-generated content and collaboration) the concept of 'Research 2.0'aroused. Research 2.0 synonymously known as 'Science 2.0' or 'Open Science 2.0' indicates the integration of open sciences principles and web 2.0 tools for the purpose of creating a platform that can be utilized for collaborative knowledge construction. This paper aims at analyzing the beneficial effect of Research 2.0 and how it can assist in placing the knowledge constructed by the research community in the Pasteur's Quadrant of the 'Knowledge and utilization graph'.*

1. INTRODUCTION

Research or Scholarly communication primarily deals with knowledge dissemination. Successful Communication and knowledge dissemination are vital elements for any scholarly research as these elements allow knowledge to grow and enable practical applications [1]. The importance of communication lies in the fact that knowledge, when kept undistributed, lacks the ability to affect the society. According to Newton, scientific progression is relative to the phrase "Standing on the shoulders of giants"–meaning knowledge generation does not aid the society unless it can be exploited by future researchers (to build on the existing knowledge) and the society for practical implementation.

Prior to the advent of academic publishing system, researchers were closed and secretive about their discoveries. Eminent researchers used to send 'anagrams or scientific cipher' to fellow researchers for entitling themselves with credit for their work. The journal publication system in its earliest form entered the research market in the 17th century [2]. 'Philosophical Transactions' which issued its first publication in 1665 was the first English journal focusing only on research. Since 1665, the journal publication system has grown and evolved to be the vital entity of any modern research [3]. With countless technological advancement, print medium cannot be agreed to be the monopolized communication channel for distributing information in the present generation. Academic researchers have moved to various online platforms where the research process and outcome is said to be more productive in nature, in addition to the conventional publication practices.

The arrival of web 2.0 technologies in 2004, opened up a novel pathway in the cyber world where users were able to interact, share and collaborate with one another [4].Web 2.0 introduced various social tools that were the prime agents of a major paradigm shift - transforming the passive web users of web 1.0 to active content creators [5]. According to Waldrop [6], these social media platforms are expected to revolutionize the academic research process. Research 2.0 is a subset of 'Open science'–a collaborative knowledge generation system that aims at complete transparency in the knowledge creation as well as knowledge transfer process of scientific discoveries and academic research. With its characteristics of being open and collaborative, web 2.0 was observed to be the ideal platform to exercise 'open science' which led to the growth of Research 2.0. Hence, the term 'Research 2.0' denotes the adoption and use of various social media tools to enhance the academic research process and promote knowledge dissemination by making it more accessible and collaborative.

2. PASTEUR'S QUADRANT

The knowledge and utilization graph proposed by Stokes [7] is a taxonomical framework used to categorize academic and scientific research based on the scale of utility. As shown in the Fig. below (Fig. 1), knowledge and utilization graph is a two dimensional graph with four Quadrants separating X-axis denoting knowledge creation (discovery) from the Y-axis which is focusing on utilization or application oriented research (knowledge implementation/innovation). By dividing the discovery and innovation quadrants, a continuum quadrant named the 'Pasteur's quadrant' was derived for placing

research that own dual functionality –theoretical/ scientific advancement as well as societal/ commercial application. This user-inspired framework depicts the importance of prudent research falling under the Pasteur's quadrant as it serves both as an input for future research and can also be used for immediate application for social or commercial gain.

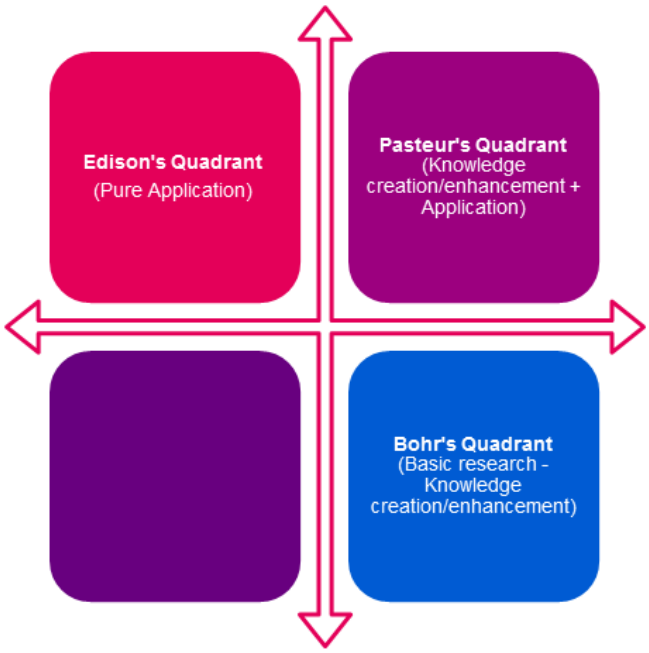

Fig. 1: Stroke's knowledge and utilization graph

Researchers still believing in the conventional academic/ journal publishing system tend to limit the access of information regarding their research work for their fellow and future researchers. Thus the limitation of knowledge transfer forms a massive barrier to enhance the existing work and implement them for societal welfare or development as a whole. Such research, over a period of time losses its validity and utility. There by lacking the ability to enter into the Pasteur's quadrant of utilitarian research.

