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Reconceptualising Science Education Practices from New Literacies Research

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ABSTRACT: In light of profound socio-economic and technological changes, the research from New Literacies has raised fundamental questions on the nature of literacy in the way we read, write, and communicate. Yet, in science education, research in literacy has been largely restricted to the domain of print-oriented academic language. This paper aims to set the issues of literacy in science education in a broader context by responding to several challenges raised in New Literacies research: (a) the attention to youths' diverse cultural and media practices, (b) the sociocultural practices of specific discourse communities, and (c) the increasing multimodal semiotic landscape. The paper presents a model that synthesizes various research areas in New Literacies for the development of new pedagogy and classroom practices in the nexus of literacy and science education. The proposed model provides a convergence of diverse theoretical perspectives from research in various disciplines, and presents an opportunity for cross-disciplinary research in both science and literacy education.

KEY WORDS: New literacies, multimodality, youth literacy, third space, scientific literacy

INTRODUCTION

The nature of literacy in the way we read, write, and communicate in diverse activities is rapidly changing in response to broad social, economic, and technological changes. Increasingly, educational scholars around the world are recognizing the inadequacies of traditional notions of literacy based on universal, print-oriented, and mono-modal forms of language in meeting the context of a multicultural and knowledge-driven society. A broad and interdisciplinary movement under the term "New Literacies" is currently exploring the implications of this shifting nature of literacy in the contemporary classroom. As an emerging construct, New Literacies can mean various things to different researchers. Leu and colleagues (2009)

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make a distinction by defining *New Literacies* (uppercase) as a broad research movement that encompasses diverse *new literacies* (lowercase) research in more specific areas or from specific disciplinary perspectives. The common characteristics of new literacies research that constitute the broader movement of New Literacies include: studying the multifaceted social practices that arise from diverse ways of using new media and technologies, and defining new skills and dispositions required for meaningful participation in these practices under a globalized and technological world (Coiro, Knobel, Lankshear, & Leu, 2008).

Although research within the New Literacies movement is diverse and inclusive in accord with its goal of redefining literacy in a broader context, most of the work within school settings tend to be limited to the language arts classrooms. Very little work is carried out in the content areas of teaching and learning, particularly in science education. At the same time, there have been several constructive dialogues, or "border crossing", between researchers from the language arts and science education communities in the past decade (see Linder, Östman, & Wickman, 2007; Saul, 2004; Yore, Bisanz, & Hand, 2003). These dialogues aim to understand the connection between literacy and science in order for both fields to mutually inform each other in their trends and developments. However, with few notable exceptions, studies within this literacy-science nexus have yet to explicitly take into account a broadened conception of literacy that developed (and is developing) from New Literacies. As such, this limits the scope of theory building and pedagogical developments that can potentially emerge from a synergy of research between New Literacies and science education.

In this paper, I raise two key questions in order to drive further conversation among researchers from various communities. First, how can emerging developments from New Literacies inform new research and pedagogical directions in science education? Conversely, how can research in science education help to frame the evolving definition and directions of New Literacies? Through a synthesis of multiple theories and research studies from both areas, I argue that there is potential in adopting several perspectives from New Literacies in order to broaden a view of literacy in science education responsive to an epochal change in the 21st century. At the same time, I also argue that there are great opportunities for New Literacies researchers to use the science classroom as a unique and crucial site in exploring current issues of multimodality, enculturation, and hybridity.

This paper begins with a broad discussion of the changing social, economic, and technological times for the purpose of contextualizing the emerging shifts in thinking about literacy. The paper then reviews four specific new literacies research areas that hold promises for the reconceptualization of literacy in science education. These new literacies

areas are a sociocultural perspective of literacy (confusingly called *New Literacy Studies*), youth literacies, multimodality, and multi-literacies. Subsequently, the paper synthesizes the various new literacies perspectives and proposes a model to operationalize what was reviewed in the literature for science classroom practice.

CONTEXT OF NEW LITERACIES

The broader context that drives New Literacies is the changing times from the old capitalism (or Fordism) to the current global new capitalism (Gee, 2004; Hall, 1996). While the old capitalism is characterized by centralized mass production, hierarchical management, and a stable employment structure, new capitalism is driven by technological innovations and disruptions, rapidly changing information, distributed management and regulations, and unpredictable, project-oriented employment. In this changing context, many educators from various fields (e.g., Gee, 2004; Lave & Wenger, 1991; Luke, 1998) have warned that our prevailing educational system and practices, which view knowledge as a fixed system of expertise embedded within school-based texts (e.g. textbooks), are grossly obsolete in meeting the demands of the workplace. Furthermore, the current educational system is also ill-equipped in preparing future generation to address the social and economic challenges brought by the new forms of global capitalism, such as inequalities and precarious employment. Therefore, many of them have argued that with the changes in the new capitalism, the definition of what constitutes literacies has also changed dramatically.

