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“Think bigger about science”: Using Twitter for learning in the middle grades

Ryan Becker & Penny Bishop

Abstract: This article examines the use of Twitter as a learning tool in a middle grades science classroom. Relevant research, the direct experience of the teacher leading this unique initiative, and the invaluable perspectives of his middle level students are included to inform interested stakeholders. Following a discussion of open versus closed digital environments, a rationale for why open forms of social media, like Twitter, can be appropriate for middle grades students is explored. The ways in which one author integrates Twitter into his teaching is then described before student outcomes are explained, including the voices and perspectives of students themselves. Finally, the challenges teachers might face in using Twitter with students are discussed and recommendations are offered for those considering integrating social media into their pedagogy.

Keywords: *Twitter, social media, science, middle level, technology*

***This We Believe* characteristics:**

- Students and teachers are engaged in active, purposeful learning
- Educators use multiple learning and teaching approaches

Introduction

Middle level educators have a deep awareness of their students’ tremendously social nature. Young adolescents yearn to be connected with their peers, whether sharing excitedly during lunch, on the school bus, or in the hallways, and regardless of whether they are face-to-face, across a room, or immersed in a screen. Digital tools, including social media, now enable these interactions at an almost ubiquitous level, both in and out of school. Students’ social media use has become so prevalent that fully 82% of 13-year-olds report using social network sites

regularly (Lenhart et al., 2011). Moreover, of those teens who use social media, the vast majority believe their use has a positive influence on their social and emotional well-being (Rideout, 2012).

Over the past decade, educators have attempted to capitalize on students’ affinity for technology by integrating it into learning experiences. Indeed, digital tools have the potential to engage and motivate students (Downes & Bishop, 2012; Hur & Oh, 2012); to increase academic outcomes (Eden, Shamir, & Fershtman, 2011; Lazakidou & Retalis, 2010); and to improve attendance and discipline (Solomon & Schrum, 2007). With the explosion of Web 2.0 technologies, students’ use of the web has morphed from a consumption-dominated experience to one in which they can create, share, and collaborate (Crook, 2008; Schuck, Aubusson, & Kearney, 2010). With so many new technologies at their fingertips, educators may feel overwhelmed by the possibilities. Using social networking tools to enhance student engagement and learning is tempting yet where does one begin?

We—Ryan, a middle school science teacher, and Penny, a teacher educator—have increasingly become intrigued by the potential of Twitter as a means for teaching and learning in the 21st century. In this article, we examine Ryan’s use of Twitter as a learning tool in a middle grades science classroom. We first provide context for this tool by describing the distinction between open and closed digital environments. We then explore why social media, including Twitter, might be useful for middle grades students in particular, given the nature and needs of young adolescents. Next we describe the ways Ryan integrated Twitter into his teaching. Following this, we outline the perceived outcomes for students, including the perspectives of middle grades students themselves. Finally, we consider challenges of this practice for teachers

and conclude with recommendations for educators who are considering integrating social media into their pedagogy.

Open and closed environments

In less than a decade, the emergence and evolution of tools such as blogs, wikis, social bookmarking sites, Google Docs, YouTube, Facebook, and Twitter have transformed virtually all aspects of students' web experiences. Learning platforms (e.g., Edmodo, Google Classroom) that integrate aspects of Web 2.0 technologies into structured and regulated digital learning spaces have also emerged. At its core, each tool provides opportunities for sharing, interaction, and collaboration—albeit to differing degrees and among differing populations, especially when considered along a spectrum of openness.

In schools, students using platforms like Edmodo, as well as tools such as blogs, wikis, and Google Apps for Education, tend to interact digitally with other students within a teacher or school-defined framework. Sometimes referred to as “academic social networking,” this approach to teaching and learning “combines aspects of social networking with an academic focus as the teacher guides students in a virtual constructivist learning environment” (Taranto & Abbondanza, 2009, p. 38). From teacher-generated starting points, students use digital networking tools to share perspectives and opinions with their classmates, comment on those of others, and participate in virtual discussions (Taranto, Dalbon, & Gaetano, 2011). Because this approach relies, at least initially, on teacher-generated prompts, and has a user population that consists only of classmates, it is considered a “closed” digital environment, and one that falls toward the restrictive end of the Web 2.0 spectrum. Teachers often prefer closed digital environments because they provide predictability and structure as well as the ability to monitor users and moderate discussions.

In contrast, at the open end of the Web 2.0 spectrum lie more publically popular forms of social media such as Twitter and Facebook, tools actively used by hundreds of millions of diverse users throughout the world. While it is also possible to place parameters on them, these tools rely on their inherently open nature to generate the vast networks and global, real-time communication that define them. In short, these tools present “open” environments whose users, and uses, have few restrictions. Started in 2006, Twitter is one such venue that is “a real-time

information network that connects you to the latest stories, ideas, opinions and news about what you find interesting” (Twitter, 2013). Consisting of more than 280 million active users worldwide, Twitter utilizes tweets—bursts of information in 140 characters or less—to enable users to share perspectives and media with others throughout the world in real time. People receive tweets from whomever they “follow,” and send tweets to whomever “follows” them.

