Communicating Science in the New Media Environment: The Advancement of Science Literacy

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"Science literacy is the artery through which the solution of tomorrow's problems will flow"
- Neil deGrasse Tyson

Abstract

Science is the social foundation that encompasses all facets of life, from educating individuals, to allowing them to make informed decisions in their daily lives. Science is ultimately our way of learning about life; thus, the field of science education must acknowledge the significance of, and pressing need for scientific literacy in creating conscious, well-informed citizens in today's world. The debate on the credibility of science content and information offered by media experts is especially pertinent to science communication. New media is the new sphere that allocates knowledge and its processing to various audiences. New media technologies have revolutionized the realm of interactivity, allowing for knowledge-sharing platforms to be among the novel digital forms of communications. This exploratory study discusses the fluctuating familiarity with the term "scientific literacy", that extends beyond the use of skills. The purpose of this study is to examine the Egyptian public's utilization and consumption of new media tools, with a focus on scientific information and popular science topics. Moreover, this study aims to examine the Egyptian public's perception of the concept of "scientific literacy", and delves deeper by investigating the different levels of science literacy that make an individual "scientifically-literate." This study used an online questionnaire to assess motivation factors for new media preeminence in science communication in comparison to traditional media. The study also provided examination of success factors for the advancement of scientific literacy in Egypt, as well as factors prohibiting that advancement of scientific literacy.

Introduction

In 1963, a landmark study was conducted by Price et al. and published by Columbia University Press, entitled "Little Science, Big Science" examining the difference

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between "little" and "big" sciences (Lievrouw 2010). Their study described "little science" as scientific information conveyed by amateurs, engaged in informal interactions and discussion; the study concludes that "little science" is replacing "big science," which is mass-produced, and globally circulated scientific information that is controlled and developed by professional scientists and media conglomerates.

With the advent of new media, the recognized and established enterprise of "big science," and interpersonal forms of science communication, have faced new social and technological challenges. The progress of new media has enabled user connectivity, and helped foster the proliferation of digital spheres, focusing on knowledge-sharing. New media is the second generation of the internet, enabling a novel form of participatory culture, revolving around user engagement and interaction. New media, as a collective term, includes individual networking formats, like blogs and podcasts, as well as collective formats like social networking sites (SNSs). The term new media also refers to video and photography platforms and wikis; collaboratively-developed platforms, allowing for users to add or edit content.

New media, also known as social media, created venues and resources for scientific communication that combine immediacy, credibility, and deliberation (Merton 1973). SNSs are eminent platforms for the access and visualization of science. Some key examples of SNSs include ResearchGate and Slideshare. Nevertheless, these interactive sites also indicate a blurring of institutional and disciplinary boundaries. This obscurity surrounding institutional boundaries comes with imperative consequences for the ways that scientific knowledge is generated, not only among science experts and professionals, but also among the informed and involved online public.

New media transforms science communication from a relatively linear process of gatekeeping, publishing, directed-search and retrieval, to a multi-stakeholder socialized digital sphere of interactivity, discussion, and recommendation (Lievrouw 2010). New media introduced "prod-users", blurring the lines between producers and consumers of information, and enabling any Internet user to create and share content. Building on this idea, new media are changing people's expectations about the sources, availability, and uses of information. A question worthy of discussion is whether the growing use of an interactive new generation of computer-mediated technologies (new media) could revive modes of science communication, that contrast with big science. Competing with the old-fashioned hierarchy of science communication means defying science institutions' hegemonic structures, which currently dominate the research realm, the publishing industry, and platforms that communicate science-related topics (McGarity and Wagner 2008).

As advocated by Price et al. in the 1960's, the revival of interest in informal, interpersonal communication in science, opened the way for mixed approaches that considered documents and interaction together as integral aspects of scientific and scholarly communication. This perspective has become relevant as computer-mediated technologies have become an integral element of ordinary scientific research (Lievrouw 2010). Conceptual frameworks established in literature, such as Lievrouw & Carley (1990), are reviewed and applied to patterns of online engagement and interactivity among users, resulting in what is identified as 'telescience' or citizen-science (Lievrouw 2010). The term "telescience" is an adaptation of NASA's attempt to describe "geographically dispersed, intensely communicative research groups and collaborators, electronic journals, and teleconferences" (Lievrouw and Carley 1990, P. 458). "Telescience" depicts the proliferation of User-Generated Content (UGC), characterizing the growing importance of new media technologies in scientific communication.

Despite the plethora of research on science literacy, there is a lack of research that assesses science communication in the new media environment in the Arab world, including Egypt. This study examines how new media may help in advocating science communication in an environment that inevitably develops basic presentation of scientific literacy. This study sets out to provide an overview of "scientific literacy", providing an explanation of why the term should be referred to as "scientific literacy" rather than "science literacy". The importance of redefining the term as "scientific literacy" places the emphasis on the word "literacy", which allows for the linkage of scientific literacy to skills and values attributed to the responsible citizen. The importance of enhancing scientific literacy is placed on an appreciation of the nature of science, the development of personal attributes and the acquisition of socio-cultural skills and attitudes. The study will measure the understanding of scientific literacy, factors needed and obstacles challenging the implementation of scientific literacy in Egypt and the Arab world.

