Journal of Adolescent & Adult Literacy 55(2)
October 2011
doi:10.1002/JAAL.00013

(pp. 100–109)

What It Is They Do: Differentiating Knowledge and Literacy Practices Across Content Disciplines

Do the literacy strategies used in English language arts work for mathematics? What does it mean to be literate in particular subject disciplines? Best practices in literacy may require specific strategies for each discipline.

Holly Johnson | Patricia A. Watson
with Tina Delahunty | Patrick McSwiggen | Tara Smith

> "A lot of people in the field are like the little kid with the screwdriver and the toaster. Let's take it apart and see why it works." (Tara Smith, mathematician)
>
> "Math is puzzle generating; thinking about and playing with knowledge." (Patrick McSwiggen, mathematician)
>
> "Maps are such a small part of what we do." (Tina Delahunty, geographer)

In construction work, a variety of tools facilitate getting the job done. Those who frame houses use different tools from those who do electrical or plumbing work. Using appropriate tools makes the job easier to do; the tools used and the amount of time needed depend on the site and the job. The size or qualities of one type of tool also serve particular purposes.

Take a hammer: While a myriad of hammer types is available, an expert would not use a ball-peen hammer to work on upholstery or to hang drywall. Many in construction, however, might have similar tools regardless of their specialty—common tools like screwdrivers and wrenches—but there are qualitative and quantitative differences between construction workers' toolboxes when it comes to their tools of choice and specialty.

In respect to disciplinary literacy, the same principle applies. There are particular literacy tools that better serve particular content areas, but we often find in content area literacy textbooks that the same tools are considered appropriate regardless of discipline. The best tools for constructing knowledge complement the work to be done, and toolmakers need knowledge of the field so they can develop the most appropriate tools. If literacy educators are not conversant in multiple content areas, we cannot teach the appropriate tools for the disciplines that our candidates will teach.

Discovering what tools our disciplinary colleagues across academic fields use for acquiring knowledge, and further knowing what they identify as necessary knowledge in their disciplines, was the aim of this project. Thus, we began to work with disciplinary experts to address what it means to be literate in the fields of mathematics and geography. We specifically targeted experts

who had connections to the schools or colleges of education at our universities.

What follows are our current understandings of the disparate fields of mathematics, geography, and content area literacy writ large along with a description of the project we undertook to produce these understandings. Our discoveries are the broad strokes of our understandings and are juxtaposed with our own experiences as content area literacy educators. They are complemented by the voices of students, especially those in the field of mathematics who cannot "figure out why [they] have to take so many literacy courses."

Our collaboration with disciplinary experts is presented here as an example of the kind of work that is needed to develop the field of disciplinary literacy, and is guided by our desire to inform teacher preparation. It should be noted that our disciplinary colleagues do not represent the entirety of their fields, as there are vast differences even within their own disciplines. Thus, while knowledge can be garnered from this study, we caution against generalizing, as our disciplinary colleagues have cautioned us.

Situating the Study

Content area literacy has a long history rooted in the paradigm of applying cognitive strategies to content specific texts (Moje, 2008). Developing from Gray's (1925) work with study skills at the beginning of 20th century and continuing through Harold Herber's (1970s) work, the idea of teaching cognitive strategies for making sense of text dominates content area literacy textbooks.

Recently, however, theory in content area literacy has begun to focus on adolescent literacy, including issues of culture, social interaction, technology, and diversity. Researchers and theorists have encouraged those involved with content area literacy instruction to adopt a disciplinary approach, which is a more complex view of literacy instruction that addresses the literacy demands specific to content areas and is based in the belief that deep knowledge of a discipline is best acquired by engaging in the literate habits valued and used by experts in that discipline (Lee & Spratley, 2010; McConachie, Petrosky, & Resnick, 2009; Moje, 2008).

Through reading, writing, and thinking in ways common to the discipline, students deepen their knowledge and understanding of disciplinary content. This paradigmatic shift presents enormous challenges to those of us engaged in the preparation of teachers. What seems evident is that to engage in a disciplinary approach to content area literacy, we must first know about the literacies and texts of particular subject areas.