Despite its global reach and its power to connect individuals with shared interests, we know remarkably little about the use and effectiveness of applying Twitter, and other “open” social networking tools, in middle grades settings. The few studies that do exist, however, show promise. For example, Van Vooren and Bess (2013) found a positive correlation between the use of Twitter and eighth-grade student performance on standardized tests. The majority of other studies of Twitter use focus primarily on post-secondary education, such as in nursing education (Skiba, 2008), marketing classes (Rinaldo, Tapp, & Laverie, 2011), student perceptions of instructor credibility (Johnson, 2011), and college students' grades and academic engagement (Junco, Heiberger, & Loken, 2010). Given young adolescents' unique developmental needs, their social nature, and their affinity for technology, understanding how Twitter might be used for teaching and learning in a middle grades classroom has considerable implications for educators.

Twitter and the nature of early adolescence

During early adolescence, students explore new understandings of themselves and their relationships with others, develop lasting perceptions of themselves as students and learners, and actively envision their futures (National Middle School Association [NMSA], 2010; Stevenson, 2002). Because these perceptions emerge from the formative crucible of early adolescence, they are often deeply forged. The guided use of open forms of social media in school offers new ways for students to access, engage with, and make sense of the world around them, both within and outside of their classroom walls. Importantly, rather than supplanting experiential learning, social media can complement these experiences, and holds the potential to spark a deeper and more intrinsic desire to pursue such activities, both in school and in students' many other life spheres.

For some middle grades teachers, such a leap can be daunting, given the age of the students and the reality that open social networking tools require relinquishing a degree of structure and control. Yet such an act can be precisely what students this age need developmentally. Opportunities to pursue personalized, content-specific connections, and to discover, explore, and share novel, content-rich resources via social media, can be empowering for young adolescents. Guided by a knowledgeable educator, the infusion of social media into teaching and learning may also provide valuable embedded learning opportunities related to both digital citizenship (Lenhart et al., 2011; Ribble, 2011) and new literacies (Coiro, Knobel, Lankshear, & Leu, 2008; Greenhow & Gleason, 2012; Greenhow & Robelia, 2009).

Social media comprise an important dimension of adolescents' lives. Surveys and reports repeatedly demonstrate the prevalence and significance of these tools in the lives and interactions of children (Lenhart, Purcell, Smith, & Zickuhr, 2010; Lenhart et al., 2011; Project Tomorrow, 2012; Rideout, 2012; Vockley, 2007). Furthermore, use of social media is not restricted to topics of personal nature alone. The National School Board Association's (NSBA) report, *Creating and Connecting: Research and Guidelines on Online Social—and Educational—Networking* (Vockley, 2007), found that "almost 60 percent of students who use social networking talk about education topics online and, surprisingly, more than 50 percent talk specifically about schoolwork" (p. 1). Citing the ubiquitous nature of social media both in the lives of students and society writ large, Taranto and Abbondanza (2009) stated, "banning social networking or even denying its popularity is not only inappropriate but also borderline irresponsible when it comes to providing the best educational experiences for students" (p. 38). From their perspective, "schools must embrace and provide opportunities for teachers to utilize social networking in a responsible and structured manner to support academics" (p. 38).

The use of open forms of social media in school has the potential to positively impact middle level learners in many ways. In an era fraught with concern about privacy, cyber safety, and inappropriate content, parents' and teachers' concerns are understandable. However, the prospect of combining adolescents' social and intellectual affinities with meaningful opportunities for them to engage with a personalized, authentic audience—unrestricted by time, space, and geography—is too promising to

dismiss. Twitter is a tool that affords these learning possibilities.

Using Twitter for learning: Ryan's classroom

To best understand the context in which Ryan's eighth-grade physical science classes use Twitter, it is helpful to understand the following characteristics of his classes and his middle school in general. Woodstock Union Middle School is a relatively rural, grades 7–8 school with a total population of approximately 150 students. During the 2013–2014 school year, the student population was 93% White, with 27% receiving free or reduced lunch (FRL) and approximately 19% receiving special education services. Each science class is approximately 80 minutes in length and is heterogeneously grouped. The students fall along a spectrum of ability levels in reading, writing, and mathematics, including English language learners and those receiving special education services. All students have their own school-issued netbook that they bring with them to each of their classes and wireless Internet access exists throughout the grades seven–12 building.

