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To Learn About Science: Real Life Scientific Literacy Across Multicultural Communities

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To Learn About Science: Real Life Scientific Literacy Across Multicultural Communities

Adriana Briseño-Garzón, Kristen H. Perry, and Victoria Purcell-Gates

Much of the current research on scientific literacy focuses on particular text genres read by students within the classroom context. We offer a cross-case analysis of literacy as social practice in multicultural communities around the world, through which we reveal that individuals with no formal education, as well as people with varied levels of schooling completed, customarily and actively engage in literacy events with the goal of learning about science as part of their everyday lives. We argue that these outcomes substantiate the notion that multiple ways of being scientifically literate actually exist and that scientific literacy in its most fundamental sense is crucial in science education, despite the fact that the most common definitions and notions of scientific literacy have predominantly considered its derived sense (Norris and Phillips 224).

Introduction

Many definitions and approaches to science or scientific literacy have been set forth by institutional authorities, educators, and researchers from varied fields of study, such as science education, disciplinary literacy, and social research on public engagement with science (AAAS; Hand et al.; Lemke). Different disciplinary takes on science education and literacy have yielded distinctive interpretations of terms, theoretical perspectives, lines and methods of research, as well as relatively independent bodies of knowledge around a common topic (Feinstein). The analysis we present here is theoretically framed by two converging fields of inquiry: science education and disciplinary literacy.

Science educators and science-education researchers rather indistinctly use the terms science literacy and scientific literacy as interchangeable. According to Roberts (732), the term *scientific literacy* predominates in the literature and is pervasively used in a number of countries. *Science literacy*, on the other hand, is particularly utilized by science educators in the United States as a result of its appearance in the official documents published by the American Association for the Advancement of Science in 1990 and beyond (Roberts 732). For many researchers the discrepancy has no implications, although some consider that the terms differ in meaning. Considering that researchers in the literacy field have also consistently made use of the term

scientific literacy in their investigations and reports, we have opted to use the term scientific literacy.

Although educators and researchers from all disciplines have asserted that cultural, personal, and contextual factors influence a reader's approach and appropriation of a text (Barton and Hamilton; Perry, "Genres"; Purcell-Gates, *Other people's, Cultural; Street, Literacy, Social*), most research on scientific literacy stemming from science education and disciplinary literacy approaches has been carried out in one specific context—the school—and has traditionally looked at a particular type of involvement with the discipline—the "effective learning" of school science. Our study aims at contributing a richer view of what reading and writing about science mean for people with different social, cultural, and educational backgrounds. We looked at the roles that scientific literacy plays in the everyday lives of people outside the formal instruction environment by investigating the following research questions: 1) Do people read or write scientific content outside of the formal school context? 2) If so, what do the read and written texts look like? 3)What areas of people's lives are mediated by such texts? 4) What are people's purposes for reading and writing about science beyond the context of school?

In order to address these questions, we conducted a cross-case analysis of individual ethnographic case studies that investigated the literacy practices of members of various different marginalized communities around the world. With this study we uncover the nature of scientific literacy in its most fundamental sense (Norris and Phillips 226): the purposes and everyday life practices that contextualize people's reading and writing actions, with the goal of learning about science. In doing so, we advocate for a notion of scientific literacy that expands from school science to real-life engagement with science throughout society and by citizens of all ages, and we bring together two vibrant but independent fields of inquiry. We also contribute to addressing the need for novel empirical perspectives on scientific literacy research, which has been highlighted by Hand et al. as an essential element for bridging the gaps between literacy practices and the teaching and learning of science, and between research and policies (609).

Theoretical Framework

In general terms, science-education scholars agree that the science-education reforms that have taken place in Anglo countries within the past two decades promote standards-based definitions of scientific literacy for all learners (Yore, Bisanz, and Hand 690). For instance, scientific literacy has been outlined as knowledge or understanding of the content of science and its applications (DeBoer; Eisenhart, Finkel and Marion; NRC); ability to use scientific knowledge to solve problems (AAAS; NRC); understanding the nature of science (DeBoer; Hanrahan); or ability to think critically about science (Korpan et al.). Nonetheless, researchers from both the science-education and the disciplinary-literacy fields have contributed a more socially responsive perspective on scientific literacy that goes beyond the standards-based notions. Such views imply making the learning of science more accessible to youth and providing students/

learners with access to functional and practical knowledge will allow them to evaluate ideas so they can make informed decisions or draw informed conclusions about the roles of science in their lives and those of others (Lemke; Moje; Norris and Phillips; Wellington and Osborne).

This last perspective on scientific literacy also brings into focus the specific roles that reading and writing have for science education and other disciplinary content areas—history, mathematics, English, etc. This body of work clearly considers that: a) literacy is not only the ability to read and write, but it is also a process that involves understanding and learning; b) both spoken and written language are integral parts of science and scientific literacy; and c) to be literate in any discipline, particular skills need to be developed (Moje; Norris and Phillips; Shanahan and Shanahan; Wellington and Osborne).

Norris and Phillips (225) differentiate between the fundamental sense of scientific literacy and its derived sense. According to them, the former refers to reading and writing when the content is science, or the practices surrounding the reading and writing of scientific written texts, and the latter refers to being knowledgeable, learned, and educated in science. Not many science-education scholars, Norris and Phillips argue, have contemplated the fundamental sense of scientific literacy as relevant for science and literacy education. In the disciplinary literacy field, however, researchers have made a strong argument that each discipline of knowledge demands particular ways of thinking, talking, reading, and writing and that those ways need to be taught in school through specific pedagogical strategies (Lemke; Moje; Shanahan and Shanahan). Scientific literacy in its fundamental sense then, also involves certain linguistic, cognitive, and cultural practices alongside the actual content matter of the text. In fact, a number of empirical studies have supported the conclusion that readers approach texts in different ways depending on their goals for reading them, the reader's involvement with the discipline in question, the nature and origins of the text itself, and the context in which the texts are being read (Moje 10).