Although a few researchers have begun to describe and delineate the literacy practices of different disciplines (Donahue, 2003; Draper, 2008; Shanahan & Shanahan, 2008), the work is just beginning. What does it mean to be literate in particular disciplines and how do we begin to shift to disciplinary literacy?

Draper, Smith, Hall, and Siebert (2005) described the disjuncture between content area instruction and literacy instruction as a "dualism," and asserted that teachers must explicitly instruct students about how the texts in their disciplines are created and used. Draper's (2002) work with content area colleagues yielded the understanding that some content area strategies suggested by literacy educators were contradictory to the needs of some disciplines and encouraged teachers to engage in literacy instruction that did not support learning of the discipline.

For instance, Siebert and Draper (2008) noted that content area textbooks often suggest examining mathematical problems using keywords, a practice long ago discarded by mathematical experts. Another example could be the word wall. In the construction world, it might be considered the hammer. There are all types of word walls, but in math the use of a word wall without explicitly addressing the differences between mathematics and English would be inappropriate.

Other research, however, has shown that some generic strategies have the potential for supporting readers in comprehending many different types of texts (Heller & Greenleaf, 2007; Moje, 2008). The current challenge for teacher–educators is to identify which strategies have merit and which should be discarded as well as to develop our own knowledge of the roles texts and literacy play in the disciplinary subject areas of middle and secondary schools.

Our conversations were fraught with efforts to communicate so we could understand each other's intent.

Conducting the Study

As literacy educators in teacher preparation programs at two universities, we were interested in exploring what we perceived as the disconnection between content disciplines, teaching methods, and literacy education. In essence, we considered the situation where the toolmaker has not really assessed the actual task to be done and thus, the tool most beneficial for accomplishing the job remained undetermined.

To address this disconnect, we explored content literacy texts we had used for our content literacy courses, and then approached disciplinary specialists to discuss the understandings of our disparate fields along with the discipline's key concepts and practices. Two of our colleagues were mathematicians, the other a geographer. All of us had terminal degrees in our fields and taught both graduates and undergraduates in our respective departments.

First, we conducted content analysis on 12 current textbooks and found that the types of knowledge within the texts were divided into two major categories, pedagogical and content, attending to how to teach and what to teach respectively. Some addressed the national standards, while others focused on multiple literacies or suggested particular types of strategies for each discipline.

We also examined our own experiences with teacher candidates. As content area literacy instructors, we offer courses that address literacy across the curriculum at the undergraduate and graduate levels. At both our institutions, students often question why they have to learn about reading if they are going to teach math, science, social studies, art, music, or physical education. Other challenges come in the form of skepticism related to the textbook or the types of strategies we believe teacher candidates could implement in fourth- to 12th-grade classrooms.

We then conducted interviews with our disciplinary colleagues where we shared perspectives related to texts, literacy, and practices within our fields. We consulted major academic journals and disciplinary websites to establish a greater understanding of the disciplinary fields, and we discussed our lived experiences as content/disciplinary literacy instructors.

We found the results of our study could be categorized into themes, which included major understandings of the field, literacy in the discipline, and practice of the discipline. Each is discussed in turn.

Current Understandings

We now recognize that the language, content foci, and disciplinary assumptions—in essence, the discourses—of our disparate fields created challenges to and opportunities for bridge building between us. Juxtaposing with our experiences as content area literacy educators and with the textbooks we used, showed—in stark relief—the differences between the knowledge of our colleagues and our experiences as instructors of content area literacy courses.

Our conversations were fraught with efforts to communicate so we could understand each other's intent. Often we lapsed into the use of metaphor to bridge our understandings. What we garnered from our efforts included distinct definitions and major questions of their fields; differentiation of what is considered literacy and literacy tools used in their disciplines, and; the particular literacy practices they enact within their disciplines.