Within this context, Twitter offers students meaningful connections to science, shared by reputable sources, as they develop and are shared around the world. Because these connections can be personalized, based on whom a student decides to follow, Twitter encourages students to realize connections between science and their own lives and interests. Beyond content consumption, Twitter also enables students to interact and share perspectives with others outside of their specific class. While these are often classmates, depending on his or her followers, a student's audience could extend far beyond his or her peers. Finally, Twitter encourages Ryan and his students to think creatively about ways they might share science in new ways. From a pedagogical standpoint, Twitter has been a useful way to enhance a personalized and relevant curriculum, to serve as a formative assessment tool, to provide an authentic audience, and to embed literacy tasks in science classes.

Twitter as personalized and relevant curriculum

One of Twitter's greatest strengths lies in its ability to connect students to reputable, relevant scientific people and organizations in real time. It is hard to quantify the positive impact of being able to follow—in real time—

notable science enthusiasts like Neil de Grasse Tyson and Bill Nye, reputable national organizations such as the National Aeronautics and Space Administration (NASA), popular science-related programs such as PBS' NOVA, Discovery Channel's MythBusters, and National Public Radio's (NPR's) Science Friday, as well as current science missions such as the Mars Curiosity Rover mission (see Figure 1) and the European Space Agency's Rosetta Mission. This new dimension to science class offers constant access to up-to-the-minute perspectives, developments, and resources that can be used at any time to illustrate a concept, foster a discussion, or simply to share a fascinating nugget of science. Furthermore, because students can choose to follow any science-related person or organization that their teacher follows (including their peers), and they are encouraged to search for and recommend new individuals to follow, whom students follow is not only relevant and reputable, but also highly personalized. As a result, the lists of science-related individuals whom students follow can vary significantly and, importantly, are based on their individual interests.

Beyond simply following relevant science-related sources, students also tweet themselves. Sometimes this

involves students tweeting a picture or video that illustrates a certain science concept (e.g., acceleration) during class or as part of a homework assignment. However, students are encouraged to share science-related tweets anytime, regardless of whether or not they are part of an assignment or connected to a particular unit of study. Students can generate their own tweets (see Figure 2) or retweet an existing tweet. In either case, their interest reaches an audience beyond the walls of the classroom. When students find an especially interesting tweet they can "favorite" this tweet within Twitter and/or add this tweet to a portion of their electronic portfolios entitled "Science I Like!" In the case of the latter, students take a screenshot of the tweet, post it within their e-portfolio, make the screenshot an active link to any link that was part of the original tweet, and offer a brief reflection on the content and personal relevance of the tweet.

Twitter as formative assessment

Twitter can also function as a valuable formative assessment tool. Because tweets are sent and received instantaneously, they illustrate students' thoughts, perspectives, questions, and opinions in real time. Additionally,

Figure 1 Mars Curiosity Rover



Figure 2 A student's tweet



students can reply to one another's tweets. This added feature provides the opportunity for mini discussions to emerge around specific tweets. Furthermore, if accounts are not "protected," hashtags (letters or words preceded by the # symbol) can be added to tweets, which enables the categorization of all tweets that include a specific hashtag. Hashtags are powerful because they create a separate space for related tweets that can be easily referred back to at later points—unlike one's main Twitter stream, where received tweets are quickly buried by newer ones. When students' tweets are displayed on an electronic SMART Board, formative assessment may occur with students as an active part of the process. Using a SMART Board allows all students in a class to simultaneously view the enlarged tweets of all of their classmates.

Twitter can also be a formative assessment tool both within and outside of the classroom, and for a variety of purposes. Ryan often asks students to tweet examples of specific science concepts. For example, students have tweeted personal examples of Newton's First Law, sentences from science writing assignments, examples of favorite mixtures (including personally captured photos), science connections to holidays (e.g., Thanksgiving), and responses to specific poll questions (via a tool called Twtpoll). When asked to tweet outside of class, students are always encouraged to view and respond to their peers' tweets. When completed in class, tweets are enlarged and displayed on the SMART Board for everyone to see. In cases where a poll is used, depending on its type, Ryan and his students can see basic response statistics (e.g., average

rating, range of ratings, pie charts, etc.). In all cases this provides quick insight into students' understandings and misconceptions, while simultaneously providing a glimpse into how they are connecting science to their own lives and interests.

In addition to using Twitter to gauge student understanding as they move through specific units, students can also tweet to start or conclude a unit. When used as a closing activity, one can probe their perceptions regarding the essence of big ideas, concepts, and units. For example, upon completing the chemistry portion of the year, students needed to summarize chemistry in a single tweet (see Figure 3). Because this practice required students to reflect on, mentally rank, and draw connections between chemistry concepts that they covered, and then to distill this down to 140 characters or less, Ryan was able to see what students perceived as the essence of chemistry. When used as an opening activity, one can gauge prior knowledge and potential misconceptions (see Figure 4). In both cases, because tweets are shared with followers, and with all students via the SMART Board, students are able to consider the perspectives of others. Whether used before, during, or as a concluding exercise to a unit of study, Twitter can be used as a formative assessment tool to monitor and analyze student learning in order to guide instruction.