3. RESEARCH 2.0

Research 2.0 is a form of collective intelligence where online social media tools are employed for knowledge creation and dissemination. These virtual cognitive tools are viewed to catalyze the research process by using an open and collaborative approach for solving scientific/academic problems [8]. Research 2.0 includes tools such as emails, blogs, microblogs, social networking sites, discussion forums etc. These tools form the informal or new channels of scholarly communication that are currently diffusing among scientists and researchers for utilizing them in their studies [9].

In the traditional research setup, researchers are isolated and only the studies with positive results are sent out for publication in reputed journals. But this culture fails to understand the significance of research studies that were stopped due to negative or negligent findings. By sharing the Knowledge generated from such studies, repeated and needless research on similar subjects can be avoided. In the Research 2.0 system, researchers are always connected with each other irrespective of their geographical location. Hence a fellow researcher could be cautioned before taking up an unnecessary study. Moreover the studies with negative findings can be published in blog posts or forums to restraint fellow researchers from taking up the same study [3]. Another unique feature in the Research 2.0 system is that, the research process is not only opened up to fellow researchers but it is also open to amatures, students and general public to pitch in their viewpoints.

4. FACETS OF RESEARCH 2.0

Presently there is a non-existence of a single integrated platform that encompasses all the characteristics of Research 2.0. Scholars are seen to utilize the existing web 2.0 tools that were initially designed for commercial and public use in a scholarly approach. Hence Research 2.0 is multifaceted and is dispersed all across the web. Four of the most prominent Research 2.0 systems are discussed below

4.1 Scholarly/Scientific Blogging

Blogs that were originally designed in the non-scholarly genre, when utilized for scholarly communication is known as scholarly/scientific blogging. These blogs are predominantly used by researchers to publish updates regarding their work. In addition to academics, blogs are also used by science communicators such as journalists, activists, hobbyists etc [1]. For instance, blogs are virally used for science journalism by journalists in the given area of study/research [10]. Hence scholarly blogs and general blogging/ micro blogging sites like twitter are acquiring importance as a new medium of knowledge transfer and occasionally, knowledge creation [11].

The motives behind science blogging vary from sharing knowledge and viewpoints to gaining online reputation. Blogging also serves as a creative platform to organize author's ideas, brainstorm with fellow researchers and interact and create relationships outside the author's field of study. A survey done by Kovic et al [12] showed that 74% of medical bloggers' prime motive was to share practical knowledge and skills while 53% of them claimed that blogs were a manifestation of their creativity.

One of the most successful and collaborative research initiatives employing scientific blogging technique is the Polymath Project conducted by British mathematician Timothy Gowers. Gowers publicly posted a difficult unsolved mathematical problem in his blog on January 29th, 2009 stating that he is open to receive any viewpoints or solution that might aid in solving the problem. Though the Polymath Project got off to a slow start, in 37 days it gained about 800 mathematical comments after which Gowers claimed that the

project not only solved his original research problem but also a much tougher one that included the original as a special case [8].

The role of twitter in the ED-MEDIA 2009 conference showcased the potential of blogging platform in the creation and growth of research/ scholarly communities. ED-MEDIA is an annual international conference on 'Educational Multimedia, Hyper-media & Telecommunication. In the year 2008, the conference organizers started employing twitter as a communication channel to provide details regarding the conference such as announcements, live stream of keynote speakers etc. This medium gained rapid popularization and the EM-MEDIA community had an exponential growth–increase of user base 10 to almost 177 within a few days. The highest growth percentage (87.8%) was recorded during the conference days [13].

4.2 Crowd Science

The extended nomenclature of "Crowd science" includes terms such as "citizen science", "networked science" and "massively-collaborative science" [8, 14]. Crowd science is a form of crowdsourcing technique where a part of the research work is outsourced to the general public (crowd). Crowd science denotes a partially decentralized research process, where geographically dispersed group of individuals possessing knowledge or interest in a given field of research enquiry is assigned with tasks that would foster or aid the overall research study. Crowd science can also be related to Luis von Ahn's 'human computation' approach in which a large number of people are assigned with numerous small tasks that were initially unsolvable through computation [15].