Major Understandings of the Discipline—Patterns and Their Importance

The major understandings in both geography and mathematics focus on patterns. The questions asked in each field are specific and inquiry based, which allows for further construction of knowledge as well as more discovery. The field of mathematics and its subfields, includes pattern recognition/generalizing, representation of mathematical models numerically/symbolically/graphically, and the dominance of proof as its foundational knowledge base. As mathematician Patrick McSwiggen asserted,

> ultimately, [what] the mathematician wants to do is prove something about [a mathematical] model. Mathematics, however, is not about running simulations, creating computer models just to see

> what's happening, and say, 'This is the answer.' The mathematician would say, 'That's a nice example, now prove it.'

Tara Smith, another mathematician, defined the mathematics' conceptual framework as "something that is really the bigger picture of what math is. It's the conceptual framework that lets us understand 'number'; that lets us understand logical proof." In geography and its variety of subfields, major understandings focus on the interdisciplinary nature of the field and rest on the foundation of time and space/place. As geographer, Tina Delahunty, defined, "Geography is the study of patterns and processes on the earth across space and through time."

When compared, mathematics and geography examine patterns and use those patterns to create greater understandings about the world, both physically and theoretically. Geography is more time based, and mathematics more descriptive based in respect to patterns.

Mathematical questions and inquiries about patterns are largely driven by the concept of "What if?" Smith explained that when given a mathematical model, mathematicians will ask questions about removing a postulate or adding a component to see what happens to the model. She added, "Applied math is much more 'Let's see what we can come up with. We've identified these patterns; now let's see if we come up with a mathematical model that would generate those patterns.'"

Smith further explained that mathematicians ask related questions to the "what if" that address the veracity of a model or pattern. This is accomplished through questions such as, "Is this [model] fitting what we're seeing in the real world? Can you prove that always happens? How do additions or removals change the model's pattern?"

For Smith and McSwiggen, math is not so much about questions of "How does one do... [this problem, this equation]," but rather "Can I generalize this pattern?" "Can I essentialize (cut down on) the information/properties needed for proving this model's pattern?" "What are examples and counterexamples of this pattern?" "How can I verify what I am theorizing?" Smith suggested that most mathematicians are intent upon discovery of knowledge and theorems while keeping one eye on Platonic realities.

Geographers' questions are driven by patterns on the earth and the processes that created those patterns. Delahunty used the example of biomes, "Geographers would ask, 'What are the processes that created that pattern?' [The answers would include] climate, including temperature and precipitation. It's going to [include]...the earth's current axis...and the solstice, the procession of the equinox...and all this physical planetary geography; the temperature and the precipitation."

When asked about human geography, Delahunty explained the connection of human beings interacting with their environment, and how human geographers are driven by questions involving groups of people within an environment. She commented, "Pretty much everything we do is about how to improve the human condition," and concluded by suggesting that the broad fields of geography—physical and human—are moving closer together because they are so interrelated.

When comparing the questions, definitions, and major understandings of geography and mathematics, we note the use of patterns in both fields, but would suggest the content and purposes of those patterns are qualitatively different. One field is about finding and describing patterns, the other is about testing or proving the patterns and under what conditions.

The mathematicians in our study observe the real world and create patterns through numeric, symbolic, and graphical representations and then attempt to prove those patterns as a way to establish mathematical truths. The geographer may use numeric, symbolic, and graphical representations of knowledge as tools in her field, but does so for the purposes of describing patterns and processes related to groups of people and the physical environment.

One field creates the tools and the other uses the tools, with both fields doing so for different purposes. Can both then use the same language and the same types of texts? Would both fields consider literacy in the same manner?

Literacy in the Discipline—Precision in Juxtaposition

Dominant characteristics in the fields of mathematics and geography could be defined by precision in

Mathematics involves "this developed skill of being able to think through an argument...."

juxtaposition. Each discipline has a need for precision—through its texts or its language. Both have an equally strong need for juxtaposition. The "what if" of math relies on manipulating variables in juxtaposition to each other, while geography relies on how particular elements are juxtaposed to create a pattern of the physical or human geography.