Literature Review

Science Communication in the New Media Environment

Science is a means of understanding and knowing about life. It enables society and its citizens to practice and engage in the construction of knowledge to achieve favorable ends. To use and consume science in a sociable process, some level of familiarity with the enterprise of science is needed; this type of familiarity and understanding is referred to as "science literacy". This study discusses the change in familiarity with the term "science literacy." The term in this study is understood as the extension beyond the use of knowledge, to include the understanding of scientific and technological information, and the utilization and critique of information to construct a knowledgeable lifestyle.

As science literacy acts as a first step towards identifying science and understanding it, the conceptualization approach to measuring scientific literacy should be revisited. This paper suggests that the term "scientific literacy" imposes a two-layer use of scientific information or content: the first layer entails identifying and understanding the scientific information, and the second layer entails then moving to applying and criticizing scientific information that is consumed in everyday life. A fundamental step in employing scientific literacy is the public's reception and understating of science; this not only entails pure science, but also culture, social institutions, and communication. Science communication here is understood as the practicing of informing, educating, and raising awareness of science-related topics.

Another definition for science communication is offered by Liang et al. (2014), encompassing all forms of communication by scientists and about the sciences, for a specialized and well-informed audience, as well as for a lay audience. Throughout history, communicating science has been focused on findings from an investigation, which portray a superficial image of science. Furthermore, communicating science to the public seems to fall under a normative assumption among scientists that public communication is not valuable to their academic careers. They are expected as scientists to be dedicated to conducting research, rather than "broadcasting" their work in the media. Trumpeting science communicating through traditional media is thus believed to compromise a scientist's integrity and authority, in what is informally known as 'Sagan-ization'(Liang et al. 2014).

The internet and user generated content (UGC) crafted on new media platforms have endorsed information to be presented and analyzed in novel and practical ways. UGC enhanced the application and value of information and knowledge, as well as its potential to achieve useful outcomes by allowing users to incorporate knowledge in their daily decision-making process. Hence, new media is employed as one of the modalities aiding science's perception for the public. The internet and new media's two-way communication process is vital to the public's understanding of science, as well as to assessing the public's appetite for science content, as opposed to a linear mode of communication that lacks feedback on discoursed science.

In addition to the availability of a two-way communication process, new media 'prod-users' are harnessing their collective proficiencies and presenting new genres of content such as edutainment content. Edutainment content—presenting educational content in an entertaining manner—on new media platforms, act as a vital element in public understanding, as users are given the opportunity to inquire and send feedback to the source of information, as well as apply a set of skills acquired while following edutainment content. Some of the most renowned examples of new media science edutainment presenters are: *Addaheeh* popular science program, *Egychology*, *Shara' El 'Aloom*, and *Espitalia*, that all harness SNS tools—mainly YouTube and Facebook—to broadcast science content in an interactive and entertaining structure.

However, different new media tools have various usage and gratifications, and accordingly they have a different impact on the receiving audience. For example, Facebook pages present a different interactivity model than that presented by YouTube; Facebook is more dynamic and interactive, as it provides more features for the audience to engage with. Twitter, on the other hand, is more widely utilized by scientists as it enables the provision of fast and short pieces of information to a mass audience. Twitter allows scientists to share their knowledge and research with specialized and non-specialized audiences in the form of breaking news with little background noise (Shepherd 2014).

According to Science Barometer (2016), 443 out of 1006 surveyed participants (44%) use the internet as an information source for science and research (cited in Acatech 2017). Scientists now have more platforms for coverage and an abundance of publishing tools; therefore, audiences have more channels to receive scientific information. New media's communication is more reciprocal, requiring advanced level of interactivity, as opposed to traditional mediums. Nevertheless, new media have raised novel questions relating to "professional" coverage, gatekeeping of science, pseudoscience, quality of discussion and the equal integration of all stakeholders in a digital public sphere.

Frameworks for Science Communication

Science communication efforts support the establishment of a transparent and reciprocal stream of communication that contributes to outlining the role of science in society, as well as utilizing science's function in society. Literature on science communication embraces various standpoints on how science is conveyed and perceived by heterogenous audience, with what impact. For example, Trench and Junker (2001) identified five models of science communication that include all stakeholders in the communication process: deficit, dissemination, duty, dialogue, and deference. Brossard and Lewenstein (2010) introduced four models: the Deficit Model, the Contextual Model, the Lay Expertise Model, and the Public Participation Model. Furthermore, Secko et al. (2013) introduced a new typology of science communication models, beginning with the Science Literacy Model. In this framework, the Science Literacy Model's goal is to "translate" scientific information for the public, in order to give citizens the information they need to make informed decisions in their daily lives.

Translation is not confined to effective and successful communication, conversely, it entails the proper harnessing of the science communicator's skills to convey "easy" science to a lay audience using simple terminology. The second model is the Contextual Model, which—similar to the Deficit Model—employs a "top-down" information delivery. The Contextual Model goes a step further by addressing scientific information in particular, audience-linked contexts. Hence, the model asserts that the communication process should take into consideration the socio-cultural context through which information is conveyed and conversed, paving the way to the Lay Expertise Model.

The Lay Expertise Model is mainly viewed as a version of the Contextual Model. Brossard and Lewenstein (2010), however, present a compelling argument that the two are different: The main discrepancy between them is that the Lay Expertise Model assumes that local, grassroot knowledge is equal to scientific knowledge. The Lay Expertise Model breaks with the top-down notion of science communication, towards a new model of horizontal communication. The final model is the Public Participation Model, which attempts to construct the scientific process in a more collaborative and interactive ecosystem, encouraging stakeholder discussions surrounding scientific issues, with little top-down control over the content and more orientation towards a more horizontal level of interactivity (Brossard and Lewenstein 2010).

