Bringing Social and Personal Perspectives Into Standards-Based Chemistry Instruction in an Urban School District

by Donald J. Wink, Patrick L. Daubenmire, Sarah K. Brennan, and Stephanie A. Cunningham

Donald J. Wink *is a professor of chemistry at University of Illinois Chicago and director of graduate studies for a learning science program that integrates learning in the scientific disciplines with insight from other education-related fields. His work involves close collaboration with teachers and others in the improvement of teaching and learning in the Chicago Public Schools: the process of studying inquiry "close to the classroom," in authentic settings and on a large scale. Contact e-mail: dwink@uic.edu*

Patrick L. Daubenmire *earned a Ph.D. from The Catholic University of America in chemical education research. After ten years as a high school chemistry teacher and science department chairperson, Patrick joined the faculty at Loyola University Chicago, where he teaches general chemistry and serves as the Assistant Director of High School Programs in the Center for Science and Math Education. Patrick also manages the Inquiry to Build Content Science Instructional Development System, a jointly developed program of Loyola University Chicago and University of Illinois at Chicago within the Chicago Public Schools' High School Transformation Initiative. Contact e-mail: pdauben@luc.edu*

Sarah K. Brennan *has a B.S. in chemistry from DePaul University and a M.A.T. from Chicago State University. She taught chemistry and environmental science in the Chicago Public Schools for 6 years. Sarah currently works at the University of Illinois at Chicago, where she assists in the development of the Grade 10 chemistry curriculum for the Inquiry to Build Content Science Instructional Development System, a jointly developed program of Loyola University, Chicago and University of Illinois at Chicago within the Chicago Public Schools' High School Transformation Initiative. Contact e-mail: skbrennan21@gmail.com*

Stephanie A. Cunningham *has an M.S. in chemistry from the University of Illinois at Chicago and is currently pursuing a Ph.D. in Learning Sciences at the University of Illinois at Chicago. Twice she has received a National Science Foundation GK–12 Fellowship. Stephanie has been involved in the Inquiry to Build Content Science Instructional Development System, a jointly developed program of Loyola University, Chicago and the University of Illinois at Chicago within the Chicago Public Schools' High School Transformation Initiative. Contact e-mail: scunni2@uic.edu*

Introduction: Implementation of the National Science Education Standards' Standard F in Chemistry Curricula

Standard F in the *National Science Education Standards* (NSES) calls for instruction that "addresses … the role of scientific knowledge in making decisions, relationships among science, technology, politics, and society, risk/benefit analysis, assessing alternatives, and the complexity of decision making" (National Research Council, 1996). This means that such knowledge has been placed on a par with that of scientific inquiry and traditional content knowledge. Besides such prescriptive notions for what students should know, there are also strong pedagogical and sociological reasons for teaching with a focus on connections between science and society. A recent report, *The Silent Epidemic* (Bridgeland et al., 2006), investigated why students dropped out from high school by polling these students. Almost half cited disinterest in classes as a reason why they dropped out, and this factor was cited more than any other, including poor performance. Additionally, when these students were asked what would have *kept* them in school, their most common response (cited by 81% of students) was improvement in "teaching and curricula to make school more relevant and engaging and enhance the connection between school and work."

The heart of Standard F and the ideas described in *The Silent Epidemic* suggest that relevant teaching will be more effective in helping students learn traditional content, yet relevance is a complicated entity to describe, let alone to create (Wink 2005). To be effective, curricula that use social and personal perspectives to frame learning must balance several factors not typically considered in traditional curricula. First, the integrity of students must be maintained so that the curriculum retains the necessary rigor, so students may learn the content. Second, students' *actual* interests should be identified over their *perceived* interests. These actual interests can be powerful tools for helping students notice science within their lives and environments. Third, gaps in students' background knowledge need to be addressed for both traditional content, as well as their social and personal perspectives: instructors cannot assume that students automatically know, for example, why air pollution affects the environment.

