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# Learning to Teach

Language Arts, Mathematics,
Science, and Social Studies
*Through Research and Practice*



A publication of the Department of Curriculum and Instruction
Leigh Chiarelott, Ph.D., Interim Chair | University of Toledo

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## Language Arts, Mathematics, Science, and Social Studies *Through Research and Practice*



*Learning to Teach Language Arts, Mathematics, Science, and Social Studies Through Research and Practice* publishes manuscripts that address curricular innovations, thoughtful discussion of current issues for practice, or essays that inform, advocate for a position or persuade. Manuscripts must address content education.

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## Section on Language Arts



## Section on Science



## Section on Social Studies

# Language Arts

# English Class 2.0: Social Media in the 21st Century Classroom

Jessica O'Connor

**Abstract**: In the world today social media use is an exceedingly common form of communication. Many people receive the majority of their information from digital sources. More reading takes place online than with actual books. Teachers of the English language arts (ELA) need to recognize these changes and appreciate social media as a 21st century literacy. ELA teachers must take steps to incorporate social media into their lessons to help their students succeed in a digital world. It is the responsibility of ELA instructors to teach literacy and communication and there is no better way to do that today than to use social media.

## Introduction

What memories from high school stand out the most? If you're like most people you probably don't remember the tests you took, your homework assignments, or your grades. You probably remember friendships, great learning experiences, and the life lessons you learned. Part of what should be taught at the high school level is life skills. Students need to be prepared for life beyond high school just as much as they need to understand the content, perhaps even more. Students should be learning valuable skills that enable them to be successful; and regardless of the path they choose after high school, students will always be required to communicate with other people. Communication is a very important part of English language arts (ELA). Teachers must be ready to teach students the communication skills needed for the world they live in.

The English language arts standards are listed under several umbrellas, such as: literature, writing, speaking and listening. ELA has branched out in recent years to include different forms of media; students may now study a painting, a song, or a movie in English class the same way they study a story. New media have become a very important part of the interpreting and analyzing that happens in English class. Social media has had a profound effect on how humans communicate with each other; because of this effect, it seems like a logical stretch to add social media to the ELA classroom. The question then becomes: how can we bring social media into the classroom and use it to meet the standards of learning?

## Using Social Media to Meet the Standards

The National Council of Teachers of English (NCTE) (1996) published a booklet listing the standards that students should be meeting in their classrooms. These standards supplement and agree with the Common Core Standards that most students in the United States are required to meet. The NCTE standards point out that students should be able to read, understand, and interpret all forms of text, including formal and informal. Social media is a form of text, because it is a type

of written communication; it may be informal, but students are still required to understand it. The NCTE standards mention that students should be able to adjust their communication skills for different purposes; this means that students should know how to speak during a job interview as well as how to speak to their friends when making plans through a text message. The standards continue by saying that students should be comfortable using different forms of media, understand different types of language and dialects, and use different forms of written, spoken, and visual language for many different reasons. After examining these standards, it does not make sense to keep social media out of the English language arts classroom.

In his thesis, Smith (2014) discusses how social media use in the classroom can be used to meet standards. Smith points out that students today do most of their reading online, rather than through traditional print. Students also get most of their information online. He notes that the standards involving reading and writing can and should be expanded to incorporate all digital media, including social media because of how common its usage has become. Smith believes that digital forms of media can easily be used to teach required skills such as critical thinking and analysis, communication, and literacy. Smith discusses forms of traditional literacy, like novels, and how they may make students feel trapped and confined in the academic type of thought. Students feel this way when they read a traditional text because their world commonly revolves around digital texts; traditional texts are not always relatable for students today. When students are able to use digital literacies, such as social media, in the classroom they feel more comfortable with their learning. Most students already feel that they have mastered the skills needed to navigate the digital world. This feeling of mastery leads students to be more comfortable with digital sources, and therefore helps teachers to bridge the gap between school, home, and personal lives. This makes learning more relevant to students, while they are still able to meet the same standards (Smith, 2014).

While Smith (2014) points out that students are more interested and engaged while using digital literacies in the classroom, he does not argue that these should take the place of traditional literacies. Smith believes that students who use social media and other digital literacies in the classroom to meet the standards of learning for ELA are able to take the skills they learn and apply those same skills to more traditional texts. Smith believes that educators should be able to create classrooms where new and traditional literacies coexist, so students are more prepared for the digital world in which they live. Now that it is clear that social media can help students meet the standards, we must explore why it is important.

## What Makes Social Media So Important?

Social media is important because it is a 21st century literacy (Youngblood, 2014). This statement leads to two more questions; what is a literacy, and what makes a literacy a 21st century literacy? The term 21st century is only used to clarify that social media is a literacy that is specific to the 21st century; it is a new literacy. Perry clears up the question of what a literacy is by quoting an article from by Barton and Hamilton which lists the six propositions of the nature of literacy:

1. Literacy is best understood as a set of social practices; these can be inferred from events that are mediated by written texts.

2. There are different literacies associated with different domains of life.
3. Literacy practices are patterned by social institutions and power relationships, and some literacies become more dominant, visible and influential than others.
4. Literacy practices are purposeful and embedded in broader social goals and cultural practices.
5. Literacy is historically situated.
6. Literacy practices change, and new ones are frequently acquired through processes of informal learning and sense making. (as cited in Perry, 2012 p.54)

Based on these propositions, literacy is so much more than being able to read and write. It is based on our culture, our methods of communication, and the time in history. Literacy is constantly changing because of what is happening in the world at any given time. Social media is an important part of how humans communicate and it is woven deeply into current cultures. The prevalence of social media when it comes to communication and culture makes it into a literacy.

Social media has been around for a few years. Facebook, one of the most popular forms of social media today is a website used for sharing pictures, stories about life, and networking with friends, family, and colleagues. When Facebook was launched I was in college and it was the early 2000s. You were unable to sign up unless you had an official university email address. Although social media began growing in popularity as early as 10-15 years ago, its popularity has risen over the past few years. Facebook has evolved from a networking site made only for college students to a networking site where you can connect with your grandmother, your boss, or your best friend. Social media doesn't seem to be going away anytime soon.

A 2014 article by Youngblood is where I first noted the term *21st century literacy* to describe social media. Because of the newness of social media as a literacy many teachers are hesitant to add it in any way to their classroom curriculum. However, Youngblood (2014) discusses how important it is for teachers to update their strategies and methods for students who are used to doing everything digitally. Using social media in the classroom offers an opportunity to engage these students. It also gives students a chance to work collaboratively, which often benefits their personal learning. Students become more motivated when using social media, and because of this motivation and engagement are able to use social media to build deeper understandings of texts (Youngblood, 2014). Now you may be thinking, we know social media is a big deal, and a huge part of life these days, but how in the world do we implement it in the classroom?

## How Do You Use Social Media in the Classroom?

### *Facebook in the Classroom*

Facebook is one of the most popular forms of social media today. Therefore, it is of particular importance and interest to discuss how it can be used in the classroom. Watson (2012) conducted a study using Facebook in a 12th grade classroom. Students were asked to analyze Facebook conversations in which they had participated. Students were convinced the assignment would be simple, because of the simplistic nature of Facebook status updates. They were quite surprised when that was not the case. Students had trouble interpreting the meaning and mood behind the words

on Facebook. They had to very carefully read them and think about them. This led them to use a close reading method, which generally leads to deep understanding and discussion in an English classroom. Students took time thinking about and discussing the status updates, and were eventually able to reach several conclusions. Students were able to point out that the text was informal and successful in its purpose. They also noted that in order to understand the text the reader must have the same language, cultural, and social understandings, and background as the writer. The students recognized that social media creates a space for young people to develop new informal language in a way young people did in years past just by speaking to each other. Students began to understand that there are many layers to a text, whether it was formal or informal, and learned some text analysis skills. Students were able to look at a Facebook status update and think about it critically, analyze it, interpret it, and discover meaning.

When Facebook is integrated into a classroom in this manner, students are learning skills that help them to meet ELA standards. As previously mentioned, the standards for ELA include the ability to critically look at all different types of text; this is exactly what the students in Watson's study did. The students were able to take the same skills they learned by analyzing social media and use them to analyze more traditional and formal pieces of literature (Watson, 2012).

### *Twitter and Fan Fiction in the Classroom*

In an article by McWilliams, Hickey, Hines, Conner, and Bishop (2011), Twitter, another popular social media site is discussed. Twitter is referred to as a micro-blogging tool; users can "tweet" thoughts that are no longer than 140 characters. In this article, the authors talk about an assignment where students were asked to "tweet" as a character from *The Crucible*. A traditional piece of literature was used along with Twitter in order to prove that educators can create assignments that are engaging and socially meaningful while still meeting standards and teaching traditional literacy skills. Twitter was chosen for its simplistic nature; students began the assignment using an informal mode of communication and gradually moved on to more formal modes. This gave students a chance to see that a variety of texts can be used for communication and to see how each of these can be important. Once students completed tweeting as their character and developed a deep understanding of who their character was as a person, they were asked to create a "fan fiction" story based on their character. Fan fiction is also a popular form of social media, in which fans of a certain story or character write stories based on the original. Fan fiction actually involves students in deep close reading of texts and requires a great understanding and thorough analysis of the original text. This is because fan fiction stories must stay true to the original character and text. Students were then asked to "beta read" each other's stories; in the fan fiction world, a beta reader is a proofreader. If an author of fan fiction writes a story that does not accurately reflect the character or story they are writing about, the beta reader will not approve. Finally, students were asked to create a critical analysis essay based on the original text. This unit plan managed to combine several types of social media and traditional literature in the classroom. Students were able to meet the standards while using several different assignments as stepping-stones leading up to the most difficult

task. By the time the students reached the critical analysis essay they had already developed a thorough understanding of *The Crucible* and its characters. This unit also had the added bonus of making learning into a social activity that increased student motivation and engagement (McWilliams et al., 2011).

## Conclusion

As a teacher of ELA I have actually had experience teaching using social media. During my year of student teaching I managed to create several assignments using both Facebook and Twitter. These assignments were created to aid students in understanding themes and character development in both *To Kill a Mockingbird* and *Romeo and Juliet*. My findings with these assignments were consistent with the research. While engaged in assignments that utilized social media as a learning tool, students were interested and motivated. Students who did not tend to work very hard in class were putting more effort into completing their assignments. I plan on integrating the use of social media into my future classroom on a regular basis. In fact, I have trouble understanding how a language arts teacher could successfully teach a class without it.

There is no way an educator today can overlook the evidence for using social media in the classroom. Social media is a 21st century literacy; and English teachers have always had a responsibility to teach our students to be literate when interpreting both formal and informal text. If social media is today's informal communication it must become part of the classroom. Using social media as a learning tool in the ELA classroom is the best way to teach students to become effective communicators in today's world and to engage students who are immersed in today's digital culture.

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**Biography**

Jessica O'Connor received a Bachelor of Arts in English from the University of Toledo in 2006. After spending several years at home with her daughters, Jessica returned to the University of Toledo for a Master of Education degree. This fall Jessica will be teaching 11th and 12th grade English and publications at Delta High School.

# James Paul Gee, Video Games, and the Language Arts Classroom

Benjamin E. Simmons

**Abstract:** The 21st century has dramatically changed the way scholars view education. James Paul Gee has written extensively on the contemporary cultural phenomenon of video games in recent years in an attempt to provide a new vision for what it means to teach and learn effectively. This article will *think along* Gee's theories in order to let his ideas form and shape how educators conceptualize the three essential ingredients of a language arts classroom: the teacher, the student, and the text. It concludes that (according to Gee) good learning happens when teachers lead students into having embodied experiences with texts which enable them to create and adopt new identities as readers, writers, thinkers, and ultimately as more humane beings.

## Introduction: Gee and Video Games

The exciting progress and amazing achievements of the 21st century have created entirely new challenges and obstacles for teachers of the English language arts. In fact, an entire field of scholarship has developed that examines the way learning has evolved since the emergence of the Internet. Scholars who examine this ongoing development are collectively known as the New Literacies Studies movement, and have examined contemporary learning in light of new technologies and other facets of contemporary life (Coiro, Knobel, Lankshear, & Leu, 2008). One notable member of this movement is James Paul Gee, who has recently written extensively on the cultural phenomenon of video games, and which he thinks have a great deal of light to shed on how language arts teachers should educate 21st century students.

In the introduction to *What Video Games Have to Teach us About Learning and Literacy*, Gee's (2007) first and most comprehensive analysis of this topic, he recalls how he first started playing video games with his son, Sam. He was amazed, upon observing his son playing a children's video game, at the cognitive demands that even a simple game designed for children made on his 6-year-old son. Moreover, when he himself tried to play the game, he (a tenured professor) struggled to do so successfully. Exploring this phenomenon further he found that the more he played, the more his performance improved, and also the more difficult the game became. Moreover, he found his newly developed skills to be improving parallel to the game's rising difficulty. It became obvious to him that the video games were actually *teaching* him how to play well.

Upon further investigation (and many games later), Gee came to the conclusion that video games are actually educational machines, and that the quality of learning principles and game sales are directly proportional. Put another way: for a game to be successful, it must successfully educate players. This proves to be a salient line of inquiry because people (young and old) can spend hundreds of hours on video games, becoming quite informed and very skilled in different ways in the process. Here the heart of Gee's inquiry becomes clear: if games clearly promote deep and

meaningful learning, then why can't schools do it as effectively (or as engagingly)?

## Digital Class vs. Physical Class: Teacher, Student, and Text

Gee's case for the reality of learning in video games, supported by contemporary research, amounts to an articulation of a comprehensive vision of education and what it means to learn. The resulting synthesis is incredibly stimulating, but lacks practical illustrations or case studies that usually are included in educational research. If Gee's ideas are truly useful, however, then his work should be able to inform any discussion of educational practice. With that in mind, this article will attempt to *think along* the work James Paul Gee has done on video games in order to inform a description of the three essential ingredients of any language arts classroom: the teacher, the student, and the text. It will become obvious that Gee's work is not only fascinating in its own right, but a helpful corrective for many faults within traditional perspectives on education. All references, unless otherwise noted, are to Gee's (2007) previously mentioned study.

