Chapter 55
Web 2.0 Technologies, New Media Literacies, and Science Education: Exploring the Potential to Transform

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Introduction

The title of our chapter is bold – potential to transform? You may be doubtful, and rightly so, as many sophisticated technologies have preceded those known as Web 2.0 and, with few exceptions, their impact on science education has largely fallen short of expectations. The following vignettes show why we think this time it may be different.

Vignette 1

Mr K, an 11th grade pre-calculus teacher, feels his students need more time with the concepts they are working on in class, and decides to capitalize on students' interests with the Internet by integrating blogging into daily classroom practice. Each day, one student is expected to scribe the day's lesson in his or her own words and, thus, collectively, the class would be, as the teacher encourages, constructing a textbook for the world. Though no specific guidance was given, students quickly took up the practice with fervor – posting warnings, reminders, elaborate graphs and diagrams, inside jokes as well as apologies for imperfections – all addressed to their peers. Though most students shared an initial skepticism about blogging, they unanimously described their ultimate dependence on the blog for understanding the course content and participating successfully in class. They also described its contributions to development of community and shared ownership in each other's learning. Though the

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B.J. Fraser et al. (eds.), *Second International Handbook of Science Education*,
Springer International Handbooks of Education 24, DOI 10.1007/978-1-4020-9041-7_55,

teacher did not introduce it with such lofty goals, the lived classroom blog transformed how students engaged with the concepts and participated in their own meaning-making around mathematics. (See http://pc30s.blogspot.com for one of this teacher's classroom blogs and http://oletango.blogspot.com/2006/01/what-if-your-blog-was-gone.html for his students' perceptions of their blogging experiences).

Vignette 2

Ms Frizzle (as she refers to herself), is a progressive and passionate middle school science teacher. At the time of her blogging, she was working in an alternative school in the Bronx where she is the only science teacher – and therefore the only teacher in her school trying to implement student-centered, inquiry-based science instruction as a means to empower her urban students. Only 3 years out of graduate school, she has passionate commitments and creative ideas, but also many questions about how to engage her students centrally in their own science learning in ways that transform their school science identities. She turns to blogging as her primary means to think on paper and engage with a like-minded professional community. She posts regularly (3–4 times a week) with stories of her daily adventures filled with wonderings, commentaries on resources she found useful, rants consisting of passionate and well-supported arguments about pedagogical dilemmas and social justice issues, and requests for support and help. A blogging community soon develops that provides Ms Frizzle with encouragement, resources, and collaboration, thus transforming her professional learning. (For a sample of Ms Frizzle's blogging work, see http://msfrizzle.blogspot.com/.)

Both of these real-life examples suggest that blogging, as well as other technologies such as wikis, video/photo sharing, social bookmarking, and multiuser virtual environments (often referred to as Web 2.0 technologies) can indeed play a key role in implementing the vision for science education agreed upon by many professional organizations, but rarely a reality in schools. For years, national reform movements in science education have been advocating for student-centered instructional design that results in students conducting investigations over time, providing evidence-based argumentation and explanations, developing understandings, abilities, and values of inquiry as well as of science content, working collaboratively to analyze and synthesize data, and publicly defending ideas and work (e.g., National Research Council (NRC) 1996). This, in turn, calls for learning experiences that elicit and explicitly build on learners' individual prior understandings, skills, and creative expressions; experiences that capitalize on social networks to support interpretation and meaning-making; and experiences that engage learners centrally in the authentic and core practices of a given discourse – exactly what we saw happening in Mr K's class and Ms Frizzle's blog through the practice of blogging.

While these considerations suggest the potential of Web 2.0 technologies for the future of science education, we have found very little research on this topic in the science education literature – especially of an empirical nature. Therefore, our goal in this chapter is twofold: (a) to report on selected results of research on Web 2.0

technologies outside of science education informed by New Media Literacy (NML) as a theoretical paradigm, and (b) to report on our own empirical research to date on the use of just one Web 2.0 technology – blogging – with science teachers and students, as an example of the kind of empirical research on these emerging technologies that could be especially fruitful for science education. First, though, some information about Web 2.0 technologies and NML is needed.