Despite the disperse anatomy of science communication models, this study focuses on elementary models utilized to examine the directions of knowledge acquisition and dissemination convenient for the development of a media convergence ecosystem in the region. In 2008, Trench introduced a fundamental multi-model framework of expert-public interaction in science and technology communication. The first model is the Deficit Model, the second is the Dialogue Model, and the third is the Participation Model. This framework was vital in comprehending the science and technology communication process as an evolutionary continuum, paving the way for novel frameworks and models' integration.

The deficit model believes that the audience do not 'understand' scientific concepts due to lack of knowledge and information exchange (Brown University Science Center 2014). Using this conception, Bucchi (2002) argued that both the public's understanding of science, and science's reporting, are measured against the standards of science, resulting in the media being blamed for misrepresentations of science. A review of the discussion of public communication in the publications of professional societies suggests that a Deficit Model remains the default option in many sectors of science (Trench and Junker 2001). The public's engagement with the scientific content in the Deficit Model is limited to what is being offered by the media.

Wynne (1995) writes that public engagement with science activities is "based, albeit ambiguously on closer inspection, on replacing the previous Deficit Model's primitive one-way assumption about educating an ignorant public into '(scientifically) proper attitudes.'" (cited in Trench 2008: 122). Ramification to deficit model includes addressing the public's alleged lack of scientific understanding through a more "active" communication process. The ineptitude of a linear and passive communication process has been discussed by renowned communication theorist Denis McQuail, noting that the audience is conceptualized as the body of 'receivers of messages at the end of a linear process of information transmission'(McQuail 1997).

The Deficit Model survives as an effective foundation for science communication. Yet, McQuail's discussion of an interactive two-way communication process gradually gave way to the contextual model of communication. The application of a one-way dissemination process conveyed through the deficit-model application continues to coexist with two-way models that place varying emphasis on interactivity, such as the Contextual Model of Science Communication. However, while the Contextual Model theoretically aims at increasing knowledge and changing attitudes, some have critiqued it as being another version of the Deficit Model that maintains "top-down" information delivery and places scientific knowledge above other forms (Secko et al. 2013).

Through the Contextual Model, scientists share their information that fits their specified audience's needs. Understanding the public's needs calls for active listers and audience in an entwined communication process. The uses and gratification option, offered by the new media ecosystem, enables the audience to be active in selecting the level of interactivity in a given topic of interest. As digital and online media assumed a much larger place in the mass communication field, the notion of "audience" has come under greater strain, often giving way to the notion of "users", which is drawn from information and communication technologies. Concepts of interactivity have been extensively debated, not only as they refer to human-computer interaction, but also as they refer to mediated communication processes between individuals and groups (Trench 2008).

The last model of science communication is the Participation Model; this model requires for primary stakeholders to engage and participate equally in discussions about science and technology. For the stakeholders to engage in discussion on content, they need to be equipped with adequate tools and have the platform for such a participatory process. New media is one of—if not the only—platform that enables a vivid interactive process among audiences, users, scientists, institutions, and policy makers.

Significance of "Scientific Literacy"

Science literacy is often interpreted as identifying the basic facts established by science, but the concept entails much more (Snow and Dibner 2016). The term "science literacy" was first coined by Paul Hurd in the late 1950s, and was initially used to describe the comprehension of science and its application to society (Laugksch 2000). Still, various interpretations have been presented to expound the term "scientific literacy". For instance, Durrant (1993) postulated that scientific literacy is what the general public ought to know about science. Jenkins (1994) opined that "science literacy" commonly applies to an appreciation of the nature, coupled with some understanding of the more principal scientific ideas. In addition to that, Brewer (2008) declared that scientific literacy is the exposure to media content (newspapers, magazines, or TV) and the ability to comprehend and critique the content discussed.

For the last few decades, the term "scientific literacy" has been used and debated in literature (Gallagher and Harsch 1997). This paper argues that the accurate terminology should be "scientific literacy" rather than "science literacy", since "science literacy" entails understanding and processing, while "scientific literacy" entails the application of such accumulated knowledge to decision-making on a daily basis. Furthermore, this study posits that "scientific literacy" is more than the "understanding" of basic knowledge of science facts, and that the focus should be expanded, to include the perception of scientific processes and practices, familiarity with knowledge application, a competence to evaluate the products of science, and finally, an ability to engage in civic decisions about science and science-related issues.

"Scientific literacy" is still a polysemous term, as its definitions do not necessarily converge. The methods of acquiring scientific literacy still lack consistency; Norris and Philips (2003) contend that the term "scientific literacy" has been used to embrace various components including: Knowledge of the substantive content of science, and the ability to distinguish science from non-science; understanding science and its applications; knowledge of what counts as science; the ability to think scientifically; the ability to use scientific knowledge in problem solving; and, knowledge needed for intelligent participation in science-based issues; among other elements.

In addition to that, the National Science Education Standards define scientific literacy as: "the means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences" (Dani 2009: 289). However, in 1987, Hirsch presented a science education community-focused definition: He indicated that "scientific literacy" is concerned with the usage of science, and should not entail the application of science, or as he called it, "doing science". Hirsch (1987), therefore, outlined the concept of "scientific literacy" as: the knowledge one needs to understand the scientific component of public issues (Laugksch 2000).