Literacy and Scientific Literacy

Oral and written language is the symbol system most often used to do, teach, and learn about science, and the importance of language for scientific literacy has also been acknowledged (Hand et al. 608). Yet, the perceptions of the roles of language in science education, as well as the research approaches employed to investigate the roles of oral and written language in science teaching and learning, are constantly changing and have dramatically shifted over the last decades (Rudolph; Yore, Bisanz, and Hand). The initial focus on oral language as a source of speech and on the readability of textbooks eventually evolved—as a result of the development of the cognitive sciences and constructivist perspectives on learning—into an interest in the role of language in science and in science teaching and learning and the roles of learners' social and cultural context. Thus, in recent times we have seen an increasing awareness of the importance of the literacy component of scientific literacy, as well as of the social situated-ness of

any learning event (Yore, Bisanz, and Hand 690). In fact, reading and writing research in science education has increased in the past two decades, although according to Rudolph (66) and Yore, Bisanz, and Hand (691), most of it has been conducted in classroom settings with textbooks and worksheets as main focus points, and little has been done to explore the reading and writing of texts with scientific content in other contexts or the nature of the texts that are being read and written by people in order to gain new understandings around scientific topics and themes.

Studies concerned with the science education of a non-scientific public have been less common and diffused across a number of disciplines and fields (Rudolph 69). For the most part, such research has focused on the producers of the scientific texts, not on their readers and those readers' personal purposes and goals. For instance, Rudolph concluded that the main purposes of written texts geared for the general public are to explain the process of science, to foster scientific literacy, and to teach about the science of everyday things (70). Also, texts about science have been used in order to bring individuals from the non-scientific public, particularly underrepresented groups, closer to a meaningful relationship with science (74).

Disciplinary literacy, too, has seen a shift in perspective and focus through time. First, researchers focused on students' development of cognitive text processing strategies as a means of enhancing content-area learning without taking into consideration the specific demands of each discipline. Then more recently, disciplinary literacy moved to an approach that considers that learning disciplinary concepts takes place when students learn how knowledge is produced and consumed within the disciplines (Yore et al.). Other lines of current disciplinary literacy research focus on the particular roles of the linguistic processes of the disciplines and their implications for each content-area education (Halliday and Matthiessen). Disciplinary literacy researchers have also attempted to take the cultural practices and cognitive processes present in students' everyday lives into account and to draw from these in the process of creating novel subject-matter instructional tools (Barton; Moje; Roth and Lee). According to this perspective, content-area instruction should begin with students' interests, knowledge, and practice (Moje 5). Yet, this disciplinary literacy tradition has strongly focused on young students and their learning of the disciplines within the classroom setting; the greater part of the work done on connecting youth's culture and literacy practices to disciplinary knowledge, language and literacy comes from secondary English language arts and social studies (Moje 5).

Another branch of literacy research that has also employed a sociocultural lens has focused on the reading and writing of different written genres outside of school settings (Barton and Hamilton; Purcell-Gates, *Other people's, Cultural; Street, Literacy*). These researchers have viewed literacy as more than a collection of technical, acontextual skills, but rather as a tool that mediates people's lives and which reflects the social practices, history, and ongoing and shifting interactions that take place in the many contexts of people's daily lives.

There have also been numerous international calls to link language and scientific literacy with different audiences and language communities, stressing that multiple and varied language or literacy tasks could in fact increase both science understanding

and language performance (Yore, Bisanz and Hand 691). In this regard, some research has been conducted in order to explore the reading and writing practices of scientists in their scientific inquiry endeavours (Berkenkotter and Huckin; Yore, Hand and Florence). However, few researchers have focused on exploring the nature of scientific genres amongst the lay people, and the purposes for using those genres, outside the context of formal instruction (Yore, Bisanz and Hand 693). Moreover, little has been done in the past to address communities that are socially, culturally, and economically marginalized from mainstream societies, and to explore the situations and contexts that influence their reading habits, strategies, and choices. Therefore, our research into scientific literacy outside of the classroom setting and into the everyday lives of culturally diverse people, framed by the view that scientific literacy exists in different forms, represents an important empirical contribution to both science education and disciplinary literacy.

The Cultural Practices of Literacy Study (CPLS). This research study, as part of the Cultural Practices of Literacy Study, is framed by theories that view literacy as always situated within social and cultural contexts and within relationships of power and ideology (Barton and Hamilton; Street, *Literacy*). Reading and writing, including reading and writing about science, is more than knowing words and locating information in a text. Many different elements contextualize and give meaning to any reading or writing event, such as the context where the event takes place, the characteristics of the text itself, the purpose for reading or writing, and the social and cultural backgrounds of people, as well as their linguistic and cognitive practices. Consequently, the analysis of any literacy practice is shaped by and interpreted within the sociocultural and sociolinguistic contexts within which it takes place (Barton and Hamilton; Bakhtin; Street, *Literacy, Social*; Vygotsky). This highlights the fact that texts are written and read for varied purposes and with varied meanings within specific sociocultural and sociolinguistic contexts. A pharmacist, for example, might read detailed chemical information about a new drug that has recently been developed, in order to be fully informed about the drug before dispensing it to patients, while a farmer might read the same text in order to make informed decisions and choices related to the use of the new product.