According to McSwiggen and Smith, mathematical literacy involves the functional "number and graph sense" but extends to the interpretation of graphs and the connections between numerical and graphical representations. To be literate in the field of mathematics, however, requires the ability to be conversant in your particular field of mathematics. It involves being well read, or the ability to discuss the major results in the field and to read a research paper in your field. McSwiggen asserted that mathematics involves "this developed skill of being able to think through an argument...[which is] what one would like to have addressed when children are being educated."

According to Delahunty, being literate in the field of geography is not about knowledge of absolute locations, like locating countries and their capitals on a map. Geographic literacy is much more about cultural consciousness, awareness, and the perspectives of others.

The common thread through all geography is that geographers look at patterns and processes on the earth, through space and through time. Processes that create the patterns often involve the cultural groups present within a location. So, geographic literacy requires the examination of links between the physical locations and the human activities that occur there.

With the emphasis on juxtaposition in respect to patterns and processes, being conversant in their fields, and the ability to make connections in mathematics and geography, there might be an assumption that the texts they use would be similar. Yet, a simple examination of the content texts used to teach these disciplines in K–12 classrooms reveals vast differences. What are the texts commonly used by geographers and mathematicians? And what about the language of their fields?

"Texts" of the Discipline. We embrace Smagorinsky's (2001) definition of text, which "refers to any configuration of signs that provide a potential for meaning" (p. 137). The texts noted by the mathematics in this study include "the incredible amount of knowledge in their heads," which comes from reading journal articles and other written works in their field or related fields, lectures and presentations of ideas from others, and from, "just plain thinking about what they've observed and what they've read and internalizing it....This enables them to see connections across areas because they have this huge wealth of knowledge" (Smith, personal communication, 2009).

Other texts include examples and proofs from others in the field along with the tools, techniques, and theorems others used to prove their arguments. Smith contended there is a "definite style to mathematical writing that takes time to become comfortable with. Students struggle with 'how do I read mathematical texts?'" She continued by stating, "So many of the textbooks now are just busy, busy examples—fluff." With this she further asserted that mathematics has its own language and grammar, which can more readily be seen in the classic texts of mathematician Dolciani (1967), who wrote a series of *Mathematics Structure and Method* texts in the 1960s. Reading Dolciani's mathematical arguments begins to develop mathematical grammar and thinking in respect to proofs and argument.

When considering the texts of geography, maps have always been critical tools for investigation and representation of data. Mapping, however, has come a long way since the days of pull-down maps and atlases. Today, geographers use Geographic Information Systems (GIS) on computers or handheld devices. GIS allows geographers to view, interpret, and visualize data in ways that reveal relationships, patterns, and trends. Related to GIS, remote sensing allows geographers to look at the earth remotely through aerial photography and satellite imagery.

Delahunty gave the example of a current project where geography students are examining satellite images taken 10 years apart. She described how the students examine and classify the water, vegetation, and build up visible in those images. Then they create

a map to show the percent change. It is a visual way of representing landscape change. Maps, then, are the texts used by geographers to represent knowledge in terms of patterns and processes.

To extend their investigations across longer expanses of time, geographers also make use of archival sources, usually in the form of journals and other academic texts. Delahunty stressed that geographers value the physical collection of data in a location. However, she described the use of popular texts such as *National Geographic* and travel guides like *Fodor's*, as sources for building background knowledge about a location to be investigated.

Other important sources for building background knowledge related to the perspectives of cultural groups might include media reports from outside the United States. Delahunty's advice to her students is, "Broaden your perspective so that you may better understand the pattern. Don't just get your knowledge from television news."

Language of the Discipline. When we discuss language, we are addressing the vocabulary used, the sentence grammar of the discipline, and the way in which symbols may be used. The language of math is different from English, but both are used to understand mathematics. The key for mathematics language is precision and careful definition. There is also a grammar that typically begins with "Let" as in "Let 'A' equal...." Apprentices of mathematics must learn the language of math, the syntax and grammar of proof, and learn how to read the classic texts, which use more mathematical language than current textbooks.