As life progresses, so does science, allowing for more developments and innovations to occur, stirring up discussion and debates. A society with high levels of scientific literacy would be able to objectively debate and ultimately reach better decisions. Being scientifically literate will ensure an individual to receive and analyze information in the proper manner (Ogunkola 2014). In addition to this argument, Walberg (1983) suggested that scientific literacy will empower individuals to participate more intelligently in the productive sector of the economy and therefore concluded that scientific literacy should be seen as a form of human capital that influences the economic well-being of a nation in a number of different ways.

Drawing from such discrepancy in conceptualization, the elements that constitute scientific literacy has also been a topic of debate. For example, Shen (1975), Shamos (1995), and Bybee (2008) have identified distinctive types of scientific literacy: Practical Scientific Literacy, Civic Scientific Literacy, and Cultural Scientific Literacy (cited in Ogunkola 2014). They presented Practical Scientific Literacy as the type of literacy that entails basic survival decisions, such as health. Civic Scientific Literacy is identified as the type of literacy that enable citizens to become aware of science related issues to be better equipped to make meaningful decisions in a socio-cultural context. Finally, Cultural Scientific Literacy is the type of literacy that utilizes the motivation to search and desire to acquire knowledge on science as a central accomplishment of any human being.

Interpretation of scientific literacy came as "an acquaintance with science, technology and medicine, popularized to various degrees, on the part of the general public and special sectors of the public through information in the mass media and education in and out of schools" (Shen (1975: 45). In 1995, Shamos identified three distinct types of scientific literacy and their definitions: Cultural Scientific Literacy, True Scientific Literacy, and Functional Scientific Literacy. The conversion of scientific literacy conceptualization was revived as Bybee, Powell and Trowbridge in 2008, provided a second layer of analysis by providing dimensions to every type of scientific literacy.

In 2002, Nisbet et al., provided an explanation of why scientific literacy matters. Their study shed light on the significance of scientific literacy, as we need critical and informed citizens in face of present and future challenges. Science may help in saving this planet and sustain its limited resources, as it is a responsibility of every individual to deliver this planet in a better condition to future generations. Moreover, with the application of scientific literacy, citizens will be able to participate in decision-making processes with well-developed understanding of scientific and technological aspects.

Today's world is in desperate need of citizens with critical minds, rational thinking, familiarity, and skills. Citizens who will be able to question foundation of surrounding assertions, search, evaluate, and debate science information via media platforms that will inevitably build a well-supported structure for personal decision-making alternatives (Ajayi 2018). Finally, these interconnections of individual and society's knowledge will contribute to the well-being and economic development of countries (DeSemir 2010).

Scope of the Study

At the heart of public understanding of science, lies the notion of scientific literacy. Scientific literacy is an indispensable component of education in our modern society and it is crucial to teach science to all citizens, not only for those who are actively engaged or chose careers in science (Ogunkola 2014). The National Science Foundation (NSF) attempted to measure science literacy with regular surveys since the late 1980s. Adapting NSF methodology, this study conducted an online questionnaire in order to measure the Egyptian public's perception and understanding of science, science literacy fundamentals, and their consumption of science-related issues via new media platforms. Though the population for this study is the Egyptian population, youth, those whose age ranges from 18 to 30 years old, represent the active age group with high new media consumption as a filtration element. The study conducted a snowball, non-probability sample.

The study examined various elements regarding the advancement of scientific literacy, and the implementation of a digital ecosystem for science communication dissemination. The questionnaire was designed to examine the basic familiarity of the Egyptian public with scientific literacy, their level of engagement on SNSs, motivation to seek science-related information on computer-mediated tools, and, what they believe to be the main obstacles towards implementing scientific literacy in Egypt and the Arab world.

Measures

Independent variable: Identified as the level of social media engagement.

Dependent variable: Identified as the rudimentary understanding of scientific literacy.

Research Methodology

This study used a survey as the research method, as it is a research technique that investigates, examines, assesses, or evaluates the issues that constitute a research problem (Wimmer and Dominick 2006). A snowball sample was used to ensure the respondents' engagement to SNS. The online questionnaire was conducted in Arabic and distributed over the two main SNSs used in Egypt; Facebook and WhatsApp, over the duration of four weeks. The questionnaire was inspired by Miller's (2004) proposition that science inquiry begins when asking survey respondents to say whether they feel they have a clear understanding of what it means to study something scientifically.

The study's questionnaire included demographic questions like age, gender, and education. A filter question was used to examine the respondents' use of new media tools, to ensure the sample's level of engagement on SNSs, The number of SNSs used was an indicator of the level of engagement, as well as the types and names of SNSs used to seek science-related information. Respondents were asked to provide their preferences on the type of content they search for, and were asked to indicate which platform they refer to in search of scientific information in the new media environment. This was then followed by questions examining motivation factors behind searching for science-related topics.

A distinctive approach to measuring scientific literacy was presented by Brossard and Shanahan (2006), highlighting the problem that previous studies inevitably took for granted: Previous studies implicitly assumed respondents are aware whether they are scientifically-literate, even with no proper measurement of that. To tackle this drawback, respondents were asked to provide their familiarity with the term "scientific literacy", prior to providing a referenced definition for the term, to assess for the term's conceptualization. Following in Miller's (1983) footsteps, the questionnaire proposed questions that relate to conceptualizing what is identified as the 'scientific approach,' and 'scientific thinking', and were asked to identify their degree of knowledge of science, and their understanding of the term "scientific literacy" and what it entails. Finally, to better asses what elements are needed to advance scientific literacy, respondents were asked to identify main obstacles prohibiting the implementation of scientific literacy.