In this paper we identify and examine the scientific-literacy practices that have been reported by members of a collection of marginalized communities around the world. With this analysis, we explore what scientific literacy means to our participants in those social, cultural, linguistic, and economic contexts. We furthermore argue that investigating literacy practices in relation to science will provide a more realistic picture than now exists of the literacy and scientific worlds of students and their communities. At this time, what researchers know about scientific literacy and the lay public is limited and has not been a relevant focus of research. Researchers have acknowledged that we do not know much about people's appreciation or engagement with science, given the limited systematic inquiry in this field (Shapin 13). Our analysis offers a step towards filling this gap.

Method

The case studies from which the data for this analysis come represent a portion of the case studies that were conducted under the auspices of the Cultural Practices of Literacy Study. CPLS offers a theoretically grounded model to analyze and interpret accounts of literacy in context, and, for our purposes here, offers a unique approach to understanding scientific literacy across cultures and from the perspective of those who make use of written science genres (Purcell-Gates, Perry and Briseno).

The Cultural Practices of Literacy Study

Located at the University of British Columbia, CPLS is a large umbrella project focused on examining language and literacy practice in marginalized communities around the world (http://www.cpls.educ.ubc.ca/). Overlaying the Cultural Practices of Literacy Study is the primary focus on students and communities that have been historically marginalized in society and mainstream schools. CPLS consists of three main dimensions: (1) the collection of ethnographic case study data on the ways that literacy is practiced within specific cultural contexts; (2) the creation of an expanding database that allows for cross-case analyses of literacy practice (such as this one); and (3) the design of models of literacy instruction that reflect these data and that provide links between the literacy worlds of students and literacy instruction within formal educational contexts (Purcell-Gates, Perry and Briseno).

It must be stressed that CPLS researchers do not count frequencies or instances of a given text or event. Rather, we seek to capture an overview, or range, of the myriad practices available in a community, as well as the contexts that shape these practices for the participants of the study.

Currently, the Cultural Practices of Literacy Study includes a total of 24 individual case studies. All CPLS case studies focus on people engaging with print through literacy events within these contexts, and all of them contain data about the texts that mediate the sociocultural contexts within each case study and for each participant. Each CPLS case study examines literacy within sociocultural contexts and documents larger structures such as political, economic, historical, religious, linguistic, and power systems. In addition to describing literacy practices, each CPLS case study is also designed to answer its own specific research questions relevant to that particular sociocultural context. Although researchers pursue their own individual research questions, each researcher also collects data using a common methodology that allows the studies to contribute to the overall Cultural Practices of Literacy Study database and that allows for principled cross-case analyses.

The research study herein reported is one such CPLS cross-case analysis. With it, we begin to unveil: (a) the types of texts that are being read or written within particular sociocultural communities with the goal of learning about science, health and/or technology; (b) the purposes for which such texts are read and written; and (c) the domains of social activity in which such activities fall. Therefore, the present

CPLS cross-case analysis provides a much-needed exploration of the scientific-literacy practices that occur in people's everyday uses of language and literacy, with a particular focus on marginalized groups' perspectives. The present report is not, however, a frequency count of the number of scientific-literacy events, nor is it an analysis of the readers' interpretations of the contents of the texts or their impact in people's scientific understanding. Rather, we provide an exploratory overview of the landscape of scientific literacy amongst marginalized people around the world.

Data Collection for Cultural Practices of Literacy Study

All Cultural Practices of Literacy Study case studies are organized around a common methodology for data collection and data analysis, which allows us to conduct principled analyses across multiple cases. Common CPLS data sources include: (a) field and participant observation of the ways that people engage with print, and of the social, cultural, and political contexts within which such events occur; (b) semi-structured interviews with participants; (c) documentation of 'public texts' (through photographs or collection of artifacts) such as texts found in stores, advertisements on bus stops, newspapers, and so on. For a detailed description on the data collection and data analysis methods and schemes used in CPLS, see Purcell-Gates, Perry, and Briseno and http://www.cpls.educ.ubc.ca.

Again, CPLS researchers do not aim to document the frequency of people's reading and writing events. Also, CPLS is not specifically focused in scientific literacy but in documenting the wide range of literacy practices of the members of the communities under analysis, which may include scientific literacy. For example, science-related literacy events often emerged as casual or spontaneous comments made by participants about the things that they regularly read and/or write in their daily lives.

Coding System for the CPLS Studies

Our common coding system permits researchers to systematically analyze data from individual case studies in ways that reflect the theories of literacy as socially situated, socially semiotic, multiple, and mediating social lives. All literacy practice data from the Cultural Practices of Literacy Study case studies are coded at the literacy event level. Following Shirley Brice Heath, we define "literacy event" as any observable or reported instance of reading and writing. Our codes include theoretically-based codes (e.g. social activity domain; text type; purpose; and function), as well as descriptive codes (e.g. mode of literacy engagement: reading, writing, listening to; language(s) of the text; or whether the event occurred in participant's childhood or adulthood) and demographic codes (e.g. participant's age, gender, occupation(s), country of birth, native language(s), language(s) spoken at home, language(s) read or written, level of schooling completed, etc). Codes that are relevant to this analysis are included in Table 1.

Table 1: CPLS codes containing relevant information for the cross-case analysis on scientific literacy

Code	Definition
Domain of social activity (Dm)	Reflects a focused area of common activity engaged in by people that can be named and recognized as shaping textual activity, social relationships, roles, purposes, aims, and social expectations. Examples are entertaining oneself or having fun; participating in family life; attending to health and hygiene; participating in formal schooling; and working.
Function (Fn)	Is what happens in order to achieve a given comprehension or expressive purpose. A literacy event's function is implied by the text. A function drives the intent of reading/writing.
Social Purpose (Pr)	Is the ultimate goal of the literacy event within a particular social activity domain. The social purpose is implied by the domain, as opposed to the function which is implied by the text itself. For example, in the domain of working, the purpose of writing a resume is to apply for (and perhaps) receive a job.
Text type (Tx)	Genre of the text involved in any literacy practice, as defined by purpose of the text and relevant textual features. The materiality or form of the text (e.g., book, magazine, notebook, and digital forms) is also included in this code.
Mode (Md)	Type of literacy activity: reading or writing.
Language (Lg)	The language of the text involved in the literacy event.
Demographic data	Age, gender, spoken languages, level of schooling, occupation, access to computers and internet, etc.