A distinctive feature of New Literacies is characterized by an epochal change in everyday technologies and its associated cultural practices (Coiro et al., 2008), although what specifically constitutes the "new" literacies is currently still under debate. Lankshear and Knobel (2007) introduce two useful constructs distinguishing the new elements as comprising new "technical stuff" and new "ethos stuff". The new technical stuff consists of emerging technological trends and developments of the new epochal change. Although technology has been widely used in schools as early as the 1920s, when film and radio were first introduced, and later televisions and computers in the 1950s and 1980s respectively (Cuban, 1986), there are two developments that significantly differentiate this period from the earlier ones. The first is the dramatic shift from isolated print and *analogue forms of production to the ease of "mixing" or hybridization of multimodal media, such as text, images, photographs, music tracks, videos, animations, and voice recordings, into a new creation o*n interactive, interconnected, and ubiquitous devices. The second development is that the means of media production are readily available and distributed to the masses. Thus, many of the new media available on the Internet today (e.g., YouTube videos,

online photographs, Wikipedia entries, podcasts, blogs, fan fictions) were made by ordinary people who own nothing more than a cell phone, computer and Internet connection.

The new ethos stuff is the cultural practice aspect of New Literacies. This is characterized by the emergence of a new "mindset" that sees the world as fundamentally changed in terms of the "new ways of being that are made possible by new tools and techniques, rather than [the old mindset of] using new technologies to do familiar things in more 'technologized' ways" (Lankshear & Knobel, 2007, p. 10). Such a new mindset generally sees literacies in terms of participation in collaborative practices and distributed expertise in a shared enterprise, instead of the conventional views of literacy as personalized competence and authorship located within hierarchical institutions. This new ethos has implications for education in two areas: one, the shifting requirements in defining competencies in the workplace and two, the kind of expectations from the so-called "Generation Z" or "Next Generation" toward learning.

In the first area, literacy use in the contemporary workplace is now increasingly dominated by tasks that involve socially recognized ways of generating and communicating multiple and complex forms of information within and among members of a shared community (Lankshear & Knobel, 2003). Such demands require a view of literacy as "the flexible and sustainable mastery of a repertoire of practices with the texts of traditional and new communications technologies via spoken, print, and multimedia" (Luke & Freebody, 2000, p.8). In the scientific community, the use of advanced visual representations and dynamic modeling tools is ubiquitous. These representations and tools include three-dimensional animations, real-time videos, and virtual simulations that are used in conjunction with globally-linked numerical databases. Furthermore, new information technologies are being used by geographically separated scientists to create what has been called *collaboratories* (a mix of collaborate and laboratory), thereby producing new possibilities for the collaboration and distribution of joint scientific work and experimentation (Finholt, 2003). Therefore, to be literate in the 21st century laboratory would require students to be versatile in using these multimedia tools along with the cultural practices of using these tools. Thus far, studies in technology-enhanced learning environments have found that students often lack the skills and practices in making sense of the complex information presented in scientific tools and simulations (McLuckie, Rodrigues, Taylor, & Williamson, 2007).

In the second area, the expectations from the new generation of learners have also changed, as a result of increasing diversity of literacy practices made possible by technological innovations. Gee (2000) argues that the new capitalism calls for "shape-shifting portfolio people" who are able to "shape-shift" their identities by rearranging their skills, experiences, and achievements according to the new social and economic opportunities.

Thus, these people, many of whom are the teenagers of today, think of success in terms of accruing a flexible portfolio or resume of practices, and they act accordingly as such. In this new paradigm, there is now an increasing recognition that academic literacy is just one among many literacy practices to be accrued in one's portfolio in order to be successful in life. As teenagers accrue these literacy practices outside of school, there is much we as educators can harness from their resume of practices for classroom learning and activities.

PERSPECTIVES FROM NEW LITERACIES

From the changing social, economic, and technological contexts that drive the research in New Literacies, three recurring themes can be distilled. The first theme is an increasing importance ascribed to cultural diversity, thus giving rise to the need of studying literacy as multifaceted sociocultural discourse practices, belonging to diverse communities. This is the central basis for the research perspective in *New Literacy Studies*. The second theme is a growing recognition of the diverse literacies centering on "shape-shifting portfolio" youths, who are accruing a multitude of literacy practices from their out-of-school participation and engagement with ubiquitous multimedia devices. This is the study of *youth literacies*. The third theme is an increasing awareness of an expanded semiotic landscape in which meanings are made by multiple semiotic systems other than natural language, and the increasing ease of hybridization of multiple modes in media production. This is the basis for *multimodality* and *multiliteracies*.

New Literacy Studies

The New Literacy Studies (NLS) was a term coined by Gee (1996) to denote a tradition of sociocultural research in the study of literacies. NLS should not be confused with the broader term of New Literacies used in this paper. According to Gee (1998), NLS is one of numerous movements within a larger "social turn" that placed emphasis on interaction and social practice instead of the private minds of individuals (Gumperz, 1982; Latour, 1987; Lave & Wenger, 1991; Vygotsky, 1986; Wertsch, 1991). Building on the work of several literacy theorists (e.g., Barton & Hamilton, 1998; Gee, 1996; Street, 1984), NLS asserts that there are "many different literacies as there are sociocultural distinctive practices into which written language is incorporated" (Gee, 2004, p. 280). On the grounds that reading and writing are always carried out with respect to a text of a certain type for specific purposes, literacy is conceived as social practices that are connected to a specific form of language within specific social groups or discourse communities.