Twitter as authentic audience

Twitter provides an authentic audience that extends beyond the immediacy of the classroom. Students using Twitter can

Figure 3 Students' summaries of chemistry

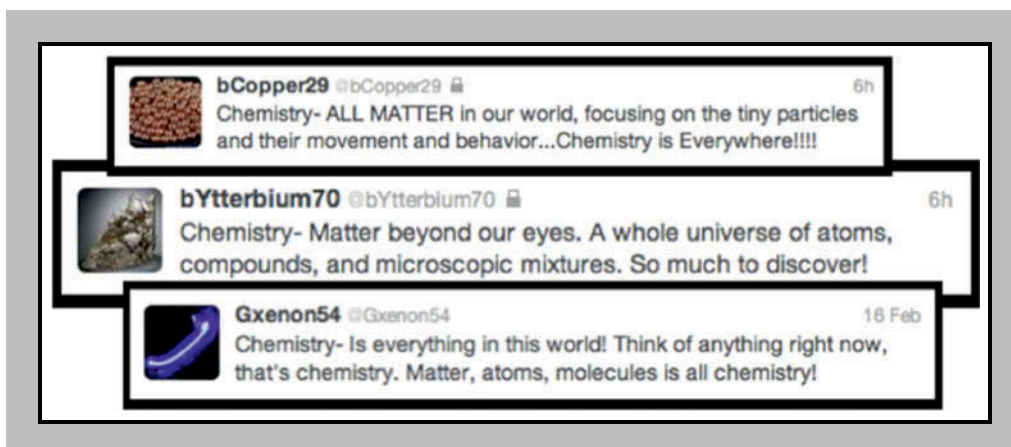


Figure 4 Window into a student's prior knowledge regarding chemical reactions



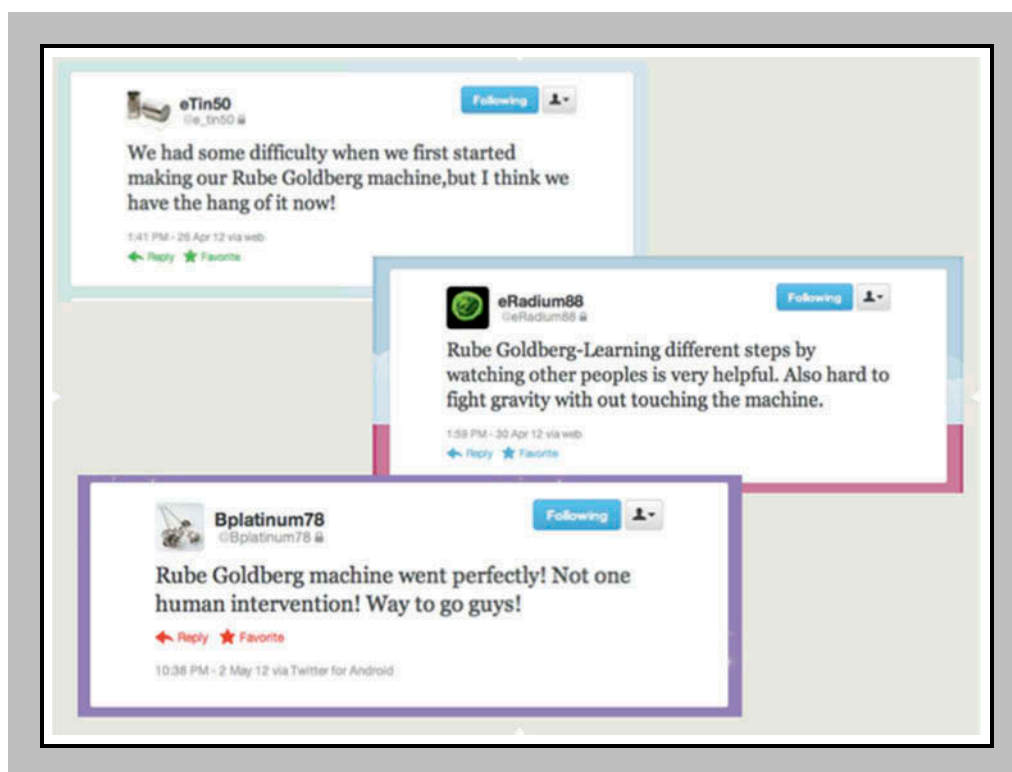
be followed by both classmates within and outside of their specific classes. As a result, in virtually all cases, tweets reach an audience that is greater in number than would otherwise be the case in a traditional classroom setting. Because the driving motivation of audiences on Twitter is shared interests, audience composition within this framework is virtually unlimited. For example, students who are especially interested in space could be followed by fellow classmates, an astronomer who shares their love of space, or even an actual astronaut. If any two people are on Twitter and they share an interest, each is a potential audience for the other.