Math language is highly structured and sequential. McSwiggen stated that it is difficult for many students to "grasp the distinction between example and proof." When asked, students are often able to give an example where something is true, but they cannot generate the reason *why* it is true. Smith gave another example where English and mathematics are convoluted:

> What's shocking to me is the struggle with the inclusive "or." When I tell my kids you can have ice cream or cookies, I don't mean both. But, mathematically, if I say A or B is true, it means at least one. It could be more! So, there are those kinds of things about the way the language is very precise. And learning the precise language of math comes with time, and with reading and writing math.

In geography, the language is specific, but also borrowed from multiple fields across the disciplines of social and physical sciences. The reason? Technology. Maps and mapping have changed dramatically with the development of GIS and remote sensing technology, the vocabulary of the field has changed as the terminology specific to these technologies has become the common language of the field. A recently published dictionary of GIS terms included more than 1800 terms (Wade & Sommer, 2006).

According to Delahunty, geographers must have a basic knowledge of many disciplines, including history, economics, and earth science. This basic knowledge is critical to the identification of the patterns and processes foundational to geographic understanding.

While geography has its own vocabulary, such as deforestation, alluvium, jet stream, igneous, and lithosphere, which are specific to describing physical locations, the language that facilitates discussion of physical and cultural patterns is often the language of other disciplines that would be considered "English" in the field of mathematics. Mathematics has its own precise language and its own naming capabilities; geography uses language from across multiple fields as a way to juxtapose the thinking of the field.

The vocabulary, grammar, and symbols—the language—of mathematics and geography play crucial roles in understanding each discipline and becoming conversant in them. And as McSwiggen commented, becoming conversant in the field is the mark of understanding what it is those who work in the field do.

Practice of the Discipline—Making the Connection Real

In both mathematics and geography, connection to the real world, to other information, and to what is possible and probable is the defining characteristic. Mathematicians observe, theorize, and prove arguments. To become a mathematician, the most important attribute a person might have is the proclivity to ask the right kind of questions, which Smith asserted is "the biggest literacy tool."

In geography, one of the most powerful literacy tools used is metaphorical thinking.

Ways of Thinking. Mathematicians must think in logical, sequential, and structured ways. They must be organized, and they must use precise language in their efforts to expand the thinking in the field. The common arithmetic taught in grades Pre-K–8 forms a foundation for mathematics, and typically what happens in those grade levels is the use of example and observation of patterns. Moving beyond example and observation to the creation of valid proofs is the hallmark practice of mathematicians.

Historically, there have two main branches of geography, which have had different practices: human geography and physical geography. Human geography is concerned with the patterns of human existence—how humans create and sustain the places that make up the earth's surface. Physical geographers study patterns of the physical world—climates, landforms, vegetation, soils, and water. Delahunty noted that the field of geography is moving away from this human/physical dichotomy.

Geographers today study the linkages between human activity and natural systems. "If a geographer is studying physical geography, it is for the benefit of humans—to understand their environment and to be able to better survive in it. If a geographer is studying culture and looking at economic geography, again, it is about human survival and prosperity, which will relate to the physical location where they live." Geography, as the study of the earth's landscapes, peoples, places and environments, is quite simply about the world in which we live.

This kind of thinking is critical to the discipline of geography. Delahunty maintained that children in elementary schools can begin to think in these spatial ways, and that practice with this kind of cognitive activity would prepare them for the intellectual pursuits of geography.

Useful Literacy Tools. Through our work with disciplinary experts in the disparate fields of math and geography, we sought to identify the specific kinds of knowledge needed to comprehend texts and construct knowledge in those fields. While we sought to understand our disciplinary colleagues' ways of reading and thinking, we also presented them with cognitive tools and strategies commonly taught in content area literacy courses, with the goal of identifying those that would be most useful and relevant to novices in these disciplines.

Becoming a mathematician is developmental and can begin at an early age if given the appropriate tools and guidance. Math students, then, need the opportunities to play with or work through the knowledge they are learning. Some of that working through could occur in a form of content area literature circle (Johnson & Freedman, 2005), whereby students work in small groups to (a) think aloud about the mathematical processes they use, (b) engage in "what if" conversations about the patterns they see in mathematical models, and (c) use the language of mathematics with as well as practice think alouds while creating proofs.