There are several different ways to address Standard F and the need to have students learn the way science knowledge affects society and their lives. Two will be considered here. On the one hand, instructors can attempt to insert relevance within existing curricula activities. This is versatile, but such efforts can be tangential and easily cut from a curriculum when content demands are high. Another alternative is to use curricula that embed the learning of traditional content in scenarios or themes that address social and personal perspectives. Several texts are now available to do this, including *Living by Chemistry* (Stacy, 2006), *Active Chemistry* (Freebury and Eisenkraft, 2006), and *Chemistry in the Community* (American Chemical Society, 2006).

In this chapter, we describe a multilevel, multiyear effort to use several science texts that have very strong emphases on Standard F of the NSES, in a district-wide initiative of Chicago Public Schools in order to increase the percentages of students who meet and exceed Illinois Learning Standards (Illinois State Board of Education, 1997). This initiative has the potential to be a model for other school districts, particularly those that face the challenge of high dropout rates and poor student preparation for high school, because these are at the center of the challenges this initiative addresses.

Our discussion of this initiative will focus on the chemistry portion of the curriculum, which uses *ChemCom.* In doing so, we will address five issues that arise when using a theme-based text to teach science and to attend to Standard F:

1. Articulating a national curriculum with a particular set of state standards.
2. Teaching in a spiral, need-to-know method and mapping content coverage.
3. Addressing inquiry, life science, and earth and environmental science standards while teaching chemistry from social and personal perspectives.

4. Embedding assessment that reinforces both content learning and learning about the social and personal perspectives of the curriculum.
5. Using the text (in our case, *ChemCom*) to assist teachers in addressing particular students' needs in the following areas:
   a. student motivation to learn,
   b. lack of preparedness from previous schooling experiences,
   c. appropriate instruction for English language learners (ELL) and students with special needs,
   d. development of both skills and thinking of "gifted students," and
   e. relevance of context-rich themes to students growing up in an urban environment.

Any instructor teaching with a theme-based textbook will encounter variations of the first four issues. Our examples, though, draw from our specific work with *ChemCom*. Therefore, the last issue relates to some specific opportunities while working with *ChemCom* in a context committed to building content understanding through inquiry teaching with a large number of urban students.

Articulating With State and National Standards

Mike Ciesielski

Any educator teaching in a K–12 public school must understand his or her state standards and associated assessment systems. We work in the specific context of Chicago through participation in the High School Transformation Project. The project assists schools who have low percentages of students who meet and exceed state learning standards. The first cohort of 14 schools formed in fall 2006. The second cohort includes 11 schools beginning in 2007, and a third cohort of up to 20 schools will join in 2008. Selected schools are provided with a three-year Instructional Development System (IDS) in each of mathematics, English, and science. Each IDS involves current and research-based curricula and pedagogy, teacher training and coaching, materials and resources, and clear, well-defined tools of assessment. For our project, a team from Loyola University Chicago and University of Illinois at Chicago provides an "Inquiry to Build Content" science IDS. First-year students learn biology using *Biology: A Human Approach* (Biological Sciences Curriculum Studies, 2006), then proceed in the second year with *Chemistry in the Community* (American Chemical Society, 2006), and finish the IDS in the third year with *Active Physics* (Eisenkraft, 2004).[1] In order to ensure appropriate and meaningful implementation of our assessment program, professional development activities help coaches and teachers understand the benefits of data-driven decision making. Teachers also have ample opportunity and support to use assessment data to make instructional decisions at both a fine-grained and a "big-picture" level.

In our case, we needed our curriculum to work with both the NSES and the Illinois Learning Standards (ILS). Of course, some of this had already been done, at the national level, when the developers of *ChemCom* created a detailed description of how it aligns with the content standards of the NSES (Fig. 1).

However, because the NSES are only advisory, the "real" standards for us were the ILS. These form the basis of a set of statewide assessments for public school students at the end

[1] Concurrent with or following completion of this IDS, students may choose to take science electives at their respective schools. These courses were not included as a necessary part of the science IDS within the transformation initiative.