### *The Teacher*

Gee's work on video games is rooted in his early work on discourse, and it is within that framework any description of what he thinks teachers are and do must originate. In an unpublished conference paper from 1989 (titled "What is literacy?"), Gee lays out foundational concepts and ideas that will guide his subsequent research and writing. He identifies two "discourses," or ways of interpreting and expressing information, that are common to all people. Primary discourses are "our socio-culturally determined way of using our native language in face-to-face communication with intimates" (Gee, 2007, p. 5), and are developed naturally through enculturation and socialization. They are also inescapable, in the sense that everyone has a "default" location from which they interpret the world around them. Secondary discourses are any other mode of interpretation and expression that one learns throughout life in order to interact with groups. A standard concern for language arts teachers such as literacy, then, is most importantly *fluency* in a secondary discourse - in that case expressing oneself in and interpreting the English language correctly. In Gee's analysis of video games, the secondary discourse that students learn is the video game itself, with all its attendant skills and knowledge. There is a way of acting and thinking present in games that students learn as they play.

What this means for our concept of the language arts teacher is clear: teaching is, because of the nature of discourses, always initiation into a social group who uses that particular secondary discourse. To put it another way: teaching is a process of induction, not indoctrination. This breaks the traditional (and often maligned) picture of master and apprentice that has inflated many egos and crippled many students' independence. To Gee, teachers invite students into a new and larger world where they think, act, and even value differently. Hierarchy is thus removed in favor of partnership. In one sense this makes teaching more difficult because there is no simple way to teach students something so extensive. It is also, coincidentally, difficult to standardize. And yet, does not this model explain a great deal about the way language functions and why culturally marginal students tend to have more

difficulty succeeding in scholastic (specifically language arts) contexts? It is not a function of ability or effort or value; it is a function of which groups control and shape the dominant discourses (linguistic and otherwise) in our educational systems, and thus is a social justice issue.

### *The Student*

What students are, as learners, is best articulated in the second chapter of Gee's (2007) book on video games. There, Gee considers the world-creation within video games, and how players' identities in the virtual reality intersect and interact with their identities in the real world. Through the players' ability to construct their characters, and to then make decisions and progress as those characters, Gee develops a tripartite theory of identity. In any game, three forms of identity are active and present. First, there is the virtual identity that a player assumes in the virtual world of the game, and is distinct from his or her real world identity (the second part of Gee's equation). Third, and perhaps most important, is what Gee terms the projective identity which is constituted by the choices and actions taken by the player in the virtual reality. In this identity a new space is created, in which there is an interaction between and a transcending of both the virtual and real identities as taken separately. "Since these aspirations are *my* desire for [the character], the projective identity is both mine and hers, and it is a space in which I can transcend both her limitations and my own" (Gee, 2007, p. 51). This aspect of gaming, which is true of all video games, is a dialectical reality that is both powerful (in the sense of emotional involvement and requiring time and energy) as well as necessary for good learning.

In a classroom, the parallel to the virtual identities in games is constituted by the ideal towards which we are calling our students (the secondary discourse of "student scientist/reader/historian/mathematician") and into which we are trying to initiate them through our instruction. The real identities of students do not change; the same limitations, prejudices, damage, and complexities of each individual are present and active in both. Projective identities in the classroom are the students' interaction with and ownership of the discourse of the content in which the student articulates a new voice and enters it successfully, even if imperfectly. This is an event of deep, active learning that Gee describes as an almost miraculous moment, and is indeed an astounding articulation of what it means to learn (that is, to become). Notice how this schema develops naturally out of Gee's discourse-rooted theory of learning mentioned above.

In the case of teaching language arts, teachers try to create an environment in which students can develop projective identities of "readers" or "writers," or even just as "thinkers." Thus the teacher, as initiator, is not simply bringing students into a group, but creating the space in which students actually become different people. In the case of the humanities, this becoming is oriented to a deeper or broader concept of what it means to be human. What this means practically is that language arts teachers need to create opportunities for students to "try on" these new identities and practice them, to take baby steps, as it were, in their pursuit of reading, writing, and thinking as co-members of humanity as a whole. Thus, the skill sets that students are learning, the posture they adopt in relation to solving new

problems, is what we are actually teaching them when we read *Hamlet* or any other work. This flies in the face of the obsessive focus of many schools on declarative knowledge and the standards of content for "the test." For Gee, until the focus of learning changes from imparting facts to creating spaces of becoming, then active and transformative learning will always a by-product of education instead of its goal.

### *The Text*

The function of the text in the language arts classroom is best approached through the lens of student experience, which Gee (2007) discusses in chapter 3 of his book on video games. To some cognitive scientists, the brain is like a computer that holds symbols inside that corresponds to the outside world, and through education learns to manipulate them in different ways. Others (including Gee) view the brain as an integrated collection of experiences that are tied unavoidably to the real world. For these thinkers, education involves not only learning to make connections among but also actually having these experiences. Observable patterns are the foundation of all learning in this view, and any meaning or learning that is achieved in this manner is referred to as being "situated," or embodied in real-life experience.

In the virtual world of many video games, an immersive story provides the context in which new information is discovered, evaluated, implemented, and given its meaning (which can often change as the story progresses). This is essentially how learning needs to happen in classrooms if students are to ascend beyond purely definition-based, shallow understanding of new concepts or words. If there is no connection to a broader narrative context or tangible world experience, students will not truly understand the information. Magical Realism in literature (i.e. the work of Salman Rushdie) can provide a useful illustration of this point. If students can define that specific movement in history but cannot give tangible examples of how an obviously fantastical story can still communicate profound truth, or cannot see and feel the emotional impact of choosing to write that story in that way, then do they *really* know what Magical Realism is? Their knowledge would be shallow, and therefore useless to them beyond one moment in one particular classroom. For Gee, this is what happens in so many schools when learning is taken out of the realm of genuine educational experiences. We rob students of the one sure way to truly understand something by a neat, skill-and-drill-ready reductionism that divorces ideas from their real world context. This is what John Dewey (2004) called an unhealthy adoption of a mind-body dualism. If Gee and others are correct about the way our brains process and construct information, then teachers need to seriously evaluate how and if they adequately situate and embody information for their students. Gee's point is that video games are a model of how that can be accomplished successfully.

How this relates to teaching the language arts is perhaps the most challenging area of Gee's vision. How can students have genuine embodied experiences with something that, by definition, does not actually exist (viz. fiction)? The answer lies in how teachers get students to interact with texts. Students can have meaningful experiences with texts in a number of ways. One way is that they can do something with it, whether by writing in order to extend a text or by way of a project of some

sort. They could also (and this is more desirable) have the experience of identifying emotionally, of empathizing, with characters or circumstances. It has been said that humans read to know they are not alone, and that experience itself is "embodied" in Gee's sense of the word. This perspective also calls into question the value of teaching exclusively the "classics," with which students may have a more difficult time having educative, empathetic experiences. If deeper learning in the language arts presupposes experiential interaction with texts, then why would we not teach texts with which student would have an easier time connecting? This concept, we must admit, is difficult to implement. And yet, if Gee (2007) is right in saying "… There really is *no other way to make sense"* (p. 87), then can teachers do anything other than continually apply themselves to the task of creating meaningful connections between texts and students' lives?

## Conclusion

The work of James Paul Gee on video games evidences a conception of teaching and learning that can greatly inform the teaching of the English language arts. Good language arts teaching (according to Gee's work) happens when students have embodied experiences with texts which enable them to create and adopt new identities as readers, writers, and thinkers within a broader discourse of English language proficiency. As they are initiated into this broader world through texts, the status of the English language arts as a humanities discipline becomes even more operative. For the most important secondary discourse students learn in their educational career is the discourse of being human, and the language arts (viewed from Gee's perspective) play an essential part in students coming to understand their place in the world and take responsibility for their own lives. Thus, the English language arts are spaces in which students become more fully human. This is a goal towards which every educator would do well to strive, and to which all teachers (including Gee) can happily subscribe.

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### Biography

Ben Simmons teaches high school Language Arts and Religion at Dakar Academy, an international school in Dakar, Senegal, West Africa. Ben recently completed his master's degree at the University of Toledo, and has a Bachelor of Arts degree in English from Toccoa Falls College.

# Science

# Scaffolding Reading and Comprehension of Scientific Texts

Alyssa Hoop

**Abstract**: Although science learning standards emphasize creating scientifically literate citizens, use of texts in science lessons has decreased over the past two decades. Since 1996, the percentage of students who are *capable* of reading has increased, but the percentage of students who *comprehend* their reading has remained unchanged. In order to improve reading comprehension, use of current event articles provides a scaffold that promotes engagement in reading. Recent headlines addressing teachable science concepts included: "Several Americans Possibly Exposed to Ebola Virus", "Sounds Detected from Comet in Space", and "19 Year Old Develops Device to Remove Plastic from Oceans." As an alternative to teacher-directed lectures, current event articles engage students in active learning about scientific phenomena, while also improving their reading comprehension skills.

## Reading Comprehension

Reading comprehension is a complex cognitive process that involves both lower and higher level processing of information to extract meaning from text (McNamara & Magliano, 2009). The education reform emphasizes the importance of scientific literacy (National Research Council, 1996), as there has been a long-standing and well-established link between learning in all domains and text comprehension (Sinatra, Broughton, Diakidoy, Kendeou, & den Broek, 2011). Since 1996, the percentage of students who are *capable* of reading has increased, but the percentage of students who *comprehend* what they are reading has remained relatively unchanged (Sinatra et al., 2011). This is obviously a problem because educators are using texts to convey concepts, but are not helping students develop the skill set required for comprehending and interpreting the information provided.

Surprisingly, in science classrooms the use of texts has decreased significantly over the past two decades, as greater emphasis is being given to hands-on, inquiry-based learning (Sinatra et al., 2011). When constructing lessons that engage students in inquiry-based learning, secondary science teachers experience emotions including fear of change, a desire to embrace change, and for some, confusion about how to scaffold the learning of more complex skills for students (Lapp, Grant, Moss, & Johnson, 2013). Frequently, educators overlook the importance of utilizing texts to engage students in discussing and understanding key scientific phenomena. One possible reason for this avoidance is the complex nature of most science textbooks or publications. These types of articles are beneficial in developing an inquiry-based curriculum because they are written by actual scientists to describe their experiments and outline their findings. Reading these expository texts can help students develop a deeper understanding of the content presented if more attention is focused on how to read and comprehend these scientific discussions. It is not enough for educators to get students to read texts. The students must also be explicitly taught how to comprehend science texts.

### *The Challenge of Science Texts*

Text processing requires inferences be made by the reader to establish coherence between successive sentences. Scientific reading is difficult for students because of frequent coherence breaks, unrealistic assumptions about readers' background knowledge, unfamiliar or highly technical vocabulary, and a high density of new concepts (Sinatra et al., 2011). Traditional science texts are typically "low-cohesion" texts (limited connection from one sentence to the next), which means they require readers to generate even more inferences to fill in conceptual gaps. Current event articles are an advantage in this case because they are often written for the general population. The authors of these texts make few assumptions about readers' background knowledge and use more familiar vocabulary. If new or unique vocabulary is introduced, it is often accompanied by a brief definition or a source. For example, in science, a *solution* is a term used to describe a mixture of two or more substances; whereas a *solution* in mathematics is the answer to a problem. Having this distinction made evident within a text can improve student motivation to continue reading a text and subsequently promote comprehension.

As students progress through secondary school, academic demands increase, and many of these increases come in the form of reading (Ness, 2009). Students struggle with the transition from learning to read narrative text in the early grades to reading expository text in the science classroom in the upper grades as they begin reading and writing to gain information (Montelongo & Herter, 2010). The ability to comprehend expository texts in content-area textbooks and scientific articles is critical to academic success (Ness, 2009). However, as academic demands on secondary students become more cognitively complex, explicit reading instruction diminishes. On average, less than 3% of instructional time in secondary science classrooms is spent on explaining, modeling, scaffolding, and assisting students in using effective reading comprehension strategies (Ness, 2009).

Students tend to struggle comprehending scientific texts because they lack the necessary prior knowledge and reading strategies to generate inferences from the reading (Hall et al., 2015). In addition to complex language, science texts often include data tables and graphs, which students must analyze and interpret. Students have a tendency to look at these sections superficially and anticipate supplemental instruction from the teacher instead of constructing their own conclusions. Educators often do not spend time clearly explaining to students how to examine and analyze data sets which only complicates the reading process.

Teachers of content areas outside of English, including science, often believe they lack the time and knowledge to help students develop the necessary skills for reading comprehension (Ness, 2009). In the secondary science classroom, educators are often faced with groups of students at drastically different reading levels. It is challenging for teachers to find texts that are versatile enough to address the needs of all learners. Finding texts and differentiating text instruction to address all learners is an extremely time consuming component of lesson planning. Teachers could assume it is easier to avoid using texts and approach the content using other instructional strategies, such as lecture. Another difficulty that science educators face is finding engaging and relevant texts which are appropriate for the skill level

of their students. Many scientific texts can be very dense, as they have traditionally been meant to be strictly informative. It is challenging to get students engaged in reading when they do not perceive the text to be interesting. Science textbooks, which are most commonly used in classrooms, are often dated and do not contain accurate and relevant content (Ness, 2009).

However, there is renewed interest in the use of refutation texts as a tool for promoting conceptual change and science learning based on the ideas that learning in science can occur when students contemplate or change their preconceived notions about the natural world (Sinatra et al., 2011). A refutation text includes elements of argumentation that specifically targets the readers' misconceptions about a topic (Tippett, 2010). For example, the article titled, "Several Americans Possibly Exposed to Ebola Virus", can be used as a refutation text to discuss modes of disease transmission, treatments, and affected population. Doucleff (2015) states,

> All of the individuals who are being flown back to the United States are free of symptoms, the CDC said. A U.S. healthcare worker who tested positive for Ebola while in Sierra Leone arrived at the NIH on Friday and was in serious condition. It is not clear how the person became infected with Ebola. While the virus has killed about 10,000 people in Sierra Leone, Liberia and Guinea, only a handful of cases have been seen in the United States, Spain and Britain. The world has recorded more than 24,000 Ebola cases so far, with nearly 10,000 reported deaths…. (Doucleff, 2015, para. 3)

These characteristics of viral infections often lead to misconceptions because they are commonly confused with characteristics of bacterial infections. Utilizing this type of text engages the reader because it is a relevant scientific phenomena and it addresses key concepts that students should learn in a life science course, such as biology.

## *Useful Strategies for Improving Reading Comprehension Skills*

**Instructional scaffolds.** When reading comprehension skills are addressed, teachers help students make meaning of text by asking and answering questions, summarizing, examining text structures, using graphic organizers, predicting, and clarifying. For example, simply analyzing the title of a current event article and asking students to predict what they expect will be discussed can help students become more actively involved in reading the text. Engaging students in discussions about the topic before reading a text can elicit misconceptions amongst students.