What mathematicians do is converse, and K–12 students can be apprenticed through their own inquiries and through invitations such as math circles which disrupt the resistance "of laying themselves out there on the line and [finding that] maybe they're wrong" (McSwiggen). Thus, talk in math circles, where students can make concrete what they are forming in their heads, and thinking aloud, where the formulation of their thinking takes place, are two of the most powerful literacy strategies teachers can use in mathematics classrooms.

Reading math, and not just math examples, would also allow students to begin using the grammar of the field, as would the play with and creation of logic puzzles. In addition, we would also suggest students read classic mathematical texts and then practice by writing their own mathematical texts to begin using mathematical grammar.

Comparing English and mathematical phrases in a T-Chart would also be a useful literacy tool for young people developing as mathematicians. And, the writing of simple proofs, parsing examples of proofs, and the discussion of sequence as they marked their charts or made Venn diagrams would also help students to articulate their mathematical reasoning.

Interestingly, in geography one of the most powerful literacy tools used is metaphorical thinking. Yet, to create metaphor, students need to understand

the discipline and its use of spatial and temporal patterns. Delahunty emphasized that, while knowing capitals and locations on the map are important, this type of knowledge is not the work of geographers in the real world.

Note taking and note making are the primary literacy tools K–12 students would use for identifying intertextual patterns as well as for the collection and organization of information to make those intertextual connections. For example, when shown an I(nquiry) Chart (Hoffman, 1992), Delahunty immediately identified this graphic organizer as useful in the collection and analysis of information from geographic sources.

The I(nquiry) Chart is a framework for examining research questions by integrating what is already known about a topic with additional information found in several sources. Delahunty, however, felt that the commonly taught Cornell Notes strategy (Pauk, 1974) for note-taking would not be particularly useful in geographic learning because it does not promote the examination of data and ideas across a variety of sources.

Visual literacy is another crucial tool in a geographer's world. Delahunty asserted that learning to read satellite images and aerial photography, as well as primary photographs of locations and cultures, is important. Grids and questioning strategies like those provided by Ogle, Klem, and McBride (2007) prompt students to examine the purpose, source, point of view, and impact of primary source documents and images and can lead to the kind metaphorical thinking necessary for developing geographic content knowledge.

Making the content of geography and mathematics concrete in students' heads means content area literacy educators will need to work more closely with disciplinary experts like McSwiggen, Smith, and Delahunty so that we, too, can become more concrete in our knowledge of disciplinary literacy.

Discussion

This project represents our initial efforts to identify discipline-specific knowledge and understandings that will allow us to move beyond generalist notions of content area literacy. We did not begin, however, with the assumption that the strategies and tools, developed and taught through a long tradition of content area teacher preparation, are without value. Instead, we began the quest for a paradigm of content literacy instruction that is relevant and useful to preservice and inservice teachers as they prepare 21st-century students for careers and for higher education. As a result of this study, we have garnered three understanding from which there are clear implications for teacher preparation and development in the field of disciplinary literacy.

First, our disciplinary experts were firmly convinced that the teaching and learning that occur in K–12 content area classrooms and what is published in the traditional textbooks for the disciplines bear little resemblance to what actually occurs in the day-to-day work conducted in the field. Our experiences in middle and secondary classrooms confirm that, to a large degree, what occurs in schools is the transmission of knowledge through lectures and talk about the discipline, rather than the actual doing of the disciplines of math and geography.

Literacy instruction in content area classrooms should aim to build an understanding of how knowledge is constructed within the discipline, rather than transmitting knowledge about the discipline. Teacher educators and teacher candidates would be well served to use the tools, work at the construction site, and be apprenticed to journeymen who understand the field and its tools.

Our second understanding applies to teacher preparation. Our experts agreed that, frequently, the university students who aspire to teach in these fields view themselves as only teachers of the field—not content experts. The understanding that we drew from our initial explorations was that, to be literate in a discipline, means not just accumulating knowledge about the discipline, but understanding the discipline's important theoretical ideas. It means understanding what questions are important to the discipline and how to seek answers to those questions. It also means being able to read and write successfully within that discipline. Mathematics and geography teachers must be literate in these ways to apprentice their grades four through 12 students in the discipline.