Figure 1. Articulation of ChemCom with NSES Content Standards

	Overview: NSES Content Standards, Grades 9–12, vs. *ChemCom* Coverage						
	A. Science as Inquiry	B. Physical Science	C. Life Science	D. Earth and Space Science	E. Science and Technology	F. Science in Personal and Social Perspectives	G. History and Nature of Science
Fundamental abilities, concepts, principles	Abilities necessary to do scientific inquiry	Structure and properties of matter	The cell	Energy in the earth system	Abiltities of technological design	Personal and community health	Science as a human endeavor
	Understandings about scientific Inquiry	Structure and properties of matter	Molecular basis of heredity	Geochemical cycles	Understandings about science and technogoly	Population growth	Nature of science knowledge
		Chemical reactions	Biological evolution	Origin and evolution of the earth system		Natural resources	Historical perspectives
		Motions and forces	Interdependence of organisms	Origin and evolution of the universe		Environmental quality	
		Conservation of energy and increase in disorder	Matter, energy, and organization in living systems			Natural and human-inducced hazards	
		Interaction of energy and matter	Behavior of organisms			Science and technology in local, national, and global challenges	

- ChemCom addresses all aspects of these fundamental abilities, concepts, or principles
- ChemCom addresses most of these fundamental abilities, concepts, or principles
- ChemCom addresses some of these fundamental abilities, concepts, or principles
- Not typically addressed in first-year chemistry courses

of the junior year known as the *Prairie State Achievement Examination* (PSAE). The PSAE includes the ACT exam and also content-focused subject tests in English, mathematics, and science. The subject tests have been written by the State of Illinois following a series of framework statements linked to the ILS. These framework statements do indeed include statements related to social and personal perspectives, meaning that for students to do well they must be able to link their knowledge to socially and personally relevant questions.

We showed how our curriculum met these standards in a "bottom-up" fashion. We took the most specific standards (the PSAE framework statements) and determined where they are covered in our curriculum. We also noted that certain things are, inexplicably, missing (these include redox reactions, for example), so we mapped the additional content that we, as chemists, knew our students needed to prepare for college. Because the PSAE framework statements had already been mapped to the ILS and the links between the ILS and NSES had already been shown, we therefore had a standards map for our program.

However, in our program, we had another requirement, because we are actually working not just with 10th grade chemistry, but also with biology and physics. This created both a need and an opportunity to create a single, comprehensive, three-year vertical alignment of scientific concepts and skills (Table 1). By making connections to these overarching themes (see chapter 3) among the three independent curricula, we could support teaching and learning about a more comprehensive understanding of science. These themes have the promise that knowledge will build to an authentic perspective that the student holds, formed alongside content knowledge because the content is learned from a social and personal perspective consistently and over three whole years.

Table 1. Conceptual Goals of Science Instruction

Conceptual Goal Standards Alignment	Science Skill Set
Matter and energy	Design and conduct investigations
Evolution	Use mathematical reasoning
Interactions	Using evidence to make informed decisions
Force and motion	Interacting with groups
Inquiry and technology	Communicating scientifically
Nature of science	

An example of the advantage of this vertical alignment comes from lessons coded as addressing "matter and energy." This allows us to explicitly link instruction in biology (metabolism and personal nutrition) to chemistry (atmospheric chemistry and the environment) and to physics (electrical energy and the home). Note that in all three cases, the vertical alignment highlights how a single scientific theme occurs in three different sciences *and* in three (or more) social and personal perspectives. Thus, social and personal perspectives become the basis for reinforcing the unity of science across multiple standards.

Teaching on a Need-to-Know Basis

As mentioned, teaching from a theme-based text creates excellent opportunities to address Standard F, as Fig. 1 shows for *ChemCom*. However, there is still the important question of how these texts address the teaching of traditional chemistry content. There is a tension that arises, probably inevitably, in such a situation. Teaching thematically means that we generally only teach what is needed for that theme. This may only be *part* of a chemistry concept. Of course, a good curriculum returns to the concept later on and "completes" it. This means that the curriculum is inherently *spiral*. Each time a part of the concept is introduced, students learn it from a social or personal perspective. On the other hand, spiral, theme-based instruction can be a problem if instructors feel it is important to teach "all" of a given content area at once. Documenting the way this "spiral curriculum" works with wide-ranging content standards requires curriculum developers to trace the growth of concepts across units.

Table 2 shows how we have done this in our program by listing how *ChemCom* teaches periodicity over time. Different aspects of the concept are introduced only when that aspect is needed, but ultimately, the concept is covered completely.