Some effective ways of improving student reading comprehension include matching texts to students' knowledge level and providing explicit instruction aimed at teaching students to use reading comprehension strategies for comprehension monitoring, paraphrasing, and elaborations. In my experience, many students are accustomed to reading an entire text from start to finish and then going back through the text to attempt to clarify their thoughts and make meaning of the text. By providing explicit instruction that required students to separate a text into smaller sections and paraphrase each section, students felt as though the reading was less daunting. Consistent with the ideas of Montelongo & Herter (2010) and Ness (2009), when students finished paraphrasing each section, they often were knowledgeable enough about the text to engage in discussions and ask relevant

questions. The students then had a much more concise amount of information available if they needed to refresh their memory about a section of the text. One of the biggest problems science educators face in promoting reading comprehension is simply the lack of time spent using these strategies or even engaging students in reading expository texts.

**Technology.** Additionally, technology can play an integral role in promoting student motivation and further skill building. Current students are less likely to pick up and read a newspaper when they have such easy access to web-based articles through their smart phones, laptops, or other devices. Making technology available for students in the classroom so they can quickly look up unfamiliar vocabulary definitions and pronunciations can help encourage students to be more active in the reading process. Online texts are becoming more prevalent and easier to access so these are great tools to utilize with a generation of students that are so technologically dependent. For example, websites, such as *Science Daily*, are devoted to publishing scientific news articles and are a useful approach to engaging students in learning how the field of science is always changing, with new discoveries reported on a daily basis.

**Close reading.** As addressed previously, it is not sufficient to simply get students reading texts; a big issue in science classrooms is reading comprehension. Content area teachers often lack the skill set to help engage students in improving their reading comprehension abilities (Ness, 2009). Encouraging collaboration amongst teachers, especially involving literacy specialists, can help content teachers determine the most effective strategies for skill building in the classroom (Wigfield, 2004). For example, a relatively new, but effective literacy strategy used by literacy specialists is *close reading* (Shanahan, 2012). This strategy encourages a transition from passive to active reading in which the reader thinks about the meaning of the text as they read. Close reading is an intensive analysis of a text to come to terms with what it says, how it says it, and what it means (Shanahan, 2012).

Close reading requires that students read and then re-read texts, with the focus of each reading differing in complexity and order of thinking. The first read is simply to familiarize the student with the text and get a general idea what thoughts and concepts are being addressed. Subsequent reading(s) are focused on what the text means, what the author's point is, and why the text is meaningful. As mentioned previously, during these readings it is important to teach students how to divide texts into smaller sections so that the task of reading the article seems less daunting.

When engaging students in reading more complex science articles, such as those published in peer-reviewed journals, this division is already done. Typically these texts are set up with headings that separate the text into sections for the reader. By asking students to focus on a single section of an article, they may be able to comprehend that section better than if they read the whole article. By separating the text into smaller sections, the student can gauge their comprehension of what is being read as they go. Students ultimately rely less on the "search and find" method of comprehension in which they simply pick out key phrases or vocabulary. When utilized in the classroom, it may be beneficial to have students work in pairs or small groups so that during one of the readings, one student can read aloud while the other listens and writes notes or questions about the article. Close reading is gaining popularity in secondary schools but typically still only in English classrooms. This is

a simple, yet effective strategy that can be used to promote reading comprehension in the science classroom.

## Conclusion

Pre-service and novice educators should recognize that utilizing scientific current event articles and published studies can help promote student engagement in reading. Utilizing these texts and providing proper instruction and scaffolding can improve reading comprehension of secondary science students. Engaging students in discussions about texts is a key component of transitioning to deeper, conceptual understanding and can supplement hands-on activities that promote inquiry-based learning. Ultimately, improving reading comprehension skills will help create more scientifically literate citizens.

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**Biography**

Alyssa Hoop obtained her master's degree in secondary education from the University of Toledo as a Woodrow Wilson Teaching Fellow. She previously completed a master's degree in molecular and cellular biology while conducting neuroscience research. In fall 2015, Alyssa will be an integrated science teacher at Rogers High School in Toledo Public Schools.

# The Chemistry Topics that are Effectively Taught Using Virtual Chemistry Laboratories

Brittney Kuhlman

**Abstract**: With advances in technology, teachers struggle when determining whether to replace a Virtual Chemistry Laboratory (VCL) with a traditional chemistry laboratory in secondary chemistry classrooms. A VCL is a virtual simulator that accurately portrays a traditional chemistry laboratory. Knowing the chemistry topics that can be taught through a "good" VCL will make a beneficial impact on students' abilities to think about and learn chemistry. This manuscript discusses the topics that can be successfully taught using VCLs, along with the features of an effective computer simulator. VCLs are useful in understanding mathematics in chemistry, investigating phenomenon at the microscopic level, in learning spatial abilities, when students struggle using laboratory equipment, and when they accurately depict a physical laboratory.

## Introduction

As a chemistry teacher, I commonly hear students say "This is hard" and "How in the world could you memorize all of this?" Sure there is some memorization in chemistry but most understanding of chemistry involves thinking. How can teachers engage students in thinking about abstract concepts that you cannot see and apply mathematical reasoning to explain those concepts? With advances in technology, teachers have new and innovative ways to help students learn. Science technologies like a Virtual Chemistry Laboratory (VCL) can promote students' conceptual understanding in chemistry and has shown to be just as or more effective as learning through traditional laboratories (Hawkins & Phelps, 2013; Pyatt & Sims, 2012). With that being said, how do chemistry teachers decide on whether to implement VCLs or traditional chemistry laboratories in the classroom? The answer lies in the chemistry topics that are most effectively taught through a VCL and the kind of simulation technology being used.

Not everyone agrees on using VCLs solely in teaching a specific concept. According to the National Science Teachers Association (NSTA) (1999), "Computers should enhance, but not replace essential 'hands on' laboratory activities" (p. 1). In their public policy statement, the American Chemical Society (2014) stated, "The Society believes that there is no equivalent substitute for hands-on activities where materials and equipment are used safely and student experiences are guided" (p. 1). However, research has shown that VCLs can be valuable alternatives to physical laboratories (Hawkins & Phelps, 2013; Pyatt & Sims, 2012). Because of the disagreements on how to implement chemistry laboratory instruction, teachers struggle with deciding when to use VCLs. This manuscript discusses the topics that can be successfully taught using VCLs, along with the features of an effective computer simulator. Knowing the chemistry topics that can be taught through a "good" VCL will make a beneficial impact on students' abilities to think about and learn chemistry.

## What are Virtual Chemistry Laboratories?

Before I can start discussing the chemistry topics that are successfully taught using VCLs, it is important that I define a VCL and how it compares to traditional laboratories. Simulators initially made a powerful impact on society in 1928 when Edwin Link developed the flight simulator used to train thousands of military aviators before and during World War II (Feisel & Rosa, 2005). Today, simulators are not only for piloting sophisticated aircraft or ships but also in operating nuclear power plants or complex chemical processing facilities (Feisel & Rosa, 2005). A VCL is a virtual simulator that accurately represents a traditional chemistry laboratory. Physical chemistry laboratories, also known as traditional or real laboratories, involve students interacting with concrete materials without any computer-based support (Chen, Chang, Lai, & Tsai, 2014).

Many resources have used the term *hands on* to describe traditional laboratories. However, there are also sources that use the term hands on to describe physical or virtual laboratories. When the NSTA (1999) says "hands on" in their position statement, they mean physically being able to use real materials, like chemicals and laboratory equipment. However, whether or not a laboratory is hands on should not matter on the physicality of the experiment but rather if the materials, physical or virtual, are being manipulated (Klahr, Triona, & Williams, 2007; Pyatt & Sims, 2012). "In both physical and virtual situations, children's hands remain active and in control of the materials under investigation" (Klahr et al., 2007, p. 185).

## Understanding Mathematics in Chemistry

According to Bruce, Bliem, and Papanikolas (2007), chemistry is the first time students apply advanced mathematical concepts to solve real problems. Mathematics can be used in a variety of ways in VCLs. When using quantum mechanical software programs, students can build molecules, calculate their vibrational frequencies, and observe the vibrational modes as the molecules bend or stretch (Bruce et al., 2007). Other mathematical programs enable students to integrate complex equations, as well as allowing them to see the myriad calculations that comprise molecular orbital theory or determine values of the virial coefficients (Bruce et al., 2007). Simulations like the program, Virtual Substance, transforms physical chemistry concepts such as radial distribution functions, phase transitions, and real gas (versus ideal) behavior from abstract mathematics to real-world understanding (Bruce et al., 2007). From this study, it is evident that computer simulations can be beneficial in learning chemistry concepts that involve mathematics, especially thermodynamics. However, more research needs to be done to show the effectiveness of learning abstract mathematical concepts in chemistry through VCLs.

## Microscopic Phenomena

In education, a VCL can involve investigating phenomena that are not easily visualized (Chiu, DeJaegher, & Chao, 2015; Feisel & Rosa, 2005; Plass et al., 2011; Trindade, Fiolhais, & Almeida, 2002). The Next Generation Science Standards (NGSS) indicate teachers should implement scientific practices constructing

explanations of phenomena in the classroom (NGSS Lead States, 2013). However, it is difficult to develop molecular level explanations of observable phenomena, which are critical to complex science understanding (Chiu et al., 2015). Investigating phenomenon at the microscopic level in chemistry can be effectively taught using a VCL. Traditionally, teaching a phenomenon at the microscopic level involves using models that are presented in the textbook (Frailich, Kesner, & Hofstein, 2009). However, this limits the understanding of structure and matter. For example, the static models of metals, in which all particles are firmly fixed, are limited in their potential to scaffold students understanding regarding motion of electrons and its resulting electrical conductivity (Frailich et al., 2009). By interacting with the observed phenomena, in the virtual environment, students are able to make more meaningful experiences and learn by thinking and interacting with the phenomena (Trindade et al., 2002).

By changing the traditional ways of viewing microscopic concepts (models and images), there can be a more defined explanation of the phenomenon. Virtual simulations can enhance students' understanding of diffusion, gas laws, and phase changes (Plass et al., 2012). Molecules can be visualized using a virtual environment and their observed behavior can be visualized when undergoing phase changes. A good simulation is a valuable replacement of the real experience if it teaches abstract concepts better than direct experience (Winn et al., 2006). This is especially true when the simulation successfully uses metaphors to show phenomena that have no perceptible presence in the real world (Winn et al., 2006).

## Spatial Abilities

Simulations provide students with the capability to gain the spatial abilities to understand microscopic phenomenon (Trindade et al., 2002). Because students lack the visualization and spatial abilities to understand molecules, desktop three-dimensional (3D) virtual reality environments can be beneficial in enhancing students' understanding of molecular shapes (Keeney-Kennicutt & Merchant, 2013). Second Life simulations, where students create an avatar, allow students to engage in a 3D reality where they can manipulate molecules. With 3D images that improve the visual and spatial abilities, students will be able to discern isomers or observe more detailed structures of matter.

Physical laboratories use a combination of images and models of molecular shapes to describe what is being observed. My students struggled with molecular models and atomic orbitals. While learning atomic orbitals, students were confused or had mixed ideas about the shape of the orbitals and how electrons behave in an atom. Describing that phenomenon to those students, by drawing cross-sections of the atom on the board, makes it quite difficult for students to understand that the atom is 3D, along with the orbitals. Changing the way students observe atoms, can enlighten students on what is really happening at the microscopic level.

With VCLs, students can investigate why molecules are shaped a certain way and observe the angles between atoms and lone pair electrons of a molecule in 3D. They can also manipulate molecules and see how the symmetry of the molecules affects the polarity. They can change the electronegativity of the atoms and see how that affects the polarity and consequently the bond type. VCLs provide students

with more ways they can interact with science that can be more difficult to do in physical laboratory. This is because, VCLs allow students to visualize the particulate nature of chemistry (Hawkins & Phelps, 2013).

## Laboratory Equipment

According to Hawkins and Phelps (2013), using a VCL will only be at the cost of the instruction of laboratory techniques used in a traditional laboratory. There is a correlation between laboratory technique and conceptual understanding. "Conceptual understanding is related to the students' ability to effectively gather relevant information about a given phenomenon, and effectively interpret these data to form a conceptual model" (Pyatt & Sims, 2012, p.143). Students' level of understanding of how to properly collect and interpret data will not matter if the data they gather are inaccurate. As a result, the accuracy of the data limits the students' overall conceptual understanding and potentially causes misconceptions to arise. Therefore, in studies where students used the equipment improperly in the physical laboratories, VCLs resulted in greater learning gains above and beyond those achieved in physical laboratory experiences (Pyatt & Sims, 2012). However, physical laboratories can provide students with the opportunity of learning the observed phenomenon, if carried out with proper instruction and guidance.

When learning how to identify laboratory equipment, virtual laboratories have shown to be a beneficial alternative to physical laboratories (Dalgarno, Bishop, Adlong, & Bedgood, 2009; Tatli & Ayas, 2013). Students who struggle using laboratory equipment could benefit greatly using a VCL. VCLs can help students learn laboratory equipment for those who are physically unable to be in a laboratory. It is crucial that students learn how to do many laboratory techniques in the laboratory, however, if the equipment usability is affecting students' understanding of the underlying concepts, then it may be more beneficial to use the VCL.

## Type of Simulation

What is a "good" VCL? There are many simulations available free online for teachers to use. Instead of going through and naming all the simulation software that I find acceptable in a chemistry classroom, I am going to explain what to look for in a good VCL. A good VCL accurately depicts the real experience. Doing an empirical formula of a hydrate investigation through a VCL has shown to be an effective replacement of the physical laboratory due the experience being accurately portrayed in the VCL (Pyatt & Sims, 2012). In *The Child and the Curriculum*, Dewey (1902) wrote, "The map, a summary, an arranged and orderly view of previous experiences, serves as a guide to future experience" (p.20). VCLs can be considered as maps (abstractions) of the real world to guide students in learning chemistry concepts (Winn et al., 2006). Because of this, the closer the simulated experience is to the real-world experience, the more students will learn from the experience (Winn et al., 2006).

"Early criticisms of simulations were that they were too rigid, the models were too unrealistic, or simulated results really did not adequately represent real-world systems and behavior" (Feisel & Rosa, 2005, p. 125). Simulations that allow students to make whatever molecules they desire, even molecules that do not exist

in nature can lead to misconceptions. With many simulations it is important to have students keep in mind the science concepts and principles that justifies what they are discovering in the laboratory, just like if they were performing the laboratory physically. With advances in technology, simulations could eventually completely replace physical experiments no matter what the concepts being taught are due to the simulations becoming more *real* (Feisel & Rosa, 2005).