Source: Purcell-Gates, Perry and Briseno.

The CPLS coding system provides a consistent, theoretical way of linking individual literacy events to a larger set of contextual data, such as interview transcripts or field notes. Each study with its codes, along with its corresponding field notes, photos, artifacts, and published and unpublished reports, is loaded into an electronic and searchable database. The large CPLS database allows researchers to perform queries according to particular research interests, and to go back to the original field notes and interpretations.

Data Collection for Cross-Case Analysis: Selection of Cases for Analysis

To identify instances of scientific literacy in the database, we began by exploring our list of functions for reading or writing "Fn". The Fn code captures the immediate communicative intent of a reading or writing event and is directly connected to the nature of the text and from the perspective of the participant. The Cultural Practices of Literacy Study database includes instances of function codes such as "To learn about science", "To learn about plants/gardening", and "To learn about human physiology". All original Fn codes that refer to science, animals/plants, health/physiology, technology, and psychology were included in this initial phase of case selection. Following this line of reasoning, we argue that any text genre that from a participant's perspective is used with the goal of learning about science, health, and/or technology ought to be identified as a crucial component of that person's scientific-literacy practices.

We deliberately chose to include health and technology in this analysis of scientific literacy because we consider these knowledge areas to be closely related to the current scientific endeavour as well as components of the science curriculum for elementary, middle, and high school students around the world. On the other hand, we also chose to leave any activities that relate to participating in formal schooling out of this analysis, because we were particularly interested in providing readers with a fuller and clearer picture of non-school related scientific-literacy events. For instance, the many reported instances of parents/guardians helping children with school related activities were not taken into consideration for this analysis.

Generic Fn codes such as "To learn about interesting things", "To compose essay", "To record notes from reading", and "To summarize information" were also investigated. After identifying the relevant Fn codes, we returned to the database to more closely examine the contextual data from field notes, transcripts, and researchers' interpretations and reports. By this means we were able to: a) corroborate which literacy events were actually related to learning about science, health and/or technology and b) give context and meaning to the selected literacy events. Analyzing literacy practices data in conjunction with the overall contextual data for each study is an essential step in any CPLS cross-case analysis, as this provides a grounded perspective of the contextual factors that surround each of the selected codes and literacy events. In other words, the literacy event data cannot stand on their own and must be analyzed and understood within the sociocultural contexts in which they occur. After identifying the relevant literacy events along with their corresponding case studies—as described below—we queried the large electronic database to pinpoint information that we considered pertinent for the objectives of the present cross-case analysis, including domain of social activity, purpose for reading or writing, text type, mode, and language (Table 1). We also identified relevant demographic data.

Cases Included in this Analysis

From the database, we identified numerous reading and writing events that had learning about science, health, and/or technology as a goal. These events were represented in 19 of the 24 case studies that currently comprise the CPLS database. Altogether, these 19 case studies represent diverse social and cultural communities worldwide (Table 2). Our findings speak to the fact that scientific-literacy activities are represented among the real-world literacy practices of a wide variety of marginalized participants and communities.

Table 2: Individual CPLS case studies included in the cross-case analysis on scientific literacy

Case No.	Description
Case 1	Ecology of reading and writing and the everyday lives of the inmates at the state prison in Oaxaca, Mexico (Clemente and Higgins).
Case 2	Literacy practices of a group of elementary school students living in a shelter in Oaxaca, Mexico (Clemente and Higgins).
Case 3	Literacy practices of future English teachers currently enrolled in a university teacher education program in Oaxaca, Mexico (Clemente and Higgins).
Case 4	Attitudes toward and usage of English among two farmers in Puerto Rico (Mazak, "Appropriation").
Case 5	Usages of English in a rural, Puerto Rican community (Mazak, "Negotiating").
Case 6	Literacy practices of several families living in a marginalized, mainly non-English L1 neighborhood of urban Vancouver, Canada (CPLS).
Case 7	How a U.S. course in writing and technology helps university students acquire a technology discourse and reflect critically upon digital literacy practices (Eyman).
Case 8	Literacy activities, beliefs and values of two Chinese-American bilingual families (Zhang).
Case 9	Changes of one family's literacy practices brought about by life changes after immigrating from Korea to Canada (Kim).
Case 10	Home and school literacy practices of a group of fifth grade, urban students attending an after-school program in the U.S. (Kersten).
Case 11	Literacy practices of three male Sudanese refugee youth living in Michigan, U.S. (Perry, "Sharing").
Case 12	Literacy practices of Sudanese families with young children living in the U.S., focusing on literacy brokering (Perry, "Genres").
Case 13	Elementary students' literacy practices in L2 (Spanish) and emergence into Spanish literacy as L1 Zapoteco speakers in Mexico (Velasco-Zárate).
Case 14	Literacy practices of two adult Cuban refugees in the U.S. (Rosolová).
Case 15	Literacy practices of parents with no or low schooling, who have moved from rural to urban areas to provide greater educational opportunities for their children in Oaxaca, Mexico (López).
Case 16	Literacy practices in an East Vancouver (Canada) neighborhood whose elementary school ranks in the lowest quartile of British Columbia schools (Moayeri and Smith).
Case 17	Literacy practices of students in a Bolivian Fe y Alegria School, teachers' preparation to teach in culturally responsive ways (Gates and Purcell-Gates).
Case 18	Literacy practices of L1 Spanish migrant farm worker families in the US, and their children's literacy experiences attending English Head Start programs (Purcell-Gates, "Literacy practices").
Case 19	Relationship between the in- and out-of-school literacy practices of marginalized Nicaraguan immigrant students in Costa Rica (Purcell-Gates, "Cultural").