Table 2. Chemistry in the Community and the Spiral Treatment of Periodic Properties

Unit Section	ChemCom Social or Personal Perspective	Concepts of Periodicity
2.A	The periodic table enables us to categorize element properties, helping us document the usefulness of certain elements.	Periodicity of properties, metallic vs. nonmetals, nuclear charge as the basis of atomic number and integrity of the table of elements
2.B	To obtain metals in a useful form from ore requires chemical reactions, including oxidation-reduction reactions.	Periodic trends in reactivity, oxidation-reduction behavior of the elements, protons and electrons equal in neutral atoms, ions formed by electron transfer
3.A	Different parts of petroleum are made of different alkanes that, despite their variety, are based on the same kinds of bonds.	Electron shells, valence electrons, and covalent bonding (Lewis structures)
6.A	The effects of ionizing radiation on human health, including disease and diagnostics, are based in the reactions of atomic nuclei.	Structure of the atom, isotopes, transmutation (changing) of elements through nuclear processes

Addressing Other Standards Through a "Relevant" Text

As suggested in Fig. 1, a text that covers personal and social perspectives also provides opportunities to address other standards, in particular the inquiry standard (Standard A), life science standards (Standard C), and earth and space science standards (Standard D). Chapters 4, 5, and 6 in this book deal more directly with these standards. Here, we note how our work to support chemistry instruction through *ChemCom* has allowed us to address aspects of those other standards. This is important within standards-based curricula, such as in Illinois, where state standards do require students to be tested on content outside of biology, chemistry, and physics.

The way in which thematic texts address nonchemistry standards is by the selection of the themes themselves. This means that in most cases, thematic teaching almost automatically touches on a broader set of standards (Brunkhorst 1997). For example, in Unit 7, students learn about the flow of energy from the Sun to Earth. This unit describes sunlight as a source of food energy in earth's ecosystems (NSES Standard C and ILS 12C), simultaneously providing a perspective for learning chemistry and also reinforcing the biology that the students learned the year before.

Of course, an inquiry text like *ChemCom* also addresses Standard A, learning about scientific inquiry and about learning through inquiry methods. In our case, the students in our program have already experienced work with an effective inquiry-based text, *BSCS: A Human Approach*. They learn to work from the "5E" inquiry model (engage, explore, explain, evaluate, and elaborate). To maintain this method of inquiry, we mapped the way that *ChemCom* can also be seen as using these same "5E" activities.

The "5E" mapping provides pedagogical continuity with the first year of our curriculum. But the thematic method of *ChemCom* also introduces a further kind of inquiry, by emphasizing that learning occurs purposefully through weeks of exploring content relevant to the solution of problems within society. Such design inquiry contrasts to disciplinary inquiry that is found in the development of science content understandings (Rudolph, 2005). Inquiry that shows how chemistry is useful also addresses Standard F directly.

A specific example of this comes from mapping the chemistry content of *ChemCom*'s Unit 1 with a student project to address the cause of a fish kill in a community (Table 3).

Table 3. Excerpts of Mapping of Design Inquiry Instruction With Content Knowledge, From Unit 1 of *ChemCom*

Chapter Section	Water Quality Perspective	Science Content
A.2 Uses of Water	Water use and amount	Water as a chemical compound and its use throughout daily life
B.4 Particulate View of Water	Water purity	Water in chemical mixtures and as a solvent
B.14 What Are the Possibilities?	Dealing with data	Using observations to form scientific predictions
D.1 Natural Water Purification	Water purification	Hydrologic cycle of water

The final aspect of inquiry learning that needs to be developed is in the development of student understanding of inquiry itself (Abraham, 2005). In this case, we chose to use a metacognitive strategy, where we gave assignments that require students to reflect on the content and the social or personal meaning of what they have experienced, especially in the laboratory. Our method was to take all three texts and embed their lab work in the Science Writing Heuristic (SWH) (Greenbowe and Hand, 2005; Hand and Keys, 1999; Keys et al., 1999). The detailed experimental procedures of many *ChemCom* activities were retained to guide students in their investigations; however, we also presented templates to the students that put the lab in the context of the SWH and also included specific questions that require students to sum up their understandings in the end. In many cases, these questions also reinforce the social and personal perspective that is behind the activity.