Web 2.0 Technologies, New Media Literacies, and Their Potential Relevance to School Science Reform

What do we mean by Web 2.0 technologies. These are new technological tools – such as those listed in Table 55.1 (although new ones continue to be developed every day) – that allow for easy viewing and creation of content along with the capability for sharing, editing, commenting, connecting, or tagging, all means which allow others to interact with the content created. The following characteristics set them apart from their predecessors: (1) access – to both ever-expanding information resources and to a variety of people, cultures, and potential identities (e.g., Gee 2003); (2) connectivity – with the interlinked network of other people, information, and ideas through the webbed structure of these social tools (e.g., Livingstone 2003); and (3) multiple modalities – for expanding the mediating practices which construct relationships and knowledge (e.g., Jewitt 2008).

NML, in turn, is a theoretical framework that has been used to explore the uncommon participation opportunities made available through these emerging technologies. NML redefines literacy as not just reading and writing but rather the process

Table 55.1 Examples of Web 2.0 technologies and related practices

Web 2.0 Technology	Related practices
Publishing and commenting (a) Blogging (b) Pod/vodcasting (c) Micro-blogging (d) Streaming Media (e) Audio/video commenting	User-centric organizing of content and tools (a) Employing Really Simple Syndication (RSS) (b) Building mashup applications (c) Creating compound documents
Socially constructing and categorizing content (a) Co-constructing wikis (b) Sharing documents (c) Video/photo sharing (d) Creating media mashups	Communicating in real-time (a) Text-based instant messaging (b) Audio/video instant-messaging (c) Document and application sharing
Connecting to people and information (a) Social networking (b) Social bookmarking/folksonomy/tagging	Interacting in complex interactive environments (a) Gaming (b) Participating in simulations (c) Engaging in multiuser virtual environments

Table 55.2 Linking science education goals with NML affordances

Reform-based science goals	NML affordances
Engaging students in: • Collaborative investigations over time • Productive public communication of ideas and work	Prioritizes: • Participation in developing global community • Collaboration • Distributed knowledge
Enabling students to: • Provide evidence-based argumentation and explanations. • Analyze and synthesize data and defending conclusions	NML are: • Openly authored, placing the requirement for evidence on the author • Situated practices in both the type of technology and the way it is used • Transactional processes that invite experimentation and pushing boundaries • Multiple, multimodal, and multifaceted
Students develop: • Understandings, abilities, and values of inquiry. • Knowledge of science content	Requires: • New social practices, skills, strategies, and dispositions for their effective use

and practices of meaning-making within social networks. Key to NML is a focus on collaboration, distributed expertise and authority, and collective or shared knowledge (Lankshear and Knobel 2006). Unlike frameworks such as instructional technology, information technology, educational technology, and computer aided learning, which foreground the computing devices used in the classroom setting, NML shifts the focus to the impact these emerging technologies have on socially constructed meaning-making. As Bill Cope et al. (2005) warn us, it is not the tool itself that affords these new forms of participation, but rather how the tool is employed by specific users in a specific context. This is well illustrated in our two vignettes, as in both cases the realized benefits of blogging depended on the specific ways the teacher decided to use this tool and create learning opportunities around it, as well as the various ways other participants (students or colleagues) chose to take up or engage with and even change these activity structures (e.g., DeGennaro and Brown 2009).

There are interesting parallels between NML and a reform-based vision of science education – as both represent a paradigm shift from traditional, transmission model of learning that most of us have experienced as learners (e.g., Anderson 2002) and are still prevalent in schools. To make this more evident, in Table 55.2 we have identified essential goals of reform-based science and matched these with critical elements of NML (based on the extensive literature review by Julie Coiro et al. 2008).

The parallels highlighted in Table 55.2 suggest that carefully designed classroom engagement with Web 2.0 technologies could provide science teachers and learners

participation structures not common (and some not possible) within traditional classroom learning (e.g., 50-min, synchronous class periods, geographically constrained by four-walls within a given building), which, in turn, could help meet science goals. Yet not all classroom applications of these technologies will realize this potential due to a shift in mindset required by NML which is the critical catalyst connecting the learning opportunities and the specific uses of a tool. (More about this necessary shift in mindset is offered later in this chapter.)