With this view, NLS posits that every individual, through the process of enculturation into the norms and values of their respective discourse communities, acquires various literacy practices as ways of using language to make meaning of human experience. Although there exist multiple literacy practices, they are not all equally valued within certain institutions (e.g., schooling) such that some are more dominant while others are marginalized. NLS argues that the old capitalism favored one such literacy practice – the "academic language", and provided those who wield it with economic success and political power. However, in the new capitalism, with the increasing economic and political importance of distributed affinity groups (Gee, 2004) and communities of practices (Lave & Wenger, 1991), the monopolizing influence of academic language, although still strong, has waned considerably.

Youth Literacies

Since the last decade, the study of youth literacy, culture, and identity has been the focus of several educational researchers (e.g., Alvermann, 2001; Barton, 2003; Brown, Reveles, & Kelly, 2005). One factor driving this focus is the recognition that many youths, particularly those from urban schools, are increasingly disconnected from formal schooling. Within science education, large-scale surveys carried out in the U.S. and U.K. have shown that nearly half of young people aged 14 to 16, both boys and girls, found school science boring (e.g., Ebenezer & Zoller, 1993; Jones, Howe, & Rua, 2000). Interestingly, the same studies have also shown that the majority of these youths surveyed found science to be interesting, accessible, and useful for jobs. Such contradiction between students' interest in science and their dislike for school science points to the need to engage youths and lessen the potential alienation they feel from school science (Osborne, Simon, & Collins, 2003).

To address this disconnection, many science educators have strongly advocated the need to examine how youths' cultural knowledge and experiences can be used as resources to link with school science. One example in science education can be seen from the work of Buxton (2006), who raises the issue of authenticity as a crucial component in overcoming the shortcomings of academic science learning. Instead of an authoritative approach in formal science programs, he argues for a "youth-centered authentic science" that starts by examining youth culture in order to explore a ground up approach to learning science. Barton (2003) also argues for a model of ''youth science'' in out-of-school settings that caters to youths' interests, perspectives, and desires, and uses that to teach science concepts as required.

Several studies have also focused on youth's literacy practices from out of school. With the emphasis in new media, researchers are increasingly exploring the range of digital media-rich literacy practices engaged by

youths such as blogging (e.g., Bortree, 2005), media authoring (e.g., O'Brien, 2006), online fan fiction writing (e.g., Black, 2005), and playing video games (e.g., Alvermann, 2001; Gee, 2007). In most instances, the level of proficiencies exhibited by these youths and how these new media were used for the enactment of their social identities across various lived worlds have been documented. For example, O'Brien (2006) showed various vignettes of youths, who although deemed as "struggling readers" in school, were considerably enthusiastic and competent in representing their interest and life worlds through various media productions. Collectively, these studies raise important questions as to why students, who can competently engage in complex literacy tasks associated with rich media, struggle with traditional school-based literacy. The consensus often points to the need to re conceptualize literacies beyond narrow print-centric notions in a restricted setting to encompass these multimedia practices in diverse contexts. Many have also argued for such proficiencies and meta-discursive practices to be considered as legitimate "funds of knowledge" that youths have and can be readily harnessed for school-based literacy such as school science" (e.g., Hull & Schultz, 2001; Moll, Amanti, Neff, & Gonzalez, 1992).

Multimodality

Multimodality is an emerging field concerned with how human beings make use of different semiotic systems, like language, depiction, gesture, and music, to represent or make meanings (see Jewitt, 2008; Martinec, 2005). The increasing attention to multimodality in educational research was triggered by the shift in the new media age from the dominance of writing in printed materials towards the relatively new dominance of images on the digital screen (Kress, 2003). The early theoretical foundation that informs work in multimodality was derived from Halliday's (1978) social semiotic approach to language. Although Halliday's initial interest was to develop a linguistic framework (i.e., SFL), various theorists in the 1990s began to broaden his theory to include other semiotic systems of meaning such as images (Kress & van Leeuwen, 1996), music (van Leeuwen, 1998), movement and gesture (Martinec, 2000), and mathematical symbolism (O'Halloran, 2000).

An important development in multimodality is a common language for analyzing how disciplinary knowledge is shaped by the semiotic design within a particular discourse or disciplinary domain. Called a *metalanguage* by the New London Group (1996), it consists of three aspects of meaning that are realized in any semiotic text (Halliday, 1978):

(a) ideational meaning – for constructing thematic content about the world,
(b) interpersonal meaning – for enacting stance and relationship toward oneself and other people, and

(c) textual meaning – for connecting disparate elements into a broader coherent text or entity.

These three kinds of meanings are applicable for any type of semiotic mode of representation, be it language or the system of images or gestures. Furthermore, this metalanguage is applicable in analyzing meanings in every content area, such as English (Benson, 2008), Mathematics (O'Halloran, 2000), Visual Arts (Duncum, 2004), Music (Pramling & Wallerstedt, 2009), or Science (Kress, Jewitt, Ogborn, & Tsatsarelis, 2001).