In addition to the students' tweets described above, students sometimes tweet about a project they are doing in science class. These tweets could generate potential ideas or update others on their progress. For example, when students were making Rube Goldberg machines, many used Twitter as a tool to share inspiring videos of successful machines in preparation for the project. Several students felt inspired enough by their own progress during the project that they took to Twitter to share their excitement

(see Figure 5). In another instance, Ryan used Twitter to virtually include his students in his presentation at a technology conference. Back in the classroom, students were shown a video of a peer group's Rube Goldberg machine from another class. Students then tweeted specific examples of physics concepts that were illustrated in the video and that they had recently explored. At the same time, Ryan shared the same Rube Goldberg video with his audience at the conference. The concomitant timing enabled his audience to watch the students' tweets come into his Twitter stream in real time. This provided an illustration of a live and authentic application of Twitter as well as an authentic audience for his students.

Indeed, that students themselves are an authentic audience for reputable science-related individuals and organizations is also a powerful outcome of middle level students' use of Twitter. As audience members in this real-time network, students are exposed to science content that is inherently more connected—both to current events and their personal interests—and delivered with more context than traditional

Figure 5 Students' Rube Goldberg tweets



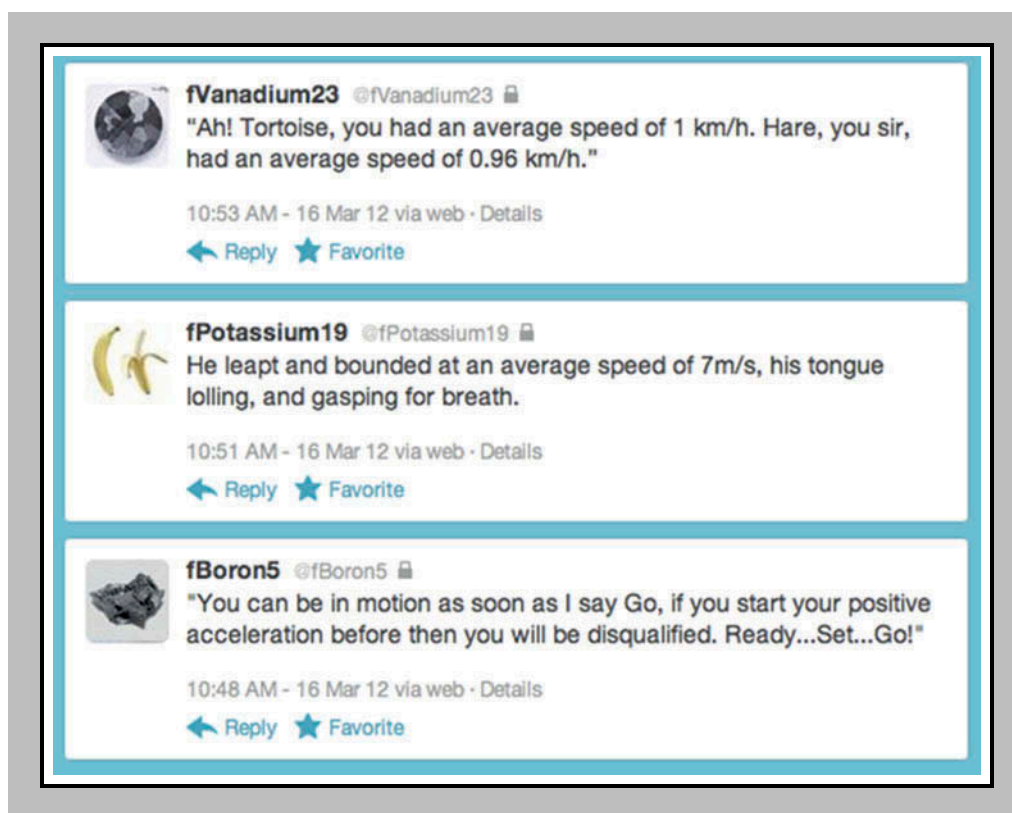
textbooks. This degree of personalization and relevance can exceed even the most valiant teachers' efforts to personalize instruction based on interest. Furthermore, because tweets come from organizations in addition to individuals, students also begin to become familiar with reputable science organizations throughout the world. Here again, the value exceeds simply exposing students to relevant science content or concepts. Students have opportunities to become familiar with long-standing organizations that will likely be at the forefront of science-related exploration, discoveries, and policy development throughout their lives. At a time when STEM interest is perhaps as high as it has ever been in our country, such familiarity will likely have a positive effect on the likelihood that these students mature into knowledgeable, scientifically informed adults.