Selected Findings from Research on Web 2.0 Technologies and NML Outside of Science Education

As Web 2.0 technologies are only now emerging and empirical research on their use in science education is very limited, it is worthwhile for science educators to learn from research conducted in other educational settings using the framework of NML. A recent search of the top 15 journals that relate to education and educational technology (as rated by the impact factor in the Journal Citation Reports database) identified only 89 articles on the use of Web 2.0 technologies in school settings, most of which lacked empirical consideration of either implementation or impact. These findings are similar to those of Ian Robertson (2008), who conducted a much larger search focusing on just wiki and blog technologies. Yet selected examples from this body of research can be helpful in explicating the issues and concepts that are emerging within this arena – as summarized below.

Methodological Considerations

An important lesson gained from these pioneering research studies is that unique methodological issues emerge when researching Web 2.0 technologies. Particularly informative is Margaret Cox's (2008) historical analysis of the evolution of research questions and agendas in education from the 1950s to the present as technology changed. First, her study highlights the importance of addressing issues specific to changes in technology. In response, we propose the following:

- Can we transfer the tools of research to the online world (Jones 2004)?
- How do we keep a clear research focus when crossing disciplines (Livingstone et al. 2008)?
- How do the technologies and practices intersect and inform one another (Anderson 2008)?
- How do we develop methodologies when participants (Leander and McKim 2003) and artifacts (Burn 2008) are socially constructed, spatially distributed, and constantly changing?

Second, she points out that particular types of questions call for particular methods and approaches. Below we identify primary types of research questions that are especially relevant to applications of Web 2.0 technologies in education and how some researchers have addressed these questions productively:

- *How are these technologies being used in educational settings?* These studies are typically large-scale investigations aimed at understanding the way that Internet technologies are used, accessed, and implemented (Anderson 2008). While each study utilized different tools, overall most employed surveys of large groups to describe trends in the use of tools.
- *What interactions are occurring due to the integration of these technologies in education?* As this area of study is so new, many questions currently posed around NML relate to understanding the learning environment and the interactions occurring in that environment. These questions suggest methodologies and approaches that are more ethnographic in nature. Field observations involve participating in the environment, whether as a lurker reading the posts being created or as a more visible participant who has created an avatar in a 3D virtual environment.
- *What is the impact of use on the classroom, teacher, and students?* Here the focus is on understanding the experiences of the individual within the online environment and how these experiences change the actions, practices, and meaning-making process of that individual – whether teacher or student. Case studies have been used to study the experiences of youth in digital environments (Thomas 2008), relating to identity (Gee 2004), agency and authority (Hammer 2007) or literacy development (Lam 2006), as well as the experiences of teachers as they implement Web 2.0 technologies in their classroom (Leander 2007) or use them to develop their own identities as reform-minded science teachers (Luehmann 2008a).

Relevant Findings

Five themes emerged from a consideration of the current literature on the use of Web 2.0 technologies in education. Below we examine each of these themes, highlighting the work that has been done in NML within education more broadly; these same themes are used later to discuss findings of our NML work in the contex of science education.

Potential for Teaching and Learning

This theme, threaded throughout the literature on these technologies, often explores out-of-school practices to see what learners do with these technologies when not under the constraints of teacher and curriculum goals (e.g., Gee 2004). James Gee's (2003, 2004) foundational work on the learning principles informing participation in video gaming, as well as his discussion of online spaces when looking at gaming communities, highlight the powerful affordances that these technologies hold for

learning. While drawing implications for how educational communities could utilize these technologies, he also recognizes that the affordances he identifies may not translate to classroom learning because of differences in participants' motivation and purposes for engagement.

Identity Work Facilitated by These Technologies

The reflective, social, and flexible nature of Web 2.0 technologies make them ideal to support (and study) changing identities (e.g., Carlone and Johnson 2007). Rebecca Ward Black (2007) followed the use of fan fiction writing for a student in an English as a Second Language (ESL) classroom. Black noted the ways in which, through authentic, written interaction, the student refined her use of language while working to develop her identity as a competent user of English.

Construction and Social Organization of Content

The social and shared nature of Web 2.0 technologies opens up new ways to construct and organize content both within and outside the classroom (Davies 2006). In his research on the use of wikis by preservice teachers during field placements, Ian Robertson (2008) found that using this Web 2.0 technology resulted in students and their teachers assuming additional roles as well as investing more in the organization and relationship of content.