An example of the integration of all these inquiry strands and Standard F in a single *ChemCom* activity is found in Unit 1, "B.11: Water Testing" investigation. Here, students test water samples for the presence of dissolved ions. First, we have documented how well this matches with the idea of an *Explore* activity in the 5E model, alerting teachers and students to the presence of experiences that students will use as the basis of their learning. Second, our SWH template asks students to document beginning ideas by reflecting before the lab on what they have seen on TV, read about, or experienced firsthand about medical tests. After students perform the experiment and write claims that they can make based on evidence they have collected, a concluding question asks them to think again about the medical testing discussed earlier, now suggesting to the students how what they have learned may change how they think about medical tests. Third, this activity has been flagged for them as crucial to the content they will need to know in order to perform well on the benchmark assessment associated with each of the unit themes known as *Putting It All Together,* or PIAT, allowing for the personal perspective of the unit to be a foundation for their learning about ion testing.

Assessing Student Progress

Content testing in Illinois includes not only content, but also understanding both science inquiry and how science links to social and personal perspectives. Therefore, our assessments also must measure to what extent students have linked their knowledge to issues outside the classroom. Therefore, they include questions linked directly to the thematic organization of the units.


Mike Ciesielski

Our IDS provides a standards-based assessment program that is designed to support our approach to a vertically integrated sequence of courses. Students are assessed approximately every eight weeks throughout the academic year with both formative and summative exams. These exams are articulated with the Illinois Learning Standards and resemble, in both format and content, what students will encounter on the content-focused science exam taken on day two of the PSAE. The formative assessments provide data to analyze student progress toward meeting standards.

However, formative and summative assessments alone do not measure all we wish to know about student learning. We have also developed embedded benchmark assessments that are articulated with our vertically aligned scientific concepts and skills (see Table 1). Because all of the courses are built around the same key concepts and skills, teachers will be able to measure students' mastery of these skills both in individual courses, and over time, as the sequence of courses unfolds. Because the benchmark assessments are drawn from in-class work, they also capture how well students can *use* their emerging understandings. Each benchmark assessment identifies for the teacher the target concept or skill for a particular lesson, the specific student task that will be used to assess this skill, and the rubric to be used for grading the identified task. A common set of rubrics linked to our IDS concepts and skills provides consistent and clear student evaluation. In addition to the grading rubric, teachers are provided with examples of student work that correspond to meaningful differences in mastery of the concept or skill being assessed. In this way, assessment is built into the fabric of the entire program and is one of the essential supporting elements of classroom instruction.

The benchmark assessments also attend to student progress in areas related to Standard F. For example, in Unit 1 PIAT, we have identified the Nature of Science/Science as a Human Endeavor as the key concept for assessment.

The material in this lesson focuses on accumulating evidence to address a concern for society: clean water. This, therefore, emphasizes the nature of science as a data-gathering enterprise in service of human needs. The role of argument in bringing specific scientific facts to the attention of the community is also treated.

The teachers are then asked to look, in particular, at the way students use evidence about chemistry *and* the relevance of chemical concepts to the social question of the cause of a fish kill. In order to get full marks on the assessment, we suggest that students show that the data have meaning to society only if they are accepted as part of the argument. This underscores the need for students to develop an understanding of how science presents results that are *then* embraced (or not) by the community.

Other benchmark assessments are more conventional, ranging from proportional reasoning to questions of particulate representations of molecules. So, too, most of the formative and summative assessment questions are recognized as testing students on "standard" content. However, the presence of significant numbers of assessment items that link student learning to the social and personal perspectives of Standard F means that the standards are articulated to the tests.