The meta-language within the disciplinary domain of school science is being developed by several researchers in multimodality and science education. For instance, Kress, Jewitt, Ogborn, and Tsatsarelis (2001) documented the complex ensemble of representational modes (e.g., image, gesture, speech, writing, models, spatial and bodily movements) brought together by science teachers to construct particular scientific meanings. They argue that scientific knowledge construction involves a "dynamic process of transformative sign-making" from one mode of representation to another, with each mode playing a particular meaning-making function. This inherent connection between scientific knowledge and multimodal composition is also substantiated by several researchers working on scientific texts (e.g., Lemke, 1998; Unsworth, 2001). In an analysis of scientific publications, Lemke showed how science concepts are seldom composed of a single mode of representation, but are "semiotic hybrids" that are simultaneously verbal, mathematical, visual-graphical, and action-operational. In this sense, science concepts are seen as multimodal semiotic constructions of multiple modes assembled in canonical and institutionalized ways (Lemke, 1990; 1998). Influenced by this notion, several studies further investigated how science teachers and students, in various grade levels, use multiple modes of representation to construct scientific knowledge, for concepts such as the water cycle (Márquez, Izquierdo, & Espinet, 2006), electricity (Prain & Waldrip, 2006), the gas model (Givry & Roth, 2006), chemosynthesis (Jaipal, 2009), work-energy (Tang, Tan, & Yeo, 2011), and soil profile (Cook, 2011).

Multi-literacies

Multi-literacies is a pedagogical framework developed by a group of scholars known as the New London Group (1996). The term "multi-literacies" was introduced in response to a more expansive notion of literacy brought about by two major changes similar to what I have discussed previously: one, the multiplicity of representational and communicational landscape associated with new technologies, and two, the increasing cultural and linguistic diversity arising from globally networked communities. The research in multi-literacies is closely related to NLS and multimodality due to the involvement of scholars such as James Gee, Gunther Kress, and Norman Fairclough who were prominent in pioneering

these fields. However, unlike NLS and multimodality that tend to be more descriptive, there is a more concerted effort in multi-literacies advocates on the need to redesign literacy curriculum and pedagogy across the globe to one that is socially and culturally responsive to the changing landscape of the 21st century. In addition, multi-literacies stresses the need for a critical form of literacy where students take a critical stance toward their sources of information from all kinds of media (Luke, 1995; Street, 2003). This involves an understanding that all forms of knowledge and practices are shaped by particular combinations of language and symbolic systems under certain social and political contexts.

REFRAMING LITERACY IN SCIENCE EDUCATIONAL RESEARCH & PRACTICE

Each of the reviewed new literacies area holds a broader view of literacy that could potentially shape the future of science educational research responsive to an epochal change in the 21st century; particularly the attention to the needs of youths' diverse cultural practices of using media and technology, the multimodal semiotic landscape, and critical literacy. In this section, I present a synthesis that takes into consideration the various theories and analytical lens from NLS, youth literacies, multimodality, and multi-literacies. In particular, NLS provides the theoretical insight to reframe literacy as social practices unique to different sociocultural communities, and the classroom as a cultural space in which various literacy practices are brought into conversation. Youth literacies provides the basis for incorporating students' funds of knowledge as well as supplies the ethnographic knowledge of their interests and expertise. Multimodality provides the analytical lens and meta-language in analyzing how scientific knowledge is constructed through language and multimedia resources. Lastly, multi-literacies provides the pedagogical principles that aim to make classroom practices responsive to the changing demands in a new epoch.

In this synthesis, I propose a model that integrates the various aspects of new literacies for a broader conceptualization of scientific literacy in a new epoch. This model is presented in three phases: (a) harnessing youth cultural resources, (b) scaffolding multimodal practices, and (c) hybridizing a third space.

Harnessing Youth Cultural Resources

The first phase starts with an exploration of young people's diverse interests and cultural experiences in some aspects of the natural world. This is important in alleviating their disengagement and alienation with formal science learning. Although the idea of starting from youths' interests and knowledge is commonly known, what I am proposing in this model is not

as straightforward and requires some theorization and research in new areas. First, we need to rely less on our own assumptions of what youths know and are interested about (Jenkins, 2006), and conduct empirical research on their out-of-school experiences and funds of knowledge that can be used as resources for science learning. A notable research is Barton and Tan's (2009) study which examines students' interests and knowledge with regards to their cultural food in order to incorporate their out-of-school knowledge in a science unit on nutrition. This example illustrates how in-depth ethnographic studies are needed to examine students' funds of knowledge in a local context before designing interventions to harness their interests and experiences.

As we explore further the students' cultural worlds and experiences, the second area that needs further theorization and research is a better way of thinking about what we mean by "culture." This requires a view of literacy that involves different *meta-discursive practices* – as ways of speaking, listening, and dealing with texts – they use to participate in their social network of activities. In a research study related to getting a group of urban middle school girls interested in science, Eisenhart (2001) offers an insightful way of seeing culture not in terms of the students' backgrounds or prior experiences with science, but more in terms of the symbolic forms of representations made available through networks of activities and media that intersect in local events involving the students. From this perspective, students move in and out of various intersections (e.g., classroom, peer groups, online spaces) and draw on the available symbolic representations as they participate in these intersections. This approach to culture breaks down a homogeneous and essentialist view of youth culture against the culture of science, and helps us focus instead on the multiple literacy practices that people use to navigate across dispersed networks of activities.