Necessary Change in Mind-Set

To benefit from the learning affordances identified above, participants must shift the way they consider possibilities, goals and ways to achieve these goals (Lankshear and Knobel 2006), as using new media literacies represents a dramatic shift in how we interact with one another and what we value. Greater value needs to be given to actions and knowledge that are dispersed over those individually held, tools used for mediation and relationship-building over those used for knowledge production, a focus on the collective rather than the individual, and a move to digital multimedia spaces from stable, textual spaces. Kevin Leander (2007) examined the use of online technologies in classrooms where every student had a laptop. He identified the critical impact of teachers' attitudes and beliefs regarding how knowledge is constructed on the roles offered and taken up by students and teachers.

Lived Practices and Uptake

Web 2.0 technologies involve movement toward more equalized power structures due to the ability for multiple users to be instrumental to the development of the sites.

As these practices are brought into the classroom setting, the ways students take up (or don't) the teacher's instructional design become critical to its successful implementation as shown in a study by Leonard Annetta et al. (2008) of the use of virtual environments in a graduate class. They found that the variations in the ways that students negotiated and lived out the student-teacher's assignments had a significant impact on the extent to which the teachers' designed affordances were realized.

Empirical Research on Science Teachers' and Students' Bloggings as a Case

The use of Web 2.0 technologies in science builds on work which has been discussed within this handbook and other published work (e.g., Webb 2006). While recognizing the potential of technology for enhancing science education in her study of varied instructional technologies (IT), Mary Webb suggests that for true integration to happen, a redesign of the science curriculum is necessary. Although her focus was primarily on less connective forms of technology than Web 2.0, her arguments hold for these new technologies as well.

To offer deeper insights about the implications of NML for science education, we now briefly report on four complementary empirical studies informed by NML where we investigated ways in which science students' and/or teachers' blogging practices nurtured reform-based learning:

- Classroom Blogging 1 (CB1): This study examined how two teachers – Mr K, the veteran math teacher featured in the first vignette, and Ms T, a first-year biology teachers – introduced, structured, and used very different classroom blogs for their classes, and the learning opportunities and benefits students and teachers derived from these experiences with blogging (Luehmann and MacBride 2008; MacBride and Luehmann 2008).
- Classroom Blogging 2 (CB2): This study expanded on the previous one by investigating various components of teacher instructional design and corresponding lived experiences of nine additional science classroom blogs to which middle and high school students actively contributed (Luehmann and Frink 2009).
- Teacher Blogging 1 (TB1): The blog created by Ms Frizzle, the extraordinary science teacher blogger featured in our second vignette, provided very rich material for an in-depth case study of how this teacher used blogging very effectively as a professional development and advocacy tool (Luehman 2008a, b).
- Teacher Blogging 2 (TB2): In this study, we investigated how maintaining personal professional blogs in a graduate course supported 15 practicing science teacher learners (Luehmann and Tinelli 2008).

Table 55.3 briefly identifies key elements of each of these studies.

Table 55.3 Overview of four studies of blogging in science education

Study	Bloggers	Research questions	Data sources	Key findings
CB1	Class – 11th grade pre-calculus; 9th grade biology	How did each teacher structure, and students use, the blog? What were the participants' perceived benefits?	Teachers' interview; blog content (1 year each); students' written descriptions of blogging impact	Identified different blogging practices. Defined learning opportunities afforded by different blogging activity structures as well as key components of these activities. Described perceived benefits of teachers and students.
CB2	Class – nine diverse science classrooms	What affordances do blogs offer science teachers engaged in implementing reform? How were teacher designs taken up by students?	Teacher responses to five reflective prompts, blog content (3 months each).	Described range and representativeness of classroom blog uses. Investigated alignment of priorities across three phases of teacher design. Identified opportunities for and impact of teacher-designed student agency. Investigated range of ways various instructional classroom designs were lived.
TB1	One exceptional science teacher blogger	How and why did blogging provide opportunities to engage in teacher learning and identity work?	Blog posts and comments (1 year), email exchanges, phone interviews with colleagues	Described the personal professional use of one exceptional teacher blogger with special attention to how blogging supported wrestling with challenges of being an urban reform-minded science teacher. Identified perceived professional learning benefits. Explored connection between realized benefits and investment in blogging practices.
TB2	Fifteen secondary science teachers in a graduate-level course	In what ways did blogging provide opportunities for social interaction that supported professional learning among practicing science teachers?	Blog contents (1 year); blogging survey responses.	Described perceived benefits of personal professional blogging for science teachers. Explored various types of cognitive, emotional, and social work participants collaboratively engaged in through blogging.