## Conclusion

A unifying theme in this manuscript is a VCL tends to be at least as effective as a traditional laboratory, if not more, depending on what the students are doing in the laboratory. This paper assumes teachers have the resources and time to implement a VCL or a physical laboratory. However, VCLs offer a unique opportunity for "hands-on" activities with virtual materials that avoid many of the disadvantages of physical hands-on materials, including safety concerns, limited materials, cost, and time shortage (Donnelly, O'Reilly, & McGarr, 2013; Klahr et al., 2007; Tatli & Ayas, 2013).

The difficulty of a VCL is deciding on the appropriate situation to use it in the classroom (Hawkins & Phelps, 2013). VCLs provide the opportunity to allow more students to do science in a way where teachers do not have to worry about improper use of equipment getting in the way of learning and in a way that was impossible before due to the topic being too abstract or too astronomically small to investigate. VCLs are useful in understanding mathematics in chemistry, investigating phenomenon at the microscopic level, in learning spatial abilities, when students struggle using laboratory equipment, and when they accurately depict a physical laboratory.

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## Biography

Brittney Kuhlman received a Master of Education through the Licensure Alternative Master's Program at the University of Toledo and a Bachelor of Science in Pharmaceutical Sciences at the University of Toledo. In fall 2015, Brittney will be teaching secondary science at Paul T. Albert Memorial School in Tununak, Alaska.

# The Problematic Nature of Teaching Inquiry: What Can We Do To Help Preservice Teachers Meet the Challenges of Implementing Inquiry In The Classroom?

Doug Rogaliner

**Abstract**: The national standards encourage the use of inquiry-based instruction to teach difficult scientific concepts. However, inquiry is very difficult to implement and very few teachers are using inquiry-based instruction in the classroom. Inquiry is a problematic term that this article will define. If science reform is going to be successful, then reform of science teacher preparation at the preservice level must occur. This article will argue that teacher preparation programs need to do a better job of understanding teacher apprehensions and better equipping teachers with authentic field experiences, support frameworks and materials, and practicum placements in open inquiry classrooms that will ultimately mobilize the vision of the standards.

## Introduction

The National Science Teachers Association's (NSTA) (2015) position statement on scientific inquiry proclaims, "understanding science content is significantly enhanced when ideas are anchored to inquiry experiences" (p. 1). The NSTA recommends that all K-12 teachers make inquiry the centerpiece of the science classroom, which will help ensure that students develop a deep understanding of science and scientific inquiry. Although there is a general consensus among science educators that inquiry-based learning is ideal, in practice, few have successfully implemented inquiry in their classroom (Ireland, Waters, Brownlee, & Lupton, 2012). What are the reasons for the success and difficulties associated with implementing inquiry in the classroom? One question that comes to mind is whether or not preservice teachers are being adequately prepared to implement inquiry in the classroom. Most teachers have no educational background in the history of science or any first-hand experience in practicing science. Thus, they tend to portray science as a collection of facts, principles, and concepts with little or no instructional attention given to the processes by which scientific knowledge is made public and validated (Wallace & Kang, 2004). The purpose of this article will be to advocate for changes to be made in preservice teacher preparation programs to better support teachers in acquiring the skills, knowledge, and dispositions necessary to foster teaching science through inquiry.

## What Is Inquiry?

A problem with teaching science through inquiry has been with "the lack of a commonly accepted understanding of what it means to teach science through inquiry" (Osborne, 2014, p. 178). The National Science Education Standards (NSES)

defines scientific inquiry as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (National Research Council [NRC], 1996, p. 23). According to the NSES, scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NRC, 1996). Thus, inquiry is described in the standards in a variety of ways, leaving one to create his or her own images of what constitutes inquiry teaching.

In pondering what it means to teach science as or through inquiry, Anderson (2002) poses the question: "Is the emphasis on science as inquiry, learning as inquiry, teaching as inquiry or all of the above?" (p. 1). What is the distinction between these three ideas of inquiry?

*Scientific inquiry,* as it relates to how science takes place, "refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (NRC, 1996, p. 23). Scientific inquiry refers to the particular ways of observing, thinking, investigating, and validating that scientist's use (American Association for the Advancement of Science [AAAS], 1993). According to the NSES, *learning as inquiry* "refers to the activities of students in which they develop knowledge and understandings of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 1996, p. 23). This describes students using, in the classroom, the same processes that scientists employ to study the natural world. These processes include: "asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments" (NRC, 1996, p. 105). The last idea of inquiry, as outlined in the NSES, is *inquiry teaching* (Anderson, 2002). "Inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (NRC, 1996. p. 3). This statement is the focusing theme for the reform movement of teaching science through inquiry instruction.

## Levels of Inquiry

Research shows there are many misconceptions and limited views among teachers as to what inquiry is and looks like in the classroom (Capps and Crawford, 2013; Crawford, 2007; Osborne, 2014; Withee and Lindell, 2006). Inquiry-based science is often confused or associated with *hands-on* science. For some teachers, inquiry relates to any time students work in a laboratory setting or on open-ended worksheet questions. For others, inquiry means any activity that is project-based or collaborative. In order to make sense of what inquiry teaching is, the concept of different levels of inquiry was first described by Schwab (1962). Wee, Fast, Shepardson, and Harbor (2004) later described four types or levels of inquiry activities: confirmation, structured, guided, and open. Different levels of inquiry help scaffold the process to support students' success. All levels or forms of inquiry should play a role in science education (National Research Council [NRC], 2000), yet most teachers are familiar with only the first two types (Lustick, 2009).

Inquiry lessons can be designed at any of the four levels depending on the

capabilities of the students. The common denominator among the four levels of inquiry is that students answer a research question about a scientific phenomenon by analyzing data. It is important to note that the data does not necessarily have to be collected by the students. Data can be provided as long as the students are conducting the analysis and drawing their own conclusions (Bell, Smetana, and Binns, 2005). Many worthwhile hands-on activities often seen performed in science classrooms do not involve a research question or data analysis. For example, constructing a model of DNA or a cell can be worthwhile activities, but without the process of analyzing data to answer an investigative question, these activities are just confirmatory exercises that do not lead to deeper levels of thinking.

The inquiry continuum progresses in complexity depending on how much information or scaffolding is provided to the student (Wheeler and Bell, 2012; Arslan, 2014). The four-level model illustrates how inquiry-based activities can range from highly teacher directed to highly student centered (Bell et al., 2005). In *confirmatory* inquiry, the most basic level, students are asked to confirm an answer to a teacher-provided question or a previously taught concept through a hands-on type of activity involving data analysis. Advancing to *structured inquiry*, the research question and procedure are still provided by the teacher, but now the students do not know the expected outcome of the investigation. These first two levels of inquiry are most often conceptualized in the literature by developing teachers (Ireland, Watters, Brownlee, and Lupton, 2012; Winschitl, 2004) and found in textbooks or *cookbook* laboratory manuals (Wheeler & Bell, 2012). At the third level of inquiry, *guided*, students are still provided a question, but now they have to develop and carry out the procedures to answer the question. Finally, in the most complex form of inquiry, *open*, students investigate questions about scientific phenomenon that are student-formulated and then design and carry out the procedures to answer the questions.

## Challenges to Implementation

While researchers and the educational community do not widely agree upon a precise definition of inquiry, The National Research Council states, "For students to understand inquiry and learn to use it in science, their teachers need to be well versed in inquiry and inquiry-based methods" (NRC, 2000, p. 87). However, few teachers have experience with scientific inquiry and thus have very informal conceptions of inquiry and how to enact inquiry in the classroom. Perceived barriers to implementation of inquiry-based instruction, both internal and external compound the problem raising the concern about how difficult it is to implement open inquiry instruction in the classroom, even for the most experienced teachers (Capps & Crawford, 2013; Crawford, 2007). Thus, is it realistic to expect beginning teachers to enact advanced levels of inquiry while they are still looking to master content understanding, planning skills, assessment strategies, and classroom management? The complexity of teaching science through inquiry and the demands on a teacher to take on a myriad of roles may be important reasons why this kind of instruction is so difficult (Crawford, 2007). Inquiry is a complex and difficult task and preservice teachers often report that they feel ill-prepared to support students in open inquiry when coming out of their methods courses (Anderson, 2002).

"Traditionally, secondary science methodology courses rely upon teacher-centered direct instructional strategies to teach teacher candidates about student-centered, inquiry-based pedagogy" (Lustick, 2009, p. 584). To better prepare inservice teachers in the use of inquiry in the classroom there are a few changes we need to make to traditional methodology courses that this article will recommend.

## Recommendations for Preservice Teacher Preparation Programs

Traditional methods curriculum that includes instruction for lesson planning, assessment, reflective analysis of teaching, classroom management, and the nature of science are still necessary (Lustick, 2009). However, to expect preservice teachers to teach with inquiry, it can be argued that they need to be taught and learn through inquiry. Therefore, the first thing that we need to do to better prepare preservice teachers to implement inquiry is to allow for the use of authentic inquiry-based field experiences to teach inquiry pedagogical strategies. The recommendation would be to add to science methodology courses or required undergraduate course work, including a specific course allowing for an authentic scientific inquiry experience. Authentic scientific inquiry experiences are forms of engagement that resemble what scientists or researchers do in their daily work (Hsu, Roth, and Mazumder, 2009). Authentic experiences put teachers side-by-side with scientists or researchers allowing them to develop an understanding of the processes involved in the development of scientific knowledge. A case study by McLaughlin and MacFadden (2014) involved teachers participating in an authentic inquiry experience where they worked alongside scientists in the Panama Canal to document ancient biodiversity. By participating in the authentic inquiry experience the teachers "learned the requirements of the scientific community in which they participated and began to assimilate its values and practices" (McLaughlin & MacFadden, 2014, p. 943). This study indicated that participation in authentic field experiences in scientific inquiry is essential in changing teachers' conceptions and practice of inquiry-based instruction (McLaughlin & MacFadden, 2014).

The literature shows that teachers' use of inquiry in the classroom is influenced by previous research experiences (Windschitl, 2004). In a study by Windschitl (2004), those teachers with research experience enacted higher-levels of inquiry in the classroom, where those with little or no research experience tended to use only confirmation type activities and no forms of higher-level inquiry. Another type of authentic field experience called Research Experiences for Teachers (RET) provides teachers with authentic research experiences with the goal of giving teachers a vision of inquiry that will then help them implement inquiry-based teaching (Blanchard, Southerland, & Granger, 2009). Blanchard et al. found this type of program could be transformative for teachers leading to a better understanding of the nature and processes of science. Thus, to improve teacher preparation programs with the goal of more inquiry in science classrooms we will need to develop courses of study that utilize the surrounding resources and environment to provide student teachers the opportunity to experience scientific inquiry first-hand.

A second recommendation to improve preservice teacher preparation programs is to create frameworks and materials that support preservice teachers' efforts in implementing higher-levels of inquiry in the classroom (Rees, Pardo, &

Parker 2013). There are a lot of resources available in print and on the Internet for teacher-centered lesson plans and activities, but very little in the way of open inquiry that novice teachers can use as models of instruction. "Well-designed science curriculum materials can serve as a critical tool for teachers to use to engage their students in science as inquiry" (Forbes, 2013, p. 180). Because teachers have little time to design instructional materials it is important that they be able to effectively determine the educational value of existing materials and be able to adapt them to inquiry practices to best promote students' science learning (Duncan, Pilitsis, and Piegaro, 2010; Forbes, 2013). However, with often-limited conceptions of inquiry, adapting traditional science curriculum materials to foster inquiry-based learning is challenging for developing teachers and, thus, needs to be a focus of methods programs.

A final recommendation for the improvement of teacher preparation programs is to focus on providing opportunities to view inquiry in action during teacher practicum experiences. Findings from a three-year study by Fazio, Melville, and Bartley (2010) involving thirty-four preservice teachers indicated that a major challenge of implementing inquiry-based teaching is that preservice teachers are not getting the opportunity to view science teachers performing inquiry-based science with students during their practicum. The study indicated that only 29.4% of the preservice teachers got to view inquiry during their practicum experience. Harlen and Allende (2009) suggest preservice teachers be provided with practicum placements in open inquiry classrooms led by experienced mentor teachers utilizing effective strategies and frameworks. In support, Crawford (2007) identified the level of mentor teachers' support and openness towards inquiry as a key influencing factor among preservice teachers' adoption of an open inquiry approach in the classroom. Thus, it is critical that teacher education programs work to recruit and develop a pool of mentor teachers that can model inquiry and support student teachers in their instructional development.

## Conclusion

It has been a few decades since the educational reform documents (AAAS, 1993; NRC, 1996) first called for the adoption of inquiry-based instruction for science education and yet there is limited implementation and acceptance in the classroom. This article suggests that if science reform is going to be successful, then reform of science teacher preparation at the preservice level must also occur. To enact teaching science as inquiry requires that teachers develop approaches that situate learning in authentic problems and mimic the way in which scientists do science. To do this, a better job is needed in teacher preparation programs of understanding teacher apprehensions and better equipping teachers with the following: authentic field experiences, support frameworks and materials, and practicum placements in open inquiry classrooms that will provide the self-efficacy for teaching science through inquiry. However, improving science teacher preparation at the preservice level is not enough. If the goal is to mobilize the vision of the standards to teach science through inquiry, then continuous teacher professional development that is authentic and situated in practice will also be necessary.

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## Biography

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# Inquiry: A Setting for Reasoning

Lori L. Schwab

**Abstract:** Inquiry is a complex instructional approach that requires students to ask questions, collect and analyze data, form and justify explanations, and connect the explanation to scientific concepts. However, because it is so complex it often falls short of its potential in everyday practice. This difficulty results from teachers attempting to focus on inquiry as a whole or emphasizing the importance of asking questions and collecting data. This manuscript brings attention to reasoning, where students make the connections between new and old information. It is reasoning that allows students to explain the data they have collected and connect it to scientific concepts. When students are able to explain and make connections they are better able to comprehend the content.

## Introduction

Inquiry was a word I learned on the very first day of my science methods course. It was introduced as an instructional approach that moves away from the *scientific method* and puts the students in the drivers seat as real scientists. Every member of my cohort was in agreement that this was the way science should be taught, so when the time came to plan our first lesson using elements of inquiry we were all excited and extremely intimidated. Our focus was on how to get students to ask good questions and properly collect data. We spent hours discussing how important it was to the lesson and racking our brains trying to think of how we could pull it off. Filled with ideas of how we could help students ask questions and collect data, we thought we were ready to take on inquiry in the classroom, but boy were we wrong. We had fallen into the trap of the *scientific method* that we all loathed and its ineffectiveness was apparent in our student assessments; all of our students were struggling to understand the content we thought we had taught so well. It is easy to see how misguided we were now as I prepare to enter the professional field, but at the time it seemed so crucial in making inquiry effective. My cohort members and I were mistaken, but in a way that happens to most novice science teachers. Upon realizing that our great plans had not worked out the way we thought they would, I set out to find the reason why and to help others new to inquiry like myself avoid the trap.