Twitter as embedded literacy

Twitter enables students to practice embedded forms of literacy, including both traditional and new literacies. In terms of traditional literacies, students sometimes tweet a favorite sentence or two from specific science writing assignments. The practice of sharing select sentences provides them with opportunities to see how their peers approach the same writing task. Because this exercise focuses on a very specific item of analysis, typically addressing very specific criteria, it enables students to compare their approach to those of their classmates.

From a physics perspective, for example, when rewriting the classic tale, *The Tortoise and The Hare*, students can see in a few seconds a wide variety of successful sentences meshing science and story—a challenging skill

Figure 6 Students meshing science and story



for most students (see Figure 6). In addition to functioning as a tool to support writing, Twitter exposes students to a variety of forms of science-related, informational text. The majority of tweets students encounter include links to articles, blogs, studies, etc.—often supported by additional media (e.g., video). Encounters with these forms of text, initiated by self-interest and choice, further supports the development of traditional forms of literacy.

While the value of traditional literacies is unquestionable, the ubiquitous nature of the Internet, including the continual evolution of associated tools and technologies, has led to the emergence of what many consider new literacies. As Coiro et al. (2008) noted, “Literacy is no longer a static construct from the standpoint of its defining technology for the past 500 years; it has now come to mean a rapid and continuous process of change in the ways in which we read, write, view, listen, compose and communicate information” (p. 5). In their review of research on literary practices and social media, Greenhow and Gleason (2012) concluded, “literary practices on social network sites can be viewed as new social literacy practices,” (p. 470) and posited, “similar themes are playing out on Twitter” (p. 471). Because students’ use of Twitter engages them in practices, and a digital environment, conducive to the development of new literacies, Greenhow and Gleason believe that these elements indeed “indicate emerging new literacy practices” (p. 471). Web 2.0 technologies, including Twitter, are also altering the way the public consumes, experiences, and makes sense of science. Speaking to this reality, Brossard and Scheufele (2013) noted, “A world in which one in seven people actively use Facebook, and more than 340 million tweets are being posted everyday is not the future of science communication any more. It is today’s reality” (p. 41). Students’ use of Twitter immerses them in this new reality, enabling them to actively participate in communicating and consuming science in new and diverse ways.

Outcomes for students

When considering the impact of Twitter on student learning and engagement, an attractive and straightforward approach is simply to track the number of tweets students send. However, this approach does not necessarily convey how often students visit Twitter, what they have read or viewed, or the questions, discussions, and realizations that may have resulted. An analogy is trying to predict how much students are learning by counting the

number of times they raise their hands in class. While a student who raises his or her hand often is likely to realize positive academic outcomes, one cannot assume that a student who does not raise his or her hand often is not going to realize similar gains.

Ryan used Twitter to help his students realize four primary objectives: to increase student exposure to reputable science in real time, to broaden the audience for their work beyond the classroom, to expand opportunities for connecting science to their own lives and interests, and to consider new ways to communicate about science. He measures the effectiveness of Twitter qualitatively via surveys, occasional small-group interviews, and classroom observations and discussions. He especially values student responses to Google surveys as this method of data collection is anonymous, completed individually, and enables him to collect and archive feedback that directly addresses his four primary objectives. Eighth-grade students during two separate academic years have completed the same survey, which is designed to be simple and straightforward. Using a 4-point Likert scale (strongly agree, agree, disagree, strongly disagree), the survey asks students to share the degree to which they believe Twitter enables them to realize the four objectives. Optional space invites students to add comments below each response and a final question asks them if they have any additional comments or feedback.

The following sections provide a summary of student responses to the four Likert scale questions regarding the four objectives for using Twitter. Through quotes, students’ voices are also included in each section below to enrich the numerical data. Throughout all phases of their use of Twitter, student input and feedback has been critical.

Connections to science

Following real scientists on Twitter allows us to connect with them and share each other’s discoveries.
(Eighth-grade student)

Ryan’s first objective was to provide opportunities for meaningful connections to science, shared by reputable sources, as they develop and are shared around the world. Ninety-five percent of students surveyed agreed or strongly agreed that Twitter enables them to follow real science, in real time, as it develops around the world. In one student’s words, “I feel this way because we get to see what’s going on around the world in real time and I think it’s amazing that

we get a chance to do this in school.” Other students were more specific in their feedback, with one stating “NASA, and scientists that I follow, tweet a lot about cool science stuff,” and “At the moment, I am ‘following’ many different scientific organizations such as NOVA, NASA, Bill Nye, and other scientists.” Lastly, some students appreciated the “real” nature of the scientists they follow as well as their discoveries. In one student’s words, “Real people that know a lot about science get to share it with you.”