Methodological Contributions

Throughout these four studies, as we tried to explore the realized potential of blogging to transform science education toward more reform-based practices, we have wrestled with a number of methodological issues similar to those reported earlier from the literature:

- How does one search for powerful examples of classroom blogging, as many are not public and few evidence the shift in mind-set allowing for a dominant student presence? We used websites targeting their blogging tools for K–12 education (e.g., EduBlogs). We also employed a snowball method (Goodman, 1961) to identify strong examples – namely, once we found one blog evidencing an NML mind-set, we used its blogroll and "shout outs" to identify others.
- How can a researcher interview teacher bloggers in ways that supports connection-making with the blogging practice? We have used Skype and Voicethread, two additional Web 2.0 technologies, as tools to conduct our bloggers' interviews, as they allowed interviewees to employ multimodal and hyperlinked resources to enhance their responses.
- How can a researcher characterize general use of blogging? To paint the landscape of particular learners' use of blogs as a basis for exploring participation structures and benefits, we repeatedly employed a number of descriptive statistics such as: (1) number of posts, comments, lines, and questions written by students compared to teachers; (2) number and types of multimedia elements employed; and (3), number of explicit connections to others through hyperlinks, references, or dialogues. In addition, we regularly counted instances of emergent themes for focus of post (e.g., a day-in-the-life, social justice, inquiry) and type of work (e.g., wrestling, ranting, resource-sharing).
- How can researchers study an environment that has the potential to constantly change? Blogs, like all Web 2.0 technologies, can constantly evolve. In order to freeze participation to allow us to analyze its use, blogs were transcribed through a process of copying and pasting their contents, including a screen shot of the home page, into a word processing document with line numbers added.
- How can researchers most effectively tell the stories of the implementation and impact of the integration of NML in science education contexts? Online peer-reviewed journals offer a valuable alternative to print-based media to report on Web 2.0 technology research. For example, our article on classroom blogging (Luehmann and MacBride 2008) published in the online journal *THEN* (http://thenjournal.org/feature/175/) allowed us to embed primary and secondary sources including hyperlinks to specific student and teacher posts and a podcast of the interview with the teacher blogger.

Key Findings

Using the same organizing themes identified earlier, we now highlight key findings that span our published work. These findings can be used to situate or inform other investigations of blogging or to inspire similar work with other Web 2.0 technologies.

Potential for Teaching and Learning

Clearly, our primary goal for studying blogging in science education has been to explore its potential for supporting teaching and learning. Our findings from the analysis of Mr K's and Ms T's classroom blogs (CB1) revealed that students as well as teachers felt that blogging nurtured classroom community, encouraged voices not often heard in classrooms (e.g., non-English speakers, multimodal, typical non-speakers), provided students more and different valued opportunities to understand course material, nurtured a sense of ownership of learning, provided uncommon opportunities to learn participation skills unique to online environments, and provided the teacher with a unique window into student thinking.

Our work to understand how participation in blogging might support science teacher learning demonstrated that blogging contributed to Ms Frizzle's development of her professional vision and dispositions; led to new understandings of content, pedagogy, and her students; and positively affected her practice by helping her in planning – all dimensions of teacher learning identified as important in the literature. In addition, she engaged in many practices deemed valuable in the teacher education literature: connecting practice to her autobiography, engaging in critical inquiry, interacting with professional community, critically reflecting on practice; integrating expert voices, and engaging in long-term professional work. (TB1). These same practices were also used productively by science teachers' blogging in the context of a graduate class (TB2).

Clearly, however, this learning and impact depended on the unique ways in which blogging was implemented and taken-up in each case – as addressed later.