Demographic Characteristics of Participants

This cross-case analysis reports on the data from approximately 380 participants. Some of these 380 individuals were focal participants in their case studies, while others were non-focal participants (e.g., relatives or community members whose literacy practices may have been described by focal participants or who may have been observed by the researcher but not directly interviewed). Participants from the different social and cultural communities in the cases described above included children, youths, young adults, adults, and seniors ranging in age from 5 to 70 years old. Females and males were fully represented in our database, although the female population for this particular analysis was slightly larger.

This analysis included individuals with differing levels of schooling completed. Participants ranged from having no schooling whatsoever to participants with doctoral degrees; all levels of schooling completed in between were represented (e.g. some elementary/primary school, some high school, and some college, and master's degrees). It is interesting to note that over 40% of participants of this cross-case analysis only completed some elementary school or had no formal education at all. Approximately one half the participants who had no formal schooling or only some elementary schooling were children under the age of 12; their levels of schooling therefore compare to their ages. The remaining half, however, corresponds to young adults and adults between 13 to 70 years of age. This indicates that, according to our data, adults with limited formal education were reading and writing to, from their

perspective, learn about science in their everyday lives. Close to 15% of participants had completed some college, and another 15% held a college degree. Only about 6% of participants had attained graduate degrees.

Participants' occupations also represented a rich range of activities, including: actor, baker, business owner, carpenter, child care provider, construction worker, doctor, domestic help, electrician, factory worker, fisherman, government employee, housewife/homemaker, migrant farm worker, school principal, secretary, shoemaker, store clerk, student, subsistence farmer, teacher, and no occupation.

The pool of people included in this cross-case analysis represented a rich variety of first or home languages including: Aymara, Baria, Chatino, Chontal, Cree, Konkani, Latuka, Nuba, Tlingit, Triqui, Vietnamese, West Indian Patois, Zande, and Zoque. However, literacy and literacy instruction in these communities took place primarily in the following languages: Arabic, Dinka, English, French, Greek, Hindi, Ilocano, KiSwahili, Korean, Madi, Mandarin, Marathi, Mixe, Punjabi, Quechua, Spanish, Tagalog, Tamil, Vietnamese, and Zapoteco.

The communities included in this research study were diverse and unique, but shared the common characteristic of a marginalized status within their respective socio-political communities. The groups of people herein included were comprised of immigrants (both legal and illegal), refugees, citizens, and legal work/study visa holders. Nearly 50% of participants lived in urban settings, while almost 30% resided in rural areas; around 20% lived in suburban settings, and a small percentage dwelled in small towns. Less than 30% of the participants had computers in their homes, and only 15% had access to the Internet through home connections. However, almost all participants had Internet access near their homes—a fact that had a direct impact on their access to texts used to learn about science.

In the findings section, we will describe and elaborate on the nature of the reading and writing events that can be catalogued as components of the scientific-literacy practices of the participants and their communities.

Findings and Discussion

Our analysis indicates that participants read and wrote about science as part of different activities that were not related to school endeavours. Such literacy events took place in many different spheres of people's lives and involved a diverse range of text types that were read or written for varied social purposes.

Scientific Literacy across Different Domains of Human Activity

Science reading events largely exceeded science writing events, and the reading events were engaged in for a wider range of social domains. Science reading was done within the following social activity domains: Entertaining oneself, having fun "ENT"; participating in family life "FAM"; attending to health and hygiene "HTH"; acquiring

or disseminating information/news "INF"; maintaining tools and home environment "MTN"; transacting with school-like learning practices "SLL"; engaging in self-motivated education/personal improvement "SME"; and working "WRK". Science writing, on the other hand, was reported or observed within the following social activity domains: ENT; FAM; HTH; INF; SME; and WRK. These outcomes accord with other studies of literacy practice that document a higher incidence of reported reading than writing events (e.g., Purcell-Gates et al). As will be fully discussed, our findings, give a sense of the everyday scientific-literacy events for participants and communities from participants' perspective.

Of course, many of the reported reading and writing events related to science had a connection with formal instruction or schooling, and took place as a result of people's direct involvement with science learning at school. These instances are not, however, discussed in this paper.

Our analysis offers rich evidence that varied scientific-literacy events occurred outside of formal schooling. Non-educated as well as educated people, as part of their everyday lives, read and wrote about science as part of their leisure activities, as a source of information about current events, as a means of attending to their own health, and as a result of a self-motivated interest in learning and improving their understanding of the natural world. Examples of reported scientific-literacy events include a prisoner in Oaxaca, Mexico reading a science article in a magazine in order to pass time; a Bolivian mother writing an informative summary about a reading on diverse topics, including science, in order to explain information to her child; a Mexican immigrant farmer in the U.S. reading information books about pregnancy and child diets in order to keep her family and herself healthy; a child in a shelter reading a textbook about geography in order to make sense of the news in the newspaper; a low-educated Oaxacan parent reading about plants and gardening in order to learn something new; two young Sudanese refugees in the U.S. reading a children's picture dictionary to learn about animals and satisfy curiosity; a farmer in Puerto Rico learning information about animal health in order to meet job requirements; and a Vancouver resident of an immigrant neighbourhood reading about technology in order to be able to fix computers. In this particular case, the woman explained to the researcher that although she is not an educated person, she is now capable of using a computer, installing programs, and actually fixing and putting together machines from parts—results of her own interest and reading practices:

> **Participant**: Yeah. Well I read a lot of stuff on like, I'm getting really good at the computer. I do all my own thing on it. Like I've learned from … well I didn't go to school, I just did it on my own.
>
> ***Researcher***: Like figuring out the word processing and that kind of stuff?
>
> **Participant**: Yeah. And how to fix it, take it apart.
>
> ***Researcher***: Oh really?
>
> **Participant**: I take them all apart.