Findings and Discussion

The survey received 106 responses. The majority of the sample were females constituting 68 percent. People aged 25 to 35 constituted 47 percent of the sample, followed by 41 percent who were above the age of 36, with only 12 percent aged between 18 and 25. The majority of the sample (73 percent) had obtained a Bachelor's degree. For the screening question on new media usage—which was intended to assess new media usage and on what platforms—all of the 106 respondents were new media users. Nearly all of the sample were Facebook users (95 percent). Other tools indicated by respondents as their go-to application were: LinkedIn, WhatsApp, and Pinterest.

To assess SNS uses and gratification, respondents were asked if they use new media to search for science content and science-related issues. Nearly half the sample (48 percent) stated that they use new media—SNSs, in particular—to search for science-related issues and information, while 35 percent said they sometimes search for science information on new media tools, and 20 percent never searched for science information or science news on new media platforms. In an attempt to identify how the sample perceives the nature of science, respondents were asked to recognize which topics fall under the realm of science. Respondents were able to recognize science in all suggested topics to varying degrees. The top three main areas recognized were: health (81 percent), food and nutrition (70 percent), and economy (41 percent). The sample was asked to identified if there are other topics that are identified as science-related topics, and responses were limited to technology, social science, and biology.

For media-tool selection, respondents were asked to choose which media platform they use when searching for scientific content or information. Online websites were the top-ranked platforms used (82 percent), followed by SNSs (43 percent), followed by television (20 percent). Choosing online websites as opposed to traditional media may be attributed to the practicality of new media, the engaging visuals, and prompt updates of information. The sample's choice of online news sites as the first choice for seeking scientific information indicates that there is a common perception that SNSs lack content credibility. Respondents accessed SNSs and online news sites equally; this could be triggered by the lack of gatekeeping on SNSs, and dissemination of pseudoscience. Still, "pseudoscience" assessment and science content factors were not introduced nor evaluated.

The quality and credibility of sources used in narrating science-related information must be put into consideration when measuring science communication in the new media environment. Recently, there have been trends toward pseudoscience that have gained popularity despite their utmost irrationality. To measure rudimentary application of credible science-related information, respondents were asked if they trust online science content found on social media and SNSs. Surprisingly, the majority of the sample (71 percent) chose "sometimes", 22 percent had no trust in online science content, and seven percent denoted they trusted online science content. To further assess the perception of online content credibility, respondents were asked to indicate, based on a 5-point Likert scale, ranging from very credible (5) to least credible (1), how credible they though science content is. The majority of the sample were neutral 59 percent, surprisingly only nine percent believe it is credible, two percent very credible, 21 percent not credible, and 11 percent least credible.

To examine the motives behind acquiring science content and information, respondents were asked to include reasons for following science related issues. Almost equal percentages were given to the following reasons: "love for knowledge and science" (66 percent), and "keeping up-to-date with trends (65 percent), live events, and breaking news." 49 percent indicated that they search for science content in order to "enhance their daily personal decision-making processes through science." 24 percent said their search was due to "curiosity", and 11 percent stated that their search for scientific content was "out of joy and entertainment: leisure time." Others indicated "work purposes" as another reason to seek information on scientific topics. Nevertheless, it is vital to mention that this questionnaire was distributed during the COVID-19 pandemic in the year 2020, which may have skewed the results with more individuals likely accessing health related science news online and through SNSs.

To examine the significance of science dissemination and the communication of science in media, the sample was asked if they found the reporting and communicating of science content in a regular or frequent manner and important, or not. The majority of the sample (81 percent) responded with yes, 18 percent were neutral, and only 1 percent saw science dissemination as "not important". This high percentage favoring frequent science coverage, reaffirms the public's understanding of and appetite for science, and refutes the idea that science is rejected by lay audiences due to its complex nature. However, as mentioned above, this number could have been skewed upwards given the outbreak of COVID-19.

Widavsky and Dake (1990) define a scientifically-literate individual as someone who is conscious of science and technology, and supportive of science as an institution (as cited in Bodmer 1985). This section of the questionnaire focused on assessing the understanding and conceptualization of scientific literacy-related actions and practices. For the evaluation of scientific literacy, this questionnaire asked a simple question pertaining to the understanding of the terminology itself. Respondents were asked to indicate if they were familiar with the term "scientific literacy", without providing a statement nor information on the expression. 35 percent of the sample self-reported that they understood the term "scientific literacy", 40 percent said they were uncertain, and 25 percent indicated that they did not understand the terms.

In an attempt to examine the accuracy of respondents self-reported science literacy familiarity, the questionnaire provided UNESCO's definition, inspired by the Programme for International Student Assessment PISA (2009), on scientific literacy. Respondents were then asked to indicate if, after reading the provided definition, they believed themselves to possess the basics skills needed to be a scientific-literate individual. UNESCO defines scientific literacy as "an individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen." (UNESCO 2009: p. 5)

This definition was chosen as it tackles focal points of scientific literacy as depicted by this study, including but not limited to, understanding domains of scientific knowledge and effect on individuals and society, as well as how acquiring scientific inquiry skills will enhance the daily decision-making process and elevate standards of livings in various ways. Respondents presented similar percentages to the previous question on the identification of the term "scientific literacy". 47 percent of the respondents said they have the set of skills needed to be scientifically-literate, 31 percent indicated that they are not sure, and 21 percent said they lack the skills needed, which is a lower percentage than the previous question on identification of the term (25 percent).