As teacher educators, we must begin to build programs that promote, or even require, expertise within the disciplines our teacher candidates aspire to teach. We must create teacher-preparation curricula

Take Action!

For content area literature circles in mathematics:

1. Find a text that would prompt students to ask questions such as "What if" or give them a prompt to ask them to think about the language of mathematics and how it is different from English. Older students could be given a short section of Dolciani's (1967) text that would allow students to discuss the grammar of the text while younger students could be given a picture book that presents a "problem" that could be addressed mathematically.
2. Have students read the text, with the assurance that this is another way of reading mathematically.
3. Place students in groups to discuss the grammar or the language and how it differs from English (if reading a mathematical text), or how the language of the text would be different if expressed mathematically (if reading a "problem" text). Initially, discussions should be short (about 10–15 minutes).
4. Ask students to highlight phrases that they want to discuss with the whole class.
5. Discuss as a whole class the phrases students have targeted. Content area literature circles can be used with textbooks with similar prompts, but textbooks are often not mathematically sound.

For content area literature circles in geography:

1. Find a text that would allow students to address the specific language of geography. For younger students, this would be the vocabulary, and for older students, this could be geographical concepts or GIS systems. *National Geographic* also has live stream videos that could be used as a text.
2. Students would meet in groups to discuss the particular language of the text.
3. The class would meet as a group, and the teacher would guide the students in building their conceptual and grammatical knowledge of the discipline.

that are based on the practice that students construct knowledge of a discipline by engaging in the habits and practices that are valued and used by experts in the field.

The last conclusion from this study addresses the importance of interdisciplinary collaborations across those involved in teacher education. In essence, we are all teacher educators, although our disciplinary colleagues have rarely identified themselves as such. We realized the value of exploring the topic of disciplinary literacy and the potential these explorations hold for improving the opportunities adolescents may have for constructing knowledge of content and practice in the content areas.

As literacy experts, we were surprised by the commonalities we found where we least expected them. Our math colleagues talked extensively of the value of asking students to talk through their processes for problem solving, an activity immediately recognizable to us as a think-aloud whereby students would work in small groups or circles and talk through their mathematical processes. In discussing the process of constructing knowledge from geographic data, we shared graphic organizers with Delahunty, which she immediately recognized as useful.

In many cases, we find it becomes a matter of building a common vocabulary related to particular tools and practices. Our content experts recognized and embraced some of the current content literacy strategies as appropriate for supporting students as they learn to do the disciplines. Through this project we began to see that content literacy curriculum, rather than being irrelevant, could actually move teachers closer to doing rather than simply reporting or talking about the discipline they teach.

Looking Ahead

In concluding, we would like to return to the construction metaphor with which we began. In construction, builders and craftsmen use a multitude of tools, but they rarely design those tools. Engineers and toolmakers are expected to design and refine the tools of the trade. In turn, excellent toolmakers would never design tools for a task without studying the task or consulting the people who would use them.

For years, content literacy educators have promoted the use of tools (strategies and texts)

in content area literacy courses with little or no consultation with experts from the actual disciplines in which these tools are useful. Some of the tools have become obsolete because newer, more effective tools have been designed. Through our collaborative work with colleagues in mathematics and geography, we have begun the consultations necessary to know about and to use better tools for the tasks to be completed.

There is still much to learn, much to discuss, and much to ponder in respect to the tools and practices used by these experts. Next steps need to include connecting with more disciplinary experts across other fields to understand and implement with preservice teachers the strategies suggested for becoming literate.

We also need to conduct further research with teachers as they implement particular disciplinary strategies in their classrooms. We should continue building relationships that bridge the gaps between content knowledge and disciplinary literacy with the ultimate aim of understanding that to be literate in a discipline we must construct content knowledge through the practices and habits of mind common to that field.

References

Dolciani, M.P. (1967). *Modern school mathematics: Structure and method*. Boston: Houghton Mifflin.