## The Problem

It is easy to get caught up in an overwhelming amount of detail when using inquiry in the classroom, especially when it is a new and unfamiliar approach. What many teachers do not realize is that the questions and data, while essential pieces of the puzzle, are not where student learning takes place. When teachers focus too much time on these areas the inquiry lesson flounders and student comprehension suffers. Hume (2009) concluded this as well after polling sixteen current science teachers about inquiry. This study found that although science teachers agree with the use of inquiry in the classroom, they lack in-depth knowledge regarding how to implement

inquiry effectively. This paper is intended to help inform teachers who are new to inquiry in science about where their attention should really be when implementing an inquiry lesson: helping students use reasoning.

## Defining Inquiry and Reasoning

It is important to clarify what is meant by the terms inquiry and reasoning in order to understand the role reasoning plays in inquiry instruction. These terms will be used often throughout this paper, but they can mean different things in different fields. For the purposes of this paper, the terms will be used as defined in this section.

Inquiry is a complex instructional method that engages students in a scientifically oriented question, collecting data, evaluating and analyzing data, forming an explanation that answers the question, connecting their answer to scientific concepts, and justifying and conveying the explanation to others (National Research Council, 1996). This method is flexible; there is no order in which all of these features should be followed. The importance of this instructional approach is that it focuses completely on the student and is shown to be one of the most effective approaches for teaching science (Magnusson & Palinscar, 1995).

Reasoning is a relational process, by which an individual integrates information and connects it to previous knowledge (Dauvier, Bailleux & Perret, 2014). This ability to analyze information, find patterns, link information, and apply it is the basis of what psychologists call intelligence (Dauvier et al., 2014). When reasoning is included in the classroom, students spend time actively focused on the content and are more successful integrating it into what they already know. Therefore, it is reasoning that builds new knowledge for students, as they are able to link new information to old information and restructure old information in new ways, which results in a better understanding of a concept and ensures that the students remember the concepts. This is even more beneficial when added into the inquiry process. Reasoning can play a crucial role in inquiry because it is how students analyze their data, form an explanation that they can justify with evidence, connect the explanation to scientific concepts, and apply concepts to new situations.

## What Role Does Reasoning Play in Inquiry?

Current research regarding inquiry has uncovered a glaring issue with this instructional approach: a lack of emphasis on student reasoning. However, many do not realize this because inquiry is not often broken down into pieces and studied. Generally, research focuses on the approach as a whole, but it seems that by not analyzing all of the pieces individually we have missed identifying the crucial element of inquiry. Reasoning is the step between experiencing a natural phenomenon and understanding scientific concepts. It is the process by which students take what they experience, piece it together into an explanation of their own, and connect it with what they already know.

### *Analyzing and Reorganizing Data to Form Explanations*

Without reasoning, students would never be able to make sense of natural phenomena because they are not focused on analyzing and reordering their data. This was shown to be the case in a study conducted by Chen and Hsiao-Ching (2015). These researchers implemented the same inquiry lesson with and without an emphasis on reasoning, to determine how critical reasoning was to inquiry. The data collected by these researchers showed improvement in student comprehension for both groups, but improvement was significantly higher in the group that emphasized reasoning. This improvement was attributed to the time the students spent on working with their data (Chen & Hsiao-Ching, 2015).

There are many other studies all with similar findings. They also indicate that student comprehension relies heavily on how well the students are able to form their own explanation of what they experience and the data they collected, which is done through reasoning. For instance, Hogstrom, Ottander, and Benckert (2010) analyzed student interactions in an inquiry classroom and found that unless prompted otherwise by the teacher, student interactions were only focused on procedure. Students were reluctant to attempt to explain their results and conversations did not reflect the use of reasoning strategies. The student assessments reflected a lack of student comprehension resulting from the absence of reasoning (Hogstrom et al., 2010). Peker & Dolan (2012) supported this idea while studying interactions between experts in the science field and students. They found that scientists focused on interpreting and explaining data (which are both facets of reasoning) when interacting with students, which resulted in higher student comprehension at the end of the lesson (Peker & Dolan, 2012).

These findings all suggest that reasoning is critical in ordering information in new ways that allow students to explain an idea. This explanation is a key feature of inquiry and it is where the students use reasoning to give meaning to their data. In order to do this, reasoning also requires students to integrate their data or new information into the knowledge that they already have, which is referred to as making connections or linking ideas.

### *Making Connections and Linking Ideas*

Making connections between ideas, information, or data is a part of how students integrate information into personal explanations. Therefore, making connections is a large part of reasoning. Krajcik, McNeill, and Reiser (2008) concluded this in their research on the Learning-Goals Driven Design Model, where the initial inquiry lesson did not result in a higher understanding of the content. Their findings indicated that in the initial lesson students had few opportunities to link information or use what they learned in a new setting, which resulted in no change in student comprehension. Another study done by Kock, Taconis, Bolhuis and Gravemeijer (2013) also highlighted the importance of linking new and old information. These researchers analyzed problems with inquiry in the classroom by observing lessons and analyzing student assessments. One major problem they found was that students failed to connect their data with their previous knowledge, which resulted in little change to student comprehension.

Making connections and reorganizing information into new explanations are how reasoning helps students develop a deeper comprehension of the content. By doing the reasoning themselves or with their peers they are essentially required to integrate the information into their science knowledge. If students are reasoning during the inquiry process their overall science achievement will improve.

It is clear that inquiry is not as effective without the inclusion of reasoning. Student achievement relies on their ability to comprehend the concepts covered in class, but without reasoning even inquiry fails to increase student comprehension and achievement. Therefore, reasoning is the key element of inquiry and should be treated as such by teachers in the science classroom.

### *Inquiry as a Tool for Reasoning*

However, the research findings in the previous sections do not mean that reasoning and forming explanations are the only parts of inquiry that matter. As stated by Kock et al. (2013), if there are issues in the other areas of inquiry (such as forming questions and collecting data), then the students will struggle to reorganize information and make the necessary connections needed in developing their explanations. Thus, it appears that inquiry provides the setting in which students experience science first hand and use reasoning to draw their own conclusions.

For example, students need to work with the equipment and collect data regarding their question; otherwise they will not have any new information to integrate into what they already know. Also, explanations can only come by analyzing data and looking for patterns, and both data collection and analysis require a question as a guide. So, inquiry as a whole is the foundation in which reasoning with the intent to form an explanation can occur and if students are able to draw their own conclusions and apply them to new situations then they have a higher mastery of the content.

## What Does This Mean for Teachers?

Looking at inquiry as a whole for the first time can be daunting. It is easy to become overwhelmed, but the information from this paper should help provide a starting point for understanding the importance of reasoning and determining how to implement reasoning more effectively in the inquiry process.

If teachers are focused on helping students use reasoning within an inquiry lesson, then the students will likely gain a deeper understanding of the content and improve their achievement in the classroom. In the classroom, reasoning can take many forms, but there are ways for teachers to know that productive reasoning is occurring. Often, reasoning will include collaboration or some form of communication. It is much easier to reorganize and connect information if the students are able to verbalize or write down their ideas. Also, students can share their ideas with peers to get feedback from others on whether or not their explanations sound plausible.

Communication surrounding reasoning will also involve more conversations focused on the data and content instead of only discussing lab procedures. If the students are using reasoning, their explanations should be more in depth and

represent their individual data as justification. The students should also be able to use their explanation to make predictions if they have been using reasoning, because they will be able to make connections between their explanations and new information.

If reasoning is emphasized during the inquiry process, research suggests there should be a significant increase in student achievement and comprehension that will reflect on any assessments. They will also become noticeably better at reasoning as they continue to practice using it throughout the year. This means that as the year progresses their ability to reason and form logical explanations will increase and it will take less time for them to reorganize and connect information.

Inquiry is such a complex instructional approach but it can be extremely effective, so teachers and students will benefit from devoting time to make it successful. With this research, teachers should be better prepared to face the biggest task in making inquiry effective, planning and supporting the use of reasoning to develop explanations. By acknowledging how crucial this is in building student comprehension, teachers can find ways to encourage and support their students. A big part of this is in the planning, if teachers remember inquiry is really all about getting students to reason through a problem and explain it on their own, then they can plan supports appropriately and prepare themselves to help students achieve.

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## Biography

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# Why Teach Evolution? Going Beyond the Laws and Standards

Lindsay Traver

**Abstract**: Although evolutionary theory is often viewed as a controversial issue among society, within the discipline of science it is not. As evolution education is taught within secondary public schools, science educators are often faced with the question *why are we learning this*? Educators often resort to justifying its teaching in terms of the laws and standards surrounding evolution. However, evolutionary theory has value beyond the laws and standards within the scientific discipline; values that stem from the purpose of science education. Within the Nature of Science, evolution is a unifying theory substantiated by evidence across the sciences, explaining the diversity and unity of life. This article provides reason for the exclusive teaching of evolutionary theory beyond laws and standards.

## Introduction

> *It's nearing the end of the year and Mrs. Smith knows what that means; it's time to teach about evolution. As she sits down to begin planning she begins to think about her past experiences during evolution instruction. Immediately she dreads the idea of students asking her questions and putting her on the spot because of their own preconceptions surrounding evolution and its controversial nature. In her experience, students seem more prepared with questions for her during evolution instruction than any other time of the year, including why are we learning this? When answering this question she would respond with because it's in the standards and the law says so, projecting the idea that evolution was a necessary evil within science. While this response has provided her with a quick resolution to the resistance posed by students, it has rarely had a lasting impact, as students began asking the same question just two days later.*
>
> *As this question replays over and over in her mind she thinks about the laws and standards answer that she usually provides students. She knows it's not enough because even after being given her answer students still ask and want to know why they have to learn about evolution. Therefore, before writing out any sort of plan, she asks herself an almost identical question: Why do I have to teach this?*

Mrs. Smith is not the only teacher that dreads teaching evolutionary theory due to its association with controversy. In a study conducted by Hermann (2013), 100% of the teachers surveyed indicated that they believed evolution to be controversial with religion being the primary barrier to evolution instruction. Berkman and Plutzer (2011) found that due to the controversial nature of evolution, 60% of educators surveyed were not strong advocates for either evolutionary biology or nonscientific alternatives. This often lead to educators only teaching parts of evolution in which they could avoid controversy, justifying it as a necessary evil, similar to Mrs. Smith. In addition, they provided multiple positions to their students about the unity and diversity of life, regardless of their relevance to science. Although evolutionary

theory is viewed as controversial, receiving reluctance in its teaching and learning, it is a necessary concept for students to understand as set forth by the laws and standards. However, as seen in Mrs. Smith's classroom, going beyond the laws and standards is necessary in justifying instruction surrounding evolutionary theory. Expanding upon the laws and standards provides students with the justification necessary to engage them in the concepts of evolutionary theory (Cooper, 2014). Therefore it is important to understand why we teach evolution and evolution only, within secondary public schools.

## What is the Purpose of Science Education?

When considering why we teach evolutionary theory it is important to first understand why we teach science. According to Rutherford and Ahlgren (1990), there are many problems that will appear in the future that must be faced by individuals, the United States, and the world that will be dependent upon humans' wise use of science, technology, and mathematics; the three overlapping disciplines of scientific literacy. In order to use science wisely one must know science well, or be literate in the field of science. This demonstrates that the purpose of science education is to provide students with knowledge to become scientifically literate.

Throughout the introduction to *Science for all Americans,* Rutherford and Ahlgren (1990) provide multiple ideas and definitions composing scientific literacy. They describe the many facets that compose scientific literacy as,

> being familiar with the natural world and respecting its unity; being aware of some of the important ways in which mathematics, technology, and the sciences depend upon one another; understanding some of the key concepts and principles of science; having a capacity for scientific ways of thinking; knowing that science, mathematics, and technology are human enterprises, and knowing what that implies about their strengths and limitations; and being able to use scientific knowledge and ways of thinking for personal and social purposes. (pp. xvii-xviii)

From this definition of scientific literacy they then produced a definition for a person who is considered to be scientifically literate:

> One who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes (Rutherford & Ahlgren, 1990, p. xvii).

Through both of these definitions there are common overlapping themes, which makes sense due to the fact that in order to be a scientifically literate person, one must display scientific literacy. If the purpose of science education is to produce scientifically literate students and scientific literacy includes the elements provided above by Rutherford and Ahlgren, how does evolutionary theory fit within the purpose of science education? In other words, why should we teach evolutionary theory and it alone, within our science classroom?

## The Nature of Science

Rutherford and Ahlgren (1990) describe the nature of science as being a component of scientific literacy when they define scientific literacy as including an understanding of scientific ways of knowing and an understanding of science as a human enterprise. This directly relates to the teaching and learning of evolutionary theory, in which an understanding of the nature of science provides reasons for why we teach evolution as the only scientific explanation for the unity and diversity of life on Earth.

An understanding of the nature of science begins with an understanding that there are many ways of knowing in the world and that science is a way of knowing about the natural world. As a scientific concept, evolutionary theory can be described as not being in controversy with students' religious beliefs due to the fact that both ideas are a different way of knowing about the world (Dobzhansky, 1973). This idea demonstrates the exclusiveness of evolution to science education, as evolution is described as the scientific way of knowing about the unity and diversity of life on Earth. Therefore it is important to understand what it means to know scientifically and the relevance that knowing scientifically has to evolutionary theory.

According to the National Academy of Sciences (1998), within the nature of science, scientists seek to explain the natural world through the use of confirmable data. Confirmable data is defined as "the results obtained through observations and experiments that can be substantiated by other scientists" (p. 27). From this definition it can be seen that any explanation not based on confirmable data is not science, including myths, personal beliefs, religious views, philosophical axioms, and superstitions (National Academy of Sciences, 1998; National Science Teachers Association, 1997). So what, what does that have to do with evolutionary theory?