Following the perception and understanding of scientific literacy, and based on the aforementioned definition, it was imperative to ask respondents what they deemed the biggest obstacle towards successfully implementing scientific literacy in Egypt. Options varied from "school", "traditional media", "social media", "family and friends," and "NGOs". The majority of the sample chose "school" as the primary obstacle limiting scientific literacy in Egypt (87 percent). This number reaffirms the notion that science is cumulative and time is needed in order to educate individuals on how to master the skill of scientific thinking, and to enhance scientific inquiry. Moreover, the identification of science in everything surrounding us is key to integrating scientific thinking in our daily life. "Social media and SNSs" are identified as the second obstacle towards implementing scientific literacy (64 percent), followed by "traditional media" (48 percent), "NGOs" (41 percent), and lastly, "family and friends" (34 percent). Other factors included "books and scientific research publications" as key players in advancing scientific literacy in Egypt, but that constituted only 1.5 percent of the overall perception of respondents.

Building on the literature and the relationship between science communication and new media, the questionnaire asked whether the sample believes SNSs are better than traditional media outlets in providing science content due to the use of visuals and emerging technologies. More than half (55 percent) stated that social networking sites deliver better science content than traditional media, 25 percent were neutral, while 20 percent rejected this proposition. From those who agreed with the transcendence of SNSs in providing science content, the questionnaire sought to measure which factors were believed to have caused such transcendency.

Based on aptitudes of UGC, the following elements were suggested as the factors affecting the communication of science in the new media environment: the use of visuals and infographics, user-medium interaction and engagement, informal language, word choice, and content selection. The highest percentages were granted for the use of visuals and infographics (40 percent), and informal language use, and easy word choice (32 percent). Meanwhile, the respondents still acknowledged the availability of sources and abundance of background information.

Finally, respondents were asked, from their point of view, what is the main obstacle to scientific literacy in Egypt and the Arab world? Inadequate sources of scientific knowledge was selected as the main obstacle (29 percent); 28 percent referred to deficits in the educational system and adaptation of science inquiry skills and knowledge; 22 percent believed that poor science communication and inadequate explanation of complex concepts was the principal problem behind lack of scientific literacy; 14 percent said "lack of science sources and knowledge"; and si percent referred to "fake-science news or pseudoscience" as the prohibiting factor towards the achievement of scientific literacy.

From the data interpretation, it is clear that the Deficit Model is still dominating the communication process. Nonetheless, new media has balanced the diverse flow of information and science communication to the public. New media has created a two-way dialogue adapting to the technical means of the Deficit Model which has dominated traditional media, while enabling continuity for change in the ecosystem. As Bucchi and Trench (2008) state, science communication models can coexist as policy instruments, and they are not mutually exclusive. Public engagement concerns should be at the forefront of Egypt's science communication model.

Digital platforms and digital media content are no longer concepts of the future, they are of the present; industries and audiences alike should be able to incorporate these tools in their consumption pattern as a supply and/or demand. Science communication initiatives and efforts need to invest in novel forms of cyberspace, which will inevitably advance the Contextual Model as a first step towards an inclusive model that integrates the public, media, and scientists together.

This study's findings indicate that scientists and science organizations need to pursue a dialogue-based relationship with all stakeholders instead of a long-standing

Deficit Model of science communication in Egypt. Media stakeholders need to recognize the importance of advancing science-related issues in the contemporary context, as it is evident that there is an appetite for science information, granted presentation in an easy and entertaining format as indicated by the sample, is present. Scientific organizations need to track and amend diffusion models of science-related coverage, as argued above. The significance of science relies partly on the fact that it fits all streams of life, so it should be understood and practiced in the sociocultural context that is appropriate for its consumers and audience.

Conclusion

"Mysterious, magical, or dangerous" is how Long and Steinke defined science (1996: 587). To interpret science's nature and employ it, it is in the hands of scientists to merge science into a meaningful context to lay audiences through media consumption. As Irwin and Wynne (1996) argue, science knowledge only receives public legitimation if it is communicated in a way that accounts for sociocultural context. New media, a collaborative platform network of SNSs, allows for such conceptualization of science in a culturally-relevant context. Computer-mediated Communication (CMC) in general, and new media in particular, have revolutionized our modern media ecosystem, our content production, and consumption habits.

With new media's collaborative nature, users are able to create, critique, demand, and participate in a reciprocal process of science communication. In addition to that, the previously existing boundaries between the audience and institutions are blurring. Knowledge is no longer confined to certain channels, nor is it under the authority of a media conglomerate or agenda-setting. New media practices, mental habits, ways of cultivating, and means of acquiring knowledge are all fertile soil for the advancement of scientific literacy (Leah 2010).