Identity Work Done Through These Technologies

We employed the theoretical lens of identity development for much of our research conducted on teacher learning through blogging, because we feel it offers a long-term and holistic look at the person doing the growing and respects that learning involves much more than simply cognitive growth and development (Luehmann 2007). Our findings indicate that in addition to the cognitive work of wrestling with dilemmas, blogging gave teachers uncommon opportunities to engage in the emotional work involved in implementing reform as well as the social work that can support both of these other types of work (TB2). Blogging also provided opportunities

for telling powerful stories of oneself and one's practice, fostering a unique professional community, demonstrating confidence in a variety of professional roles, positioning oneself in larger professional discourses – all important elements of identity work (TB1, TB2).

Construction and Social Organization of Content

Through our work, we learned that classroom blogs are more different than they are similar due to teachers' activity designs. When examining the nine classroom blogs (CB2), we were able to identify 11 unique activity structures (i.e., assignments or specific uses) used in science classroom blogs, only four of which were engaged by half or more of participating teachers. We learned that teacher instructional design of classroom blogging consisted of four distinct (and rarely aligned) components: curricular goals, instructional priorities, activity structures, and contents of rollout to students. Finally, not surprisingly, the degree to which the activity structure, as it was introduced to the students, allowed for students to exercise agency determined to what extent students *could* interact with teachers to modify how the classroom blogging was being used and in so doing maximize and individualize realized learning benefits.

Realized professional learning benefits of teacher blogging were connected to two primary and complementary conditions: the presence of an active blogging community and the investment of the blogger. An active blogging community was nurtured through publishing detailed posts, soliciting input, referencing others work, and offering detailed descriptions of issues. Clearly, the teacher blogger must commit a significant amount of time and effort to this professional practice to fully reap its benefits. These elements (community and investment) represent a reciprocal relationship, as we found that the primary motivation for engaging in blogging is the social networking made possible through the blogging community (TB1, TB2).

Necessary Change in Mind-Set

Realized benefits of classroom blogging were the result of the nuanced ways activity structures were implemented by a given teacher (e.g., required elements, option of anonymity). Activity structures in the classroom blogs we examined (CB1, CB2) varied dramatically with respect to their alignment with the priorities of either reform-based science education or those of NML. Evidence of the teacher mind-set could be found in a number of key decisions with respect to instructional design: the level of involvement of outsiders; the positioning of students (as authors of posts or just comments); the presence of positive interdependence of students with one another; the length of the blogging experience and the degree of student autonomy.

Lived Practices and Uptake

The realization of certain blogging affordances in classroom practice was not simply a matter of correct design, however; lived experiences, determined by both how students took up the design (or not) and how the teacher responded to students' participation, contributed to the resulting benefits of classroom blogging (CB1, CB2). There were times students did more than what was asked of them in the teacher-designed activity structure; in these instances, blogging enabled students' access to additional resources and opportunities for learning such as hyperlinked and multimodal resources, a broader community and audience, and additional and different opportunities to engage peers and the teacher. This finding suggests that blogging, by itself, holds potential for scientific work to emerge through students' (as well as teachers') initiatives (CB2).

Conclusion

This chapter started with a bold statement regarding the convergence of reform-based science education and the learning affordances of emerging technologies. Both our research and others cited in this chapter provide evidence that Web 2.0 technology is already enabling the change that many in science education have sought for years. The emergent nature of this dialogue requires that we make recommendations rather than conclusions. Critical to framing our movement forward are the following suggestions:

- Research needs to continue to focus on the intersection of the goals of reform-based science goals and the meaning-making practices enabled by newer technologies.
- Investigating NML requires reexamining typical research methods and designs to employ those that consider unique implications of Web 2.0 technologies in the context of reform-based science education.
- Many additional Web 2.0 affordances specific to science education will need to be identified and examined through cases of actual implementation.
- Although we have identified five specific themes in the literature, many potential research areas remain such as scaffolding online participation over time, exploring interactions between in-class and online practices, and designing for positive interdependence with peers as well as outsiders.

Due to the critical convergence of the goals of science education and the affordances of emerging technologies as identified in this chapter, it is indeed time to further explore this potential to change the ways that learners are engaged in their learning, both students as well as teachers.

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