Researcher: You can take like the hard drive?

Participant: I like taking things apart … When I bought my first computer I got the screwdriver out and I took it all apart.

Researcher: Oh really? I would be terrified.

Participant: I add memory, I do all sorts of things, clean them.

An interesting finding is that in fact, many of the reported reading events that had learning about science, health, and technology as a goal, fell within the domains of entertainment and self-motivated education. The fact that participants engaged in science-learning practices out of the school setting moved by personal motives suggests that such scientific-literacy events could impact people's appreciation and understanding of science beyond the aims and scope of formal schooling. This outcome, then, challenges the widespread interest in school science as the only avenue for science education and raises questions about the actual significance of investigating and valuing students' everyday worlds.

Table 3: Purposes for engaging in reading events, outside the domain of schooling, that have learning about science, health and/or technology as a goal

In order to alleviate depression/stress/ loneliness	In order to learn/improve skills in another language
In order to apply for/get a job	In order to meet job requirements
In order to be correctly informed	In order to monitor child's learning/ achievement
In order to be entertained	In order to pass time
In order to be informed about events/ issues	In order to relax
In order to educate oneself	In order to satisfy curiosity
In order to improve one self	In order to share text/information with someone
In order to keep self/family healthy	In order to understand content
In order to know if one needs medical care	In order to understand instructions
In order to learn new things/skills	In order to use a computer
In order to learn/improve literacy skills	

Social Purposes for Reading/Writing to Learn About Science

We expect social purposes and domains of social activity to be intimately related, since according to our model of literacy practice (Purcell-Gates, Perry and Briseno), the social purpose or reason for any reading or writing to be done is implied by the domain of social activity in which the literacy event takes place. However, an exploration of the social purposes for reading or writing about science provides a more clear and detailed picture of the objectives attained by the members of the communities included in this analysis, when engaging in the aforementioned literacy events beyond the domain of formal schooling. The social purposes related to reading about science are outlined in Table 4, and Table 5 shows the social purposes related to writing about science beyond the formal schooling context.

Table 4: Purposes for engaging in writing events, outside the domain of schooling, that have learning about science, health and/or technology as a goal

In order to be entertained	In order to play/do/solve game/puzzle/ activity
In order to get website information	In order to remember events/dates/infor- mation
In order to keep self/family healthy	In order to share text/information with someone
In order to learn new things/skills	In order to understand content
In order to learn/improve skills in another language	
In order to pass time	

Table 5: Text genres read and/or written by the participants of the different CPLS studies, with the goal of learning about science

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13	Case 14	Case 15	Case 16	Case 17	Case 18	Case 19
Advertisement													R						R
Almanac																	R		
Caption										R									
Copy text												W							
Dictionary												R			R				
Encyclopedia entry	R														R		R		
Encyclopedia set	R												R						
Essay			W										W						
Feature story																R			R
Fiction narrative			R	R															
Information note		W		W		W	W	W				W	W						
Information text	R/W		R/W	R	R	R/W				R	R	R	R/W	R	R/W	R/W	R/W	R	R
Instructional text	R	R	R	R	R	R	R	R/W		R	R	R	R		R	R	R	R	
Instructions																	R		
Manual																R			
News story				R									R		R		R	R	
Novel																	R		
Product catalogue						R													
Reading notes			W										W						
Research report						R	R									R			
Search term			W					W	W										
Self-help text						R							R						
Sentence		W																	
Table of contents				R															

Social purposes for reading about science. Some examples from the data include: a farmer in Puerto Rico reading a news story related to science "in order to relax"; an East Vancouver parent reading about technology "in order to share text/information with someone", in this case his children; an East Vancouver mother reading pamphlets about health "in order to be informed about events/issues"; a Zapoteco native reading a science encyclopedia "in order to learn new things/skills"; a Puerto Rican farmer reading health handbooks "in order to meet job requirements"; and, as illustrated in the following quote, a Nicaraguan immigrant in Costa Rica reading magazine articles about medicine and health "in order to keep self/family healthy":

> **Participant**: In these "Selecciones" magazines, there is always a section on medicine. The one I am reading now talks about how to floss your teeth. It talks about dental hygiene. It talks about cavities and how they are formed. All of that. The issue I am reading now has all that information. Dental care. I have it here … It exactly talks about those things, about health care, I mean personal hygiene and dental care … Here. I have read up to this page … It also talks about obesity and how to prevent obesity in children … See? It talks about nutrition and what the children need, and has a nutrition pyramid.

Social purposes for writing about science. Some examples of writing events include: members of bilingual Chinese American families creating instructional materials "in order to teach a lesson" on geometry and astronomy; a Korean mother in Vancouver typing search terms in a browser "in order to get website information" about health issues; and a future English teacher in Oaxaca, Mexico, taking notes in English from reading information text about interesting facts in nature "in order to learn/improve skills in another language". The following quote exemplifies this last event:

> **Participant**: I like reading about many things, like nature and also politics, and entertainment too. We have many books at home. But I also like to write down about the things I found most interesting … So that is what I do during the day …
>
> ***Researcher***: You don't do it in Spanish?
>
> **Participant**: No
>
> ***Researcher***: Because you want to practice your English.
>
> **Participant**: Right, my English.