Evolutionary theory is just that, a theory. In science, theories are defined as "an overarching explanation that has been well substantiated" (National Academy of Sciences, 1998, p. 4). When people argue against evolutionary theory it is often because they view it as *just a theory,* discrediting what the word theory means within science (National Academy of Sciences, 1998). However, when one understands how the word theory is defined in science they can begin seeing the significance of the words evolutionary theory to the sciences. Evolutionary theory, according to the National Academy of Sciences (1998), explains "the similarities among living things, the diversity of life, and many features of the physical world we inhabit" (p. 3), which is supported from results from various disciplines within science. Therefore evolutionary theory is science, in that it is an explanation of the natural world that has been supported by confirmable data collected through observations and experiments substantiated by other scientist. As it is a scientific theory with only non-scientific alternatives, due to the lack of supporting confirmable data, evolutionary theory is the only appropriate concept to be taught within a secondary public science classroom (National Academy of Sciences, 1998).

Referring back to the purpose of science education it can be seen that science as a way of thinking and knowing, and recognition of the diversity and unity of the natural world are essential elements of scientific literacy. Because evolutionary theory is related to science as a way of knowing and an explanation for the unity and diversity of life, evolutionary theory alone is a necessary theory to be taught within secondary science classrooms. And as it is our job as science educators to stride

towards the purpose of science education, it is essential that we include evolutionary theory within our instruction.

## Evolution as a Unifying Scientific Theory

Another important aspect of evolutionary theory that makes it fit within the purpose of science education is that it is a unifying concept among the sciences, especially the life sciences. The National Science Teachers Association (NSTA) (1997) defines the theory of evolution as a unifying science concept because it is the “theory that living things share ancestors from which they have diverged” with “abundant and consistent evidence from astronomy, physics, biochemistry, geochronology, geology, biology, anthropology, and other sciences” in support of the theory (p. 3). This same idea is also presented by the National Academy of Sciences (1998) when they are describing evolutionary theory as a scientific theory. To demonstrate that the theory is a unifying theory among the sciences they explain that confirmable data, in support of evolutionary theory, has been drawn from fields including many areas of biology, chemistry, physics, geology, and other sciences.

Evolutionary theory is also a unifying idea within the life sciences as well as among the scientific disciplines. As a core idea in the life sciences, evolutionary theory encompasses the three core ideas in the life sciences, cells as the basic unit of life, interactions, energy and dynamics within an ecosystem, and heredity (the inheritance and variation of traits) (National Research Council, 2012). Farber (2003) explicitly calls evolutionary theory “the central organizing theory of the life sciences” (p. 347), demonstrating the unifying nature of evolutionary theory within the biological sciences. Supporting this statement Farber refers to evolutionary theory being a scientific theory well substantiated by confirmable data, as addressed in the previous section.

The unifying abilities of evolutionary theory have been displayed as scientists have studied and explained the unity of life. In the article “Nothing in Biology Makes Sense Except in the Light of Evolution” Dobzhansky (1973) describes the unity of life as being explained by evolutionary theory, due to the fact that heredity is only encoded in two ways, DNA and RNA. He also addresses the method of translation as a universal code among living things; translation is the same process used in all living organisms to produce proteins. Because life contains these universal codes, especially for heredity, it is suggested that “life arose from inanimate matter only once and that all organisms, no matter how diverse in other respects, conserve the basic features of primordial life” (Dobzhansky, 1973, p. 127). DNA, RNA, the method of translation, and especially inheritance, as described by the National Research Council (2012), are key concepts within the life sciences, consolidated within the theory of evolution. When we, as science educators, teach our students about DNA, RNA, the method of translation, and the inheritance of traits we have the opportunity to relate the concepts to evolutionary theory, demonstrating its unifying abilities.

Evolutionary theory as a unifying theory within the sciences coincides with the definition of scientific literacy. One purpose of science education is that a scientifically literate person is one that “understands key concepts and principles of science,” making evolutionary theory, as a unifying and key scientific concept,

essential to be taught within secondary science classrooms (Rutherford & Ahlgren, 1990, p. xvii).

## Conclusion

Mrs. Smith asks herself again**,** why do I, as a science educator, exclusively teach evolutionary theory within my science classroom? With confidence she knows the answer she is going to provide to her students this year. Because evolutionary theory is a scientific theory supported by confirmable data, a unifying theory among the sciences, and a core idea within the biological sciences. By providing her students with this answer, while keeping it in mind during her planning, Mrs. Smith knows that providing students with instruction on evolutionary theory is required to produce scientifically literate students meeting the purpose of science education. As science educators it is our job to promote scientific literacy within our classrooms, requiring the teaching of evolutionary theory and evolutionary theory only, due to the fact that it is the only explanation in science for how life on Earth has come to be today.

Now that we, as science educators, can see why we teach evolutionary theory exclusively within our secondary science classrooms, we can provide students with answers beyond *because the law says so* or *because it's in the standards*. So when students begin to ask the same question that Mrs. Smith previously received about evolutionary theory, *why do we have to learn about evolution?*, we should be prepared with a confident answer. As your science teacher it is important that I provide you with the tools and content necessary to understand and learn science. Therefore, we are going to learn about evolutionary theory because it is the only scientific explanation for the unity and diversity of life on Earth. As a scientific theory evolution is supported by vast amounts of data collected from many scientists. Evolutionary theory can also help us better understand any concept we have learned this year, and many that you will learn in future science classes, because it is a unifying scientific concept. By providing students with this concrete answer, educators have potential to increase their students' motivation and engagement, increase their understanding of evolutionary concepts, promote scientific literacy among students, and move towards the purpose of science education (Cooper, 2014; Gerber, Mans-Kemp, & Schlechter, 2013).

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## Biography

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# The Effects of Student Collaboration when Constructing Scientific Arguments

Scott Weis

**Abstract**: Scientific argumentation is currently a popular topic in secondary science education. Scientific argumentation is defined as the connection between claims and data through justifications or the evaluation of knowledge claims in light of evidence, either empirical or theoretical. National science standards place a strong emphasis on teachers implementing argumentation in their classrooms. Research suggests that students who participate in scientific argumentation exhibit better conceptual understanding of scientific principles than those who do not. Furthermore, students who work in collaborative groups are able to construct stronger arguments than students who work independently. This manuscript will inform the reader of what scientific argumentation is, its importance in science classrooms, and why students should work in collaborative groups to construct their arguments.

## Introduction

Argumentation has been a part of human culture for thousands of years. In the 4th Century B.C., Aristotle wrote *The Art of Rhetoric*, which outlined the rules of argument and persuasion. However, the current trend of implementing argumentation in science classrooms is a relatively new idea and should not be overlooked. Argumentation is an important practice that should be implemented in all high school science classrooms. Student collaboration should be an essential focus for teachers when employing scientific argumentation into their classrooms. When implementing argumentation into their classrooms, science teachers should encourage students to collaborate with each other and build off each other's prior experience and knowledge to construct their arguments. Collaboration also allows students to discuss their thoughts and ideas and promotes the social aspect of argumentation. The National Research Council (NRC) (2012) describes *constructing explanations* and *engaging in argumentation* as two of the eight essential science practices in its *Framework for K-12 Science Education*..Additionally, the Next Generation Science Standards place a significant focus on constructing arguments supported by evidence by including the word *argument* 132 times throughout the standards (Next Generation Science Standards Lead States, 2013).

The traditional view of science education is perceived as a basic transfer of information and concepts from expert to novice, or teacher to student (Osborne, 2010), but this approach is not universally accepted. Hake (1998) and Sampson and Clark (2009) provide data to support that students working in collaborative groups while participating in scientific argumentation is more beneficial for conceptual understanding than independent work. It is important for students to participate in argumentation in science classes because science itself is based on arguments. If we,

as educators, can encourage students to think and act more like scientists, this can lead to students being more interested and engaged in science, as well as improve their conceptual understanding of the content (Osborne, 2010). Whether you are a beginning teacher or have been teaching for many years, this manuscript can help you understand the importance of implementing scientific argumentation into your classroom and why you should encourage students to work in collaborative groups to form their arguments.

Scientific argumentation encourages students to apply concepts in abstract ways to help them master the content. "Because students are exposed to new ideas, ways of thinking, or ways of talking or writing about the topic that they can integrate with their developing understanding of the content and the practice of scientific argumentation" (Sampson & Clark, 2009, p. 453). It is noteworthy to mention that in scientific argumentation, students are not necessarily partaking in a debate but they are constructing an argument in support of a particular claim (Nussbaum, 2008). Students are not choosing sides of a topic to be debated; they are simply constructing explanations with evidence and reasoning to describe a scientific phenomenon. This manuscript will stress the importance of using scientific argumentation in high school science classrooms, as well as explaining the benefits of student collaboration when participating in scientific argumentation. The goal of this manuscript is to inform the reader of what scientific argumentation is, why it is important to use it in science classrooms, why students should work in collaborative groups to construct their arguments, and how to group students to promote successful argumentation.

## Scientific Argumentation

Why is scientific argumentation essential in science classrooms? To begin, there is a growing emphasis on argumentative discourse in science classrooms (Zohar & Nemet, 2002). The understanding of why ideas are wrong can matter just as much as understanding why other ideas may be right (Osborne, 2010). Argumentation plays a central role in the building of explanations, models, and theories as scientists use arguments to relate the evidence they select to the claims they reach through use of warrants and backings (Toulmin, 1958). Tiberghien (2008) summarizes, in *Argumentation in Science Education: Perspectives from classroom-based research*, the place of argumentation in science education in terms of three goals: knowledge about nature of science, developing citizenship, and developing higher order thinking skills. Scientific argumentation promotes critical thinking by students because they are asked to construct detailed explanations of a claim using evidence and reasoning. Also, students are asked to consider rebuttals and counter-arguments that oppose their claim. When participating in scientific argumentation, a claim is an answer to a central question in which they are researching.

Next, it is vital to clarify what is meant by the word argument. Argument has both an individual and social meaning. The social meaning is that of a dispute or debate between people opposing each other with contrasting sides to an issue (Jimenez-Aleixandre & Eurduran, 2008). In other words, an argument can be either an inner chain of reasoning or a difference of positions between people, and there is a link between the two. Social argumentation can be used effectively to

increase higher levels of thinking (Jimenez-Aleixandre & Eurduran, 2008). Thus, argumentation in scientific topics can be defined as the connection between claims and data through justifications or the evaluation of knowledge claims in light of evidence, either empirical or theoretical (Jimenez-Aleixandre & Eurduran, 2008). This is important to note because without evidence and reasoning, a claim has no validity and argumentation cannot take place. For example, Zohar & Nemet (2002) state that an argument consists of either assertions or conclusions and of their justifications, or of reasons or supports, whereas argumentation refers to the process of assembling the components of claims, data, warrants, and backings. A warrant is often referred to as reasoning, particularly why a student used a certain piece of evidence to justify their claim (Sampson & Clark, 2009). Backings are support and explanations for warrants (Sampson & Clark, 2009). When students participate in scientific argumentation, they are attempting to either confirm or disprove a scientific claim that is backed up with evidence and reasoning. The evidence can be collected through experimentation or from prior theory and research on the topic.

Argumentation is central to scientific practice because scientists frame arguments, weigh evidence, construct warrants in support of hypotheses, and discuss alternative explanations (Toulmin, 1958). Scientists engage in argumentation to develop and improve scientific knowledge (von Aufschnaiter, Erduran, Osborne & Simon, 2008). Students need argumentation to learn science by articulating reasons behind their views and presenting alternative ideas or claims about others' views (von Aufschnaiter et al., 2008). "Without argument and evaluation, the construction of reliable knowledge would be impossible" (Osborne, 2010, p. 464).

When students begin to participate in scientific argumentation, it starts with a central question that they will attempt to answer. The answer to this question is essentially the student's claim. Next, it is necessary for students to collect data to use as evidence to either support or refute their claim. Data can be collected through conducting an experiment or from performing research of other studies. Students must understand that data is not evidence. Data must be analyzed and interpreted to show how it either supports or disproves a claim. Students participating in scientific argumentation must provide reasoning, which is to specify a clear connection explaining how the evidence gathered supports their claim. Lastly, students may consider alternative claims to the question and prepare a rebuttal or counter-argument that refutes other possible claims. When students work in collaborative groups, they may be exposed to alternate claims that could be addressed. When implemented correctly in science classrooms, argumentation can help students be more successful in understanding science concepts.

## Why is Collaboration the Key to Success?

Learning is typically a social process that involves the communication between student and teacher or between students (Nussbaum, 2008). Argumentation is a social activity and students should be given the opportunity to collaborate with each other when they are constructing their scientific arguments. When students collaborate with each other during scientific argumentation, they are provided an opportunity to construct arguments together, as well as to evaluate their current scientific explanations (Sampson & Clark, 2009). "A collaborative effort might also

enhance students' learning *from* and *about* scientific argumentation" (Sampson & Clark, 2009, p. 453).

Scientific argumentation promotes discourse and student literacy because it allows students to compose oral or written arguments. It is possible for students to construct scientific arguments on their own, but research has shown that collaboration in constructing scientific arguments benefits students' conceptual understandings of the content. When working in collaborative groups, students have the chance to build off each other's ideas and to discuss complex problems. A study conducted by Sampson & Clark (2009) set out to determine if working in collaborative groups helped students to develop better scientific arguments than if they worked individually. They asked the following question: Do students who engage in argumentation with others demonstrate superior performance on the mastery and transfer task than students who engage in argumentation alone? The results show that students from the collaborative group produced significantly stronger arguments than those from the individual group. This suggests that collaboration can help students to learn from and about scientific argumentation (Sampson & Clark, 2009). Working in collaborative groups initially can allow students who are struggling to receive clarifying help from their classmates to improve their understanding. In a way, working in a collaborative group is like a scaffold to help prepare students to be able to construct their own scientific arguments in the future.

Student involvement and collaboration in science learning has shown to be effective in other research as well. For example, Hake (1998) performed an analysis of 14 physics classes where students were either taught using traditional lecture or a collaborative approach. The students in the former group showed a 25% growth from pretest to posttest. In classes where lecture was stopped for student discussion in small groups, students showed an average growth of 48% from pretest to posttest. The results of this study indicate that student performance and conceptual knowledge increases with increased collaboration and discussion. This principle of collaboration can be applied to scientific argumentation to assist in students' understanding of the content.

## Group Composition

The simple act of grouping students together, even with minimal instruction or past experience with scientific argumentation, can result in greater learning in the same amount of time (Sampson & Clark, 2009). However, in order to be most effective, students should be explicitly taught the details of constructing scientific arguments and necessary scaffolds should be in place when first introducing this activity. Groups should be composed of roughly three to four students (Wilkinson, 2002). Levine and Moreland (1990) stated, "People who belong to larger groups are less satisfied, participate less often, and are less likely to cooperate with one another" (p. 593). Interestingly, there is evidence that indicates an advantage in learning when students are grouped based on similar ability level (Wilkinson, 2002).