Therefore, in order to understand and harness students' diverse cultural experiences, we need to examine their literacy practices in terms of the symbolic representations they encounter in various out-of-school activities, and find points of overlap and divergence with those used in school science. For instance, if we want to bridge students' experiences in various sports toward the learning of mechanics (e.g., forces, speed, and momentum), we can examine what the important symbols in different sports are, how they are used and experienced, and how they shape students' representations of themselves and others. Brown and Kloser's (2009) study of high school baseball players' talk serves as an example in making this connection. In their study, they identified a set of baseball terminologies and symbol systems that factor in their learning of physics, and concluded that the "discourse of baseball, much like that of science, include complex conceptual, symbolic, and linguistic features" (p. 291).

In addition, much of students' prior knowledge about science and technology comes from their exposure to popular media in the form of

magazines, television dramas and documentaries, advertisements, science fiction, blogs, online forums, and video games. Although such popular media have often been critiqued for their inaccurate portrayal of science, their influence over young people's image of science is undeniable. As they often give the impression that doing science is "cool" (Dubeck & Tatlow, 1998), there is much potential in using these media, and their embedded symbolic forms of representations, to help students compare them with the canonical representations of science.

In operationalizing this model for pedagogical practice, one suggestion is to invite students to bring a science-related multimedia text they have come across through their out-of-school experiences. Such multimedia text includes not just printed material but also other forms of media such as video, music, animation, and website. Part of this invitation is to incorporate students' funds of knowledge and foster a sense of ownership toward what they are going to learn. With these multimedia texts, teachers may want to introduce the science topic whenever possible in order to situate the learning in a context that the students are interested and familiar with. This is to alleviate the experience, where many students find school science only involves a transmission of facts and content of little relevance to their lifeworld. In addition, as a way to scaffold their out-of-school practices toward academic science, teachers can talk about the connections between those multimedia texts and those found in the formal curriculum. This is where I discuss the second phase in the model.

Scaffolding Multimodal Disciplinary Practices

As we incorporate the students' funds of knowledge and cultural practices, the next phase in the model involves an explicit and systematic scaffolding of these knowledge and practices toward science meaning making. The idea of scaffolding from students' everyday language and literacy is not entirely new. However, informed by the developments in New Literacies, a broader view of language and literacy now needs to be taken to encompass firstly students' interactions with new media and popular culture, secondly, a multimodal turn toward the symbolic representations used in both out-of-school and school science domains, and thirdly, the intrinsic sociocultural nature of scientific knowledge as constructed by literacy.

An important key toward this scaffolding goal is to examine how science is represented and communicated in each domain (out-of-school vs. school science). In this aspect, the meta-language developed from multimodality provides a useful analytical lens in allowing researchers to categorically contrast the differences between the out-of-school and school science domains. The earlier-mentioned studies in multimodality in the science classroom emphasize the institutionalized regularities observed in scientific texts, and how school science is formulated and organized in recognizable ways, through a certain configuration of semiotic modes by

students and teachers. By contrast, texts from popular media (including those that deal with "science") are formulated and organized differently, according to the different interests, values, and ideologies of various social groups. Such contrast highlights that in any domain, there are always certain social norms and conventions that bear on what and how meanings are made and why they must be made in a certain way. Failing to do so would render one not able to participate fully and meaningfully within that social group.

To scaffold students' out-of-school literacy practices toward scientific meaning making, a recommendation is to use science-related texts that students are familiar with to highlight their numerous contrasts with school-based texts, and compare the relative affordances and limitations of different semiotic domains. This will not only allow them to gain a conscious awareness of the configuration of semiotic modes and the structure of scientific knowledge and its disciplinary norms, but also appreciate the rationale for the way scientific content and claims are often presented. At some point, explicit literacy instruction is often necessary, such as (a) introducing key scientific terminologies, (b) describing and explaining the visual grammar of specialized diagrams, and (c) making connections across multiple modes of representation used in a scientific explanation or argument. This is because such multimodal practices, which originated from the scientific community, are not something that most students would have encountered previously nor are they able to derive on their own.

Hybridizing a Third Space

Literacy instruction that scaffolds students' knowledge and practices toward scientific multimodal practices is relevant and necessary to produce trained individuals for scientific and technical occupations. However, this is not the only goal. With the explicit contrast made between how science is represented in the semiotic domains of popular culture and academic science through a common meta-language, the stage is also set for a hybrid third space that is necessary for developing critical literacy in my model.

Deriving from Bhabha's (1994) postcolonial cultural theory, the notion of a third space has recently been used in education in constructing an "in-between" cultural space jointly negotiated among multiple (sometimes competing) discourses brought into the classroom. Barton and Tan (2009, p. 52) define a hybrid third space as one where different discourses "coalesce to destabilize and expand the boundaries of official school discourse." This occurs when multiple cultural practices in different discourses are deliberately juxtaposed to be mutually challenged, integrated, and transformed so as to generate new forms of understanding and literacy practices (Moje et al., 2004). Thus, the boundary of any discourse is not fixed, but is constantly evolving as a result of cross-boundary work and shifting context.