The individual case studies included in this analysis take account of diverse communities with varied social and cultural realities. For many of the communities represented by the participants of these case studies, life involves a daily struggle to survive within circumstances that constantly shape their daily activities and their perceptions of the world. In these contexts, scientific literacy seems to take a different meaning from that traditionally stressed by researchers and authorities (e.g. AAAS; NRC). Even when "comprehending and appreciating the nature of science" or "acquiring and using logical arguments and plausible reasoning in order to explain patterns in the natural world" might not be relevant goals for these communities, we

argue that their engagement with texts and the social purposes for which they read or write about science ought to be considered as one of the many forms of scientific literacy. As DeBoer states, "There are many ways to be scientifically literate" (597).

Texts that Participants Read and Wrote "To Learn about Science"

An exploration of the texts that were reported or observed as being read or written to learn about science across the individual case studies included in this analysis revealed the text types that were accessible, meaningful, and relevant for the communities under analysis beyond attending to formal schooling-related activities. Interestingly, our analysis indicates that although writing about science took place in fewer different domains of social activity than reading about science, we were able to identify an equally diverse arrangement of text types or genres associated with writing (Table 5).

The literary practice of reading and writing about science was part of different activities in our participants' everyday lives. Among the genres associated with reading events, information and instructional texts constitute a substantial portion of the total arrangement of reported or observed read text types, and these genres are also well represented amongst the reported writing events. *Information text* refers to print that provides content or factual knowledge for someone who does not have it and wants or needs it. It is expository text that is used outside the context of an instructional setting or activity. *Instructional text*, on the other hand, also conveys information for someone who does not have it, but it is meant to instruct or educate people on some topic, on how to do something, or to facilitate learning a particular skill. It is used within some sort of instructional setting, like school or the workplace, or at home when instruction/education is involved. This means that even though there was not a vast diversity in the reported read or written genres in relation to science, there were many reports of people reading and writing instructional text –e.g., textbooks, for their own personal purposes of learning about science, and not because the schooling context led them to such actions.

The different genres associated with scientific literacy were represented in several different physical forms, such as books, newspapers, websites, magazines, textbooks, pamphlets, and scholarly journals. Moreover, the presence of digital forms of text such as e-encyclopaedias, e-journals, reference websites, and electronic documents in general is to be acknowledged, considering the low incidence of computers in the homes of participants.

According to Yore, Bisanz and Hand (693), different text genres have been identified and associated with the doing of science, ranging from interpersonal communication notes to scientific journal papers. Other genres that aim at communicating scientific issues or content to the layperson, in the form of newspapers or magazines, have also been pointed out by researchers as elements for scientific literacy. But what has traditionally interested researchers and educators is the role of textbooks in scientific literacy (Rudolph; Yore, Bisanz and Hand).

Our examination of the literacy practices of different cultural communities shows that the elements of scientific literacy are not a uniform set of documents, but they comprise more than journal papers, newspaper articles, and traditional textbooks. Such diversity of genres associated with scientific literacy can be differentiated according to the social and cultural purposes they achieve in society –e.g., texts that popularize information generated in the scientific community. Our findings show that diverse genres intended to popularize science, such as news stories and information text in the form of books, magazines, or websites, are being utilized by people as part of their cultural practices of scientific literacy. According to Yore, Bisanz and Hand (705), reports about scientific and medical research are commonly found in the media, including the Internet, and our study corroborates this assertion.

Moreover, the presence of information texts in the form of scholarly journals merits some particular consideration given the attention that this specific genre has received from education researchers in the past decades. Scholarly journals have been deemed the pinnacle of scientific work, the primary product of scientists, and one of the most used forms of print amongst scientists (Yore, Bisanz and Hand 695). Our analysis indicates that the members of the communities represented in this study read these texts as part of activities outside formal schooling, and that such activities fell within the domains of health, self-motivated education, and work. For instance, an East Vancouver resident for whom English is not her first language read a journal article to learn new information that would help her carry out her job requirements; a university student in the U.S. read an article about information technology driven by his own interests to learn new information; and an immigrant in Vancouver read a journal article on medicine with the purpose of taking care of his own health.

Some researchers have raised the question as to the influence of language and culture on science understanding and interpretations –e.g., Sutherland and Dennick. Although it is our belief that culture may in fact influence the type of knowledge constructed about nature and the outside world, and that any formal instruction should take place in the language used by learners, such discussions are beyond the scope of our analysis. However, what is relevant for this study is the fact that scientific-literacy practices actually reflect the multicultural realities of our participants. In fact, Arabic, English, French, Hindi, Punjabi, Sinhalese, Spanish, and Tamil were the languages of the texts read and written by the participants of the individual case studies included in this analysis. Also, we assert that cultural contexts determine to a greater extent the nature of people's scientific-literacy practices. For instance, a farmer in Puerto Rico is interested in the health of her children, whereas a prisoner in Oaxaca finds ways of escaping reality and alleviating stress and depression by learning about science and technology. Or Zapoteco children in Oaxaca who have Spanish as a second language are interested in learning new things and skills, whereas a Cuban immigrant in the U.S. is interested in learning about forensics driven by a personal interest and as a means for entertaining herself.

Conclusions

Scientific-literacy research offers a chance to understand science in sociocultural contexts outside of school. This analysis of scientific literacy contributes to a better and richer understanding of how science and the community members interact on an everyday basis. In this paper, we presented an analysis of literacy-practice data collected over several years in multiple cultural and social communities around the globe. With this effort, we address an area of inquiry that has been traditionally overlooked by researchers and education personnel: scientific literacy as cultural practice in marginalized communities.