Expanded audience

Whenever I tweet something about science it can go to anyone that is outside of my class or even across the world. (Eighth-grade student)

The second objective was to enable students to interact and share perspectives with others outside of their specific class. Ninety-three percent of students surveyed agreed or strongly agreed that using Twitter enables them to interact and share perspectives with other outside of their specific class. Some students considered the potential global nature of their audience, while others recognized, quantitatively, the difference between their in-class voice and their Twitter voice. One student explained, “I have as many as 52 followers on Twitter opposed to around 18 fellow classmates. When I have something important to share about science I like, as many as 52 people can see what I tweet instantly!” Some students even use their Twitter audience for academic support specifically. In one student’s words, “I talk over Twitter with other students about their projects and ask for help if I need help.” Overall, students recognize and appreciate the expanded audience Twitter affords.

Connections to personal lives and interests

It allows me to look at things that I like that are related to science. (Eighth-grade student)

The third objective was to help students make connections between science and their own lives and interests. Ninety percent of students surveyed agreed or strongly agreed that using Twitter helps them make connections between science and their own lives and interests. Many students validated this objective with statements such as “Twitter has made me think about things that I like and had me think about the science related to them,” and “If I ever see that someone tweeted about something that I use everyday I think ‘Wow that is really cool.’” Many students also

shared that Twitter has caused them to consider new ideas and to develop new interests. In their words, “I think Twitter is cool because you get to see stuff about science that you’ve never seen before,” “I have learned a lot about other places and other species using Twitter,” “It allows me to learn about science that I would normally not look for,” and “I can follow things in our world that I didn’t even know about.” With guidance, students can realize the power of Twitter as both a vehicle to connect science to their lives and current interests and, potentially, as a rich source of new curiosities and passions.

New ways to communicate science

Twitter has helped me think bigger about science. (Eighth-grade student)

Ryan’s fourth and final objective in using Twitter was to encourage his students and himself to think creatively about how to communicate science in new ways. Eighty-one percent of students surveyed agreed or strongly agreed that using Twitter helps them think creatively about new ways that science can be communicated. Students offered diverse perspectives on this statement. Some students appreciated the ability to use such a contemporary tool in class. “It was a clever idea, because it puts a modern day website that kids might be using anyway and turned it in to a school activity.” Other students recognized that Twitter shares science in different forms (i.e., links, pictures, videos). “Every amazing photo or video I find on Twitter makes me more and more interested. And I’m learning more about science every time,” and “Since people tweet and share videos and pictures, I can learn what certain things do, and why they happen.” Other students recognized the on-demand nature of Twitter. In one student’s words, “I think that Twitter is a way to stay connected with science almost wherever you go.” With increased familiarity using Twitter, as well as a deeper understanding of the networking features and capabilities of Twitter, students will likely develop an even greater appreciation for how it can be leveraged to creatively share science.

Challenges for teachers

Like any new initiative, especially one involving technology, the path to implementing Twitter in a middle level classroom is not without challenges. Students in Ryan’s classes have now used Twitter for parts of three separate

academic years. In each year, several challenges have been noteworthy.

Ryan's greatest challenge has been guiding students through the setup of their Twitter accounts. He mistakenly believed that once they had access to the Twitter site (i.e., it was not blocked by the school's Internet filter), the setup process would be straightforward. However, for a majority of classes, the actual Twitter site proved to be the weakest link. Each year, in each class, a surprising number of students were initially unable to complete the account setup process during class. These students received a message from Twitter stating that their request could not be completed and that they should try again later. Because Twitter does not have live support, there is no way to get immediate help. This presents a host of issues, as once students have formally set up their accounts they typically need significant guidance regarding who to follow and how to set up various account settings. Ultimately, many students have had to set up their accounts outside of class. Ryan then collects their account setup sheets (containing their usernames and passwords) and logs into their accounts to ensure proper setup. In schools fortunate to have a technology integration specialist or a related position, teachers can capitalize on the support of another capable adult in the building to help manage this process.

A second challenge has been finding the time within classes to guide students in how to use Twitter, to set and practice norms and expectations regarding personal conduct in this new virtual space, and to gather student feedback regarding their perceptions, experiences, and questions. In Ryan's experience, most students have not had prior experience with Twitter. Therefore, students need guidance and support as they explore all aspects of its use, including basics such as how to structure a tweet, how to assess the accuracy and reliability of content, and how tweeting differs from emailing, texting, and posting to Facebook. The finicky nature of technology (e.g., reliable Internet access, bandwidth, individual student notebook issues, etc.) further draws from the finite class time that all teachers must budget. Furthermore, as he has become more comfortable using Twitter in the classroom, Ryan has invited students to use it in different ways. This process of exploration, of course, necessitates the use of class time. As is so often the case, there rarely feels like enough time to do everything that needs to be done and, importantly, to do it well.