Though not all crowd science projects are homogeneous in nature, two key characteristics remain constant in all of them.

- The project is openly accessible to a wide range of potential volunteers
- Elements such as data files and algorithms/equations/methods that are generally kept secretive are published openly in online crowd science platforms.

Other than these two features crowd science projects are generally heterogeneous in nature denoting the fact that research 2.0 is still at its infant stage and is currently being subjected to various experimentations [16].

The Human genome project that was conducted by the U.S. Department of Energy and the National Institutes of Health is considered to be one of the most popular and the world's largest massively collaborative biological projects till date. The prime aim of the Human genome project was to gain complete understanding regarding the functioning of the human genomes by mapping all the genes present in human beings. An Online database of genes was created which is openly accessible to anyone with an internet connection. This collaborative initiative accelerated the speed of the project. The project was declared complete in 2003, much earlier than the expected duration [17].

Foldit is another prominent study that proved the high level of potential that was intact with the crowd science approach of the Research 2.0 setup. Foldit was initially started as a distributed-computing project under the name 'Rosetta@Home'. Rosetta@Home aimed at utilizing the computers of the volunteers included in the study for folding proteins virtually, when the systems are left unused [18]. In response to the positive suggestions and comments put forth by the volunteer on viewing the automated protein folding process, the research team converted the entire protein folding process into an online game (gamification) named 'Foldit' where the users were given control over the folding process. Foldit gained a user-base of 50,000 within five months, players started to master the folding process resulting in bringing out protein structure that outshined the ones done by the actual research team [19]. Many striking results gained through Foldit were published in PNAS (Proceedings of the National Academy of Sciences) and the players of Foldit were included as co-authors [20].

4.3 Collaborative Authoring and Dynamic Publishing

Most of the conventional and existing means of scholarly publications are static. But in a realistic view knowledge creation is highly dynamic by nature. In a conventional publishing setup, published content can never be revised. The only option the authors possessed to update their existing work is to opt for a new publication that encloses their latest developments [21]. In order to rectify this shortcoming in scholarly publication system, Research 2.0 proposes a novel method named 'Dynamic Publishing'. As the name suggests, in a dynamic publication system the content is in a fluid state (text and other graphic elements) and is open to a wide audience where it can be modified and developed continuously–absence a static version of the content.

Wikis and other collaborative authoring tools such as forums play a vital role in the dynamic publication system. Wikis were especially built to create and publish content collaboratively facilitating the dynamic publishing approach [22]. The three main drawbacks in this system are

- Dynamic publications have undergone frequent editing before it gets evolved into the final version. This may cause unnecessary complexity and confusion in the minds of the viewers.
- This publication system may not be an ideal or adaptable tool for all forms of publication - research papers, reports, books etc.
- Copyrights and licensing of such collaboratively authored publication.

In order to overcome the first drawback, the transparency of the draft-version of the paper may be kept limited to only a few key players. Once the paper reaches the state of a concrete research paper, it can be published openly with unlimited transparency to avoid confusion among the viewers. Since this system has not grown to a level of maximum adaptability for all forms of scholarly publications, for now these new publication tools (wikis, blogs etc) can be used as a supplement to the formal scholarly publication system. Finally innovative licensing techniques such as Creative Commons (CC-BY) can be used to avoid unnecessary copyright issues in such collaborative authoring projects.

One recent book titled 'Opening Science - The Evolving Guide on How the Internet is Changing Research, Collaboration and Scholarly Publishing' was published by springer open in 2014 that adopted the Collaborative Authoring and Dynamic Publishing format. This book was published under the creative commons license (CC-BY). Bartling [23] one of the editors of the book claimed that the book underwent six phases of development before publication. In phase one the editors had the role of inviting various authors for collaboration. This phase also included the process of creating a Google dos table to form the basic structure of the book–chapter division, title, allocation of a tentative authors etc. Skype calls were also used by the authors to interact with each other occasionally. In phase two and three, the abstracts and articles that were returning from various authors were uploaded in Google docs and links created for the same were given in the table of contents (TOC) for the editors and authors to access and discuss points regarding the articles. Images were created (using Apple Keynote) and shared using Dropbox. In phase four and five, an internal review process was conducted among the authors and the editors–all had access and power to comment on any chapter of the book. Finally the references, citations and bibliographies were added and the final proofread copy was sent to the publisher. The book is currently in its 6th phase where it is published as an open access resource at 'www.openingscience.org'.