This study's findings demonstrate that new media technologies have excelled in presenting science-related issues, partly due to the abundance of visuals and interactive means of knowledge communication. Moreover, new media is the contemporary means of communicating and it is gaining momentum across various age groups. Nevertheless, new media faces the challenges of content quality, and gatekeeping function shortages in cybermedia ecosystems. Scientists and researchers have expressed growing concerns about the quality, quantity, and the general status of science reporting in the media today. Scientific literacy is the unflawed counteraction to the new media shortage of gatekeeping resources. Today's world needs informed and competent citizens who are capable of comprehending and utilizing knowledge at hand and employing such knowledge in a sociocultural context.

However, the use of language is an obstacle in science communication around the world, particularly in the Arab region, as most of science journals and resources are in English. Also, science communicated by government officials, and companies with resources to utilize communication channels, usually comes embedded with an agenda. Moreover, mass media platforms are challenged by the hegemony of news agencies supplied content, which usually lacks a sufficient dose of science-related issues, due to the fact that they devote more time and resources to global conflict issues. Another challenge to science communication is the lack of training and capacity building, or all of the links included in the communication process. The most important link is the appropriate training of future journalists with the skills needed for better conception of the audience needs.

Limitations of the Study

Scientific literacy entails much more than skills and the understanding of science, it goes beyond conception, to include the application of knowledge acquired in a sociocultural context. This study was limited in measuring rudimentary factors related to the understanding and application of science-related issues. Also, the snowball sampling confines the generalization factor for the study.

Recommendations for Future Studies

As this was primarily an exploratory study, future research should employ larger samples to yield more statistically significant results. Measurement of the current understanding of 'science' literacy elements is necessary. A quality-oriented code of conduct for science-information online, and on new media needs to be evaluated in relation to the information's impact on audience appetites for scientific content. A comprehensive list of scientific literacy skills should be established to determine correlation factors among variables. Future studies should include aspects on scientific inquiry as depicted by Miller (1987). Miller depicted the criteria of literacy to be (1) a vocabulary of basic scientific constructs, (2) an understanding of the process or nature of science inquiry, and (3) a level of understanding the impact of science and technology on individuals and on society. Millers' structure is based on (1) coded responses to the question "What does it mean to study something scientifically?" (2) the recognition that astrology is not at all scientific, and (3) correct answers to six or more out of nine knowledge questions (Miller 1987). Additional questions should be added to assess multidimensional constructs of knowledge acquisition platforms and diffusion processes. Finally, an enhanced understanding and examination of what outlines "pseudoscience" could be explored and integrated into the research given that the boundaries between science and pseudoscience are debatable and constanty changing.

References

Acatech– National Academy of Science and Engineering, German National Academy of Sciences Leopoldina, Union of the German Academies of Sciences and Humanities (Eds.) 2017. *Social Media and Digital Science Communication. Analysis and Recommendations for Dealing with Chances and Risks in a Democracy*. Munich.

American Association for the Advancement of Science. 2016.*Communicating Science Online*. Retrieved from https://www.aaas.org/programs/center-public-engagement-science-and-technology/communicating- science-online

Ajayi, Victor. 2018. “Scientific Literacy” Benue State University, Makurdi. DOI: 10.13140/RG.2.2.13345.92009

Bodmer, W. 1985. *The Public Understanding of Science*. London: Royal Society.

Brewer, C. 2008. “Scientific literacy in the classroom.” *Actionbioscience*. American Institute of Biological Sciences.

Brossard, D., and B. V. Lewenstein. 2010. “A Critical Appraisal of Models of Public Understanding of Science.” In L. Kahlor and P. A. Stout (eds.) *Communicating Science: New Agendas in Communication*: 11-39. New York: Routledge.

Brossard D and Shanahan J. 2006. “Do they know what they read? Building a scientific literacy measurement instrument based on science media coverage.” *Science Communication* 28(1): 47–63.

Bucchi, M., and B. Trench, eds. 2008. *Handbook of Public Communication of Science and Technology*. London: Routledge.

Dani, Danielle. 2009. “Scientific Literacy and Purposes for Teaching Science: A Case Study of Lebanese Private School Teachers.” *International Journal of Environmental & Science Education.* Vol. 4, No. 3, July 2009, 289-299.

De Semir, V. 2010. “Science Communication & Science Journalism”. Media for Science Forum, Madrid. Available at: http://www.mediaforscience.com/Resources/documentos/booklet_en.pdf

Durrant, J.R. 1993. “What is science literacy?” In J.R. Durrant, and J. Gregory (Eds.), *Science and Culture in Europe* (pp. 129 – 137). London: Science Museum.

Gallagher, J., & Harsch, G. 1997. “Scientific literacy: Science education and secondary school students.” In W.Graeber & C. Bolte. (Eds.). *Scientific literacy: An international symposium* (p. 13- 34). Institut für die Pädagogik der Naturwissenschaften (IPN): Kiel, Germany.

Hetland, P. 2011. “Science 2.0: Bridging Science and the Public.” *Nordic Journal of Digital Literacy* 6 (Special Issue):326-339.

Hirsch, E.D., Jr. (1987). *Cultural Literacy: What Every American Needs to Know.* Boston: Houghton Mifflin.

Irwin A and Wynne B (eds) (1996) *Misunderstanding Science? The Public Reconstruction of Science and Technology*. Cambridge: Cambridge University Press.

Laugksch R.C. 2000. “Scientific literacy: A conceptual overview.” *Science Education* 84(1): 71–94.