In this model, a necessary condition for a hybrid third space to occur is when students are confronted with symbolic representations from competing points of view; and in our case, representations about science, nature, and technology drawn from their out-of-school communities vis-à-vis those in academic science. This juxtaposition allows students to interpret the social and cultural context of different representations, analyze the various claims made, question the underlying interests, expectations, and ideologies of its author(s), and constructively critique them. With this understanding, students can then discern when it is appropriate and suitable to use certain kinds of representation under different circumstances and purposes. For instance, the *Motor Trend* example shown earlier can be used to enable students see that the purpose of the article is not to explain a scientific phenomenon involved in the test drive (e.g., creation of downforce), but to use science to boast about the exceptional performance of a commercial product. Popular television series such as *Crime Scene Investigation* (*CSI),* which although have strong scientific connections, are produced solely for entertainment purposes and TV ratings. Thus, it is important that students are able to critique some of the inaccuracies, simplifications, biases, and exaggerations of science as represented in these shows. Second, students should also be critical of the "scientific-resemblance" claims made by commercial advertisements on technological products, and texts from activist groups of various socio-political agendas on topics such as environment, climate change, renewable energy, stem cell research, and evolution.

Although there is much one can in the representations of science from popular culture, the converse should also be true about academic science in a third space. Science students should have some understanding of the limitations of science as constrained by the social-political context in which it operates. Thus, in the same way, the contrast with students' out-of-school texts is an important step that leads to opportunity for a discussion about the working, function, and limitation of academic science. This has the advantage in helping students understand the rationale for why scientific ways of talking, writing, drawing, communicating, and acting are carried out in certain ways instead of simply think of them as "dry, boring, and authoritative" – common adjectives given by students about academic science. Such an approach is aligned with a more contemporary and authentic representation of the nature of science advocated by Erduran (2014).

According to Roberts' (2007) summary of the Uppsala Scientific Literacy Symposium, an often neglected vision of scientific literacy is to enable young people to be well-informed in their decision making and responsibilities as a citizen about science. The approach of fostering a hybrid third space that I have outlined plays an important part in this vision. One reason is that as we bridge students' interests and situations with

academic science learning, we create a relevant context to which they can relate. Moreover, part of generating well-informed citizens of science in a democracy involves students being able to critique the different representations of science made by various social groups (including scientists) as they compete for public attention and resources according to their vested interests. In an information era where all sorts of text are easily and widely accessible, and it is simple for anyone to produce a website or video in a public forum, this form of critical literacy becomes even more urgent toward that vision of scientific literacy.

CONCLUSION

In conclusion, in re-conceptualizing the notion of literacy in science education to meet the challenges of a new epoch, I synthesize multiple theories and research from New Literacies and apply them for science learning through three phases: harnessing youth cultural practices, scaffolding multimodal practices, and hybridizing a third space. This signifies a convergence of diverse perspectives among researchers working in their respective fields, while stimulating an opportunity for cross-border dialogue and research across the fields. In this confluence, the science classroom will become an increasingly important research site for diverse ideas to be hybridized, studied, tested, debated, and revised. This can benefit science education in terms of allowing a broader view of literacy that takes into consideration the needs of youths' diverse cultural practices, the changing multimodal semiotic landscape, and the importance of critical literacy in the 21st century.

At the same time, the use of the science classroom as a research site can also benefit researchers interested in New Literacies. This is due to the unique conditions that academic science presents to newcomers as a distinctive set of discourse, values, and ideologies that differs sharply from their exposure to science from popular media and technology. As Unsworth (2008, p. 377) points out, "New Literacies are diverse, dynamic, immediate, interactive, multimodal, rapidly evolving, and requisite for living and learning in the age of information and communication technologies." Preparing for this new age is not simply about the de-contextualized ability to use technologies, but more about adapting to the changing economic, social, and cultural practices made possible by new technologies in the new era. In this sense, as science is an integral part of our social and personal lives, science education offers a valuable and necessary space in this enculturation of the practices of the new era relevant to science.

REFERENCES

Alvermann, D. E. (2001). Reading adolescents' reading identities: Looking back to see ahead. *Journal of Adolescent & Adult Literacy, 44*, 676-690.

Barton, A. C. (2003). *Teaching science for social justice*. New York: Teachers College Press.

Barton, A. C., & Tan, E. (2009). Funds of knowledge and discourses and hybrid space. *Journal of Research in Science Teaching, 46*, 50-73.

Barton, D., & Hamilton, M. (1998). *Local literacies: reading and writing in one community*. London; New York: Routledge.

Benson, S. (2008). A restart of what language arts is: Bringing multimodal assignments into secondary language arts. *Journal of Advanced Academics, 19*, 634-674.

Bhabha, H. K. (1994). *The location of culture*. London; New York: Routledge.

Black, R. W. (2005). Access and affiliation: The literacy and composition practices of English-language learners in an online fanfiction community. *Journal of Adolescent & Adult Literacy, 49*, 118-128.

Bortree, D. S. (2005). Presentation of self on the Web: An ethnographic study of teenage girls' weblogs. *Education, Communication & Information, 5*, 25-39.

Brown, B. A., & Kloser, M. (2009). Conceptual continuity and the science of baseball: Using informal science literacy to promote students. *Cultural Studies of Science Education, 4*, 875-897.