4.4 Social Networks for Researchers

Conventionally, Social networking sites (SNS) were not considered as the ideal platform for scholarly communication but lately this viewpoint has been altered due to the popularity gained by many upcoming research oriented social sites such as Researchgate, Acadamia.edu, Mendeley etc. According to Nentwich (2003), SNS tend to aid in various research activities such as knowledge construction, processing and dissemination. Especially SNS are viewed to assist the scholars in acquiring information regarding literature. The creation and expansion of scientific networks consisting of individuals with similar research interests is said to be the key role for any research oriented SNS. Facebook and other similar general purpose sites are utilized for creating relationships with academic organizations, universities and fellow individual researchers.

Research oriented SNS are viewed to gain popularity and grow at a rapid rate. For instance, ResearchGate which was launched in May 2008, currently stated that it possessed seven million users [24]. Few experts contradict the positive growth of SNS (used for research and scholarly communication) by claiming that member count doesn't always correlate with usage [25]. A qualitative study done by Harley et al. [26] showed that SNS are not frequently used by academics.

Priem and Hemminger (2012) propose that SNS carries the potential to serve as a platform to publish scientific results corresponding to the decoupling natural of formal scholarly communication channels. This viewpoint is still at a debatable state where few oppose this statement claiming that networking sites are not currently an adequate place for publication [27].

5. USAGE OF RESEARCH 2.0

According to the survey done by Al-Aufi and Fulton [28], 79.6% of academics chose social media as an important and valued platform for scholarly communication. Irrespective of its value and the positive outcomes from various Research 2.0 projects there are still many scholars who are hesitant to utilize this medium across the global. According to a study among academics done by Procter et al. [25] only 13% of the samples were labeled as 'frequent users' for utilizing web 2.0 tools for research purposes. Similarly 45% and 39% of the sample fell under the 'occasional users' and 'non-active' user categories respectively.

The major reason behind this scenario is the conventional mindsets of the researchers driven by the metaphor 'publish or perish'. As a result of which knowledge created by Academics and scientist is left undisturbed until it get an official publication crediting the author. This fear enhances the risk of deteriorating the constructed knowledge for a prolonged time in a closed space which may result in knowledge decay, there by wasting the potential of the knowledge by protecting it in secrecy deprived of usage [29]. Once the knowledge gets decayed, it lacks the potential of being enhanced or applied (making it impossible to enter the Pasteur's quadrant). This research culture fails to understand that any scientific or academic research literature will contain only a small portion of the content that originated for the author, as all research process tends to build on the existing works of other researchers [30] which is highly conflicting to the 'publish or perish' rule.

6. CONCLUSION

Conventional scholarly communication setup doesn't aid complete openness or transparency in terms of Knowledge dissemination. But the advent of internet and web 2.0 technologies has provided the present generation researchers

with additional/supplement tools for communicating their ideas and innovations. According to Jankowski et al (2012 OS), online medium are not only utilized for making research knowledge open, but efforts also are made to modify the scholarly formats more suitable for the virtual world. Research 2.0 deals with the concept of using web 2.0 platform as informal scholarly communication medium for enhancing the openness and collaboration in the existing research practices.

“To make progress in science, we need to be open and share” is a sound and a relevant quote given by Neelie Kroes [32] regarding scientific progression. Lack of openness and dissemination of knowledge will results in decay. Knowledge decay will decrease the research’s potential to move into the Pasteur’s Quadrant of stroke’s Knowledge and Utilization Graph. And without entering the Pasteur’s quadrant the constructed knowledge tends to becomes redundant without any enhancement or application.

Research 2.0 setups discussed in this paper include ‘Scholarly or scientific blogging’, ‘Crowd science’, ‘Collaborative and dynamic publication’ and ‘social networks for researchers’. All the four setups are viewed to retain high transparency in their communication process. Studies such as Foldit, Polymath Project, Human Genome project and Opening Science book that are discussed in the present paper demonstrated the high potential of Research 2.0 environment in catalysing the speed of the knowledge creation process. Research 2.0 is also viewed to enhance the utilization rate of the existing knowledge by facilitating massive collaboration with fellow academics and the general public. Hence by employing Research 2.0 as a supplement tool for scholarly communication, a conventional research study can be transformed into a dynamic one resulting in dual functionality (both knowledge advancement and simultaneous implementation)..

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