A third challenge in facilitating middle level students' use of Twitter has been managing students'

encounters with objectionable material. This material has primarily consisted of the occasional presence of profanity in tweets and sexually suggestive follower requests (particularly upon account setup, despite "protected account" status). To his knowledge, students with whom Ryan has worked with have never shared offensive content or generated an offensive tweet. As he shares with students, these encounters are an unfortunate downside of using a truly global, "open" networking tool like Twitter. In an effort to process and make meaning out of these encounters, Ryan encourages students to communicate with him about instances in which they encounter offensive content and they use these instances as authentic opportunities to discuss digital citizenship and healthy decision making.

Despite the challenges described above, Ryan and the students have found the benefits of Twitter outweigh the drawbacks. In an age where media is constantly competing for students' attention, and where messages in popular media are often at odds with in-school norms and expectations, opportunities to model, discuss, and practice the appropriate use of Web 2.0 technologies is critical. Furthermore, because these opportunities arise in the context of an academic setting, students are not simply told what not to do. Instead, the focus of the experience is on how Twitter can be leveraged to realize meaningful connections to science via reputable, trusted sources. These opportunities for discussion, embedded within the positive context of using Twitter for learning, are both healthy and necessary.

Recommendations

From a pedagogical standpoint, Twitter can enhance a personalized and relevant curriculum, serve as a formative assessment tool, provide an authentic audience, and embed literacy tasks in a science class. While these were described within the context of a science class, Twitter has utility across subject areas and potential applications limited only by an educator's imagination. For teachers considering using Twitter in their classrooms, we offer several recommendations.

Engaging outside stakeholders

First, because Twitter fundamentally challenges traditional understandings of the roles of teachers and learners, as well as dramatically expands the classroom, the support of one's principal or building leader, as well as the technology

integration specialist (or equivalent), is critical. In addition to helping students gain access to Twitter (if blocked) and navigating school or district Acceptable Use policies, these individuals can also act as knowledgeable and invested stakeholders, and a support network to consult when encountering unexpected challenges. Second, because the use of open forms of social media in school falls outside of most parents' conceptions of and personal experiences in school, communicating openly with families from the beginning is essential. Explaining objectives and asking for parental permission and feedback prior to students setting up accounts is an important step. All parents should have the option to opt out of their children using Twitter. In Ryan's classroom, parents/guardians whose children do set up accounts (the vast majority) are encouraged to follow both their children and him.

Engaging inside stakeholders

In addition to consulting outside stakeholders, we suggest teachers themselves become as familiar as possible with Twitter prior to facilitating students' use of it. Twitter can function as the primary tool in a teacher's own personal learning network (PLN) and, as such, can not only expand one's PLN but also help to familiarize oneself with Twitter and its many potential applications. It is also recommended to include students as much as possible in the development and implementation of any initiative related to Twitter. Because student learning is the primary reason for using Twitter in the classroom, it is essential to use their feedback and opinions throughout the process. A student pilot group, for example, can brainstorm potential uses, test the account setup process, and discuss norms and expectations. It is also recommended to start slowly and use the restrictive measures Twitter offers. Joining Twitter truly is joining a global community and doing so comes with the usual perils associated with the Internet. Student privacy and safety must be a priority. Begin with protected accounts, which require students to approve follower requests. Teachers might also consider requiring students to develop Twitter names and handles unrelated to their real names and be taught to refrain from including their likeness, or those of their peers, in any of their tweets. Ryan asks students to create Twitter names and handles related to science (e.g., the periodic table) and/or areas of personal interest. This adds a layer of anonymity that may be beneficial from both a safety standpoint and a sharing standpoint. Regarding the latter, Ryan

contends that students are willing to tweet more openly, and receive feedback on their tweets more constructively, when their actual names are not associated with their accounts. In this way, the focus is placed on what is tweeted and not the author of the tweet.

Conclusion

Twitter offers powerful, new opportunities for middle school students to share, interact, and explore—hallmarks of Web 2.0 technologies. The dynamic nature of Twitter not only leverages middle level learners' innate social nature, but also provides teachers with a multi-dimensional, multi-modal pedagogical tool whose benefits can be realized in real time. Moreover, each student's experience is inherently personalized—from whom they follow to how they set up their profiles—and is influenced by the contributions of others throughout the world. Twitter therefore fundamentally challenges traditional paradigms of teacher, learner, and classroom. In a time when knowledge is so abundant, communication instantaneous, and digital literacy imperative, Twitter affords middle level students and teachers unique opportunities to model and practice authentic applications of an open social networking tool for learning.

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