Brown, B. A., Reveles, J. M., & Kelly, G. J. (2005). Scientific literacy and discursive identity: A theoretical framework for understanding science learning. *Science Education, 89*, 779-802

Buxton, C. (2006). Creating contextually authentic science in a "low-performing" urban elementary school. *Journal of Research in Science Teaching, 43*, 695-721.

Coiro, J., Knobel, M., Lankshear, C., & Leu, D. J. (2008). *Handbook of research on new literacies*. New York: Lawrence Erlbaum Associates.

Cook, M. (2011). Teachers' use of visual representations in the science classroom. *Science Education International, 22*, 175-184

Cuban, L. (1986). *Teachers and machines: the classroom use of technology since 1920*. New York: Teachers College Press.

Dubeck, L., & Tatlow, R. (1998). Using Star Trek: The Next Generation television episodes to teach science. *Journal of College Science Teaching*, 27, 319-323.

Duncum, P. (2004). Visual culture isn't just visual: Multiliteracy, multimodality and meaning. *Studies in art education, 45*, 252-264.

Ebenezer, J. V., & Zoller, U. (1993). Grade 10 students' perceptions of and attitudes toward science teaching and school science. *Journal of Research in Science Teaching, 30*, 175–186.

Erduran, S. (2014). Revisiting the Nature of Science in science education: Towards a holistic account of science in science teaching and learning. *Science Education International, 25*, 93-111.

Eisenhart, M. (2001). Educational ethnography past, present, and future: Ideas to think with. *Educational Researcher, 30*(8), 16-27.

Finholt, T. A. (2003). Collaboratories as a new form of scientific organization. *Economics of Innovation and New Technology, 12*, 5-25.

Gee, J. P. (1996). *Social linguistics and literacies: ideology in discourses* (2nd ed.). London: Taylor & Francis.

Gee, J. P. (1998). The new literacy studies and the "social turn". Retrieved 15 April, 2008, from http://www.schools.ash.org.au/litweb/page300.html.

Gee, J. P. (2000). Teenagers in new times: A new literacy studies perspective. *Journal of Adolescent & Adult Literacy, 43*, 412-420.

Gee, J. P. (2004). New times and new literacies: Themes for a changing world. In A. F. Ball & S. W. Freedman (Eds.), *Bakhtinian perspectives on language, literacy, and learning* (pp. xi, 349 p.). Cambridge, UK; New York: Cambridge University Press.

Gee, J. P. (2007). *What video games have to teach us about learning and literacy* (2nd ed.). New York: Palgrave Macmillan.

Givry, D., & Roth, W.-M. (2006). Toward a new conception of conceptions: Interplay of talk, gestures, and structures in the setting. *Journal of Research in Science Teaching, 43*, 1086-1109.

Gumperz, J. J. (1982). *Discourse strategies*. Cambridge: Cambridge University Press.

Hall, S. (1996). The meaning of new times. In A. Morley & K.-H. Chen (Eds.), *Stuart Hall: Critical dialogues in cultural studies* (pp. 223-237). New York: Routledge.

Halliday, M. A. K. (1978). *Language as social semiotic: the social interpretation of language and meaning*. London: Edward Arnold.

Hull, G., & Schultz, K. (2001). Literacy and learning out of school: A review of theory and research. *Review of Educational Research, 71*, 575-611.

Jaipal, K. (2009). Meaning making through multiple modalities in a biology classroom: A multimodal semiotics discourse analysis. *Science Education, 94*, 48-72.

Jenkins, H. (2008). Convergence culture: where old and new media collide. New York: New York University Press.

Jewitt, C. (2008). Multimodality and Literacy in School Classrooms. *Review of Research in Education, 32*, 241-267.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education, 84*, 180–192.

Kress, G. (2003). *Literacy in the new media age*. London: Routledge.

Kress, G., Jewitt, C., Ogborn, J., & Tsatsarelis, C. (2001). *Multimodal teaching and learning: the rhetorics of the science classroom*: London: Continuum.

Kress, G., & van Leeuwen, T. (1996). *Reading images: the grammar of visual design*. London: Routledge.

Lankshear, C., & Knobel, M. (2003). *New literacies: Changing knowledge and classroom learning*. Buckingham, UK: Open University Press.

Lankshear, C., & Knobel, M. (2007). Sampling "the New" in New Literacies. In M. Knobel & C. Lankshear (Eds.), *A new literacies sampler* (pp. 1-24). New York: Peter Lang.

Latour, B. (1987). *Science in action: how to follow scientists and engineers through society*. Cambridge, Mass.: Harvard University Press.

Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*: Cambridge University Press.

Lemke, J. L. (1990). *Talking Science: Language, learning and values*: Norwood, NJ: Ablex.

Lemke, J. L. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J. Martin & R. Veel (Eds.), *Reading Science* (pp. 87-113). London: Routledge.

Lemke, J. L. (2000). Multimedia literacy demands of the scientific curriculum. *Linguistics and Education, 10*, 247-271.

Leu, D. J., O'Byrne, W. I., Zawilinski, L., McVerry, J. G., & Everett-Cacopardo, H. (2009). Comments on Greenhow, Robelia, and Hughes: Expanding the New Literacies Conversation. *Educational Researcher, 38*, 264-269.

Linder, C., Östman, L., & Wickman, P. O. (2007). *Promoting scientific literacy: Science education research in transaction.* Proceedings of the Linnaeus Tercentenary Symposium, Uppsala.