Addressing the Needs of Students in Urban Districts with *ChemCom*

As suggested in the introduction, the first four issues that we find associated with teaching from a theme-focused text like *ChemCom* are likely to arise in almost all teaching contexts and with other thematic texts. But, in practice, teachers and curriculum developers have to address the link of a *particular* text to *particular* classrooms and students. Therefore, we wish to highlight an additional set of issues that are important in our program:

- students' low motivation to learn and lack of readiness for work in high school level science,
- potentially large percentages of English language learners and students with special learning needs,
- students with low reading levels, and
- creation of appropriate challenge levels for students who are highly capable but, because of school resources or curricula, do not have access to honors or advanced placement-level courses

The particular needs of students with low motivation and lack of prior knowledge are addressed in the use of relevant topics and activities as presented in *ChemCom*'s PIAT assignments. A high number of students enrolled in the urban high schools within this initiative come with minimal or *no* experience in science. Therefore, to draw on prior or current ideas about science, teachers must first *create* the experiences and have students generate ideas about their experiences. That is why activities that engage and explore (in the 5E model) are so important. If effective, these initial experiences engage students and assist in creating a need for learning the chemistry concepts. As a result, students do develop enough experiences to provide a basis for their learning. Equally important in engagement is the question of "relevance." Users of *ChemCom* and other thematic curricula have found that even when a scenario is not directly relevant to students, the chance to role play, problem solve, and argue about the social and personal meaning of a topic provides a powerful motivation for students, who often wind up embellishing their work to make it even more interesting.

Several strategies that are useful for all learners, but particularly for ELL and students with special needs, are described by Kimbrough and Cooper in chapter 13 of this book. We have also developed a consistent set based on our overall program and on the suggestions within *ChemCom.* The organization and use of *ChemCom* within this initiative highlights the following strategies to assist teachers in addressing students' needs:

Relevant activities and topics to engage students who are part of an urban environment (Examples include water quality and usage (Unit 1), fuels and transportation (Unit 3), and air quality (Unit 4));

- Collaborative group work (Students are involved in group work in many aspects of the curriculum, not just for lab activities. PIATs provide the best examples for such work, e.g., when students create a town council meeting with debates and presentations (Unit 1) and when they act as reporters for a school bus-idling policy (Unit 4));
- Conceptual connections within the material (*ChemCom*'s modeling matter activities require critiquing and creating visual representations of chemical activity making abstract concepts easier to understand);
- Spiral curriculum (The basis of *ChemCom* described earlier in the chapter, in which concepts are partially addressed within the context of a particular unit and then revisited either in greater depth or in application to a new context. Many concepts like atom economy and periodic relationships are woven throughout units);
- Varied forms of assessment (Incorporation of literacy strategies and the SWH instruction help students manage their learning, reading, and writing. Even for students who cannot write well, the SWH guides their thinking processes (Hand, 2006; Burke et al 2006), while they use pictorial diagrams to show experimental designs); and
- Responsibility to a community (Several activities emphasize the importance of understanding chemical concepts when making decisions in communities. The understanding of chemistry is not just for scientists but is often needed by business owners, government agencies, and neighborhood action groups. This is also exemplified in the town council meeting activities at the end of Unit 1).

Students who struggle to read and write in English are supported with collaborative group work and the SWH and are able to express their ideas in various ways as they build their literacy. As Klentschy and Molina-De La Torre (2003) have observed, when instruction successfully improves both literacy and understanding of science concepts, "students have personal, practical motivation to master language as a tool that can help them answer their questions about the world around them."

Finally, students who are highly capable can be assisted in their own further development. When placed in groups with other students of varying ability, highly capable students can be coached in becoming experts in particular topics by conducting more in-depth reporting or research. *ChemCom*'s ChemQuandries can provide guidance for such supplemental work. For example, in ChemQuandry 3 found in Unit 2 students are told that a U.S. nickel is composed of an alloy of nickel and copper—specifically 25% Ni and 75% Cu. They are asked to consider the appearance of a nickel and how this given composition might be surprising. Students are then asked to determine the difference between an alloy (a "solid solution" of copper and nickel atoms) and a simple mixture of powdered copper and powdered nickel. A highly capable student might be then asked to research the compositions of various coins (domestic and foreign) and report findings to the class.

Conclusion

We have discussed the challenges and opportunities that come to curriculum developers and teachers using materials that embed learning in social and personal perspectives—essentially, materials that implement Standard "F" as a key part of their planning. We have described this in the context of one particular effort at providing a diverse, urban high school district with a standards-based curriculum using *ChemCom*. Similar opportunities (and challenges) are present in other texts such as *Active Chemistry* and *Living by Chemistry*, which both include unit themes that organize and encapsulate the learning of chemistry.

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