Experts have highlighted that some of the goals of scientific literacy ought to be the productive participation of society in scientific practices and discourse, the making of political, community, and personal decisions based on scientific knowledge, and so on. However, it is our view that the relevance of scientific literacy ought to reside in its potential to enable people to find solutions to their everyday problems and personal questions. In its most basic and fundamental sense, scientific literacy should not be solely about economic returns or the evaluation of scientific evidence and explanations. It should not be about only understanding the nature of science or becoming scientifically proficient. It should also be about empowering people to use scientific knowledge to support their everyday efforts at living a full and satisfying life.

Our analysis does not focus on traditional notions of scientific literacy and scientific proficiency. Rather, it addresses scientific literacy in its fundamental sense (Norris and Phillips 226). It illustrates that texts read and written to learn about science play several different roles in the ordinary lives of ordinary people. Our analysis also uncovers real-life scientific-literacy events and their relevance for the layperson and their communities. Our analysis of scientific literacy reveals community members engaging in scientific reading and writing for a wide array of social purposes and within an array of social activity domains – all indicators that scientific literacy is actively practiced within different sociocultural communities. Further, this activity is present within groups that are marginalized politically, socially, and linguistically – something that may be surprising to many teachers. The outcomes of this study challenge the somewhat widespread perception that many people do not read or write beyond the school context with the genuine goal of learning about science and supports the claim that people have a very active role in their scientific literacy-related activities.

Bearing in mind that this cross-case analysis is based on literacy-as-cultural-practice data that does not have scientific literacy as a main focus of research, the outcomes we present here have significant implications for science education and science-education research. Firstly, the findings of this study acknowledge that scientific literacy, understood as reading and writing with the objective of learning about science, is an element of the quotidian literacy practices of people and that scientific-literacy events occur naturally beyond the formal schooling context and in interconnectedness to people's diverse activities. Secondly, as Stephen Norris and Linda Phillips suggest, science-instruction endeavours ought to include teachers' integrated

use and understanding of print and everyday scientific literacy practices and not just the teaching of scientific facts and theories. Teacher awareness of students' outside worlds is crucial to finding effective ways to build on the prior knowledge and experiences students bring to the classroom setting. This study represents an effort to describe the nature of the literacy practices that people from specific communities around the world consider as supporting their learning about science, health, and/or technology and therefore contributes to our understanding about what students are engaged in outside of school. As Elizabeth Moje claims, educators who can hear, understand, respect, and incorporate what students bring to the classroom are able to build on those everyday practices as resources for bridging and supporting student learning across disciplines. Finally, although the focus of this study is promising in terms of providing a grounded overview of the nature of the literacy practices that people engage in with the goal of learning about science, more research is needed in order to be able to make informed recommendations for formal science instruction. For instance, research specifically focused on the scientific-literacy practices of particular communities in particular contexts, would be useful in order to discern in detail the ways in which people interact with particular texts, the tasks they face, and the ways in which they deal with new or conflicting concepts and ultimately build on their understandings and explanations around scientific topics and issues.

Currently, explanation and argumentation are seen as crucial elements in science, science discourse, and science education (Hammer, Russ, Mikeska, and Scherr; Krajcik and Sutherland; Lemke). Research that explores how people from marginalized communities build on their real-world scientific knowledge and literacy practices in order to craft explanations and arguments around scientific topics also represents an avenue of important contributions to the field of science education. Understanding students' customary ways of structuring explanations could inform real-life instruction around canonic scientific explanation and argumentation practices.

Formal science instruction can help prepare students to engage meaningfully with the natural world only when students' real worlds are acknowledged and activities inspired by real life are implemented. To accomplish this, science education could involve instruction on the interpretation of the different types of texts and text forms that are part of science, the different domains of everyday life where science is relevant, and how all of this interrelates in the world outside of school. In doing so, the literacy worlds of students inevitably will be recognized and built upon in the formal instructional context.

One of the objectives of CLPS is to draw on real-life literacy practices in order to inform models of literacy instruction in ways that are relevant and motivating for learners. Relevance, as Miia Rannikmäe, Moonika Teppo, and Jack Holbrook assert (117), is established when learners are able to see how the received instruction relates to their customary realities. This analysis, by means of exploring the nature of learners' real-life scientific-literacy practices, represents a step forward towards a science-education model that helps learners recognise that science has relevance for their current and future lives.

In this analysis we have given voice to several minorities who are commonly excluded from the discussions around scientific literacy and what it should entail. Scientific literacy, in our view, is not a commodity that can be acquired, but a lifelong practice with real-world ends. It is always contextualized and meaningful when related to the specific needs and realities of people. Reconceptualising scientific literacy will expand the notion of science education from being solely a school-based endeavour to include all the activities that take place both inside and outside schools and the cultural and social elements that shape them.

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Kristen H. Perry is an assistant professor in the department of Curriculum & Instruction at the University of Kentucky. Perry's work focuses primarily on literacy and culture in diverse communities, investigating everyday home/family and community literacy practices, particularly among African immigrant and refugee communities. She also researches educational opportunities with respect to ESL, literacy, and higher education for adult refugees. Perry is the recipient of the National Reading Conference's J. Michael Parker Award for research in adult literacy.

Victoria Purcell-Gates holds a Canada Research Chair in Early Childhood Literacy, Tier 1 at the Department of Language & Literacy at the University of British Columbia. She is the Principal Investigator of the Cultural Practices of Literacy Study. Her main research interests revolve around the ways in which people in communities value and practice literacy in all aspects of their lives. This includes texts, written symbol systems, purposes for reading and writing, attitudes and beliefs. Victoria also has designed multiple early literacy instruction initiatives that build on young children's linguistic, cognitive, cultural, and social models for reading and writing that they acquired within their home communities.