Luke, A. (1995). Text and discourse in education: An introduction to critical discourse analysis. *Review of research in education, 21*, 3-48.

Luke, A. (1998). Getting over method: literacy teaching as work in "new times." *Language Arts, 75*, 305-313.

Luke, A. & Freebody, P. (2000). *Literate futures: Report of the Literacy Review for Queensland State Schools*. Brisbane, Queensland Government Printer.

Márquez, C., Izquierdo, M., & Espinet, M. (2006). Multimodal science teachers' discourse in modeling the water cycle. *Science Education, 90*, 202-226.

Martinec, R. (2000). Types of process in action. *Semiotica, 130*, 243-268.

Martinec, R. (2005). Topics in Multimodality. In R. Hasan, C. Matthiessen & J. Webster (Eds.), *Continuing Discourse on Language* (Vol. 1). London: Equinox.

McLuckie, J., Rodrigues, S., Taylor, N., & Williamson, G. (2007). Scientific literacy, eliteracy, and illiteracy: The interaction between two pupils and one simulation. *Science Education International*, 18, 5-14.

Mills, K. A. (2010). A Review of the "Digital Turn" in the New Literacy Studies. *Review of Educational Research, 80*, 246-271

Moje, E. B., Ciechanowski, K. M. I., Kramer, K., Ellis, L., Carrillo, R., & Collazo, T. (2004). Working toward third space in content area literacy: An examination of everyday funds of knowledge and discourse. *Reading Research Quarterly, 39*, 38-70.

Moje, E. B., Collazo, T., Carrillo, R., & Marx, R. W. (2001). "Maestro, what is' quality'?": Language, literacy, and discourse in project-based science. *Journal of Research in Science Teaching, 38*, 469-496.

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into practice, 31*,132-141.

New London Group. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review, 66*, 60-92.

O'Brien, D. (2006). "Struggling" Adolescents' Engagement in Multimediating: Countering the Institutional Construction of Incompetence. In D. E. Alvermann (Ed.), *Reconceptualizing the literacies in adolescent's lives* (2nd ed., pp. 29-45). Mahwah, N.J.: Lawrence Erlbaum Associates, Publishers.

O'Halloran, K. L. (2000). Classroom discourse in mathematics: A multisemiotic analysis. *Linguistics and Education, 10*, 359-388.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes toward science: a review of the literature and its implications. *International Journal of Science Education, 25*, 1049-1079.

Pozzer-Ardenghi, L., & Roth, W. M. (2007). On performing concepts during science lectures. *Science Education, 91*, 96-114.

Prain, V., & Waldrip, B. (2006). An exploratory study of teachers' and students' use of multi-modal representations of concepts in primary science. *International Journal of Science Education, 28*, 1843 - 1866.

Pramling, N., & Wallerstedt, C. (2009). Making musical sense: The multimodal nature of clarifying musical listening. *Music Education Research, 11*, 135-151.

Roberts, D. (2007). *Linne Scientific Literacy Symposium Opening Remarks.* Proceedings of the Linnaeus Tercentenary Symposium, Uppsala.

Saul, W. (2004). *Crossing borders in literacy and science instruction: perspectives on theory and practice*. Newark, DE: International Reading Association; NSTA Press.

Shanahan, T., & Shanahan. C. (2008). Teaching disciplinary literacy to adolescents: rethinking content-area literacy. *Harvard Educational Review, 78*, 40-59.

Steinkuehler, C. A. (2008). Cognition and literacy in massively multiplayer online games. *Handbook of Research on New Literacies.* Mahwah NJ: Erlbaum.

Street, B. V. (1984). *Literacy in theory and practice*. Cambridge [Cambridgeshire]: Cambridge University Press.

Street, B. V. (2003). What's "new" in New Literacy Studies? Critical approaches to literacy in theory and practice. *Current issues in comparative education, 5*(2), 77-91.

Tang, K-S., Tan, S. C., & Yeo, J. (2011). Students' Multimodal Construction of Work-Energy Concepts. *International Journal of Science Education, 33*, 1775-1804.

Unsworth, L. (2001). *Teaching multiliteracies across the curriculum: changing contexts of text and image in classroom practice*. Phildelphia: Open University.

Unsworth, L. (2008). Multiliteracies and metalanguage: Describing image/text relations as a resource for negotiating multimodal texts. In J. Coiro, M. Knobel, C. Lankshear & D. J. Leu (Eds.), *Handbook of Research on New Literacies*. New York: Lawrence Erlbaum Associates.

van Leeuwen, T. (1998). Music and Ideology: Notes toward a Sociosemiotics of Mass Media Music. *Popular Music and Society, 22*(4), 25-54.

Vygotsky, L. (1986). *Thought and language* (Translation newly rev. and edited / by Alex Kozulin ed.): Cambridge, Mass.: MIT Press.

Wertsch, J. V. (1991). *Voices of the mind: a sociocultural approach to mediated action*. Cambridge, Mass.: Harvard University Press.

Yore, L. D., Bisanz, G. L., & Hand, B. M. (2003). Examining the literacy component of science literacy: 25 years of language arts and science research. *International Journal of Science Education, 25*, 689 - 725.