When grouping students for construction of scientific arguments, students should be grouped with individuals with varying claims and viewpoints (Levine & Moreland, 1990). The reason for this grouping technique is to encourage students to consider alternate claims and a variety of viewpoints. By grouping those with

differing viewpoints together, the students will be able to discuss their opinions and determine which arguments are scientifically accurate or inaccurate, and what evidence can be used in their arguments. This will further help students in their constructing of counterclaims and rebuttals. Lastly, being exposed to a variety of claims may cause students to reconsider their own claims or provide further confirmation that their claim is correct (Osborne, 2010).

## Conclusion

It is critical to place a high value on scientific argumentation in your classroom to promote student engagement. Typically, students feel that argumentation is not highly valued in their class culture, and therefore, they do not develop those skills (Zohar & Nemet, 2002). By placing a great importance on students developing argumentation skills in science, students should be able to construct stronger arguments in class.

It is necessary for students to be able to construct strong arguments because the skills that they gain in participating in scientific argumentation go beyond that of the classroom and can be used in their real lives. Argumentation is an extremely hot topic in science education right now because of its inclusions in state and national standards. Scientific argumentation teaches students that in order to be valid, their claims must be supported by evidence and reasoning. Data show that students who participate in scientific argumentation in class are able to be more successful in their conceptual learning of science content than students who do not. Scientific argumentation is a social process that helps students to develop arguments based on claims, evidence, and reasoning, and to also question the claims that others make. All in all, scientific argumentation helps students in science, as well as in other content areas and outside of the educational realm.

When first developing scientific arguments, students should work in collaborative groups with their classmates. Data show that students who work in collaborative groups are able to construct stronger arguments than those who work independently. Additionally, students who have previously worked in groups were able to construct stronger scientific arguments independently than those who were always working on their own. At minimum, students should work in small collaborative groups when first learning how to construct scientific arguments. It is important that teachers understand how scientific argumentation benefits their students and how to correctly implement it into their classrooms.

One of the major barriers that must be addressed for argumentation to be successfully implemented in science classrooms is a strong understanding of the practice by teachers. McDonald and Heck (2012) conducted a study focusing on teachers' implementation of scientific argumentation in their classrooms. In the study, all five of the participants indicated that they felt argumentation was taking place in their classroom, while in fact, it was not happening in any. If teachers are unfamiliar or self-doubting of their understanding of scientific argumentation, it will be extremely difficult to implement it in their classroom. The principles of scientific argumentation should be explicitly taught and practiced in teacher preparation programs, as well as through professional development sessions.

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## Biography

Scott Weis recently received his master's degree in secondary education and licensure in AYA Life Science through the Licensure and Master's Program at the University of Toledo. He was a 2014 recipient of the Woodrow Wilson Teaching Fellowship. In fall 2015, Scott will be teaching biology and zoology at Miller High School in Corning, Ohio.

# Social Studies

# Why Social Studies Instructors Need to Teach Digital Citizenship

Jason Walton

**Abstract:** As students increase their engagement with technology, how do we as social studies educators guide them in making good choices? Dewey wrote that true participation in society could only come from an informed and empowered citizen. He also felt that the responsibility to model and shape a good citizen fell to the area of social studies. Digital citizenship has become an important citizenship issue because students often associate themselves more with a digital community than a physical one. We, in social studies, need to address digital citizenship and how students conduct themselves in this growing digital community. Digital citizenship should be taught to our students so that issues of digital safety and participation aid them in the modern world.

## Introduction

If we teach today's students as we taught yesterday's, we rob them of tomorrow.
-John Dewey, *Democracy and Education,* 1916

Sorry for the cliché. The above Dewey quote is probably one of the most overused in education, but I have an excuse. Dewey did not write it. In looking up the references to this quote, they all point to page 164 of *Democracy and Education,* and it is not there. The next step was to purchase a digital copy of the original text and search the entire document word by word. *If we teach*, *yesterday's*, and *rob* are words that do not even appear in the text. I can do this because I am digitally literate. In fact-checking my own paper, I followed a pseudo-reliable source in a blog that discussed this misquote (Thayer, 2014), then hunted down primary sources on Google's project Gutenberg, and finally purchased a digital text to do a word-by-word search. We ask our students to use primary sources in the discipline of social studies, and in the heuristic fashion of modern technology I ended up doing just that to start this paper. This demonstrates a core value of digital citizenship.

What is the value in using a misrepresented quote from a 1916 text to talk about 21$^{st}$ century citizenship? My plan was to discuss Dewey and his thoughts on citizenship, not debunk one of his beloved epigrams. One of his fundamental ideas is that a good citizen is an informed citizen and that the responsibility of school is to model and shape a good citizen. Dewey (1909) states:

> We must take the child as a member of a society in the broadest sense, and demand for and from the school whatsoever is necessary to enable the child intelligently to recognize all his social relations and take part in sustaining them. (pp. 8-9)

We want a Digital Citizen to model all the same social ideals online as they do in life. When we, as social studies teachers, address citizenship as Dewey outlined above, we now have to account for digital society as well. "Digital citizenship can be described

as the norms of appropriate, responsible behavior with regard to technology use" (Ribble, 2011, p. 10).

## Social Studies and Citizenship

The National Education Association (NEA) in 1913 believed that "the high school teachers of social studies have the best opportunity ever offered to any social group to improve the citizenship of the land" (as cited in Smith, Palmer, & Correia, 1995, p. 6). The large scope of the social studies curriculum has to ride a fine line between "an increasing amount of factual information and minutiae" (Dewey, 1937, p. 185) and the political bias regarding the interpretation of that information. Swaying toward over burdening facts or toward factual bias could make the students "easy prey of skillful politicians and political machines" (Dewey, 1937, p. 185). It was important to Dewey to balance the amount of information covered in social studies with meaning. A series of facts without meaning does not inform, but deep meaning without a proper amount of scale creates bias (Carpenter, 2006). Deprived of proper breadth and scope, it is hard to look at society with any real understanding. When we examine today's offerings of information and how we parse the Internet, media, and social networks, it is imperative that a true citizen understands how information can be skewed, manipulated and sensationalized so that we do not become "victims of political misrepresentations" (Dewey 1937, p. 185). We must teach students the societal norms that accompany digital interactions and give them the tools to make good decisions.

In order for a student to show good citizenship, "He is to be a member of some particular neighborhood and community, and must contribute to the values of life, add to the decencies and graces of civilization wherever he is" (Dewey, 1887, p. 113). What Dewey envisioned in 1887 about citizenship is true today, though the "neighborhoods and communities" may be virtual ones. Dewey believed it is the responsibility of schools to create good citizens. As of the 1900s, the area of social studies has historically been associated with teaching citizenship.

## The Evolving Nature of Citizenship

> Students today are maturing in a world where mobile connectivity is interactive, instantaneous, and ubiquitous, which offers educators the challenge and opportunity of preparing digital citizens within a global setting. (National Council for the Social Studies, 2013)

The National Council for the Social Studies (NCSS) has been in existence since 1921, and is representative of the Progressive movement in America and education at the time. A 1913 National Educational Association (NEA) report stated, "the high school teachers of social studies have the best opportunity ever offered to any social group to improve the citizenship of the land" (Smith, Palmer, & Correia, 1995, p. 6). The NEA study and its author were influenced by the democratic teachings of Dewey, whose philosophy states that one must be informed and literate to fully participate in a society (Dewey, 1909). In the 1900's this meant access to information and it means the same today. Martorella's (1997) work *Technology and the Social Studies*

*or: Which Way to the Sleeping Giant?* is often cited in works regarding technology in social studies. He was fairly accurate in predicting that the Internet would have a huge impact on the teaching of social studies, hence his metaphor of a "sleeping giant" is appropriate. The Internet has had a gigantic impact in regards to information access. When we compare 1997's technology use with today, it seems "the giant" has woken up. Martorella saw that adjusting the curriculum for the purpose of the "computer as a citizenship educator" as a necessary to adaptation for the field as technology adoption increased (Martorella, 1997, p. 513). In 1997 when this article was written, AOL was the default search engine and those few Americans who had Internet spent less than 30 minutes a day using it (Manjoo, 2009). Cell phones were the size of a brick and coverage was limited to major highways and city centers. Laptops were expensive, slow and heavy. The communication technology of today dwarfs what Martorella or any of us could have imagined in 1997.

Today the Internet is a big place. In numbers there are 3.1 billion Internet users and almost one billion websites as of June 14th, 2015 (Internet Live Stats, 2015). In one single second, there are 2.5 million emails sent, one hundred thousand YouTube videos watched, fifty thousand Google searches and ten thousand Tweets (Internet Live Stats, 2015). The average American spends eleven hours a day with some sort of digital media (Petronzio, 2015). Within this large framework we call the Internet, texting, and media, our students are learning new social behaviors. In a forum of general anonymity, good and bad things can happen. A meek student can have a voice in political discourse. But along with anonymity comes lack of accountability and this is a free speech concern. One could incite a person to political action or shame them to suicide. When does this discourse cross from heated debate to hate speech? Some legislation has been created and exercised to regulate Internet speech, but it is rarely used until harm is already done (Anti-Defamation League, 2012).

Another topic to consider is getting low income or rural students into the digital conversation. Students with access to technology are already learning digital skills. As technology jumps forward, it leaves many behind. This is an issue of access and we will have to accommodate and differentiate for learners whether they are connected or not. In the U.S. in 1915, only 20% of homes had electricity and 30% of homes had a telephone. By 1930, over 60% had phones and electricity (Thompson, 2012). The Internet is on the same adoption trajectory (Thompson, 2012). We need to prepare all our students for the awakening of this "sleeping giant" known as technology (Martorella, 1997).

## Digital Citizen vs. Digital Native

A digital citizen is not necessarily a digital native. There is an assumption that every student of a certain age can use a computer, cell phone and/or tablet. The digital divide is a term used to discuss the disparity between the people that have and are able to use technology, and those who cannot. Digital natives have been born into, or grown up in a discourse of technology use. Digital citizenship is how students conduct themselves in a digital world. If the student has no digital literacy, then they cannot develop as a digital citizen. This is not to say that as a student becomes digitally literate, they cannot learn to be a good citizen. Conversely, someone that is a digital native is not inherently a good digital citizen. Therefore, teaching digital

citizenship is important for both sides of the digital divide.

Less than 40% of American public schools' have wireless access and less than 20% of educators say their schools Internet technology meets their needs (Cohen & Livingston, 2013). The government has launched a program within its ConnectedED initiative to bring high-speed Internet connection to every school by 2018. This initiative will also train teachers in technology and assist with the purchase of appropriate equipment (Munoz & Sperling, 2013). The disparity between the *haves* and *have-nots* is an access issue straight out of the Progressive Era, when Dewey formulated his philosophy of education. Just like the progressive programs that reclassified electricity and water as a public utility, the Federal Communications Commission has ruled positively on net neutrality and classified the Internet as a public utility with the aim to make it more accessible to all. The commissioner of the FCC stated that they would use "all the tools in (their) toolbox to protect innovators and consumers and preserve the Internet's role as a core of free expression and democratic principles" (Ruiz & Lohr, 2016, p. 1).

## Teaching Digital Citizenship

The currently recognized standards for teaching digital citizenship revolve around "The Nine Themes of Digital Citizenship" (Ribble, 2011). This approach to teaching digital citizenship is formally used by the International Society for Technology in Education, the NEA, and Common Sense Education. These nine tenants of teaching Digital Citizenship to K-12 learners are represented in the concept of REPs. REPs stand for *Respect your self, Educate your self, and Protect your self* (Ribble, 2011). This system, outlined below, is used by school districts to divide these concepts into three digestible blocks and as a mnemonic device to help remember the title of each section.

- Respect yourself/Respect others
  1. Etiquette
  2. Access
  3. Law
- Educate yourself/Connect with others
  4. Communication
  5. Literacy
  6. Commerce
- Protect Yourself / Protect Others
  7. Rights and Responsibility
  8. Safety (Security)
  9. Health and Welfare. (Ribble, 2011, pp. 15-44)

A brief overview of how a REPs curriculum illustrates the scope of the initiative to teach digital citizenship. This curriculum is structured to start in elementary school with basic concepts like keeping your password secret and knowing when digital interactions are becoming inappropriate. As social studies progress more complicated concepts are introduced. Done correctly these would mirror and compliment the current real world lessons on citizenship. For more in depth information on lessons, case studies, and classroom integration, look to the books of Ribble, www.digitalcitizenship.net, and www.commonsensemedia.org. A

Google search of *REPs* and *digital citizenship* will point a reader toward a myriad of schools already posting lesson plans on these subjects.

### *Respect Yourself/Respect Others*

The first section of the REPs curriculum deals with how a student communicates, what information they share, and is that information appropriate or legal for Internet distribution. This section asks the student to define the best way to act in digital mediums. What are the right things to say and when? What are the wrong things to say and when? When is the right time for email, text or voice chat? Asking these types of questions helps to identify what kind of discourse we want to have with others. When addressing *digital access* we ask the student to look at how much time they spend online, watching videos, texting, and playing video games. Does the student have access to devices that allow them to do these activities? Can a student focus on one activity or must they multitask all the time? Digital access is multi-faceted. It can address how some students binge on media and some are bereft of it. It can be used to discuss the digital divide or digital gluttony. *Digital law* addresses fair use and copyright protection. It also instructs the student regarding the legal ramifications of bad behavior on the Internet, and can incorporate how the government is engaging with Internet providers to bridge the digital divide. *Respect your self/Respect others* addresses the *golden rules* of the Internet. Do unto others as you would have done to you; play nice and do not steal.

### *Educate yourself/Connect with others*

This part of the curriculum discusses how a student engages with technology and the others who use it. *Digital literacy* addresses the use of the mechanical, software and online tools of digital citizenship. Far beyond the technology classes that teach Microsoft Office, we must teach how to set up proper Boolean searches in Google so that we get the desired results, how to create a blog, a wiki and to navigate a forum. When looking online, what are reputable sources? Which are not, and how can one tell the difference between the two?

The discussion of *digital communication* could incorporate how a student wants to present him or herself online. Which forums do they want to use and which to avoid? What information is safe to share and which is inappropriate? *Digital communication* and *digital commerce* are similar, in that both have an element of risk assessment. Just like digital communication, how can a student tell if a commercial site is reputable or not? When purchasing online, how do we gauge risk in digital commerce? *Educate your self/Connect with others* is an area of instruction that deals with how things work, how to find one's digital voice/persona and how to engage in commerce in a digital domain.