Donahue, D. (2003). Reading across the great divide: English and math teachers apprentice one another as readers and disciplinary insiders. *Journal of Adolescent & Adult Literacy*, *47*(1), 24–37.

Draper, R.J. (2002). Every teacher a literacy teacher? An analysis of the literacy-related messages in secondary methods textbooks. *Journal of Literacy Research*, *34*(3), 357–384.

Draper, R.J. (2008). Redefining content-area literacy teacher education: Finding my voice through collaboration. *Harvard Educational Review*, *78*(1), 60–83.

Draper, R.J., Smith, L.K., Hall, K.M., & Siebert, D. (2005). What's more important—literacy or content? Confronting the literacy-content dualism. *Action in Teacher Education*, *27*(2), 12–21.

Gray, W.S. (1925). *Summary of investigations relating to reading. Supplementary Educational Monograph, No. 28*. Chicago: University of Chicago Press.

Heller, R., & Greenleaf, C. (2007). *Literacy instruction in the content areas: Getting to the core of middle and high school improvement*. Washington, DC: Alliance for Excellent Education.

Herber, H.L. (1970). *Teaching reading in the content areas*. Englewood Cliffs, NJ: Prentice-Hall.

Hoffman, J.V. (1992). Critical reading/thinking across the curriculum: Using I-charts to support learning. *Language Arts*, *69*(2), 121–127.

Johnson, H., & Freedman, L. (2005). *Content area literature circles: Using discussion for learning across the curriculum*. Norwood, MA: Christopher-Gordon.

Lee, C.D., & Spratley, A. (2010). *Reading in the disciplines: The challenges of adolescent literacy*. New York: Carnegie Corporation of New York.

McConachie, S.M., Petrosky, A.R., & Resnick, L.B. (2009). *Content matters: A disciplinary approach to improving student learning*. San Francisco: Jossey-Bass.

Moje, E.B. (2008). Responsive literacy teaching in secondary schools. In M.W. Conley, J.R. Friedhoff, M.B. Sherry, & S.F. Tuckey (Eds.), *Meeting the challenge of adolescent literacy: Research we have, research we need* (pp. 58–81). New York: Guilford.

Ogle, D., Klemp, R., & McBride, B. (2007). *Building literacy in social studies: Strategies for improving comprehension and critical thinking*. Alexandria, VA: Association for Supervision and Curriculum Development.

Pauk, W. (1974). *How to study in college*. Boston: Houghton Mifflin.

Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Educational Review*, *78*(1), 40–59.

Siebert, D., & Draper, R.J. (2008). Why content-area literacy messages do not speak to mathematics teachers: A critical content analysis. *Literacy Research and Instruction*, *47*(4), 229–245.

Smagorinsky, P. (2001). If meaning is constructed, what is it made from? Toward a cultural theory of reading. *Review of Educational Research*, *71*(1), 133–169.

Wade, T., & Sommer, S. (Eds.). (2006). *A to Z GIS: An illustrated dictionary of geographic information systems*. Redlands, CA: ESRI.

Johnson is an associate professor in the Literacy and Second Language Studies Program at the University of Cincinnati, Ohio, USA; e-mail Holly.Johnson@uc.edu.

Watson is an associate professor in the Department of Reading at the Texas Woman's University, Denton, USA; e-mail pwatson2@twu.edu.

Delahunty is an assistant professor in the Geosciences Department at Texas Tech University, Lubbock, USA; e-mail tina.delahunty@ttu.edu.

McSwiggen and Smith teach in the Mathematics Department at the University of Cincinnati, Ohio, USA; e-mail patrick.mcswiggen@uc.edu and tara.smith@uc.edu.

More to Explore

ReadWriteThink.org Lesson Plan

- "Preparing Students for Success With Reading in the Content Areas" by Scott Filkins

IRA Journal Articles

- "Linking Research to Practice in Disciplinary Instruction" by Doug Buehl and David W. Moore, *Journal of Adolescent & Adult Literacy*, March 2011
- "A Social Semiotics Framework for Conceptualizing Content Area Literacies" by Amy Alexandra Wilson, *Journal of Adolescent & Adult Literacy*, March 2011