Liang, X., Su, L. Y.-F., Yeo, S. K., Scheufele, D. A., Brossard, D., Xenos, M.,Corley, E. A. 2014. “Building Buzz: (Scientists) Communicating Science in New Media Environments.” *Journalism & Mass Communication Quarterly*, 91(4), 772–791. https://doi.org/10.1177/1077699014550092

Lievrouw, Leah A., and Kathleen Carley. 1990. “Changing Patterns of Communication Among Scientists in an Era of ‘telescience’” *Technology in Society* 12 (4): 457–77.

Leah, Lievrouw, 2010. “Social Media and the Production of Knowledge: A Return to Little Science?” *Social Epistemology*, 24:3, 219-237. DOI: 10.1080/02691728.2010.499177.

Long, M., & Steinke, J. 1996. “The Thrill of Everyday Science: Images of Science and Scientists on Children’s Educational Science Shows in the United States.” *Public Understanding of Science*, 5, 101-120.

McGarity, T. O., & Wagner, W., 2008. *Bending science: How special interests corrupt public health research*. Cambridge, MA: Harvard University Press.

McQuail, D. 1997. *Audience analysis*. London: Sage.

Merton, Robert K. 1973. “The Normative Structure of Science” In *The sociology of science*, pp. 267–78. Chicago: University of Chicago Press. [Originally published in 1942. “Science and technology in a democratic order.” *Journal of Legal and Political Sociology* 1: 115–26.]

Miller, J. D. 1983. "Scientific literacy: A Conceptual and Empirical Review." *Daedalus*, 112(2), 29-48. Retrieved from http://www.jstor.org.ezproxy.neu.edu/stable/20024852

Miller, J.D. 1987. "Scientific literacy in the United States." In *Communicating Science to the Public,* eds. D. Evered and M. O'Connor, 19-40. London: Wiley.

Miller, J. D. (2004). "Public Understanding of, and Attitudes Toward, Scientific Research: What we know and what we need to know." *Public Understanding of Science, 13*(3), 273-294. https://doi.org/10.1177/0963662504044908

National Academies of Sciences, Engineering, and Medicine. 2016. *Science Literacy: Concepts, Contexts, and Consequences.* Washington, DC: The National Academies Press. doi:10.17226/23595.

Nisbet, M. C., Scheufele, D. A., Shanahan, J., Moy, P., Brossard, D., & Lewenstein, B. V. 2002. "Knowledge, Reservations, or Promise? A Media Effects Model for Public Perceptions of Science and Technology." *Communication Research*, 2002. 29(5), 584z608. https://doi.org/10.1177/009365002236196

Norris, S.P. and Philips, L.M. 2003. "How Literacy in its Fundamental Sense is Central to Scientific Literacy." *Sci. Ed.* 87: 224-240. doi:10.1002/sce.10066

Ogunkola. Babalola. 2013."Scientific Literacy: Conceptual Overview, Importance and Strategies for Improvement." *Journal of Educational and Social Research* Vol. 3 (1). January ISSN 2239-978X

Secko., David M., Amend, Elyse, and Terrine Friday. 2013."Four Models of Science Journalism A Synthesis and Practical Assessment." Taylor & Francis. http://dx.doi.org/10.1080/17512786.2012.691351

Senam, Nsikan, and Akpan., Uwem. 2014. "The Survey Communication Research" *Journal of Education and Research*, ISSN: 2201-6740, Vol. 2 No. 10

Shamos, M. H. 1995. *The Myth of Scientific Literac*y. New Brunswick, NJ: Rutgers University Press.

Shepherd, Marshall. 2014. "Why A New Study Says Scientists Should Use Twitter." Forbes.com. https://www.forbes.com/sites/marshallshepherd/2018/11/19/why-a-new-study-says-scientists-should-use-twitter/#3eb70b883329

Shen, B.S. P. 1975. "Scientific Literacy and the Public Understanding of Science. In S. B. Day (Eds), *Communication of Scientific Information*. Pp 44 -52. Basel: Karger.

Snow, Catherine E. and. Dibner, Kenne A. National Academies of Sciences, Engineering, and Medicine. 2016. "Science Literacy: Concepts, Contexts, and Consequences." Washington, DC: The National Academies Press. doi:10.17226/23595.

Trench, B. 2008. "Towards an Analytical Framework of Science Communication Models." In D. Cheng, M. Claessens, T. Gascoigne, J. Metcalfe, B. Schiele and S. Shi (eds.) *Communicating Science in Social Contexts: New models, new practices*: 119-135. Netherlands: Springer Science+Business Media B.V.

Trench, B. & Junker, K. (2001). "How Scientists View their Public Communication. Paper presented to Trends in Science Communication Today, 6th International Conference on PCST, Geneva, Switzerland, January 2001. Retrieved on 25 November 2007 from http://visits.web.cern.ch/vis- its/pcst2001/proc/Trench-Junker.doc.

UNESCO. 2020. International Bureau of Education (IBE), "Scientific Literacy". http://www.ibe.unesco.org/en/glossary-curriculum-terminology/s/scientific-literacy

Walberg, H.J. (1983). "Scientific literacy and economic productivity in international perspective." *Daedalus*, 112(2), 1 – 28.

Wynne, B. (1995). "Public Understanding of Science." In S. Jasanoff, G. E. Markle, J. C. Petersen & T. Pinch (Eds.), *Handbook of Science and Technology Studies*. Thousand Oak, London, New Delhi: Sage, 361–388.