### *Protect Yourself/Protect Others*

Protecting one's online identity and avoiding predatory situations are issues of safety. Cyber-bullying, trolling, flaming and sexting are *digital safety* issues as well as *digital communication* issues. *Digital rights* and *digital responsibilities* address the actions you take

when faced with ethical issues. Do you cite your sources when you use them? Do you use the Internet or your mobile phone to cheat on tests? What do you do and/or whom do you talk to if you are being cyber-bullied? Last, *digital health* and *digital welfare* speak to your actual physical and mental health. Using computers can lead to eyestrain, repetitive stress injuries, and carpal tunnel syndrome. Using media late at night can disrupt your circadian rhythms and cause loss of sleep. Are you spending copious amounts of time/money on games or websites? *Protect your self/Protect others* addresses safeguarding your digital, physical, and mental wellbeing.

## Conclusion

The three content areas previously discussed harken to Dewey's concept of a school as a "model of community life" (Dewey, 1909). What is the point of technology in school if it is not used to model how we use that technology in real life? A considerable amount of digital assets we use are communal. Social media, email, commerce, and even web searches draw from a community of information creators. Every website, wiki, and blog has been generated and/or curated for our students, and we as social studies educators must teach them to navigate this information. As our use and reliance on this technology grows, so must our engagement in how it shapes our student citizens. The digital citizen is the epitome of Dewey's model of learning by doing philosophy. From book to radio to television, social studies educators have been the front-runners in helping students incorporate these technologies into our understanding of the world. In the rise of the information age, adding digital citizenship to our curriculum seems like the logical next step.

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# Review of Web 2.0 Resources in the Social Studies Classroom

Samantha Mitchell

**Abstract**: Technology is intertwined in all aspects of life, including education. Though technology is a broad term that includes a variety of resources, among those are what are known as Web 2.0 tools. These are tools that allow users to interact and collaborate online, as well as generate, manipulate, and share content easily with others. Some of these tools target social studies specifically and are changing the way students learn. Outlined in this article are a few resources available to teachers of social studies, along with explanations on how they can be used in the classroom. The impact of these tools on student performance will also be discussed, as well as ways to improve teachers' confidence in their use.

## Introduction

> *Have you previously used technology while teaching? What forms of technology are you familiar with? Tell me about a lesson plan in which technology played a prominent role in student learning. Do you see yourself using technology in your classroom? Are you comfortable with technology?*

Each of the above questions is common when interviewing for teaching positions today, and prospective teachers' answers could have a significant impact on advancement in the hiring process. In fact, some districts openly state that being "technologically competent" is a necessary skill for employment. Yet, not all teachers are aware of what resources are available to them for use in their classrooms, let alone feel comfortable in their abilities to do so. In today's world, lack of awareness or negative attitudes or beliefs could hinder chances for employment, or staying employed. This is because the current generation of students, known as "digital natives," craves technology and prefer learning in this manner (Prensky, 2001). In addition, students will need to be technologically competent for when they enter the workforce, as technology has become prevalent in most workplace environments. This has important implications for all educators, but particularly those of social studies content, as students often find social studies to be uninteresting or boring. As stated by Schug, Todd, and Beery (1984), "Students frequently are not positive about their social studies experiences. Even more alarming are studies showing that young people do not feel social studies is a particularly valuable or interesting part of the school curriculum" (p. 47). One way to combat these negative attitudes towards the subject is by incorporating technology in to lessons to make the content more appealing to the current generation of students. But technology is such a broad term with many resources that fall under it; which resources should be used? The resources that many social studies teachers are beginning to turn to as an innovative way to teach content are Web 2.0 tools.

## Web 2.0 Tools: What are They?

The term technology encompasses a wide range of tools and resources, including computer-based hardware and software applications (Wynn, 2013). Hardware refers to the computers, laptops, tablets, and smart boards with projectors. In contrast, the Internet and computer programs are among the software applications. These computer programs often fall under the category of "Web 2.0 Tools," an umbrella term used to describe a variety of online collaborative and interactive tools designed for the user to generate, manipulate, and share content easily with others in real time (Wilson, Wright, Inman, & Matherson, 2011). Some of the more common Web 2.0 tools include blogs, Google Docs, Primary Access, and podcasts, which will all be discussed in the following sections. What makes Web 2.0 tools so appealing to educators is the wide availability of them, due to the ease with which they are created. With few barriers to development and distribution of these applications, web developers have witnessed an explosion in their creation (Bull, Hammond, & Ferster, 2008). This explosion includes not only an increase in the number of applications available, but in the diversity of the applications. Known as user-generated content, these applications take the form of text, photo sharing, audio sharing, and video sharing. Though Web 2.0 tools are available to teachers of every content area, there are a few of particular interest to teachers of social studies.

## Web 2.0 Tools for the Social Studies Classroom

### *Blogs*

Blogs, applications that allow users to write and generate content within a website, are becoming increasingly popular in the classroom because they give students "a sense of ownership of the class and their work within it" (Boyd, 2013, p. 87). Blogs are essentially a form of personal publishing that allow students to share their thoughts and opinions on issues, or summarize an event. Overall, they encourage student ownership of texts and promote critical thinking, including analysis, evaluation, and synthesis. In addition, blogs typically include comment boxes that allow other users to respond to posts written by the author, providing a way for users to communicate with one another online. In the classroom setting, this function is beneficial because it promotes a collaborative learning environment in which "students participate in a network of interactions rather than just listing their own thoughts on a given topic or just writing to the instructor" (Boyd, 2013, p. 87).

In the social studies classroom, blogs allow students to write about topics discussed in class and get feedback on their opinions from their peers. For example, if learning about the American Revolution, students could place themselves in the role of a colonist and blog about whether they would remain loyal to Britain or fight for independence. Once the blog has been published, classmates can view and reply to it, writing whether they agree or disagree, and why. Blogs support students in truly understanding the content so that they can make sound arguments. Furthermore, Lenhart and Fox (2006) report that nineteen percent of Internet users ages twelve to seventeen keep a blog and thirty-eight percent read blogs. These numbers would suggest that students likely have experience with blogs, which educators should

capitalize on in their classrooms.

### *Google Docs*

Similar to blogs, Google Docs has emerged as a powerful learning tool for teachers to use to encourage online collaboration. Google Docs is a free online word processor, spread sheet, and presentation editor that allows users to create, store, share, and collaborate on documents with others, allowing individuals to work on a single version of a document at the same time rather than emailing back and forth (Roberts, 2013). This feature of Google Docs allows students to collaborate online and have discussions about any topic of their choosing. Discussions are particularly critical in social studies as "discussion promotes many of the objectives of social studies education, especially in terms of studying controversial issues, promoting critical thinking, learning democratic values, and gaining content mastery; discussion also builds tolerance among individuals and makes social studies more engaging" (Roberts, 2013, p. 130).

In contrast to traditional classroom discussion, discussion using Google Docs appears to have more advantages overall, as outlined by Roberts (2013). For instance, in terms of engagement and participation, Google Docs gives students the ability to work on one document at the same time and everyone has equal access, so no one is competing to have their opinion heard as they might in a classroom setting. In terms of time, discussions on Google Docs can span any length of time, not just one class period, and the discussion can take place outside of school. Other advantages of Google Docs are that teachers have the ability to save the discussion records for future use or reflection, and Google Docs provides real-time monitoring that allows students to receive feedback instantaneously.

### *Primary Access*

Another Web 2.0 tool becoming popular in the social studies classroom is Primary Access (http://www.primaryaccess.org), a web-based tool designed specifically for social studies instruction. Using websites that provide primary sources in digital form, such as the Library of Congress or the Smithsonian Museum, students can utilize Primary Access to combine these digital sources and produce online movies and comic strips, or create a rebus.

The first tool available with Primary Access is MovieMaker, which allows students to "assemble a montage of archival images, compose a script, and record a voice-over narration" (Bull et al., 2008, p. 276). Essentially, students are able to produce a movie about a topic of their choosing by using images they compile and set to a voice recording. Another tool available with Primary Access is StoryBoard, which allows students to create comic strips using primary sources and combining graphics and thought bubbles to the images to tell a story. Upon completion of the comic strip, students can publish and share with others. The final tool available on the website is Rebus, in which students use pictures as part of the text to tell a story. For example, students can omit words in a text and replace them with images, or add images to provide a visual representation of the text. Overall, each of these tools allows students the freedom to get creative and illustrate historical events outside of

the traditional, written summary.

### *Podcasts*

Podcasts are a form of audio sharing that allows users to present narratives, lectures, and individual or group presentations via the World Wide Web (Kemp, Mellor, Kotter, & Oosthoek, 2012). Given the characteristics of podcasts, they are emerging as a valuable instructional tool. Kemp et al. (2012) point out that the immediate educational benefit of podcasting technology is the ease with which digital content can be immediately and inexpensively disseminated to large audiences on a variety of platforms. The benefits of podcasts for teachers is obvious, as they can use podcasts to record lectures or entire lessons, which students can then download and listen to on their own time. However, some teachers are allowing students to use podcasts as a new way to complete school assignments.

In one study, a class of students used podcasts as an end-of-year assessment in which they summarized a topic they had researched over the course of the year (Kemp et al., 2012). Results from the study showed that this form of assessment kept the students actively engaged, promoted group work, language and oral communication skills, and a better understanding of the material. Though this specific study was done with students in a geography course, its implications span across all content areas, including social studies. Instead of requiring students to write essays summarizing a historical event, teachers can give students the option to summarize the event through a podcast. Though both accomplish the same goal, with the podcasts, students can express what they have learned in a manner that is unique to them; they can incorporate their personality into the presentation, which is something that may not translate on paper.

## Advantages of Web 2.0 Tools

Web 2.0 tools have many advantages for use within the classroom. Among the most important advantages is that they offer an alternative to the way students think and learn in school as well as how they communicate what they learned. Students can view content from a source other than the traditional textbook, which some researchers believe to be more beneficial for students. Jones and Madden (2002) point out that, when researching information for a school assignment, students prefer looking up information on the Internet rather than having to physically search through book collections. This is particularly true in social studies, which involves a lot of memorization of facts because students are often required to read a text and then recall information from the text, including information about people, places, and events. To some students, doing this reading online is preferable to reading a textbook.

Furthermore, using Web 2.0 tools in the classroom appears to have a positive impact on student performance. In a study by Hsin, Li, and Tsai (2014), researchers found that students who used technology and Web 2.0 tools in their classrooms tended to outperform students who did not. However, this result was contingent upon the amount of experience students had with technology. Specifically, students with more experience, as measured by their prior knowledge of computers and

their access to a computer at home, outperformed students with less experience. These results would suggest that students can excel academically through the use of technology, but only if they are taught how to correctly use it and have consistent access. Therefore, teachers and schools need to support students to be technologically competent so that they can take full advantage of all of the features technology has to offer. This requires that teachers are willing and able to support their students' use of technology. But how do teachers feel about technology?

## Teachers and Web 2.0 Tools

Martorella (1997) described technology as the "sleeping giant in the social studies curriculum" that few teachers have utilized (p. 511). Dawson, Bull, and Swain (2000) elaborated on this idea stating that, compared to other content-area teachers, social studies teachers display a greater deficiency in their use of innovative teaching methods made possible through the various technologies available to them. Prensky (2001) believes this has a lot to do with the world in which current experienced teachers grew up, which is very different from the world current students have grown up in. As mentioned previously, students who have grown up surrounded by technology are referred to as "digital natives." In contrast, Pensky refers to experienced teachers who began their careers before technology became common in classrooms as "digital immigrants," as they are similar to one assimilating to a foreign culture. These digital immigrants who are not as familiar with technology do not feel comfortable using it. Creating teachers who are "comfortable in their technologies skills and secure in their choice to use available technologies for instructional purposes poses a serious challenge" (Shriner, Clark, Nail, Schlee, & Libler, 2010, p. 37).

Lee, Doolittle, and Hicks (2006) point out that part of the problem among social studies teachers is that they often lack the resources to even try using technology in their classroom. Particularly, they lack sufficient numbers of computers for student use, lack time to learn how to use computers or teach students how to use them, or even lack access to the Internet. But teachers that do have access to these resources should be making every attempt to learn how to use them. Sahin (2008) argues that faculty adoption of educational technology is critical and teachers need to be given the training, education, and encouragement to have the necessary skills and confidence to use such technologies in their classrooms. Sahin (2008) further adds, "when levels of faculty confidence in and awareness of educational technology increases, faculty interest in technology will grow and eventually result in a higher level of faculty willingness to use educational technology" (p. 51). However, with no background knowledge, these teachers need instruction.

This idea was echoed in the study by Shriner et al. (2010) in which current experienced K-12 teachers participated in three different teacher development workshops that trained teachers on how to use different forms of technology related to the following three topics specific to social studies: how to use virtual fieldtrips to enhance service learning, how to use various resources and approaches to social studies instruction, and how to use various resources and approaches to teach geography and history of the world. Participants completed a survey before and after completing the workshops and results of the surveys showed that

participants gained statistically significant changes in their levels of confidence and competence in using the different technology resources in each of the three workshops. According to this study, even "digital immigrants" can learn to embrace technology in their classrooms, if given the tools and training to do so.

## Conclusion

As technology becomes more prevalent in our lives it is altering the way students learn, and specific aspects of technology, Web 2.0 tools, are emerging as effective instructional tools. These online tools allow students to generate, manipulate, and share content easily with others in real time, providing a unique interaction and collaborative experience different from what is offered in a "traditional" classroom learning environment. These tools have important implications for social studies teachers and students as Web 2.0 tools have the capacity to transform how students think and learn in the classroom.

Web 2.0 tools such as blogs and Google Docs are powerful learning tools that allow students to discuss content online with peers and receive immediate feedback. This form of interaction allows students to think critically and analyze what others have written, and also allows them to reflect on their own ideas. Another Web 2.0 tool, Primary Access, turns students into historical researchers and allows them to present their findings in movie, comic strip, or rebus form, which they find enjoyable. Lastly, podcasts are also rising in popularity in classroom instruction, making information widely available and with relative ease. Teachers can utilize podcasts to make lesson plans available to students for download, or students can use them as an alternative to traditional presentations or written assignments. Overall, each of these tools is changing the way students learn, but doing so in a manner that students prefer. In addition, most students not only prefer learning with these tools, but are also performing better as a result (Hsin et al., 2014). While not all teachers feel comfortable using technology, with additional education and training through professional development workshops, teachers can gain the skills and confidence to effectively use these resources in their classrooms.

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## Biography

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# Learning to Teach

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